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UNITED STATES NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

SUBCOMMITTEE ON WASTE MANAGEMENT AND
SUBCOMMITTEE ON REACTOR RADIOLOGICAL EFFECTS

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UNITED STATES NUCLEAR REGULATORY COMMISSIONERS'

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

WEDNESDAY, JANUARY 15, 1986

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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

SUBCOMMITTEE ON WASTE MANAGEMENT AND

SUBCOMMITTEE ON REACTOR RADIOLOGICAL EFFECTS

Nuclear Regulatory Commission
Room 1046
1717 H Street, N.W.
Washington, D. C.

Wednesday, January 15, 1986

The subcommittees met at 8:30 a.m., Dr. Dade W. Moeller presiding.

ACRS MEMBERS PRESENT:

DR. DADE W. MOELLER
DR. MAX W. CARBON
DR. CARSON MARK
DR. WILLIAM KERR
DR. FORREST J. REMICK
DR. PAUL G. SHEWMON
MR. JESSE EBERSOLE

ACRS CONSULTANTS PRESENT:

DR. RICHARD F. FOSTER
MR. RONALD L. KATHREN
DR. MELVIN W. CARTER
DR. FRANK L. PARKER
DR. DONALD A. ORTH
DR. MARTIN J. STEINDLER

P R O C E E D I N G S

DR. MOELLER: The meeting will now come to order. This is a combined meeting of the ACRS subcommittees on Waste Management and Reactor Radiological Effects.

I'm Dade Moeller, chairman of the subcommittees. The other ACRS members in attendance today are Max Carbon, William Kerr and Carson Mark. We also anticipate having Forest Remick, Paul Shewmon and Jesse Ebersole join us.

Our consultants are Ron Kathren, Martin Steindler, Don Orth, Richard Foster and Frank Parker. And we also anticipate Mel Carter. He's walking in right now.

The subcommittees will review a variety of items. We have in fact roughly a two and a half day or three day meeting. We're hoping to terminate about 2 o'clock on Friday afternoon. The topics that we will review include:

One, EPA's low level waste standards, which are under development. That will be covered Friday morning.

The proposed revision of 10 CFR 20. That will be covered tomorrow.

And we'll hear discussion from the AIF and ESE studies on Part 20 and related topics. That's their National Environmental Studies Project of AIF. I hope I used the right words.

Thirdly, we'll talk about several topics in

support of the NMSS high level waste management program for several high level and low level waste management research projects.

And, fifth, we'll hear a presentation on the role and activities of the committee on Interagency Radiation Research and Policy Coordination. This is a federal interagency committee established by President Reagan.

Since we probably will not have time to prepare written reports on every item that we discuss, I would encourage the members and consultants to be penetrating in their questions while, at the same time, being constructive so that we can provide maximum benefit to the various speakers.

It would seem to me, and I'm guessing, but in terms of written comments, it would probably be useful if we can prepare summaries of our talks, at least on the two generic technical positions -- the one on groundwater travel time, and the one which I'll paraphrase as the definition of the disturbed zone.

We may also want to comment briefly on the revision to 10 CFR 60, where they are altering the wording to make it conform to the new EPA standards. Relative to 10 CFR 20, I'm just not sure it is going to go out, as I understand it, for public comment. We'll hear about that shortly. And it's quite possible that we will wait for

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comment after the public comments are in.

We, of course, have commented several times in the past as that proposed standard has been developed.

The presentation on Friday morning by the committee on Interagency Radiation Research and Policy Coordination is primarily informational, as are the presentations by the AIF on Thursday.

With respect to the Interagency Committee, on a personal basis, I'm hopeful that we can encourage them to set up a group to provide some guidance on the computation of risk, particularly for nuclear facilities such as a high level waste repository.

In several letters over the past few months, the ACRS has commented on the EPA standards for a high level waste repository. And one of the committee's criticisms was that the standards were, quote, "unduly restrictive", unquote; or, quote, "overly conservative", unquote.

From my own standpoint, I found though that the number you arrive at, I mean, how restrictive are they? Ten to the minus what per year is totally dependent, directly dependent, on the size of the population that you assume is being affected by the operation of the repository.

And I hope maybe that we could get the Interagency Committee to offer some guidance on what is the proper size population to consider when you're calculating

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risk for various facilities.

Another item relative to 10 CFR 20 is the matter of the de minimis value to use in calculating collective doses to the population. Those who have read it know that they recommend a cutoff of 1 millirem a year.

Several members of the ACRS have proposed that the committee adopt a position on this, not in opposition to 10 CFR 20 but perhaps in concert with it; although I personally would agree to some sort of a cutoff in calculating collective doses, I believe that the better approach is, rather than expressing the collective doses as a single number, the better approach is to state how many people are in each dose range category, and give that as well as the collective dose.

Then no one has any problems in interpreting what it means.

Lastly, several members of the ACRS have suggested that we attempt to develop a paper or a report that might provide some perspective on the nuclear waste problem, particularly high level, or even low level.

There within the committee is a diversity of views as to how threatening are the wastes to society. And they have encouraged the committee to try to write something that would provide prospective and help people obtain a better understanding of the subject.

I think the last report that the committee wrote that approached this subject was on December 20, 1976. It somewhat boggles my mind to think that it has been 10 years, but apparently it has. And maybe we need to update that in terms of the ACRS and the review of the subject of high level waste and low level waste.

There have been a number of developments. There is the Congress, the act that they have, I guess, recently passed on the low level waste of 1985, which has significant impacts. And I hope we'll have time in some of our discussions to review that.

And in terms of the committee and this subcommittee in its reviews of the work of the Division of Waste Management of the NRC on the matters pertaining to radioactive waste, the Commissioners have clearly asked the ACRS to become involved in this subject.

And we, in fact, I and several others, went out and met with several groups in the NRC on December 13th to sort of lay the groundwork not only for this meeting this week, but we tried to sort of plan what we would be doing in the future.

As of the moment, our thinking is to have perhaps during 1986 more meetings. They would be roughly quarterly, of two or three days each. And then, inbetween, probably several of the committee members would simply go out and

meet with our staff and review what we decided at the previous meeting, and plan the next meeting.

So we'll see how that works out. Hopefully, it, or some modification thereof, will meet our needs.

Owen Merrill is the ACRS staff member here for this meeting. He's seated on my right. The rules for participation in the meeting have been announced as part of the notice that was published in the Federal Register on December the 27th, 1985. It is requested as we move along that each speaker first identify himself or herself and speak with sufficient clarity and volume so that he or she can be readily heard.

For those in the audience, if there are people who desire to speak, and we've received no written comments or requests for time from members of the public to make oral statements, but if someone feels a compelling desire to offer some comments, simply let either me or Owen know and give us your name, and approach one of the microphones, and we'll permit you that opportunity.

Here at the desk we have this new speaker system, which, instead of each person having to hold an individual microphone, supposedly, this picks up all mumbles and grumbles as we go along.

So if you're having a private conversation, back away.

(Laughter.)

DR. MOELLER: We have been provided with material in advance of the meeting, plus there are a number of items now that have been provided to each of you just this morning. One of the more important which you'll be provided with sometime today will be a copy of 10 CFR 20, as it's proposed to be published in the Federal Register -- oh, it has been published, I'm informed.

When was it published?

MR. MERRILL: December 27th, I believe.

DR. MOELLER: Is that right? December the 27th?

Well, sometime recently. But you will be provided a copy of that. You have also been provided a copy of handout number two. It says, Comments on de minimis levels. Handout number three, Comments on the EPA High Level Waste Standards. These are ACRS comments.

Handout number four, the proposed draft statement on De Minimis Collective Doses. Handout number six, which is several background level letters pertaining to 10 CFR 20. And then I see handout number one, which is the Table of Contents for 10 CFR 20. They don't have that, but you will have it shortly.

Before we proceed, let me ask if any of the committee members have comments, questions, suggestions?

(No response.)

DR. MOELLER: I see there are none.

Do any of the consultants have questions or comments before we begin?

(No response.)

DR. MOELLER: Okay. We'll launch right ahead then, and we'll begin with our first topic, which will go to roughly 10 o'clock. That's the modifications in 10 CFR 60 to make it conform to the EPA standard for that presentation; we have Dr. Daniel Fehringer of NMSS.

Go ahead.

STATEMENT OF DR. DANIEL FEHRINGER, RE:
RULEMAKING TO CONFORM PART 60
NMSS

DR. FEHRINGER: The package I'll be speaking from is entitled Rulemaking to Conform Part 60. I just brought it this morning and it didn't have a number as part of your package of handouts. I was not able to make legible view-graphs so I did not try to use transparencies. I just passed out the paper, and you have a copy you can read along with.

On page 2, I list purposes of this proposed rulemaking. Before I get into those, let me say that I'm aware that the ACRS has expressed concern about the EPA standard itself. And I'm also aware that we have not totally reached agreement between the NRC staff and the

ACRS on that issue. Nevertheless, we do have a directive--two directives really--to go ahead with this rulemaking: the Nuclear Waste Policy Act directs us to make our rules consistent with those promulgated by EPA. And the Commission has more recently directed the staff to have a rulemaking package in front of the Commission by February 15th.

So we feel at the staff level that we have to accept the EPA standard as it is for the time being, go ahead with this conforming rulemaking. And if there are additional issues to be discussed between the ACRS and the staff regarding the standard itself, we'll have to treat that as a separate issue.

DR. MARK: Accept for the time being, supposing one came to the conclusion that it's unworkable as written? How long would it take to change the EPA standard? Five years?

DR. FEHRINGER: I can't answer that. I'm not familiar enough with EPA's internal workings to give you an estimate.

DR. MARK: Well, it's taken something like that to bring out these standards. What I'm concerned about and feel should be kept in mind is that the time to change the standards is probably long compared to some of the inputs.

DR. FEHRINGER: It's a legitimate argument. I

suspect if there were a compelling argument that the standards were unworkable, that EPA might be able to move a little bit more rapidly than they did in developing th standard in the first place. But that would be pure speculation on my part.

On page 2, I list the purposes of this proposed rulemaking. The first and primary purpose is to maintain consistency between Part 60 and the EPA standards, as we were directed in the Nuclear Waste Policy Act.

Se ond is to carry out the commitments made in a Commission paper that you reviewed late last year. SECY 85-272. In that Commission paper, we documented some agreements that had been reached between the NRC staff and the EPA staff regarding the assurance requirements section of the EPA standard. And we proposed a few, fairly minor changes to Part 60 that would have the effect of making Part 60 consistent with the assurance requirements EPA proposed in their standards.

The third purpose is to simplify the overall, high level waste regulatory structure. At the present time, we have two different regulations -- Part 60 and the EPA standard. In this rulemaking, we're proposing to combine those into really one document.

We will take all the relevant parts of the EPA standard and incorporate them directly into Part 60, so that

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any interested person will have only one document to work with.

As we do that, we propose to eliminate any duplicative wording that exists between the two standards. In some cases, EPA uses different terminology than Part 60 does to describe the safe concepts. We're proposing to incorporate the EPA standards but translate them into the existing wording in Part 60.

DR. MOELLER: In your writeup on the 10 CFR 60, this is the fifth draft, January the 3rd, '86, in which we provided the proposed rule on the summary. On page 3, you talk about avoiding introduction of redundant terminology. That's in line 58 on page 3.

And you just used different words. Now, I found the word "redundant terminology", the phrase, somewhat difficult to understand. What you're saying is, where EPA uses a different word to mean the same thing, you'll simply say somewhere in your standard that this is the same word, or means the same thing?

DR. FEHRINGER: Yes, we have several places in the package where we try to explain that we mean the same thing even though we use different wording. EPA uses the phrase, "reasonable expectation", whereas, Part 60 uses "reasonable assurance". In our view, they are exactly the same concepts and if we were to adopt EPA's phrase in

addition to the Part 60 phrase, we think that would be a redundancy in terms, which would mean exactly the same thing.

"Redundant" may not be exactly the right word. We'll give that some consideration.

DR. MOELLER: When we get into the discussion...now you just said that "reasonable expectation" to you is the same as "reasonable assurance". Yet, EPA explained that reasonable assurance isn't the same. So I don't know. We'll go ahead and we'll come back.

DR. PARKER: On the same point, you say "to avoid introducing redundancy", but in fact that's exactly what you do.

DR. MOELLER: I agree. That's what's my problem. Go ahead. We'll come back to that.

DR. FEHRINGER: What I mean by redundant terminology is that if we were to adopt EPA standards verbatim as they exist, then Part 60 would have redundant terms in it.

DR. PARKER: But you're revising Part 60. You can't revise the EPA, so you revise the Part 60 totally to conform with EPA, to use their terminology and that would not be repetitive.

DR. FEHRINGER: Okay. On page 3, I summarize the types of changes that are being made, and I've touched on

some of these already. First, all of the applicable sections of EPA standards are being incorporated directly into Part 60. At the current time, Part 60 just makes reference to the EPA standard. It requires compliance with any applicable standards that EPA has promulgated.

We are proposing to delete that and, instead, insert the standards directly into Part 60.

Second, as we just discussed, some EPA terms are being changed to use Part 60 wording.

Third, some revisions to Part 60 definitions are being made to conform to the EPA terminology. We define terms like "control area" in Part 60. EPA has come up with similar definitions for the same term. And we'll be revising Part 60 definitions to use the EPA wording.

Fourth, as we discussed a minute ago, there are some changes from the Commission paper that was reviewed by you last year.

Fifth, this is somewhat important. There are no substantive changes necessary for the existing performance objectives of Part 60. At the time those performance objectives were developed, we had working drafts of the EPA standard available to us, and we knew in general what direction EPA was headed in.

With additional reviews since publication of the EPA standard, we find that there is no need to revise the performance objectives of Part 60. The performance objectives are that provisions for containment time, release rate from the barrier system and groundwater travel time.

DR. MOELLER: On your number two there, would you clarify that? You're not actually changing the EPA terms to Part 60. I guess you're changing Part 60 to read what the EPA says. It's confusing.

DR. FEHRINGER: We could not revise the EPA standard itself; it will continue to exist as an independent document. We will have the identical requirements in Part 60, but the restatement of those requirements as they are inserted into Part 60 will use Part 60 terminology.

DR. MOELLER: With a phrase explaining that this means the same thing as EPA?

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DR. FEHRINGER: Right. In the statement of considerations, it will explain where we made changes.

DR. CARTER: Dade, could I ask you a question?

What's the purpose of this? Admittedly, you are getting a lot of redundancy, as Dr. Fehringer said. But the question is, the terms that you use other places, are you concerned about the impact of these? Are these the property of NRC that you ought to maintain these other processes, or other systems?

DR. FEHRINGER: There are terms in Part 60 that we feel we need to keep because of the existing structure of Part 60. In those cases, we prefer to use those terms as we incorporate the EPA standard, rather than try to use EPA's terms and rewrite Part 60 -- terms like "anticipated processes and events" are woven throughout Part 60. And we feel that it's useful to maintain that kind of term.

DR. CARTER: But is it external to 60 also? If it wasn't external to 60, the easiest thing would be to change 60 so that you don't end up with two systems that are difficult to interpret, instead of just one.

DR. FEHRINGER: Well, for example, DOE's citing guidelines pick up some of the same concepts, so there are external uses.

MR. LANAHAN: I think there's quite a bit of guidance documents that we have put out in discussions with

them. And we've used this consistent terminology. And I think we've just confused things.

DR. FOSTER: On that point, you're staying with the term "reasonable assurance" as contrasted with going to "reasonable expectation", which EPA uses.

If I track what you have said in here, you have kept reasonable assurance but you have further qualified what you mean by "reasonable assurance" to distinguish that somewhat from the past use of "reasonable assurance".

Now, I find this very confusing in terms of the overall regulatory business. If NRC is going to use the term "reasonable assurance" in one fashion for its reactor licensing and perhaps other phases of the fuel cycle, now we have the same term which has further qualification only in reference to high level waste management. I find this very confusing.

DR. FEHRINGER: We don't really intend that it be significantly different except to the extent that you need to consider different problems in licensing repositories. The time periods are much longer. You're dealing with geologic systems which inherently have greater uncertainty than engineered systems in a reactor plant.

The general level of confidence is intended to be the same, but we want to recognize that, in licensing a repository, there are some different considerations that

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have to be dealt with.

DR. FOSTER: But you are saying that the general level of confidence in using the term "reasonable assurance" is the same for, let's say, for reactor licensing as it is for repositories in spite of the timespans and what not?

To me, this was exactly why EPA wanted to use the term "reasonable expectation" rather than "reasonable assurance".

DR. FEHRINGER: I didn't read the EPA standard that way. I read the EPA to say the same thing that I just said, that in licensing a repository, you have different considerations, the long time periods, and things of that sort.

I did not read the EPA standard to say that a lower level of confidence is appropriate. That then would be required in other licensing activities.

DR. FOSTER: Do you anticipate that the staff is going to be prepared to defend the use of that term in a licensing proceeding with, let's say, review organizations that are used to applying the term "reasonable assurance" in the reactor licensing area?

And that for the repository, lets say, a hearing board would expect to see the same degree of assurance of confidence for the waste performance as with, let's say, the hardware interreactor?

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DR. FEHRINGER: Yes. That's inherent in Part 60 as it exists now. Part 60 currently uses the term "reasonable assurance". We have a paragraph that explains that there are different considerations. In this rulemaking, we're proposing to expand a little bit on that explanation of those differences.

But the Commission has already said that "reasonable assurance" is its test of confidence for licensing repositories, and we are not proposing to change that.

DR. FOSTER: I predict you're going to have -- you're buying some additional problems by staying with the same term.

DR. MOELLER: Bill Kerr.

DR. KERR: Mr. Chairman, I believe what we're discussing is not new. The use of general phrases and their implementation, for example, in the reactor business, the ALARA terminology of Appendix I of Part 50 has a special meaning; it's different than it has in other areas.

Appendix I says when we're talking about releases from reactors, here is what ALARA means. It's quite different than what it means in other places, although I guess it is reasonable to say that there are inconsistencies in the use of the terminology. But this is certainly not the first time that has occurred.

DR. MOELLER: I guess, Dick, you would say probably the ALARA has problems also.

(Laughter.)

DR. KERR: I don't disagree.

DR. MOELLER: Parson.

DR. MARK: I don't think I'm as clear on this point as Dick Foster, but I'm inclined to agree with him that there are worries here. Supposing you're basing some implementation of probabilistic risk assessment, and it's very likely that you will be.

You could say that the mean value obtained by that method gives you a reasonable expectation. You could not say it gives you reasonable assurance. For reasonable assurance, you're going to have to add in some of the uncertainties.

And since we've been plagued by that ever since the terms got invented, I'd be happier with a reasonable expectation.

DR. MOELLER: Go ahead then, Dan.

DR. FEHRINGER: If you turn to page 5, I'll go through the specific changes that we're proposing. There are a couple of minor changes that are not included in this package, such as touching up some wording. I won't take up your time with those, but I would like to go through the major changes and point out to you exactly how we are

revising Part 60.

The first major change is to the definition of "internal control area", the line in, line out format that's listed here. You can see the change that is being made. We are revising the definition to incorporate exactly the wording that EPA has used with one exception.

EPA uses the phrase "original location of radioactive waste in the disposal system"; in Part 60, we already have the term "underground facility", which means the same thing.

We're proposing to use that phrase in this definition. Conceptually, the definition is exactly identical to EPA's.

DR. CARTER: Could I ask you a question?

Do you have any idea what the background of this is? Because I guess EPA defines this as a special source of groundwater in terms of their 5 kilometers beyond the boundaries of the facility.

Do you have any idea where this 5 number came from?

DR. FEHRINGER: In this definition of "control area", there is a long history of defining this term. This current definition is a compromise between two previous definitions. EPA started defining the control area as being a one-mile distance from the underground facility. In the

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proposed rule, it became 10 kilometers.

People argued that 10 kilometers was too big an area to commit to this activity. EPA shortened it up to 5 kilometers and put the further restriction on here that the control area covers no more than 100 square kilometers, the idea being to avoid committing any more natural resources in terms of groundwater than were really necessary to get the job done.

The question on the special source of groundwater, there's an additional 5 kilometer distance which is somewhat independent of this. My understanding of that term is that EPA wanted to avoid a case for a special source of groundwater 100 miles away from the repository had to be evaluated or considered, even though it's largely irrelevant to the performance of the repository. And almost virtually impossible to contaminate.

DR. CARTER: The thing that bothers me, I guess, is that we normally think in terms of control areas, which they define. But then they, in addition, laid on another 5 kilometer horizontal distance. It looks like to me they're defining another, quote, "control area", unquote, in the special case of water.

DR. FEHRINGER: In the special source of groundwater, they're saying special sources of groundwater which are within a reasonable distance from the repository

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must be protected to the cutoff point, and how far away from the repository you have to look for these types of groundwater is, as you say, in some respects, a second type of control area.

I think, in general terms, it should be useful to the Department of Energy in the sense that they won't have to evaluate special sources of groundwater, hundreds of kilometers away from the repository.

DR. FOSTER: When I was looking at that, somewhere I got the impression that defining it as a hundred square kilometers by itself wasn't enough, becasue you could sort of gerrymander that hundred square miles so that it was largely in the upstream direction to avoid a situation where you did not take into account the direction of drift to the groundwater from the repository, that you threw in this extra requirement of 5 kilometers, so that you couldn't gerrymander it in the wrong direction for your hundred square kilometers.

Am I correct on this or not?

DR. FEHRINGER: It is correct that the Department of Energy has a lot of flexibility in establishing the control area. They almost certainly will extend the control area 5 kilometers in the direction of groundwater flow, and less than that in the upstream directions in order to stay within the hundred square kilometer restriction.

DR. FOSTER: But did EPA have that in mind when they wrote the 5 kilometers?

DR. FEHRINGER: Yes, they did.

DR. MOELLER: How deep does the subsurface go that underlies such a surface location?

DR. FEHRINGER: The center of the earth, I guess.

DR. MOELLER: That was my thought. What if it came out the other side?

DR. FEHRINGER: I hadn't thought of that.

DR. MOELLER: Go ahead.

MR. KATHREN: I think when it gets to the middle of the earth, it might fall under the Chinese law.

DR. FEHRINGER: Page 6, I list seven new definitions that are being proposed. I have not given the wording of the definitions, but for these seven terms, we are proposing to adopt verbatim the wording from the EPA standard that was quoted in Part 60. The terms being defined are: active institutional control, community water systems, passive institutional control, significant source of groundwater, special source of groundwater, transmissivity and uranium fuel cycle.

Page 7, EPA uses the term "performance assessment" in their standard and requires compliance with the standard be determined in conformance with this. In Part 60, we already have most of the wording that requires

performance assessment, as EPA views it.

And we're proposing to add one sentence, that is underlined, which will make this requirement identical to EPA's requirement for performance assessment.

We are not proposing to use the actual term in Part 60. Instead, this paragraph will require that the same information be submitted.

Page 8, we come to the topic we just discussed, reasonable assurance. We are proposing some additional wording to the current discussion, which explains what we think "reasonable assurance" means in terms of licensing repositories as contrasted with licensing reactor plants.

We're proposing to add additional wording which will further explain the differences that we see in the concept, not in the level of confidence that's required but in the application of it to a specific licensing decision.

Let me breeze through the wording just to make sure that everybody is familiar with it. We currently explain that there are uncertainties, there are long time periods involved, and that those must be accommodated. We're proposing to end the additional wording saying, this is a quote:

"Demonstration of compliance with the performance objectives of 60.112 will also involve predicting the likelihood and consequences of events and processes that may disturb the repository. Such predictions may involve complex computational models, analytical theories and prevalent expert judgment. Substantial uncertainties are likely to be encountered and sole reliance on numerical predictions to determine compliance may not be appropriate. In reaching a determination of "reasonable assurance", the Commission may supplement numerical analyses with qualitative judgments, including, for example, consideration of the degree and diversity or redundancy among the multiple barriers of specific repository."

That is a very key factor in our judgment that the EPA standards can be implemented. We recognize that numerical analyses still have substantial uncertainties. They cannot be the sole basis for licensing decisions.

This wording will make it explicit that a licensing board or the Commission can rely on additional

qualitative judgments as well as the numerical analyses that are submitted.

DR. KERR: In a sense means that there are really no objective standards by which the process can be judged.

DR. FEHRINGER: That's not what we're trying to say. There is a standard.

DR. KERR: I'm trying to estimate the outcome of the process, not what you're trying to say, because if you depend on expert judgment, that judgment depends on the experts.

And if you get one group of experts on one project and another group on another project, what happens depends on the group of experts.

DR. FEHRINGER: Yes, that's correct. The Licensing Board is established for that purpose, to pick between the judgments that are presented and accept the one that it finds most convincing.

DR. FOSTER: Are you going to speak any further about this expert judgment today? Or is this a good place to talk about that?

DR. FEHRINGER: I had not prepared any additional discussion. If you would like to discuss it further...

DR. FOSTER: I have a question on how this squares with the statement at the bottom of page 16 of our old fifth draft, lines 376, which reads similarly:

"Analyses based on best estimates of repository performance might be found to be inadequate if substantial uncertainties are present."

I presume that best estimate might very well include expert judgment. And then this goes on to say:

"In a case notwithstanding the apparent conformity with the EPA standards, the Commission might ultimately conclude that it lacked the necessary reasonable assurance."

When I read that, it seemed to me that that was really opening up the opportunity for, let's say, throwing out reasonable assurance for those things that included expert judgment.

DR. FEHRINGER: What we're trying to say is that expert judgment must have some substance behind it. If expert judgment is nothing more than a wild guess, a best estimate is nothing more than a wild guess, the Licensing Board does not need to accept that. The Licensing Board can argue that the case has not been proved, or decide that the case has not been proven if there is no substance behind that best estimate.

DR. FOSTER: And, here, I guess, there was coupling of that with the word "substantial uncertainties". I would expect that there would be substantial uncertainties from almost any event associated with one of these

repositories.

DR. FEHRINGER: There will be substantial uncertainties. The burden is on the Department of Energy as the applicant to reduce those uncertainties sufficiently so that the Licensing Board finds that there is a basis for accepting the arguments that are made.

If the arguments are nothing more than wild guesses, the Licensing Board does not need to accept those arguments.

DR. MOELLER: Well, further confusing this though, if you go on to line 394 and line 395, it says:

"As issues mature, the Commission will, where appropriate, use the rulemaking process to eliminate the uncertainties associated with those issues."

I find that I don't follow that at all. How is rulemaking...why don't we do rulemaking then on everything, if it will eliminate all uncertainties? I don't think that's what you meant.

DR. FEHRINGER: Other people have commented on that choice of words as well. The rulemaking eliminates an uncertainty as far as the licensing process is concerned. If a particular issue has been addressed and a rulemaking has been carried out saying this is the way this particular issue is to be treated, then the licensing process is bound by that rule.

We need to have a good bit of information available to us in order to carry out the rulemaking, and that's the real rub. If we have enough information to carry out a rulemaking, we'll try to do so and thereby remove those issues from the licensing proceeding.

But, of course, we have to have the information first before we can carry out the rulemaking.

DR. MARK: I'd be a little clearer if that phrase that Dade referred to, which also struck me as hilarious and staggering, override the uncertainties.

DR. FEHRINGER: That sounds like a better choice of words.

DR. MOELLER: Ron?

MR. KATHREN: I just was curious. It falls in with what you were discussing, Dade. You said something about expert judgment without a substantial basis.

If you don't have a basis, how can it be expert judgment?

DR. FEHRINGER: That's a good point, I guess. There are self-proclaimed experts on subjects. I think you have a reasonable point that, without a basis, it's not really an expert judgment.

MR. KATHREN: I suggest perhaps that you reevaluate that because so much of decision-making will be based on expert judgment. I don't think necessarily by

self-proclaimed experts, but by individuals generally recognized as experts. And there should be some weight given to this, because I would hope they wouldn't make a judgment without some substantial technical basis for such judgment.

DR. FEHRINGER: As you're probably aware, in the licensing proceeding, all parties typically present their experts, and they typically have widely different views on different subjects.

The Licensing Board then looks into the substantive arguments behind those positions. The message we're trying to get across is that the Licensing Board must look at those bases for the arguments. And some arguments may have less substance than others.

DR. FOSTER: They must also look at the language which is in the rules very precisely.

DR. STEINDLER: Do you really mean to imply that you're telling the Licensing Board how to operate? You don't really mean that, do you?

DR. FEHRINGER: What we're trying to do is structure the rules so that the Licensing Board has the flexibility to make the decisions it needs to make without being bound by the specific wording of the rules that would constrain it.

DR. STEINDLER: I assume this is not the last

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draft that we're looking at.

DR. FEHRINGER: Right.

DR. MOELLER: Let's go on through the remainder of your comments then, and then come back to an item by item review. We are on page 10.

DR. FEHRINGER: Nine. Starting on page 9, we display how the actual requirements of the EPA standard are being incorporated in Part 60. The first requirement of the EPA standard is the preclosure radiation protection standard. We're proposing to revise Section 60.111(a) as shown. Paragraph 1 is the wording from the EPA standard which replaces the previous reference to EPA standards.

Instead of referring to EPA standards, we're proposing to incorporate the requirements directly into Part 60 by dose equivalent, and so on. Combined dose equivalent, and so on.

Paragraph 2 contains our current reference to Part 20, and that that regulation be complied with as well as te EPA standard.

DR. STEINDLER: Is there some significance to the inclusion of the phrase "at all times" in the second line from the bottom? It says: "will at all times be maintained within the limits specified".

DR. FEHRINGER: I'll have to check on that and see. That wording currently exists in Part 60. We did not

propose to change it.

DR. STEINDLER: I'm trying to find out whether there's some reason for including this obvious redundancy.

DR. KERR: What does it mean?

DR. MOELLER: I was curious if it meant if you had an annual release limit on any one day, you could not release more than 1/365th. That's what it would mean to me.

DR. FEHRINGER: I'll have to check into that with the legal staff and find out why those words are in there.

DR. STEINDLER: I'm explicitly suggesting to you that you don't check it with legal staff, that you try to figure out what the dickens you're trying to say.

Do you mean in fact what Dade just indicated?

DR. FEHRINGER: No. Part 20 does no have a daily release limit. It has an annual limit.

DR. STEINDLER: You really want conformance to Part 20 then. That's really what you want.

DR. FEHRINGER: Right.

DR. STEINDLER: Then why not simply say: will be maintained within the limits specified in Part 20, and don't get tied up in words that can be so badly misinterpreted.

A licensing board, for example, would have a terrible time with it.

DR. FOSTER: Are there some features of the

Part 20 that are not already taken care of in the EPA standard, Part 1?

When I looked at this, it seemed to me like the 25 millirems to the whole body and 75 millirems to the thyroid was more restrictive than Part 20. And I wondered why you needed the second paragraph at all.

DR. FEHRINGER: Part 20 has limits on concentrations of radioactivity and effluence entering the restricted areas independent of whether there is anyone there to receive a dose.

So, in certain cases, Part 20 could be more restrictive than the EPA standards.

DR. FOSTER: But you also have, in addition to these dose limits, you're going to have some highly restrictive concentration limits for the repository in the accessible environment.

DR. FEHRINGER: Keep in mind, this section is for the preclosure time period before the depository is operating.

DR. MOELLER: Well, in item 1, I find I don't understand the use of the word "combined", "the combined annual dose equivalent".

Does that mean you could have 25 millirem to the whole body, plus 75 to the thyroid, plus 25 to any critical organ? Is that what you mean by "combined"?

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DR. FEHRINGER: No. "Combined" refers to the doses from the two sources listed as I and double I, discharges from the repository activities and discharges from any other uranium fuel cycle activities that a person could be exposed to.

For example, if a reactor plant is located somewhat in proximity to a repository, one would need to combine the dose equivalence from both sources and restrict one or the other, so that a person did not exceed the levels listed.

DR. MOELLER: I understand that, but it also says I can have 25 millirem to the whole body, 75 to the thyroid, and it doesn't say or/and 25 to any other critical organ.

Can I, therefore, have 125 to the thyroid, and say I'm getting 25 -- or make it 100 -- can I have 25 to whole body, including the thyroid, and then 75 more to the thyroid for 100? And then I could have 50 to any single organ other than the thyroid?

I don't understand, obviously, because you didn't say...well, explain it.

DR. FEHRINGER: I believe 4 could probably be better worded. I picked up EPA's wording verbatim. Their intent is that there are three separate dose limits. And I recognize your point about the and rather than or.

DR. MARK: I thought 25 was to the whole body.

You've got 25 to every critical organ right away.

DR. MOELLER: Yes, that was my point.

DR. STEINDLER: Is there some implication here that if you have sources of dose other than what is given under I and double I, they're basically unlimited?

DR. FEHRINGER: They are limited by other standards. EPA has addressed only uranium fuel cycle activities and now repository operations in Parts 190 and 191.

DR. STEINDLER: I'm trying, but I consider that explanation not germane to Part 60 as it's being revised; because you're dealing, I assume, with protection against radiation exposure, at least the radioactive materials to be found in Part 60.

It is not in fact even referenced to 191. So the issue is supposing I had an accelerator that's operating right next door to the repository. This little section is totally silent on exposures allowed from that source.

Does that mean that the exposures allowed from that source, if you're working in a repository, can be essentially infinite? Is that what one would conclude from the silence?

DR. FEHRINGER: As far as Part 60 is concerned, that is correct. Part 60 does not address any source other than the repository.

DR. STEINDLER: That's not true. That's exactly my point. If it were only concerned with the repository, I think the board would look at this and say, well, all right, fine, that's what it's concerned with. Everything else is covered somewhere else.

But you explicitly pull out the uranium fuel cycle. Part 60 does not deal with the uranium fuel cycle. So you've brought in a new contribution, to be sure, under the guise of having read it in the EPA rules. But that raises all kinds of questions, which you haven't included here. You ought to pay attention to it.

DR. MOELLER: Again, he's using, I gather, EPA's language. And EPA has said the 25 combination. So that's the source of the problem.

DR. FEHRINGER: What EPA is saying is that a repository can contribute as much as 25 millirem, 75 to 25, if it's the only source. If uranium fuel cycle facilities are present, then that contribution to the repository must be restricted.

EPA did not look at any other sources in developing that standard.

MR. STEINDLER: Would the NRC look at other sources under those conditions? I assume it would.

DR. KERR: NRC would certainly look at release rates.

MR. PARRY: Dan, excuse me. Would this possibly bring into consideration the 200 area at Richland? Or the low level disposal facility? Both of which are, I believe, not within very close to the 5 kilometer control area.

DR. FEHRINGER: As EPA defines "uranium fuel cycle", those are not parts of the uranium fuel cycle. So any contributions from those would not affect this particular standard.

MR. PARRY: Where did EPA define the fuel cycle?

DR. FEHRINGER: It's in Part 190.

MR. PARRY: The 200 area is a reprocessing plant.

DR. FEHRINGER: That's not in the commercial uranium fuel cycle.

MR. PARRY: That's the point I'm getting at. Here we have an unlicensed operation and, certainly, the Hearing Board may well decide wait a minute and then bring forward, much to the embarrassment of the Department of Defense and the Department of Energy, that operation, try to bring that operation in.

DR. FOSTER: I notice that the language that you have here doesn't exactly track that of that new EPA

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standard in this regard. The EPA standard says the discharge of radioactive material is directly related to the management of storage; and, two, all operations covered by Part 190, is what this says.

And, instead of that, you have uranium fuel cycle operations. So the uranium fuel cycle operation is specific to yours as contrasted with the language of 190.

DR. FEHRINGER: Right. Part 190 is the standard for uranium fuel cycle operations. Rather than make reference to another EPA standard, we're proposing to use the term "uranium fuel cycle operations" and then define that term in Part 60.

It's an attempt to avoid having five documents in hand, to see what the requirements are.

DR. MOELLER: Mel?

DR. CARTER: Dan, I'm still a little bit disturbed by the areas involved here. You know, life used to be simple. We had a controlled area. Then we had everything outside the control area. And now, for example, the words you are choosing are "unrestricted areas".

And, previously, we've been talking about controlled areas plus 5 kilometers groundwater. Now, how do those terms, and maybe some others in here, relate to the geologic repository operations area, which you're talking about in the changed language here?

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DR. FEHRINGER: There are at least two distinctly different concepts here. The controlled area is an area marked by monuments and other long-lasting markers that defines the area people should not be drilling into with drawing water from, and so on, after a repository closure.

There may be a smaller area that will be a restricted area in terms that we think of in power plants, an area that has a fence around it. And people will be excluded from entering it. That's the area of concern here for the preclosure operations.

As I say, it is likely to be smaller in order to just have a more manageable size area to work with, but there are different concepts for the preclosure period of time; the geologic operations area consists of the area inside the fence.

DR. CARTER: Well, that would just be the controlled area.

DR. FEHRINGER: The controlled area is more of a post-closure concept. It's the one that's marked by the monuments and it extends out beyond the boundaries of the underground facility.

DR. CARTER: Does it go the 5 kilometers beyond what I consider to be the controlled area?

These areas, there's about half a dozen of them. And they're quite important because if you're then going to

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draw a line and write standards --

DR. FEHRINGER: Right. I agree that there are a number of concepts that can be confusing. As I said, there is this one concept here called the preclosure time for the geological repository operations area. And then there's a control area and there's a further restriction to make certain that groundwater is outside the control area in certain concentration limits.

DR. CARTER: Those areas that the EPA calls special sources of groundwater, would these also then apply? These standards would then apply to those areas?

DR. FEHRINGER: Not these on page 9. This section is strictly preclosure operations.

DR. MARK: Going back to the point Dade raised, 25-75-25, as part of the things that came to mind, I'm wondering why you should have ever accepted the EPA standards. It doesn't matter what EPA thought they meant.

Certainly, as explained by the words, it now matters what you think it means. Do you think it means 25 whole body, plus 25 total to the organ?

DR. FEHRINGER: No, I think it means three separate standards. A person must not receive more than 25 millirem to the whole body, and must not receive more than 75 millirem to the thyroid or 25 to any other organ.

The 25 millirem whole body dose would not allow

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any additional dose to the internal organs, for example.

DR. MARK: But the thyroid is purely a gratuitously issue here. We're talking about fuel that doesn't have any iodine in it anyway. So you really mean that 25 to any organ or 25 whole body, this includes whole organs. And you're probably being more restrictive than EPA meant; or maybe that's how you're going to read this.

DR. FEHRINGER: My interpretation is based on my understanding of what the uranium fuel cycle standards mean for other activities. So, in that sense, I'm being consistent with what my understanding is.

DR. MARK: You should use different words to make the same point.

DR. FEHRINGER: I don't know how to respond to that except to say that I'll check with them on that.

MR. LANAHAN: As you read the EPA standards, they indicate the exact, same thing applies to the rest of the fuel cycle. So the words should be the same and the way we interpret them should be the same as we do in uranium mills, fuel fabrication facilities.

DR. MARK: I think they should be more clearly laid down.

MR. LANAHAN: We'll have to check into that.

DR. CARBON: I wonder seriously if we aren't misinterpreting what "combined annual dose" means. As I

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read this, it doesn't refer to sub-i and sub-ii, but rather the combined annual dose shall not exceed 25 millirems, and so on. I'm not sure what that means.

But I do think the term "combined annual dose" refers to the dose.

DR. MOELLER: I am with you. I was trying to reword it. If it meant what Dan first said, it would have had to have said: the annual dose equivalent to any member of the public outside the area resulting from a combination of, one, discharges; and two, the uranium fuel cycle -- if it meant what he said.

So I am with you. I think "combined" means some of those doses.

DR. CARTER: My impression was that EPA, originally, when they came out with 190, essentially had a very special defnition of "fuel cycle" and left out waste management. And now they're saying that high level waste management is tucked into that.

DR. MOELLER: In fact, they stated that a separate standard would be issued for waste management.

DR. FEHRINGER: That's exactly what they've tried to do here, is to add high level waste repositories into the rest of the standard.

We have not tried to interpret their words here. We've just picked them up almost verbatim from their

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standard. We'll have to check into the issues you've raised and see if we can put some wording in the statement of considerations to make this all very clear and get it on the record.

DR. CARTER: The question is whether these dose equivalents and numbers on an annual basis are mutually exclusive.

DR. MOELLER: Max, then Bill, then Frank.

DR. CARBON: I think I do understand what they mean when they say "high level waste" and defining "whole body and thyroid".

DR. KERR: What are you taking back?

DR. CARBON: I didn't understand what they meant by the high level waste.

DR. MOELLER: Bill?

DR. KERR: You said that you didn't try to understand what EPA meant but just tried to make your wording consistent?

DR. FEHRINGER: I said I didn't try to change any of their wording, or try to rewrite it.

DR. KERR: Okay. I misunderstood you. I thought you said you didn't try to understand what they meant.

MR. LANAHAN: The language indicates that it's the same as the rest of the standard. And that's what we're going to assume. We'll have to look at the rest of the fuel

cycle. The combined means, you know, i plus ii, that's the way it is.

DR. KERR: It seems to me it may not be important that EPA understand, but it certainly seems to me it's important that NRC understands. It's up to them to enforce and interpret it.

DR. PARKER: I guess I want to get back to your question about redundancy in this area. It seems to me that if you are following ICR-26, you would avoid this whole question of dose equivalent. You wouldn't have to do it. In 10 CFR 20, which you're proposing to institute, you've got to go to that. So now you're going to have ICRP-2 on the one hand and ICRP-26 essentially at the same time.

I don't understand why that procedure shouldn't take place.

DR. FEHRINGER: There's a general problem with the standards which the NRC is addressing in their revision of Part 20. Let me take that under advisement and see if we can figure a way to make Part 60 consistent with ICRP recommendations and, at the same time, not do violence to the EPA standards.

DR. PARKER: It's Part 20, don't forget, not just ICRP.

DR. MOELLER: Let's move to the next page. This is important. It's obvious we're going to run over on this

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item, but it's one of the important things we're doing. So let's do it right.

DR. FEHRINGER: On page 10, we begin to incorporate the post-closure standards. Currently, in Part 60, in Section 112, we just make reference to any environmental standards that EPA may have developed. We're proposing to drop that wording and instead incorporate the standards that EPA has published.

We're proposing to incorporate them virtually verbatim. The first standard of EPA's is the containment requirements. That is listed on page 12. We have tried to virtually word for word put EPA's wording into Part 60. We say that the geologic setting and the engineered barrier system shall be designed to assure that for 10,000 years following permanent closure, cumulative releases of radionuclides to the accessible environment from all anticipated and unanticipated processes and events shall -- and from there on, the wording is exactly that of EPA's -- have a likelihood of less than one chance in 10 of exceeding the quantities calculated in accordance with Section 60.115 and, two, have a likelihood of less than one chance in a thousand of exceeding 10 times the quantities calculated in accordance with Section 60.115.

DR. KERR: Does "assure" mean something different than to provide reasonable assurance that?

DR. FEHRINGER: No. There's a separate section of Part 60 that requires reasonable assurance that all of these requirements are met.

DR. KERR: Why does this use "reasonable assurance" rather than "to assure"? It seems to me that these do not mean the same thing. Why isn't that language here?

DR. FEHRINGER: Let me take that under advisement so we can fix that wording.

DR. MOELLER: Okay. Carson, and then Max.

DR. MARK: I'm sorry I can't put my finger on it but EPA has used at some stages anyway the expression "the normal operation", "the normal performance", "undisturbed performance", or something like that, which is a quite different notion from "anticipated" and "unanticipated".

Are those EPA's words, "anticipated" and "unanticipated", or are they your reading of your words?

DR. FEHRINGER: The term "undisturbed performance to meet the standard" will show up on pages 11 and 12. It does not apply to this particular section of the EPA standard. For this section, EPA refers to all significant events and processes.

We are saying that is the same as the concept "anticipated" and "unanticipated processes and events in Part 60.

DR. KERR: And that's defined somewhere else in the standard?

DR. FEHRINGER: Right.

DR. MARK: If you're using their undisturbed performance, you get a completely different estimate than if you say "anticipated and unanticipated". That is very much more restrictive. A volcano might go on once every 10,000 years. There's an unanticipated event. And you're going to guarantee including that everything's okay.

Whereas, if you said "normal undisturbed performance", you would have an easier, more reasonable time. So you would put these words in here, or they have them?

DR. FEHRINGER: EPA used the wording. In this section, all significant processes and events that may affect the disposal system. Rather than trying to define significant processes and events, we have substituted the wording "all anticipated and unanticipated processes and events", which maintains consistency with the existing wording.

DR. MARK: Consistency with your words but not necessarily with the situation. And I think this is a very treacherous phrase you've got in here.

DR. FEHRINGER: Keep in mind that the undisturbed performance wording in the EPA standard is not applied to

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this section. The next two pages in my handout is where that applies.

DR. MARK: Still, this section is very strongly at fault because now you're going to have to go to Table A-1 and say that there's no more than 10 curies in 10,000 years of thorium, despite of whatever unanticipated events.

DR. MOELLER: I had trouble. Maybe it will be clarified as we discuss it. But, I got the impression that it says: In the absence of unanticipated processes and events -- I got the impression if anything bad happens, you can just say, Well, we didn't anticipate that, so it is okay. Maybe I'm stretching it somewhat, but that was the impression: If you didn't anticipate it, you aren't held accountable.

DR. PARKER: Particularly 10,000 years from now.

DR. FEHRINGER: The terms "anticipated and unanticipated" are currently defined in Part 60. "Anticipated" is correlated to previous in the quaternary. "Unancitipated" means those things which are less likely, but which are still sufficiently credible to be considered. The definitions are not more precise than that.

But, "unanticipated" does not include things like volcanos, massive meteorite impacts, things like that, that are just incredible to really be worrying about.

DR. MARK: But it does include human intrusion. People drill every square kilometer once every hundred years.

DR. KERR: Ten thousand years for the development of a volcano is not rapid, nor is the Ice Age.

DR. FEHRINGER: It depends on the particular site.

DR. MARK: No, there's no prediction of volcanos in 10,000 years.

DR. FOSTER: Dan, am I correct that the staff really has three classifications here? One is anticipated. The second one, which you are calling unanticipated, is really unlikely. And third is we really haven't even thought about them, which, to me, I put an unanticipated terminology on it.

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But, the third class, which says, Gee, this is something I haven't even considered, or as what you're calling unanticipated here is something that you've thought about and put some sort of likelihood on it and considered it unlikely. And, therefore, not included.

DR. FEHRINGER: In the wording of Part 60, "unanticipated" means you do not expect it to occur. It does not mean you haven't thought of it. It's a logical dilemma in trying to regulate things that you haven't thought about.

DR. STEINDLER: The transcripts of the meeting of this subcommittee of about two years ago will reveal precisely the same discussion, the same objections from the subcommittee. I don't know whether they were addressed to you or somebody else. But it didn't seem to have made a heck of a lot of anticipated or unanticipated impact on what you guys write.

But that's an issue which I think Dick raised at that point for the same reason I assume that he's raising it now. Some licensing board is going to have to fight with whoever to try and straighten out what the parties to the hearing really mean when they use reasonably simple English language.

I think this mischief is enormous, or at least the potential for mischief is enormous, or somebody at least

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recognized it when they considered this fifth draft buried back at the back end. It talks about the EPA standards, referring to undisturbed performance. And it says there:

Undisturbed performance is defined to mean the predicted behavior of the disposal system, including consideration of the uncertainties and predicted behavior if the disposal system is not disrupted by human intrusion or the occurrence of unlikely natural events, which is the word we're talking about.

Then it goes on:

The Commission considers undisturbed performance as defined by EPA to be equivalent to performance in the absence of, quote, "unanticipated processes and events".

So somebody did make that equation, unlikely equals unanticipated.

DR. FEHRINGER: And in Part 60, where we define "unanticipated processes and events", we have very similar wording. We do define the term to mean unlikely events which are sufficiently credible to warrant consideration.

As far as your comment about previous recommendations to the staff, I was not involved in that so I can't really respond.

DR. MOELLER: Let's go to page 11. I immediately see here you are saying 25 millirem to the whole body, or 75 to any critical organ. What is the difference from what we

just previously read?

DR. FEHRINGER: Again, we picked up EPA's wording. I'll just have to check into the reason for using "or" and "and" in different places.

DR. MOELLER: But, you see, it was 25 to any critical organ before.

DR. CARTER: The number has changed. It used to be 75 to the thyroid.

DR. FEHRINGER: EPA has an explanation for that. I believe, in this section, the correlation is with the dose limits of the Clean Air Act, which use these particular numbers, 25 to the whole and 75 to any other organ.

And previously, the preclosure standard was meant to correlate with the uranium fuel cycle. The only explanation EPA has is they are trying to maintain consistency with other existing standards that they have in place.

DR. MARK: But you're inconsistent.

DR. FEHRINGER: Right.

DR. MOELLER: Any other comments on page 11?

DR. FOSTER: I have one relative to the use of a significant source of groundwater outside of the control area.

I wondered, in going through here, whether these standards apply only to groundwater, which EPA classifies

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as a significant source of groundwater.

Otherwise, if you have groundwater which might be tapped by one or a few farmers, whether or not these standards apply, because it doesn't meet the definition of "significant source".

DR. FEHRINGER: EPA defines the term "significant source of groundwater". We are proposing to incorporate that definition into Part 60. The definition is: In terms of the amount of yield that a well might be able to produce if a significant source of groundwater does not include a relatively minor source of groundwater that could only serve one farm family, for example.

So this section would not apply to that type of case. A very low yield aquifer. An aquifer that can provide groundwater to approximately 10 families becomes a significant source of groundwater. And, at that point, this section would apply.

DR. FOSTER: Do you think this is the right way to do it?

DR. KERR: It's pretty unlikely that a source of groundwater that can supply only one family is going to be contaminated. It has to be a pretty restricted source.

DR. FOSTER: I guess I was visualizing a situation where you have scattered farms around a repository area where each individual has drilled down to tap and

aquifer for his own family farm use. Those individuals then would be the ones as individuals at risk.

If I read this and interpret it as I think it is intended, those individuals are not covered by the standards.

DR. MOELLER: Now, if the water, the groundwater, is used to irrigate crops and then the crops are sold widely, does that count?

DR. FOSTER: I would guess that if you were irrigating, then the amount of water available would not fall under the significant source of groundwater because you'd require a higher volume.

So I would predict that crop irrigation would be out. But not a drinking water well.

DR. PARKER: Dade, let me see if I can shed a little light on the background to this.

As you recall, Dan, it was said in one of the sessions, EPA had ultimately a collective dose rather than an individual dose. As a result of the National Academy of Sciences, it showed that you could almost construct a facility near any site where some individual would be drilling a well directly into the facility. They were urged by the Science Advisory Panel to make some provisions to protect individuals.

No one could not construct some scenario

involving a single individual might not get an enormous dose if they drilled directly into the repository, where a very small amount of water was totally saturated with radionuclides.

So this was sort of a compromise that was reached.

DR. MARK: You've made a large point of trying to use EPA's words verbatim. And this thing, we're still looking at the table of requirements, as I understand it, you have changed those words by a very wide margin. You assure that something or other happens. You say there will be a reasonable expectation based on performance assessments.

Their performance assessment includes only what they refer to as significant processes and events. It says nothing whatever about anticipated and unanticipated. Those were your words taken from some previous NRC literature.

And the combined effect of the two is really orders of magnitude from what has to be demonstrated, and orders of magnitude more restrictive.

First, you've got to assure that that means maybe 95 percent confidence. Anticipated and unanticipated is a broader class of things than they require to be examined. In performance assessment, you're not following EPA's text word for word. And you're not even given the very

persuasive translation of it. And I really think that you're branching into just a different context.

DR. FEHRINGER: On the first point, let me suggest that I will strike out the words "to assure" and say that "so that for 10,000 years". That would preserve our reference to reasonable assurance.

In Part 60, we are making the argument that significant events and processes by EPA means the same as anticipated and unanticipated in Part 60 terminology. That is one of the issues we're proposing in this rulemaking. And we will expect to receive public comment on it. In our view, the terms are the same.

DR. MARK: I don't see how one can read the words and get the feeling that they are describing the same situation.

DR. KERR: Carson, you underestimate the power of rulemaking.

DR. MARK: If we're going to make a rule, then anticipated and unanticipated sources you say are likely, then I'd be happy.

DR. ORTH: That's why I read this section.

DR. MOELLER: Let's go on. We may come back to this, but let's go ahead.

DR. FEHRINGER: Page 12 now, where we address EPA's groundwater protection requirements. Again, we've

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tried to copy EPA's wording as much as we could verbatim. As with the individual protection requirements, we are arguing that EPA's term "undisturbed performance" is the same as the phrase "in the absence of anticipated processes and events" of Part 60.

Other than that, I believe all the wording is verbatim from the EPA standard.

DR. CARBON: I have a question on paragraph C-2. I don't know if it's important or not but it says that if the concentrations already exceed the limits in C-1, the question I raise is, instead of "already exceed", suppose it's 99.9 percent? Are you going to add it on? I don't know if it's important or not.

DR. FEHRINGER: That point was raised by our own staff when they reviewed this. I don't have a good answer except to say that we did pick up what EPA put in their standard, and feel somewhat constrained by that.

It would make more sense that any increment should be limited to this amount; since EPA's wording is in place, I'm afraid our flexibility is limited to revise this.

DR. FOSTER: Dan, again, I'll call this semantics. On your first line and in the absence of "unanticipated processes", is it fair to read that "and n the presence of anticipated processes"?

DR. FEHRINGER: Yes. And to say that: If anticipated events and processes occur.

DR. FOSTER: Okay. Could I also read that:

And in the absence -- and in the presence of extremely unlikely processes?

DR. FEHRINGER: No. Extremely unlikely would be in the absence.

DR. STEINDLER: Where do you draw the line between an unanticipated and anticipated event?

DR. FOSTER: What I'm saying is that the unanticipated processes are in the middle of two things. One is the anticipated and likely thing. The other one is the unthought of and even more remote.

So if it's in the absence of the unanticipated, it could go either way. You say no.

DR. FEHRINGER: None of Part 60 restricts what happens in the event that incredible events occur. So I hope that's the answer to your question.

MR. KATHREN: If they're incredible, they can't occur. By definition, if it's incredible, it just doesn't happen.

"Incredible" means beyond the realm of credibility. If it's not credible, it can't happen.

What I'm concerned with and what I would ask is what about a credible event of extremely low probability?

I could interpret this to mean that if I have some terrible cataclysmic event, but it has a negligible probability, then I can't ever make that assurance; because by saying: In the absence of unanticipated events, I've anticipated it. Although I've anticipated it and have fixed a probability that is very, very small, nonetheless...

DR. FEHRINGER: I just have to refer back to the Part 60 definition of anticipated and unanticipated.

Anticipated in Part 60 refers to the likelihood of occurrence, not whether or not you have thought of it, and the likelihood of occurrence is linked to previous occurrence within the quarternary.

MR. KATHREN: Is that your same definition used in your proposed Revision 60?

DR. FEHRINGER: The existing definitions will remain, yes.

DR. MOELLER: In the draft of the proposed 10 CFR 60, it says events having a probability of 1 in 10,000. 1 in 10 to the 4th can be ignored. That is over the 10,000 years.

That comes out 1 in 10 to the 8th in any single year, which is a very highly unlikely event. No question about it.

Now, can you also say in the first line on page 12 -- we can substitute those other words you gave us and you can say that for a thousand years after the permanent closure and in the presence of undisturbed performance, or something like that, and with undisturbed performance?

You go on. Isn't that the same in the absence of the unanticipated processes and events -- is the same as saying the performance is undisturbed?

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DR. FEHRINGER: Yes, that is the argument we are making, trying to use existing Part 60 wording. But we are introducing another term.

DR. MOELLER: Okay. Let's go on to 13 then.

Excuse me?

DR. STEINDLER: I continue to be confused. I guess I had better apologize. But the preamble to what we see on page 12, back on page 10, what you are saying is that the geology setting and the design of the rest of the system is going to be selected so that you don't have any increase in radium 226 and 228.

Now, is the implication that it is not just a question of design but you don't want an increase due to the operation of the repository?

DR. FEHRINGER: I am not sure I understand.

DR. STEINDLER: Let me give you a "for instance." Supposing -- and I have no reason to believe this has anything to do with the real world -- supposing in fact the repository folks have been monitoring 226 and 228 radium in the groundwater system for a period of 10 years prior to their coming to you, and they plot this all out, and sure enough there is a gradual rise in the radium content of the water for reasons that are not germane. They do a little extrapolation, and they find out that if they were to in fact use the criteria that appear to be here 950 years after

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they get done with their repository operations the radium 226 and 228 content rises to 5.6 or 10 curies per liter. It has nothing to do with their operation, even if nobody put anything there, just didn't touch it, no unanticipated events occurring.

Would that preclude that site from being used as a repository?

DR. FEHRINGER: It is a very hypothetical example.

DR. STEINDLER: I don't think it is totally off the wall.

Let me put it this way: is that what you would mean?

DR. FEHRINGER: EPA standards are directed at the impacts caused by the repository. In a case like that one could argue that the natural existing conditions were what caused the rise and it was not due to the repository operations.

DR. STEINDLER: But would they be able to get away in a licensing board hearing with the wording as you have it here, with that argument?

It isn't obvious to me that they will be able to get away with that, particularly since one could argue that you don't have any radium 226 in the waste. That is not where the radium comes from over that period of time. So

any increases in these two nuclides that you are talking about would have to come from some other activity other than the repository.

Why are those things in there?

DR. MOELLER: Could we solve your problem at the bottom of page 12, you know, four lines up, if we could say the increase in the existing average annual radionuclide concentrations in water were withdrawn due to operations of the repository do not exceed....

DR. STEINDLER: That would certainly alleviate, I guess, 99.8 percent of it. But it would change drastically what you have here. If that is what you mean, that is fine.

My interpretation of what you have here simply means that somebody who has done a site characterization and finds a significant amount of radium in the water is at risk of having to show that there is not an increase up to the level of 5 picocuries per liter.

As Don and I were commenting to each other, that is precisely the place where you had just as soon put the repository because by current standards you are going to preclude people from pumping water out of it.

DR. FEHRINGER: We would have to show this was silly not to cause this.

DR. STEINDLER: That is not what you say here.

That is precisely my point, or the problem being that if you have water that is clearly undrinkable now that is a good place to put it.

DR. MOELLER: And you not only want to say that this increase was not due to the operations of the repository; you really, more specifically, want to say that this increase was not due to radionuclides escaping from the repository.

DR. STEINDLER: The election of radium 226 and 228 seems strange.

DR. MOELLER: So it has to be due to radionuclides escaping the repository.

DR. FEHRINGER: I think the way the EPA standard is stated, some change in groundwater chemistry, for example, caused by the repository could also cause this.

DR. MOELLER: Oh, that counts. Then just call it due to operations of the repository.

It still would be tough.

DR. CARTER: I don't quite understand this because these numbers are taken from the interim drinking water standards. I don't really understand the significance.

DR. FEHRINGER: EPA did take these numbers from the drinking water standards. I think No. II and No. III are the significant sections. The radium is probably not

going to be more limiting.

DR. CARTER: III is also involved.

DR. MOELLER: Of course the 4 millirem is the contribution you assume that water can make to the basic dose limit if we need to discuss that. It is their idea of proportioning out the various sources.

Okay, page 13 now.

DR. FEHRINGER: On page 13 we address some of the issues we previously discussed in the Commission paper which you reviewed last year. In dealing with EPA on their assurance requirement, a few things came up that prompted us to suggest some fairly minor changes in Part 60.

This proposed change on multiple barriers is one of those.

People have read the existing provisions of Part 60 in such a way as to interpret the possibility that the repository would not have to have a multiple barrier system. We are just proposing to add one sentence, making it very clear that the objectives of Part 60 do require multiple barriers, both engineered and natural barriers, to be used.

DR. STEINDLER: Is multiple two or three or four?

DR. FEHRINGER: Multiple is not defined. A minimum of two certainly because they can be both engineered and natural.

DR. STEINDLER: Okay.

DR. MOELLER: 14.

DR. FEHRINGER: 14 is another of the changes from the Commission paper. Here we are proposing to clarify the Commission's views on institutional control and the degree of reliance that may be placed on institutional control.

We have always agreed with EPA that the types of active institutional controls one might envision, like monitoring or guarding a site, should not be relied on as the basis for safety. We have existing wording in Part 60 pointing out certain remedial actions might be appropriate in the event of some types of human intrusion. This is meant to clarify to some extent the idea that you do not rely on institutional controls as the primary basis for saying if you do allow consideration of the effectiveness of institutional controls, do it in the overall performance assessment of the repository.

DR. CARBON: I guess I have personally difficulty understanding what performance you are correlating there. I thought you have to allow for the fact that they aren't going to guard it.

DR. FEHRINGER: What we want to do with that second sentence is allow a licensing board to take into consideration certain things that may occur. For example, to date, when the petroleum industry drills wells, if they

come up a dry hole, they typically do at least some sealing and plugging of that hole.

We think it is reasonable to assume that that same type of action can occur if someone accidentally drills into a repository. It is not reasonable to assume that the driller will pull up stakes and leave a wide open hole, which would lead to greater releases than a plugged hole.

We just want to leave open the potential to consider remedial actions of that type.

DR. CARBON: My only comment would be that I didn't understand that.

DR. FEHRINGER: On page 15 I just make note that we are incorporating EPA's table of release limits in a new Section 60.115. We have not reproduced it here because of its length. It goes on for several typewritten pages.

The only changes in the notes are strictly editorial, cross-references to sections within their standards, and we changed that to cross-references to .60.

DR. MARK: In connection with that table, a word of explanation would not be out of place in addition to the notes. It isn't crystal clear on the surface why thorium makes 10, plutonium 100 curies.

I think there is a reason for that, and that is that thorium lodges in the body to a much greater extent than plutonium.

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If that is the basis for it, it might not be unhelpful. In order to find out if that is true, you have got to radiation handbooks, which aren't here, and physiological processes, which are probably not even understood but are reasonably determined, and that number which stands out would warrant a footnote by way of explanation as to why is it different from uranium or plutonium for someone who may be reading the table.

DR. FEHRINGER: I think that is documented in EPA's technical support documents. All those numbers are based on the environmental model the EPA put together, which considers both transport of radionuclides through the environment and the physiological processes in the body.

DR. MARK: But it isn't their February 19 rule, and there again they come on with a 10. When it was sent to me, back when I first saw it, I said, what the devil is that for?

It took me only a couple of hours to discover. It wouldn't have taken Dade that long. He would have known it right off.

DR. MOELLER: No, I appreciate Carson calling that to the subcommittee's attention, and I would urge that you put in some footnote.

DR. MARK: It doesn't change EPA's words that they may have written somewhere else sometime. It would

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allow us to be with you a little better.

Of course the table is a rounded number compilation, and that, I think, is as it should be. The detailed differences are unclear. That particular one stands out because of the change of scale.

DR. MOELLER: Page 16?

DR. MARK: Incidentally, you can have all the tritium you want as far as that goes.

DR. KERR: Page 16 makes those people from Michigan very happy because significant concentrations of any naturally occurring material is not widely available from other sources. This is an adverse siting criterion. It says, I think, this is -- in the region being considered that that is an adverse criterion, and a lot of the commissions are looking at this.

MR. KATHREN: Maybe "material" could be changed to "mineral."

DR. KERR: I don't know what they have in mind. Many Michigan animal people would be delighted to see this.

DR. FEHRINGER: In the structure of Part 60, this is a potentially adverse condition. It does not mean it is an exclusion criterion. It must be considered, and the effects of the correlation between that criterion and other safety criteria must be evaluated.

DR. STEINDLER: In light of Professor Kerr's

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comment, I think you are opening yourself up to an enormous amount of mischief by putting it in in this form.

What the hell is any naturally occurring material, and what is widely available?

The argument is again, especially if you are going to go to rulemaking, you are going to have to eventually come up before the board if you want to get these things adjudicated at some reasonable rate.

We heard from Hud Miller last time. You are going to go through that as a policy proceeding with this process. It is a great idea if you can close the loop. But things like this will keep that loop open till hell freezes over -- or the lakes freeze over.

DR. KERR: At which time we have a natural place to put the waste.

DR. STEINDLER: If we can keep the temperature down, yes.

It just strikes me as being unnecessarily opening the whole process to mischief by terrible selections of both concepts and words. I think that is a good example.

DR. CARTER: Is that anticipated or unanticipated?

DR. MOELLER: Dan, of course, you explain in some of the writings why you did this.

Martin, how would you word it, or would you not

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word it?

DR. STEINDLER: I would not.

DR. MOELLER: Dan, come back and remind us why you put this in.

DR. FEHRINGER: If you look back, say 50 or 60 years, some of the minerals we now find useful were useless at that time, such as uranium. Things change with time, and deposits of materials that are thought to be worthless now may have economic value in the future, may be exploited and may be detrimental to the repository.

MR. PARRY: Dan, isn't this actually a result of the desire to get rid of some of the insurance requirements?

DR. FEHRINGER: Yes.

DR. MOELLER: Okay.

DR. FEHRINGER: The comment on the proposed rule raises the same questions we have raised. It may be that we will find it's not worth it.

MR. PARRY: I would think, potentially, intervenors would applaud it.

DR. STEINDLER: They'd make hay out of it. Let me just point out that there's going to eventually be a repository someplace and that repository now suddenly gets to be a place that has something.

You don't think that's going to give you trouble, and give you grief? I know it isn't a pre-inplacement siting criteria, but that kind of logic isn't going to stand in the way of somebody who is screaming to high heaven on this issue.

MR. KATHREN: You could write in to --

DR. STEINDLER: Where else would you find mineable plutonium but in a repository?

MR. KATHREN: The snail-darter analogy.

DR. MOELLER: Okay. Page 17. And that was a preclosure condition.

DR. FEHRINGER: Yes, it's a slight selection criterion.

MR. KATHREN: I had a question on 17 about the monitoring program and the continuation, which probably

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reflects my ignorance here.

But, as I read this, monitoring shall be continued until the license is terminated.

Suppose I'm the licensee and I decide I want to terminate the license?

DR. FEHRINGER: You need to apply to the Commission for permission to do so.

MR. KATHREN: Or I go out of business, Chapter 11 bankruptcy.

DR. FEHRINGER: We hope the Department of Energy will not go bankrupt.

MR. KATHREN: Whatever. But that kind of thing is what I mean.

DR. STEINDLER: After a thousand years, they may get tired.

MR. KATHREN: There's also how long does the license go for?

DR. FEHRINGER: The notion that we're getting at here is that there may be some kinds of monitoring that can provide useful informations after repository closure. When Part 60 was first put into place, we did not require monitoring because we had in mind the types of things that would be disruptive to the repository -- sensors down right in the repository and things coming from the surface, and so on.

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Since then, we've recognized that some types of monitoring, like monitoring groundwater flow conditions in the region of the repository, might be useful -- not so much for actually tracking the groundwater as for confirming the analytic models that were used to predict repository performance.

We're proposing to require that type of monitoring if it does in fact provide useful information.

MR. KATHREN: I'm not questioning the proposal to provide the monitoring. I guess this is more a realistic type question. The statement that you should continue it until the termination of the license -- that's what bothers me. I don't really know what that means.

Is there perhaps a loophole here either way to say that the license never terminates?

DR. MOELLER: Another thought on that, generally, if you have facilities such as this, a state or local health or environmental organization might carry on the monitoring and, in fact, they probably would. They wouldn't care whether the license existed or not.

You're only looking here at monitoring by the licensee.

DR. FEHRINGER: That's correct. There are provisions in Part 60 for termination of the license, which relates to the Commission finding that it has confidence

that the repository is working as expected.

DR. STEINDLER: Wait. The thing that I would challenge you on...just let me read you the thing that we have. In draft five, the Commission intends that a repository license not be terminated until such time as the Commission is convinced that there is no significant additional information to be obtained from such monitoring.

Can you imagine adjudicating that issue in front of a board that's been asked to determine whether or not a license may be terminated? No significant information to be gained. Good grief.

The absence of any kind of signal out of a monitoring device, for example, can be easily construed as a very significant piece of information, which means you've got the guy on the hook forever.

Is that what you meant?

DR. CARBON: Marty, you stopped too soon. Which would be material to a finding of reasonable assurance. To me, that changes the statement.

DR. STEINDLER: Let me keep reading.

Significant additional information can be obtained from such monitoring, which would be material to a finding of reasonable assurance that a long-term repository performance would be in accordance with the established performance objectives.

I'm not sure that that additional sentence, the phrase which I left out, I agree, changes things very much. So what I think is implied by your comments there, plus the changes that you're making here, is that you don't give the guy an opportunity to finish up that license and leave.

DR. FEHRINGER: He may not finish it up until the board decides it has reasonable assurance and it permits him to terminate his license.

DR. STEINDLER: How do you do that?

DR. FEHRINGER: That's the type of decision the board has to make, whether there's monitoring or not. It still has to make that decision on license termination. I don't see that this would affect it.

DR. STEINDLER: You've tied the monitoring requirement into the license termination.

DR. FEHRINGER: Yes.

DR. STEINDLER: What I'm saying is, having done that, you've provided for no mechanism, it seems to me, that is subject to adjudication in any kind of a reasonable way to allow the license to be terminated; because I can't see that any activity could ever be termed as useless toward this assurance of the long-term repository.

Remember, the models are all short-term extrapolations. Anybody who is in the modeling business and looking at potential data to be obtained over a hundred

years will say, Gee, that's enormously important to verify a model whose extrapolation is 10 to the 3rd and 4th years in an area where we don't really know precisely what they're doing, especially with the uncertainties given to you in the course of the initial license application.

I think what you've done by requiring the monitoring and making a statement here is basically saying: Look, we're not going to ever close that license.

DR. MOELLER: Bill?

DR. KERR: Marty, it seems to me the only difficulty that this might cause is it might make it somewhat more difficult to show that this is possible. I really don't think it will do any harm because, in the first place, this sort of says: The license shall go on forever. Since the life of the licensee is obviously limited...well, who knows. But it doesn't have much significance except sort of an assurance of good faith.

If this assurance of good faith -- it's bad, but it really doesn't have much meaning otherwise.

DR. STEINDLER: I come at it from two viewpoints, most of which are going to end up being delayed in front of a licensing board to see whether there is some way a licensing board could adjudicate the issue in some reasonable fashion.

But I don't see that. It seems unnecessary.

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DR. KERR: But is the issue you're worrying about the original license or the termination?

DR. STEINDLER: The termination.

DR. KERR: The license can't possibly terminate before the repository. It's got to be good for at least 10,000 years.

DR. MARK: And held by the DOE.

DR. MOELLER: Okay. Let's go to 18, which I think is the end.

DR. FEHRINGER: Yes. I just laid out the schedule which is before us. The reason I presented it is to try to discuss with you a way to get your views into the system. We've got this in this document to the Commission by February the 14th.

We've taken notes on the views you've raised verbally. If you could get a written set of views more quickly than the normal exchange of memorandums, it would be very helpful to us.

DR. MOELLER: The committee will not meet until what? About the 11th or 12th, or 9th or 10th, whatever it is.

DR. KERR: Do you want these written comments to be nonverbal?

DR. MOELLER: What I would like to do -- yes, the committee is meeting the 12th, 13th and 14th -- or 13th,

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14th and 15th. There's no way we could have written comments to you prior to that.

What I think, looking at your schedule, and I have no problem with your schedule, personally, we've discussed it this morning. I'd like to take a break, then come back and we'll go through minor or small item comments. Give those to you and then I personally would have no problem with sending it out for public comment.

But it isn't final. And we could certainly give you a committee letter in February saying we judge it's all right to go forward with public comment.

DR. MARK: On this general matter, there really is no public interest, like AIF or INPO, or any group like that; nor any corporations. It's only the Department of Energy.

DR. MOELLER: Oh, no, you'll get lots of comments.

DR. MARK: I know we'll get comments but there's nobody stuck with having to be unable to terminate a license except the DOE.

DR. MOELLER: I see what you mean.

MR. KATHREN: I said that in a figurative sense because they may not exist.

DR. MARK: If you're so-and-so, all you have to do is be taken over by General Foods and leave the license

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as one of the things that General Foods doesn't take. And then the board can talk all it likes and nothing will happen.

MR. PARRY: Dr. Mark, that's really, I don't think, accurate. The utilities are very interested.

DR. MARK: They're interested but they're not stuck with.

MR. PARRY: They're paying for it.

DR. MARK: In that sense, okay.

DR. MOELLER: Let's take 15 minutes. Then we'll resume going around the table for individual comments.

(Recess.)

DR. MOELLER: What I would like to do, we recognize by the schedule that we are slightly behind. But this is an important item. And I think what we ought to do at this point is go through with individual comments. I have a series. I'm sure others do, too. Let me just comment on some of mine. This is going through the proposed rules. I'll go through mine fast, and then I don't now whether we should...well, maybe the better thing is to take it page by page.

Did any people have any real problems prior to page 3, pages . and 2?

DR. FOSTER: Is this draft five you're working with?

DR. MOELLER: Yes. On page 3, we have already discussed the use of the word "redundant terminology" in line 58. Any other comments on page 3?

Four?

(No response.)

DR. MOELLER: On 5, I have, and this is just a personal item with me, but this use of the word in line 95, "releases of radioactivity", you release radionuclides or there may be some direct radiation. But, in my opinion, you cannot release radioactivity. Radioactivity is a property.

You use that same term on pages 9, 10, 11 and 13, as I recall. We've already discussed at the bottom of page 5 "reasonable expectation" versus "reasonable assurance", so we won't do that again.

Any others on 5?

DR. CARTER: One thing. I think there, the EPA apparently had some reason related to either the level of confidence or the level of uncertainty. And I'm not too sure these fellows have made a compelling argument not to use the same thing.

DR. MOELLER: I think that's a good point. You said, Dan, that you don't want to use the term "reasonable expectation". Why are you opposed to using it?

DR. FEHRINGER: Because Part 60 currently defines "reasonable assurance" to mean the same thing as

"reasonable expectation". We did not want to have two different standards of confidence that had to be cited by a licensing board.

DR. CARTER: Except, Dan, in this particular case, you've said essentially that the concepts are the same or identical, or whatever. In this particular case, you used the word parallel. That's somewhat different.

DR. FEHRINGER: That wording is not accurate. It should say: the standards are the same.

DR. MARK: I raised a point on that and I'm still uneasy about it. "Reasonable expectation" could go with the central value of the PRA. You don't have to say there's an uncertainty of a factor of 100 either way as a reasonable expectation.

"Reasonable assurance", you've got to have something more like the 85th or 90th or something percentile of the uncertainty range. That's a very big difference in the implementation. If "reasonable expectation" means, okay, take the best estimate value. Reasonable assurance has never been believed to be satisfied with that.

If you take a look at the seismic hazard curves, which are just expert opinions, which are guesses by factors of 10, you say then, well, I have to get into every thousand years. And this is the conservative one.

DR. MOELLER: I think we have made our point

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there. That is of concern to us.

Page 6, anything there? It's more on reasonable expectation and assurance, and we've covered this undisturbed performance and the absence of unanticipated processes.

Page 7, in line 143, you use the redundant word again. Dick, do you want to talk any more about groundwater on page 7?

DR. FOSTER: No. I think particularly with Frank Parker's explanation, I'm satisfied.

DR. CARTER: Let me ask one question on this 191.16. Does it really define this special source of groundwater for five kilometers?

DR. STEINDLER: Yes. This might be a good place to talk about this containment requirement.

DR. MOELLER: Fine.

DR. STEINDLER: In introducing the table itself into Part 60, it strikes me that you have qualitatively changed the nature of Part 60. Most of the things that I can recall in Part 60 are measurable to some extent. Table 1 is not.

Now, is table 1 going to be construed to be something that should be measured, and, therefore, have a requirement to be placed on DOE, that in order to do a complete job in providing you with a licensing document,

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that somebody is actually going to have to measure a value of some sort that is relatable to this table?

DR. FEHRINGER: We have stated many times in different places the recognition that we have to calculate what's going to happen that far into the future.

DR. STEINDLER: I guess what I'm saying is it's going to be difficult to make any measurements that relate to table 1. Somewhere in that chain, as soon as you do the measurements, you're going to start the system.

DR. FEHRINGER: The calculations we would carry out to determine the lives in table 1 involve the same things that one uses to determine plant performance objectives, groundwater travel time.

DR. STEINDLER: Is that clear from the way it's worded? If I wanted to take the adversary role, which I do sometimes, the same way Dick Foster does -- because we're looking at it from the standpoint of eventually having to adjudicate this thing -- it isn't very clear that table 1 is included as a set of performance targets entirely allowable, to be estimated by calculations, or what have you, without some measurements.

Look at it again from the standpoint of a severe critic and see whether or not I'm making any sense. But I'm really concerned that somebody is going to require DOE to do that. And it won't fly.

DR. MARK: At the top of page 8, there's a question raised about that.

DR. STEINDLER: Yes.

DR. MARK: Maybe it covers it. I'm not sure.

DR. MOELLER: Okay. Page 8. Any others?

(No response.)

DR. MOELLER: I found nine interesting -- lines 194 to 196, the doses during operations are amenable to monitoring and the applicant will be required to conduct a monitoring program to confirm that the dose limits are complied with.

I presume that's all right. But it will just be, I guess, no different than we're doing now in terms of the environmental surveillance for nuclear power plants, or anything else.

DR. FOSTER: Dade, on page 9, line 197, it talks about individual and groundwater protection requirements. I am not sure that the term "individual" is actually used in 10 CFR 60.

DR. MOELLER: Right. Is it a person?

DR. FOSTER: My comment is, if that term "individual" is in fact used, it ought to be declined. I'm not sure that it is. Looking at 10 CFR 60, I don't think we can use it.

DR. FEHRINGER: It's just a heading and a Commission, and that heading did not carry over into changes in Part 60.

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DR. MOELLER: I concur it would help us to define, just to add a phrase or something there.

DR. MARK: It could be handled perhaps by saying: This will be judged by the concentrations in air or water that can be measured. Because there is a correlation, but I'm sure your committee tells you what it is, between dose and concentration.

DR. MOELLER: Page 10. Now let me ask, looking at page 10, lines 219 and 220, there it tells me: compliance will not be required -- will not require compliance following unanticipated processes and events.

So I said to myself, you know, facetiously, earlier, I said all I could do is show that it was unanticipated or unlikely. And I don't have to show compliance.

And, yet, on page 14, it says I must have compliance.

DR. FEHRINGER: This refers to two different sections -- the individual and groundwater protection requirements are the ones which do not need to comply in the event of unanticipated events and processes. The containment requirements must consider both.

DR. MOELLER: Okay. You see, I didn't catch that.

DR. FOSTER: I wondered, on page 10, line 220,

if it wasn't intended that that read: but will not require a demonstration of compliance based upon -- instead of following. A demonstration of compliance based upon unanticipated processes and events.

That would clear it up for me.

DR. MOELLER: It would for me, too. Right, that helps. Any others on page 10?

(No response.)

DR. MOELLER: Eleven? Of course, in 11, in line 247, they hit a point I had, the correctness of the models. But we have totally separate -- you're working to confirm models, and all of that. So I felt we didn't need to discuss it here.

DR. MARK: On that subject of models, EPA has some. Must you use those? I know they're not worth using, but are they in a position to object and say you didn't use our models?

DR. FEHRINGER: No. EPA has said -- I'm not sure on the record or off the record -- that they have definitely made clear they expect better models to be used than the ones they use for their standard development.

DR. MOELLER: I've read that, too. On line 237 on page 11, you say: the quantity of radioactive material that may be released to the environment.

Okay. Page 12. That middle paragraph is

pretty powerful. But I accepted it.

Page 13. Where is the NUREG report in line 295? Did we see it?

DR. FEHRINGER: That is being prepared by a contractor. We're supposed to get a first draft of it tomorrow or Friday.

DR. MOELLER: Please let us, and I know you will, see it.

DR. CARTER: Copies aren't available?

DR. FEHRINGER: No, this sentence was written in anticipation of the receipt.

DR. PARKER: Aren't there some EPA hearings on exactly that topic?

DR. FEHRINGER: That's right. That's why we turned to them to write this discussion. The report will describe primarily the mathematical calculations necessary to construct a CCF curve. And they discuss, to some ways, ways of compiling the data that go into it. I'm not certain how much detail they go into on that.

DR. MOELLER: Page 14. Those of us on the committee, yes, this subcommittee, too, we've been through this.

On 15. again, lines 337 to 342, along in there, that's a pretty powerful decision, that an event having a probability of 1 in 10 to the 8th per year need not be

considered, or can be ignored. I forget which you say.

DR. MARK: By implication, it needs to be considered.

DR. MOELLER: In line 338, it says: Generally, events that can be shown to have a likelihood of less than 1 in 10 to the 4th in 10,000 years or 1 in 10 to the 8th per year need not receive further analysis.

DR. MARK: But you should include the 10 to the minus 8th end point. At 10 to the minus 8, you should consider it only if it's less. Or you can ignore it.

DR. MOELLER: Is that compatible with nuclear power plant reviews? Where did you get this number?

DR. FEHRINGER: This number came from EPA.

DR. PARKER: I must say, I didn't have all the difficulties with this report that some other members had because having worked on that EPA standard, most of what they're doing is just trying to match that. And the agreement.

That's terrible in many respects, but since it's the law, they have no choice except to match it. That's all this does.

DR. MOELLER: Let me emphasize here that the subcommittee should keep clearly in mind that when we're hammering on Dan, that we should put ourselves in his shoes. He's trying to make his standard compatible with

EPA.

He is not in a position to change what EPA has written, which is the law. So we respect you and we know your position is difficult -- and we're here to help you.

(Laughter.)

DR. MOELLER: Okay. Page 16. These bounding analyses in line 367, I suppose I read this and I suppose it's the standard way of doing this, so no further comment.

DR. ORTH: I have to make a comment because it sort of implies, okay, DOE, come on in and do the best job you can, conservatively. And hope it fits.

Now, if it doesn't fit, the Commission now can go off and thrash and try to decide, well, even if it doesn't fit, can we think up any extenuating circumstances?

Really, it ought to be written somehow to encourage DOE to come in with what it says down there on line 374 to 375, that it more accurately represents the best, current, technical understanding -- instead of just saying: The Commission can find, if it wants to go back and evaluate all DOE's uncertainties.

That ought to be DOE's job, not the Commission's job.

DR. PARKER: I totally concur with Don. But I'm just shocked that DOE came in with any data.

DR. ORTH: I know, but I hate to see this in a

rulemaking, saying to the public that what is going to come in isn't going to be their best guess.

DR. MOELLER: Okay. The tone. It shouldn't be the NRC's responsibility. Put the burden, if you can, a little heavier on DOE.

Seventeen. We've already discussed lines 395 and 396. We don't need that. Someone provided good words overriding the uncertainties.

DR. MARK: Excuse me, Dade. Between 16 and 17, a paragraph recognizes specifically this question of reasonable assurance and reasonable expectation. And since we're going for assurance, therefore, we'll have to put "uncertainty" in to make sure that's an NRC decision.

DR. MOELLER: Okay, page 17. Oh, we've already done that. Page 18.

(No response.)

DR. MOELLER: Again, at lines 423 to 425, the Commission's revisions related to license termination will determine the length of time for which institutional control should be maintained.

I guess I'm repeating what Ron Kathren -- may have been the one that said it. It seems to me that institutional controls ought to be required and the licensee required to stay there until a sufficient time period had passed. It seems to me we're putting the shoe on the wrong

foot.

DR. FEHRINGER: I'm not sure I understand.

DR. MOELLER: You're saying institutional controls should be maintained in line 425 until the license is terminated. I'm saying the license shouldn't be terminated until we've had a sufficient time span of institutional control. Am I making sense?

It's not a major point.

DR. FEHRINGER: What we're trying to do here is contrast this with EPA's recommendation that institutional controls be maintained for as long a period of time as is practicable.

We're trying to contrast that and say: NRC has no mechanism other than the license for assuring institutional controls. And that's the length of time it is practicable.

DR. MOELLER: Okay. Page 19, line 436 has a typographical error in the last word. And in line 437, there is no emphasis added. You undoubtedly planned to underline some of this. A word processer, many times, won't underline. That's the problem. So check that.

Pages 20 and 21 was about the monitoring. I thought your arguments were good there, to require groundwater flow and temperature, and so forth.

Page 21 and 22?

(No response.)

DR. MOELLER: Page 23, I really didn't understand the sudden discussion near the bottom where you're saying something is not the same as retrievability. Oh, it's on 24. I'm sorry, I'm on the wrong page.

Twenty-four, where you define. You said, it's interesting your saying the retrievability requirement is not presented for the reasons most people might think. It's presented to rule out deep well injection.

And you then, on line 565, say you don't mean great cost, you mean high cost. Great, to me, is not the same as exhorbitant or high.

I didn't realize that in the repository we were going to build that retrievability would be enormou. or high-cost. I thought you could retrieve it in the reverse operation of having put it in.

DR. FEHRINGER: There were two different conepts here. One is EPA's removal concept. That's what's being discussed here. We're trying to contrast that with the retrievability concept of Part 60.

DR. MOELLER: You're distinguishing between removing the waste wants in place versus retrieving it?

DR. FEHRINGER: Yes. On the bottom of page 23, EPA gives their assurance requirement saying that waste must be removable for a reasonable period of time.

Then, at the top of page 24, we describe what EPA means by that concept. And we point out that that's different from retrievability in Part 60.

DR. MOELLER: Okay. Did anyone else have -- what you're saying then is EPA's definition of removability is different from retrieval?

DR. FEHRINGER: Right.

DR. STEINDLER: You're also saying that EPA has no retrievability in your context of the requirement.

DR. FEHRINGER: Yes.

DR. MOELLER: On page 24, Nevada and Minnesota, could you tell me something about what they are doing?

DR. FEHRINGER: At the time that the NRC and EPA staffs were negotiating the arrangements on the assurance environments, copies of the wording made their way into the hands of some of the state environmentalist groups, and Nevada and Minnesota submitted a petition and rulemaking asking the Commission to adopt the wording that had been negotiated to that point as well as a few other odds and ends they threw in.

Effectively, we are doing what they asked on the assurance requirements, and the other issues they raised we will have to respond to separately.

DR. MOELLER: Are there comments on the back sections, the section-by-section analysis?

If you have comments, why don't you just call them out where they are?

DR. PARKER: I have one on page 29, lines 664, 665, talking about the thermal points here to great distances. There is no reference to that whatsoever as far as the temperatures, the age of the wastes, that sort. It seems like a dry type of subject, that is a throwaway.

But I would like to see references made to it and discussions of that. I would like to see the reference. I don't see that here, and I think it is going to cause

enormous grief.

DR. FEHRINGER: I may get some more information on that.

DR. STEINDLER: In the case of the definition on page 41, you talk about the significant source of groundwater. There is an aquifer that provides the primary source of water for community water systems as of November 18th, last year.

How far away --

DR. FEHRINGER: EPA did not define the distance from the repository.

DR. STEINDLER: Are you silent on it because the EPA is silent? Are you silent on it because you think it is not an issue?

DR. FEHRINGER: I don't think it is important. The only place this term is used is in connection with the interim protection requirement. There is a phrase in that requirement saying that it should be assumed that people consume two liters per day of water from any significant source of groundwater that happens to be present. That is one of the conditions for evaluating compliance with that provision.

Well, let me back up. There is one criterion on distance, and that is significant sources of groundwater outside the control area.

DR. STEINDLER: That just gives you the load level.

I would be surprised if you didn't get some flack out of the folks, say, at BWIP. If I understand it right, they have an interconnected set of aquifers in the interbeds that go a long way, and who knows who taps what in various places along the way, and if you simply keep going it eventually looks like those are also part of the Columbia River aquifer, et cetera, et cetera, et cetera. Heaven knows, you could find a large connection of that kind a thousand miles downstream. Somebody has surely got to be taking water out of it.

DR. FEHRINGER: I think the limiting point, though, is the edge of the control area. That is the place where the concentration would be highest and the calculated doses would be highest.

So I think if you want to evaluate the plants, do it that way by the standard.

DR. STEINDLER: I am sorry, that is not my point. Supposing no one is interested drawing water at the edge of the control area, but they are interested drawing water somewhat downstream.

DR. FEHRINGER: In that case the closest location would be limiting, and distances farther away should have lower concentrations.

DR. MOELLER: Carson?

DR. MARK: This is a paper with commentary for the Commission.

DR. FEHRINGER: This is the Federal Register notice.

DR. MARK: These are explanations. You have made a fair point about the 100 square kilometers, the 5 kilometer range as being easier to maintain monuments. That seems like one of the most trivial features in this whole business. You could certainly maintain monuments at 10 kilometers only twice as hard as at 5.

You say nothing at all about what difficulties this may put on sites. You might say none. If there is a 1000-year travel time, travel time is at least twice as long at 10 kilometers as it is at 5, or probably is, and the radioactive material that crosses the boundary would be larger at 5 kilometers than at 10.

Is this change, which of course you have to accept, going to cause difficulty with improving conformance of the site to requirements of a serious sort?

You don't say anything about that.

If you knew that it wasn't a big point, it would not be out of place to say it. But if you knew it was a big point, it might require saying, also, I don't know. But if travel times are likely to be 500 years or 5 kilometers or

1000 years or 10 at most sites, which I don't think they are --

DR. FEHRINGER: On page 28, the final paragraph does touch on what you are raising, I think. We anticipate that this will have little effect on the achievement of the requirements, et cetera.

DR. MARK: Okay. Excuse me.

I had this thought, and I started to read it, and I didn't go far enough.

That was my point.

DR. FEHRINGER: There will be some effects, but we don't think they will be significant.

DR. MARK: It might be possible to say that it will exclude sites which would otherwise be acceptable if that is the case.

DR. FEHRINGER: It is [illegible] censing decision on specific sites.

DR. MARK: I don't know because I have dealt mainly with travel times. There are preliminary indications.

DR. MOELLER: Carson, what is this?

DR. MARK: Where they comment on the control area and compare EPA's new proposal with what had been covered earlier by the 10 kilometer radius.

As has just been pointed out, mid-paragraph at

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page 28, there is a reference to the fact that they don't expect any significant effects.

DR. MOELLER: Any other comments?

Yes, Dick.

DR. FOSTER: On that same page, on line 926, it has a transmissivity greater than 200 gallons per day per foot.

I presume that foot is a foot vertically of saturation. Is that correct?

Here, you need some explanation of what that foot goes with.

DR. PARKER: It is standard general knowledge in the field.

DR. FOSTER: Well, there may be people like me.

DR. MOELLER: Any other comments? We have sort of got to wrap it up.

DR. CARBON: I am sorry, I had to step out.

You discussed page 36 in your Item No. 16 on natural resources. Let me make just one comment.

I like the concept of what is involved here, but the words "widely available" ought to be revised. I think you should say something about "reasonable available."

DR. MOELLER: Any other comments?

DR. CARTER: Dade, I just wanted to reiterate something. There may well be a potential here, at least as

far as standards, for confusion when you take 40 CFR 190 or 191 and extend it to 190 and overlay this with the drinking water standard and Part 60 or Part 20.

I think some of the terminology is not consistent, and I think that ought to be looked at again.

DR. MOELLER: Okay. I think then at this point we need to go back just briefly and reach a decision.

They have given us this schedule where they hope to send this to the Commission on February 14th. Of course, the Commission won't act immediately. It will take a few weeks for them to vote.

I am just asking the question: what is the best approach for us to take?

It seems to me we have made our comments here this morning. There is a transcript with everything we have said in it, and for us now to spend a couple hours this afternoon rewriting this down on paper seems a little bit excess.

So I would prefer to say to the staff we appreciate your coming, we particularly appreciate your responding to our comments, and we know you have taken notes. You will have the transcript, and so forth, and we would encourage you -- you don't even need encouragement, but we would concur that you will go back and check through the points and where it is possible, where we are correct

and it is possible to change it for the better, we would appreciate it if you would try to do it.

Now, who is our official -- I wouldn't call it parliamentarian, but whatever it is -- does the committee sense that this is a rule? Are we compelled to write a letter that we concur with the publication?

I guess we can if we want to. Okay.

Well, thank you once again. It represents a lot of hard work, and we appreciate the opportunity to discuss it with you in a constructive way such as we have done.

DR. MARK: Could I just add a footnote?

I didn't speak earlier of the possible use of an explanatory footnote in connection with the table to get that 10 curies of thorium. I think the same question comes up with respect to carbon-14. It is 100 curies. Strontium-90 is 1000. Any radium emitter is 1000.

Why is carbon-14 set down by an order of magnitude?

DR. MOELLER: Its half-life is so much longer than strontium-90.

DR. MARK: But 30 years is like a human half-life, and carbon-14 is 100 human half-lives, but that doesn't affect the individual any worse.

DR. FEHRINGER: These calculations were based on the population rather than individuals.

DR. MARK: You mean for 10,000 years?

I think it would not be a mistake to give that indication.

DR. MOELLER: Any other comment?

(No response.)

DR. MOELLER: Let's go on, then, with the agenda. Let me, though, pause for a moment. The next item is groundwater travel time and the disturbed zone generic technical positions.

Do you think we can finish those by 12:30 or so?

MR. LINEHAN: We could. It is going to be tight. It depends on the amount of questions.

(Laughter.)

MR. LINEHAN: On these two we do want feedback, please.

DR. MOELLER: Why don't we, John -- you are going to do them separately, are you?

MR. LINEHAN: We are going to go from one right into the other.

DR. MOELLER: Let's do one of them and see where we are on the time.

MR. LINEHAN: We could conveniently break.

DR. MOELLER: Fine, and there is no question but what we are going to do it. I was just thinking out loud on what it did to our schedule.

This is John Linehan, who will lead in on the discussion on this. Then joining us for the discussion is Dick Codell.

MR. LINEHAN: Dick Codell of our Geotechnical Branch and Mel Knapp, who is the Chief of the Geotechnical Branch.

We are going to be discussing two generic technical positions that we presently have under development.

I just want to take two or three minutes here to give an overview of how they fit into the prelicensing guidance program that we discussed with your folks in our October meeting and recently discussed before the full ACRS.

The first slide here is just to basically refresh your mind on the way we approach the problem of guidance, how we identify where guidance is appropriate.

It is this diagram right here for those of you who don't have it.

Basically what we do is, based on the performance objectives in Part 60, based on information that exists at the sites at the present time, we identify issues, and what we try to do is, working in consultation with the Department of Energy, identifying where -- looking at this full list of issues -- where guidance is most needed, is most appropriate right now.

What areas are right for guidance at the present time? What types of criteria we use to determine this. If it is a unique problem, if there is a controversial technical matter involved, if resolution of the issue is going to take a fairly long lead time, and also how important the issue is to the overall performance of the repository.

Now, the two subjects we are discussing today I think fit any of those criteria.

As I mentioned at the start, we are looking for feedback. These are the types of things we mentioned before the full ACRS that we do need feedback on, whether the level of detail in them is appropriate, whether the basic rationale of the arguments and positions we are taking appears supportable.

The next slides really just show the tie between the performance objectives and the GTP.

Basically, we have got four post-implacement performance objectives. Today we are focusing on the third one down there, the groundwater travel time, which is the performance objective for the geologic setting.

Part 60 defines that groundwater travel time in the next slide as the pre-implacement groundwater travel time along the fastest path of likely radionuclide travel from the disturbed zone to the accessible environment shall

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be at least 1000 years.

Based on this performance objective, there's two key areas, two key issues that we have identified where we figure GTP's are necessary.

Moving on to the next figure, the two questions that need answering, and we are trying to give guidance, are, number one:

What is the extent of the disturbed zone; how should it be defined; what approach can DOE use in determining the disturbed zone?

And the second question being: what is an acceptable approach for determining groundwater travel time?

What we are trying to lay out is an acceptable approach, a broad methodology to give DOE guidance. It is not something they have to follow verbatim. It is an acceptable approach, and what we will be doing on any of these GTP's is trying to work with DOE to get agreement with them on these approaches so that we have something fixed that we agree on, that we can use as a baseline, that we can work against in our future interactions with them.

I think now if I just turn it over to Dick and let him go into these, there are a couple of other pages here, but, basically, Dick is going to cover those in his presentation.

DR. CARTER: Let me just ask you one thing. The accessible environment outside the controlled area, plus five kilometers.

MR. LINEHAM: That's included. It's outside the controlled area.

DR. CARTER: It does include the five kilometers?

MR. LINEHAM: Yes.

DR. MOELLER: And when you talk of the travel time, and so forth, you're talking of the time to travel from the outer boundary of the disturbed zone to the accessible part?

MR. LINEHAM: That's correct.

DR. MOELLER: Richard, what is your background? What is your professional background?

MR. CODELL: Mostly chemical engineering. I've been working as a hydrologist for NRC and AEC for 13 years.

DR. MOELLER: Thank you.

MR. CODELL: The two positions, disturbed zone and groundwater travel time, are tied together.

(Slide.)

So you'll see a little bit of mixing at the

beginning. I intend this morning to first talk about the disturbed zone. The groundwater travel time and the disturbed zone are concepts by which the NRC wishes to establish a knowable barrier approach to waste isolation.

The groundwater travel time itself is supposed to be a strictly hydrogeologic characterization of the merit of the site.

Let's start with the definition of "groundwater travel time" because it really follows the disturbed zone and other concepts that we find in this definition.

(Slide.)

The geologic repository shall be located so that the prewaste in placement groundwater travel time along the fastest path of likely radionuclide travel from the disturbed zone to the accessible environment shall be at least 1,000 years, or such other time as may be approved by the Commission.

DR. MOELLER: Excuse me. That's one. This "or such other time as may be approved", am I to interpret that as this other time will be longer or shorter? Or can it be either way?

MR. CODELL: I believe it would be if it were shown that a particular site had less than a thousand years, the site may still be approved. But that would be up to the Commission.

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DR. MOELLER: There are no limits on this "such other time" then?

MR. CODELL: Not that I know of, that's correct.

DR. MOELLER: Does it give anyone else a problem? Or if it just meant to me that it's wide open, that it's a thousand today but we could remake the Commission tomorrow and they could go to a whole new rule.

I would have said "or slightly lesser times under unusual circumstances, or something that's been carefully reviewed and evaluated".

MR. KATHREN: A thousand years seems to be carefully reviewed and evaluated. What this says to me is the accessible environment shall be whatever time that is approved by the Commission. Why even say the thousand years? It's like passing a speed law that says: the speed limit is 55 miles an hour unless we decide it should be something else.

MR. CODELL: I'd like to make one point, that this is really talking about implementing the rules as they stand and not changing the rule. If that would help...

DR. MOELLER: This isn't in the rule.

MR. LINEHAM: Yes, it is.

DR. ORTH: That's where we can't do anything about it. It's already there.

DR. PARKER: But, more than that, doesn't the

siting guidelines give you that already, which is law? So you've got to do it in any case.

MR. KNAPP: For your information, the intent of this was that, as a matter of fact, I think if you look at the other performance objectives in Part 60, you will find similar language. The intent is to give the Commission a certain flexibility.

Among other things, it was intended, let us say that a determination was made of groundwater travel time and it came out at 990 years. We thought this would be an opportunity for mischief-making, that we did not want to be tied into that kind of technicality.

DR. FOSTER: I had a little problem with this to begin with, trying to relate this to the new Part 191, because it seemed to me that 191 was a lot more lenient, if you will. You're talking about distances there and concentrations which would never happen under the groundwater travel time performance objective -- because the water would never get there.

But these, I recognize, are different because the performance objective is in the undisturbed state, prerepository construction, if you will; whereas, the EPA rules come into play after you have established that repository there and disturbed it.

MR. KNAPP: What you've said is correct but,

remember, the EPA standard applies not for 1,000 years, but for 10,000. So if we had thousand year groundwater travel time, presuming that at the end of, say, 300 to 1,000 years, as was stated in Part 60, you begin to get significant degradation of the containers and radionuclides begin to be released. Then, in fact, they would have something on the order of 9,000 years or so to arrive at the accessible environment.

Should those radionuclides travel at the speed of the groundwater and should it take a thousand years for the groundwater to get out, there would be radionuclides in the environment.

So this is not apart from the preinplacement. As opposed to post-inplacement, this does not really constitute a ratchet on the EPA standard.

DR. FOSTER: This performance objective, of course, was established considerably in advance of the EPA rule. I'm wondering, would you like to speculate that if the EPA rule had come out first, this thousand years might have been more relaxed?

MR. KNAPP: I'm inclined to think not. When we went forward during the rulemaking exercised, EPA standard hasn't changed dramatically in this sense.

As Dan Fehringer mentioned earlier, at one time, EPA contemplated a distance to the accessible environment

of one mile. In their proposed version it went out to 10 kilometers. It's now 5 kilometers. In our rationale for Part 60, we looked at a thousand year groundwater travel time, both in a sense of one mile and at 10 kilometers.

And we did not find there was a dramatic impact on how it would affect meeting the EPA standards. We found that a lengthy groundwater travel time -- that is to say, in the neighborhood of a thousand or 2,000 -- would be helpful. I doubt that it would have had.

If we were to start over, I doubt that it would have come out very differently than it has. I can't guarantee that.

DR. FOSTER: Thank you.

MR. CODELL: Several of the highlighted words in this definition on groundwater travel time are the fastest path of radionuclide travel, disturbed zone and accessible environment.

Those will be a little clearer on the following slide.

(Slide.)

This is not the exact slide in the package. The disturbed zone surrounds the engineered underground facility. It's a distance within which the rock is disturbed, and it does not include shafts and boreholes.

The accessible environment in this slide is shown

as a linear distance away from the disturbed zone and also the surface of the earth, and also the strand below.

DR. MOELLER: When you say it doesn't include shafts and boreholes, do you mean if I have a shaft or borehole outside the disturbed zone, it doesn't count? Is that what you're telling me?

MR. CODELL: As shown on this picture, you would usually have a shaft and borehole going down to the engineered facility. I guess if it were outside of here...

DR. MOELLER: Well, I thought I saw, and I'll have to find it, a specific comment on shafts and boreholes, which I didn't understand. But, see, I'm not understanding it here.

Obviously, you have to have a shaft to inplace the weights, for example. If I drilled a monitoring well out in the accessible environment to determine the dose to people or something, or whether the radionuclides are migrating, that does not constitute disturbing that area.

MR. CODELL: Obviously, it would be disturbed but the rule is such that it excludes shaft and boreholes for the reason that since they would extend it to surface and the accessible environment, you'd automatically be violating the rule. Shafts and boreholes will of course be carefully sealed.

DR. CARTER: Can I ask you a question? What's

the exact definition of the disturbed zone boundary? Is this the difference between what's been mined and unmined?

MR. CODELL: The disturbed zone boundary, I can read it to you. It's in the package you should have received. Its defined as: A portion of the controlled area, the physical or chemical properties of which have changed as a result of heat generation by the inplaced radioactive waste, such that the result in exchange of properties may have a significant effect on the performance of the geologic repository.

That's how it's defined in the rule. I will be getting into this throughout the talk a little deeper, but it's supposed to be the zone within which all effects of putting the waste underground and the heat generation are contained.

DR. STEINDLER: Are you sometime in your discussion going to talk about why it was necessary to invoke the concept of a disturbed zone at all? Whether or not it makes any difference?

MR. CODELL: Yes, I will go into that.

MR. PARRY: Dick, excuse me. During your discussion, you mentioned shafts and boreholes. Do you plan to discuss the effect of inplacement holes? I mean, that looks like the BWIP type of facility.

Some of the facilities are somewhat different.

MR. CODELL: Yes. Those are fair game. Those are considered to be part of the underground facility. So they are part of the disturbed zone. This is just an illustration.

DR. CARBON: When you put a shaft as you've drawn in, is there any chance at all of some geologic studies have one shaft coming down and boring into another shaft?

MR. CODELL: Yes. I guess you'd call that a slope instead of a shaft. There are some repositories that would be built so that the waste would travel down a grade rather than a vertical shaft.

DR. CARBON: If it were essentially horizontal going out into the disturbed area, could you close the shaft sufficiently tight so that your definition of "flow" will still pertain?

MR. CODELL: Yes. These are important considerations, don't get me wrong. The ceiling of the shaft is very important. Any of the openings. These are, hopefully, well-demonstrated that they're properly sealed. But it is not a topic of disposition. We're trying to keep it rather narrow because we want to characterize the geologic setting as it is today, not how it will be following the inplacement of the waste.

(Slide.)

The rationale of the staff for having the

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disturbed zone is covered by the following points. It's a quantitative measure of the waste isolation potential of the natural geologic setting as it exists today.

It's conceptually simple in that it avoids many of the difficulties that have been shown throughout the morning of shaft ceiling and disturbance of the environment by the heat generated by the waste.

It prevents reliance for the groundwater travel time solely on a very small thickness of rock. For example, from what we know today, the flow of groundwater through salt is probably very slow. And it would be possible to demonstrate that a few feet of rock would be capable of satisfying the staff's thousand year groundwater travel time.

But this is not the intent of the rule. The intent of the rule is that a large part of your repository isolates the waste to prevent, for example, someone from inplacing waste in a salt dome within a few feet of the edge of the salt and the disturbed zone finally takes into account all the near field disturoances caused by the waste generation and the inplacement of waste.

(Slide.)

The staff interprets the disturbed zone slightly differently than might have been intended a few years ago. One of the problems the last item, the last slide talked

about the disturbed zone containing all influences of inplacement of the waste.

What we found and others have found in subsequent calculations is that the thermohydrologic effects are very great. That is, the convection currents in the groundwater system caused by heated water could cause influences from the site, which in many cases could go clear to the accessible environment.

Thereby, this would not be useful; if the disturbed zone went all the way to the accessible environment, it would not be a useful concept. Therefore, we've redefined -- not redefined but reinterpreted the disturbed zone. It presently is considered by the staff: it's restricted to the zone of significant changes to the intrinsic properties of the rock, such as poricity and permeability.

DR. MOELLER: It's "significant" defined?

MR. CODELL: What we mean by "significant" is that would affect the speed of groundwater transport within an order of magnitude. Actually, the next point covers it.

We're talking about a change in porocity of less than a factor of 2 and this would correspond to an order of magnitude in the permeability of a rock of low porocity.

It does not include the effects of buoyancy or viscosity of the groundwater, which are properties of the groundwater, not the rock.

DR. MOELLER: If the porosity, say, increased by a factor of 2, how much faster would the groundwater flow? Is there a correlation or a relation?

MR. CODELL: Yes, there are relations that you will find in textbooks. Not everyone agrees with them, but it is a very site specific problem.

For example, you can change the porosity in a given repository and see very little change in that flow because the resistance to flow is being controlled outside that region. But we would say it would not be more than an order of magnitude increase of velocity within the small region.

Now that I think we have agreed to the new interpretation, the Staff set about looking at the processes that might define disturbance and trying to put a bound on the size of this disturbed zone.

DR. PARKER: Won't the change in viscosity and the change in buoyancy have very profound effects on water flow?

MR. CODELL: Yes. But those are post-implacement considerations.

DR. PARKER: But that is what you are talking

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about, the disturbed zone. Before you have any disturbed zone in place, there is no disturbance.

MR. CODELL: That is true. Perhaps you would like to answer that.

MR. KNAPP: That is one of the concerns that we have with this interpretation of disturbed zone and groundwater travel time. What we would like very much to do is to stay with the pre-implacement groundwater travel time as a measure of the setting. We would like to do that for a variety of reasons.

If we considered the comparison between pre- and post-implacement, one of the questions that comes up right away -- certainly you are right -- let's see, what I will call the thermal disturbance is at its peak and there are going to be profound changes in the groundwater flow. Looking at it over a period of 10,000 years as the heat released from implaced wastes decreased, obviously this is going to be site dependent, design dependent, and other things.

But I think it would be argued that as the repository returns to its steady state, more or less, condition, it is most likely to return to a condition where the post-implacement groundwater travel time is not all that different from the pre-implacement.

One of the things that we have considered is

whether or not in fact we should use post-implacement groundwater travel time as this measurement. The trouble is if we get into that, then we get into the reasons -- well, when do you pick it? When the waste is at its most dangerous, when the temperatures are at their highest, or what?

We also then get into some complex projections of what is going to happen in the future. We have found that we are most comfortable in staying with this concept as a conceptually simple model of the merit of the setting, and we would argue that since we are going to have to look at post-implacement groundwater considerations anyway because of the EPA standards, which we went over this morning, that that would cover the principal concerns.

DR. PARKER: I guess I didn't state my question properly.

I agree completely that you ought to use pre-implacement. I have no problem with that at all. But it seems to me we are just setting up to decide where you are going to start determining pre-implacement.

I don't see how you can then separate what you are calling disturbed, by changes in the rock and changes in the fluid. They both disturb the facility. I don't see that artificial separation, how you arrived at that artificial separation. That is my problem.

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MR. KNAPP: The problem we get into is that if we consider the changes in the fluid, then the changes in the fluid can very possibly extend into the accessible environment.

DR. PARKER: I guess it is the same problem we had this morning. The English language. When you say "disturbed," it is disturbed, and you are saying, well, we are only going to have certain things that we are going to call disturbances, and we are having certain other things that we are not going to call disturbances.

MR. KNAPP: I would say that is probably accurate.

I can simply say, as I think Dick is going to get to shortly, in a number of areas we are more comfortable dealing with changes such as buoyancy and viscosity because we don't have the computational power to deal with those; whereas, we are troubled by dealing with some of the effects that Dick is going to talk about in a moment.

I see Seth standing up there. Maybe he has something to add.

VOICE: You just said what I was about to say. When we began to recognize that the disturbed zone might in some instances extend out as far as the accessible environment, we looked, I think, a little bit more closely at what the concerns were when we created the concept of a

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disturbed zone in the first place.

Kind of at the heart of that was the unpredictability of certain types of phenomena and the degree of unpredictability, and I guess it is our thought that while there are going to be difficulties in doing the modeling of buoyant flow, and so forth, it is less difficult than some of the changes to intrinsic rock properties.

That is really the basis for making the distinction.

DR. PARKER: I guess I have trouble with the last part of that statement, too. It seems to me that there are a couple of processes that are at the heart of the whole problem, and I was hearing you separate the two.

VOICE: It is not a matter of really trying to separate. What I guess we were thinking is of the purely buoyant effects. You start to get the problems with the disturbed zone if we are trying to include all of those effects within the disturbed zone that would reach out as far as the accessible environment.

That is something that we think we can model. We will have to in the context of the EPA standard, but that such things as the thermal fracturing of the rock and the changes in the porosity that would result from that we are expecting to be very difficult to predict.

DR. PARKER: I guess I have real problems with

that.

If I take another example, if you go into the unsaturated zone or you are looking at a site that may very well be in the saturated zone, I am willing to grant that you are going to have as much trouble modeling the water problems as you are with the rock problems.

MR. CODELL: There is an example later in the presentation of the unsaturated zone. I don't know if it addresses your concerns.

I think once you see the size of the disturbed zone it will partially alleviate the problem. But as Dr. Knapp has stated, these two positions do not release DOE from calculating the performance. These are measures that are quite separate and are useful in characterizing the goodness of the site independently.

As I was saying, we set about trying to define the size of the disturbed zone, and the next slide shows some of the processes which the staff considered most important to defining the disturbance of the rock.

(Slide.)

These are stress redistribution, construction and excavation practices, thermomechanical effects and thermochemical effects.

The stress redistribution is what occurs --

(Slide.)

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-- when you remove the supporting rock. The rest of the rock has to support the load.

Here is a cartoon of a typical underground facility showing the placement room and drifts. These are horizontal drifts, into which the waste packages would be placed.

Typical sizes for these openings would be on the order of, say, one meter for the drifts and up to 10 meters for the other rooms.

The staff's analysis considered stress redistribution and various estimates were made which place the distance from any opening for which any changes to the preexisting stress would be unnoticeable at about three to five diameters away.

This is of course a generic appraisal and would depend on site specific factors.

(Slide.)

Number two, construction and excavation practices.

What we mean by this is whether it is blasting or boring to remove the rock. Even with blasting, which is probably the most offensive type of rock removal, it is not likely that disturbances would propagate more than about half a diameter away. This is within the five opening diameters of about 50 meters, forecast to be the approximate

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Thermomechanical effects cause the thermal expansion of the rock with possible openings of joints and fractures. These might be important, but it is probable that the very great depths of these repositories due to the enormous pressure on the rock would tend to reseal these fractures, and we don't expect a very great effect on rock expansion beyond the 50 meters or so that is already covered by stress redistribution.

Finally, thermochemical effects.

(Slide.)

These are phase change to the rock, dissolution of the rock, and dehydration.

Phase change would be the change in the chemical form of the rock because of the increased temperature and could be either a positive or negative change in the volume of the rock.

Dissolution would be the removal of certain minerals in the rock, such as silicon, by flowing groundwater which has been heated and possibly redeposition of this dissolved silica elsewhere for other minerals.

Dehydration would be a phenomenon most important in unsaturated repositories and probably not in saturated

repositories.

Once again, we feel on the basis of some calculations performed on at least one of these mechanisms, the dissolution of silica, that these are not large scale effects and would fall within the 50 meters covered by the stress redistribution.

However, recognizing that each site is different and that the rock is made up of different minerals probably would require some sort of site specific analysis of these mechanisms for each particular site.

DR. PARKER: Both the thermomechanical and thermochemical effects, what sort of temperatures will you assume? How aged was the waste, and what sort of temperatures were you using?

(Slide.)

MR. CODELL: The calculations we performed for thermochemical effects assumed 10-year-old waste, and the temperature -- we weren't concerned necessarily right at the waste package because we are talking about having the freedom to move out a few meters based on the other mechanisms. So the temperature in the example we performed never approached 100 degrees C, slightly less than 100 degrees C.

DR. PARKER: You would have very little effect, I would guess, from either -- except in salt --

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thermomechanical?

MR. CODELL: Thermomechanical. Well, we stated that we don't expect very large effects of thermomechanical processes.

DR. CARBON: I have not been in on earlier discussions of this, but does radiation play no role at all?

MR. CODELL: It wasn't explicitly brought out in our position. I really wasn't responsible for those considerations.

I take it that this was already discussed, is that correct? Radiation?

MR. KNAPP: We didn't contemplate radiation having an impact, recognizing what we are doing here is looking at groundwater travel time. So we are looking at the impact of these phenomena on rock phenomena that would affect groundwater travel time.

Frankly, I would say that if we looked at radiation at all and looked at it very hard, we simply did not envision a mechanism where radiation would have a big impact on the portion of the rock we are talking about.

There is a counterexample in oversight, but we didn't want to consider it.

DR. CARBON: But I guess I don't want to either.

MR. PARRY: Calculations, Max, would indicate that radiation effects die after about 1.5 meters in salt.

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MR. CODELL: In summary, the staff states its position on the disturbed zone in the following way: the zone has substantial changes to intrinsic permeability and porosity of the rock surrounding the facility. It includes rock adjacent to the implaced waste so that more than just a very small amount of rock would be used to satisfy the staff's 1000 year groundwater travel time requirement, to avoid such situations as salt, where pre-implacement groundwater travel time would be very slight.

We estimate that five diameters room heights or 50 meters away from any opening except shafts and bore holes would be the minimum acceptable disturbed zone for a particular repository and that this distance might extend further when site specific considerations were taken into account.

It is also possible that DOE could propose a smaller disturbed zone, but they would have to back these up with detailed calculations and also describe to us why their site was such that they had to depend on a smaller disturbed zone to meet the 1000-year criterion.

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I have about the same amount of material on groundwater travel time.

This would be a convenient place to break and take questions.

DR. MOELLER: Do you want to ask a few questions now and on the disturbed zone?

DR. ORTH: I have one.

In the draft where -- Section 4.1, page 9, where you are talking about stress redistribution and provide the bases for the diameter that he has up here for the disturbed zone -- 4.2 gets back to construction and excavation -- it was pointed out that when you are drilling a hole -- and the literature says that the effects of damage and that sort of thing on permeability are only a very limited distance -- I just have trouble coming to grasp with the fact that when I go and drill a hole and I don't find anything there -- that must include stress distribution because I don't know how I drilled that hole -- why there is a difference between that and the 4.1 discussion on stress distribution.

I don't know if my word is clear here, but I have drilled the hole and I am only affecting it out for a diameter or so, which presumably has to include such things as stress redistribution because I actually drilled the hole.

What is the consistency between 4.1 and 4.2?

MR. CODELL: I would like to defer this question. We have two engineers from the Rock Mechanics Section of the Engineering Branch whom I think could answer that better than I.

MR. TANIOUS: I am Naim Tanious, in the Rock Mechanics Section of the Engineering Branch.

It was deliberately made different because the analysis had to take these effects separately. For one, if you look into measurements of stresses, they do not necessarily in the different reports or the literature pay much attention to changes in permeability.

So we had to make the analysis on stress changes because of the existence of the excavation. So you look for the stress distribution out there in the virgin rock such that beyond that point there will be no other changes, no effect on the excavation.

On the question of the excavation effect itself because of the method used, there was one study done by the Colorado School of Mines where they actually had a drift and they drilled holes sideways into the rock and then inserted the permeability measurement kind of instruments and drilled another drift parallel to the first drift and measured the changes in permeability because of the second drift.

So I guess to answer your point, I guess the

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first changes that were induced by the bore holes themselves were not in that measure.

The result, however, was that half a diameter away they had these things at different distances from the first drift.

If you use the bore hole excavation method with a boring machine, you would have no blasting whatsoever, no shape of the existing joints. Then the changes would be even less than half a diameter.

I don't know if I have answered your point, but that is some of the material used to support the findings.

MR. NATARAJA: Let me just add one thing.

The result of the excavation is going to be a physical disturbance of the structure of the rock itself. That is what we are talking about in the second part; whereas, the redistribution of stresses is basically a mechanism of coming back to equilibrium.

It is based on the equations for elasticity, where you put a hole in the plate, so the stresses that were being experienced by points within that solid that was removed now have been physically shifted to some other location.

That is the redistribution of stresses, and that has an effect which is different from the actual physical disturbance of the rock structure itself, opening of the

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joints and closing of the joints and displacement of the material itself.

The second one includes the first one, as you said, but the two of them can be separated physically for convenience.

DR. ORTH: I can understand that. I understood that as I read this.

But I am just saying my problem was -- as you said, the second one includes both effects. So we have measurements with both effects, which give us a certain result. Then when we separate them, we get a much further bigger effect when we take out the one little part of the two effects.

I just didn't find it consistent.

MR. NATARAJA: Simply because those two things have been observed differently. One of them is based on calculations. The other is based on observations.

DR. ORTH: Okay.

DR. MOELLER: Bill Kerr?

DR. KERR: I would assume that if you are interested in stress redistributions it isn't just because there is something nice about stress redistribution but rather that you want to know what physical effect this may have to change things.

So you aren't really interested in stress

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redistribution. You are interested in the results of stress redistribution and the effect this may have on physical structure.

MR. NATARAJA: We do have some relationships between the stresses and the permeabilities. There are some measurements.

DR. KERR: That is a part of the physical structure. Porosity doesn't change unless the physical structure changes.

Now, if drilling a hole causes a redistribution of stress and if this redistribution goes on a long distance, it certainly seems to me that drilling the hole has an effect on physical structure further away than one-half diameter, or whatever number you are using.

MR. NATARAJA: But the construction technique itself is blasting.

DR. KERR: Are you telling me if I drill a hole in a plate that has stresses on it this will redistribute the stress out to a significant distance?

Either this has an effect on the physical structure out there or it doesn't. If it doesn't have any effect, it seems to me you aren't interested in it. If it does have an effect, it is significant.

Now, if the hole is drilled during construction -- I realize that is not a theoretical hole.

It is a real one.

But it seems to me that if your theory describes what happens when you drill a hole in a plate and one of the things that happens is that you get stress redistribution and stress redistribution causes a change in physical properties out to a significant distance, it is hard for me to avoid at least a conjecture that drilling a hole has some effect on physical structure further away than this very small distance which you cite.

MR. NATARAJA: But the 50 meters that we have come up with does not necessarily mean there is going to be a significant change in the permeability all the way to the 50 meters. That is the most conservative assumption we can make.

If there is a change in the stress, we assume there is going to be a change in permeability. But how much of a change is there is not quantified.

DR. KERR: I thought you said you could calculate this.

MR. NATARAJA: This is based on a magical hole in a plate which does not require any physical damaging of the plate. The original situation is a plane.

DR. KERR: If you make your calculations on magic, I guess that is interesting but I thought what you were trying to do is to predict what is going to happen to

this physical structure.

MR. NATARAJA: The stress redistribution does not tell us.

DR. KERR: You don't really care about the stress redistribution, I don't believe. What you want to know is what happens to the physical structure -- porosity, cracks, or whatever.

I mean, who cares about the stress unless the stress tells you something about the change in physical structure?

DR. ORTH: May I make an observation?

My own interpretation -- and I am not arguing with what they have done here. Let's say we have measured a hole 10 meters in diameter, we have measured it 10 meters further, we have an effect, and they assume 50 meters is the safety factor.

DR. KERR: So that is not calculated.

DR. ORTH: That is what seems to come through to me.

MR. PARRY: The important point is how small the disturbed zone is.

MR. GRAVES: Let me try and slowly walk through it.

The goal here is to set an outer boundary to the disturbed zone. It is incumbent upon anybody who is doing

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that to try and account for everything that is of importance.

So the 50 meters is the outer limit based on a lot of thinking. So as far as the rock mechanics aspects of it, you are quite correct about the stress redistribution having impact on a facet called permeability.

So that is one of the things folks looked at. What does the stress distribution do to permeability?

Unfortunately, there is not a lot of exact science in the rock mechanics area to give you exact answers. There has been some laboratory work. There has been some physical testing.

They do have information that shows in response to stress distribution around these openings that it is reasonable to think that the permeability out a few meters or some factor of diameter around this opening becomes insignificant. You probably can't measure it with the sophisticated tools that the hydrological folks have available to them.

So that is part of the thinking. Gee, that is less than 50 meters.

Then there is a consideration about physical construction effects that have to do with things like vibration. You know, at first you have accounted for stress distribution, but in addition to that you have got to worry

about things like some contractor who goes in there with the low bid and wants to put all the dynamite in there and get large rounds blasted out. What is the effect of this phenomenon? How far out does it go?

Tests have been run by places like the Colorado School of Mines to account for this facet, and what the folks have done here individually in their technical discipline is tried to account for each of these, each of them trying to say how far out does this individually impact things, and, frankly, the 50 meters is a number that folks collectively come up with as something they are comfortable with in their technical discipline as saying that it does not have the effect on the intrinsic permeability characteristics of the rock.

I hope I have helped. Is that helping one person?

DR. ORTH: Yes. I think what it amounts to is that we can really measure things out to a diameter or two and we will assume the extrapolating, all the calculations that we can put on a nice big safety factor, and that is fine.

DR. MOELLER: Other questions on this? Do you want to go through it?

MR. PARRY: Excuse me, Dade.

The 50 meter minimum, is that in both directions,

up and down for instance?

MR. CODELL: That is measured perpendicular.

MR. NATARAJA: In all directions.

MR. PARRY: There are strata that I know are being considered that are thinner than 110 meters, or something like that.

Does that mean, then, that the disturbed zone might go into aquifers?

MR. KNAPP: I would say that is entirely correct. One of the faults of the position is that if you have an aquifer that is close enough to the implaced waste that we don't have a great deal of confidence, that the rock between the aquifer and the implaced waste is going to provide a long groundwater travel time. We hope to find that the aquifer itself is slow enough that we can get the groundwater travel time out of that aquifer.

DR. MOELLER: Okay. Do you want to go through the draft quickly and offer comments?

I notice, I think for myself, that the discussion thus far has covered a lot of my comments. We have already discussed this 1000 years or such other times as may be approved. That is on page 3, I think.

Page 4, I had a problem, and my problems gradually were resolved. But I believe it is on page 4, in the second paragraph, that you probably first told me that

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I was to examine pre-implacement travel time. You told me that I should do this because it was easiest.

That misled me until I later understood that the reason that you are pushing for pre-implacement data is because I am concerned about the environment beyond this disturbed zone, between there and the accessible environment.

Well, you didn't tell me that. I am r'ssing the words here where you said do it because it is easiest, but that struck me as a poor reason.

Does anyone else see it there? I thought it was on page 4, and I can't find it.

Oh, yes, the first sentence in the middle paragraph:

"The groundwater travel time is stated in terms of pre-implacement conditions because the NRC considers that the groundwater travel time under measurable existing conditions has more limited information needs and can be estimated with greater confidence."

That is what I am saying. Why do it because it is easier?

But later I got the point, but I had the wrong

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flavor at this point.

DR. STEINDLER: You may have had your problems resolved, but it doesn't do a thing for me. I still don't understand yet the difference between the use of the disturbed zone if you do abolish that concept altogether, put a marker somewhere in the middle of your shaft that goes down there and says from here to the environment, that is where I am going to measure it.

The pre-implacement period, there is no hole, there is no shaft, there is nothing, simply an arbitrary mark.

DR. MOELLER: But they have introduced to me conservatisms. I hear you, but I get the impression they have introduced conservatism because it is going to take some time to move from where it is in place out to the border of the disturbed zone, and that is cushion, that is extra.

DR. ORTH: You have effectively reduced the total distance by whatever the peak area of that is. It isn't very much.

DR. STEINDLER: What I am saying, in light of the uncertainties that seem to be built into the determination of groundwater travel time plus the arguments you are going to get into about what constitutes the border of the disturbed zone, the gain that you get by using the

disturbed zone appears to be zilch -- spelled with a "z."

It is an enormous amount of effort that somebody went through, and you are going to ask the applicant to go through, I assume, some fairly husky arguments and effort, and I just don't see the benefit derived by it.

The only thing that has come up so far in the discussion is Frank's comment that the disturbed zone exceeds the distance to the accessible environment. At that point I get confused even further. I don't understand how to handle that one altogether, with disturbed zone included or not.

But I assume somewhere, sometime yet today you are going to talk about why this whole exercise is worthwhile. You try to address the issue in your draft on the generic technical position paper on identification of the extent of the disturbed zone.

Before we leave the topic, I really would like to have some idea.

DR. MOELLER: Let me say back to you some of what I heard you say. You are telling me that in trying to define this disturbed zone, with a clear boundary and all that sort of thing, I am going to just get into a lot of controversy and why don't I just forget about the whole concept and just restrict the travel time to 1000 years, no less than that, from wherever the waste is out to the

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accessible environment?

DR. STEINDLER: Wherever the waste will be.

DR. MOELLER: What do I gain by defining the disturbed zone?

MR. CODELL: There are some answers, not all, but first of all, the disturbed zone is rather small, and I think it is important that it is not a great concern. It is only 50 meters or so.

There was an example of a bedded salt in which the layer may be just a few hundred meters, and therefore the disturbed zone would extend beyond that layer.

I think that is the kind of case we want to pick up with this. We want to say the post-implacement characterization; that is, the post-implacement conditions of the repository will be different from the pre-implacement, and we don't want to take undue credit for just a few meters of rock, or salt in this case, for holding back the transport of radionuclides.

MR. KNAPP: Also, basalt.

DR. KERR: It seems to me you have asked an interesting question, but it was not the same question as Dr. Steindler asked.

His question was: why shouldn't you just have travel time be 1000 years from the waste and leave it up to whoever picks the site to demonstrate that this is the case?

DR. MOELLER: And they may want to say, well, the earth, or whatever it is, the media is disturbed for a

little distance, and this will influence the flow during this portion but once it gets out to here it has been disturbed.

Dick?

DR. FOSTER: It seems to me -- perhaps I should say I have been working on the premise for a few years -- that the chief use of this is going to be in site selection, at which time you are comparing sites and also trying to get some assurance that the point that you are focusing on is going to meet the requirements of the objective.

Therefore, the thing that you need is to work with the preselection, if you will, that characterized -- site characterized information, but you are probably making this calculation of the disturbed zone, and thus the travel time, on the basis of an unfinished engineering design.

So you don't know at that time where your holes are going to be precisely. You are still working in this site selection area.

Am I wrong?

MR. CODELL: I don't think you can demonstrate the compliance of the site with the EPA guidelines rule until you have the design finalized.

DR. FOSTER: But this applies earlier, doesn't it?

MR. CODELL: Yes. It is a screening process.

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MR. KNAPP: Formal application of both this and the EPA criteria will happen at the time of licensing, but they apply from the construction authorization, at which time they will have all the designs completed.

DR. FOSTER: But you will have prior to that time gone through and made these calculations for each of your primary candidate sites, would you not?

MR. KNAPP: Yes.

DR. FOSTER: So you need something or DOE needs something to go on in trying to narrow down the particular site that they are going to have?

MR. KNAPP: I am not disagreeing with what you are saying. I guess I don't see your point.

DR. FOSTER: My point is that you do need to have some ground rules to go on on what the size of the disturbed zone is early in the game and prior to final engineering design.

MR. KNAPP: That is the reason we have put the position together and we have established the distance of 50 meters to do exactly that.

DR. FOSTER: Right. What I am doing is you are saying you need this at this stage of the game.

MR. CODELL: I would like to point out, not to give anyone the wrong impression, that the calculations that we suggest to carry out these analyses are probably much

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simpler than they could possibly be.

In Appendix V there is the analysis of the dissolution of silica. I think it is a relatively simple analysis, and that is all we would be looking for. It would not be a big deal.

MR. KNAPP: It is certainly not our intent to come up with a disturbed zone that would require a lot of definition that requires a lot of lengthy, complex analysis on the part of DOE. Our intent here is to simplify life rather than to make it more complicated.

In fact, if we are making it more complicated, that is not our intent.

DR. STEINDLER: Let me close the discussion on the point I am trying to make.

My recommendation would be -- as long as this thing is only a draft -- that your Section 2, entitled "Rationale Behind the 'Disturbed Zone,'" be expanded sufficiently so the issue that you indicated, for example, on the salt zone, which seems to have raised some concerns that I don't understand, be explained a lot more clearly.

It may be that the wizards at DOE understand exactly what you have got here, but I frankly doubt it.

You give me two arguments for getting involved in the first place. The first one says, gee, fellows, we are really interested in the far field. That doesn't do a

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thing for me because, having said that the disturbed zone is small, because you are clearly left with the far field.

The second one says we are going to consider the disturbed zone because we are going to consider the disturbed zone. That didn't strike me as making a whole lot of sense.

I think you need to have a look at it from the standpoint of the comments you have heard and see whether or not you might want to amplify this.

DR. MOELLER: I think your statements help me a lot.

In other words, on page 4, as I say, I didn't like this statement or didn't understand the statements about being primarily interested in the pre-implacement conditions because they were the easiest to measure.

What they ought to say is we need to know pre-implacement conditions as well as post-implacement conditions because there are going to be some disturbed zones and some undisturbed zones and the groundwater travel time will be a function of how much time is spent in the disturbed zone -- meaning zone not a defined area for volume but more as just a total consideration of the problem before them.

Frank?

DR. PARKER: This may have summarized it, but I

think the problem that Dick is talking about is when you go to licensing post-closure is of concern; it is not the pre-closure.

It has to go much, much earlier. I think you will want to find something relatively soon. In the disturbed zone you have past philosophies by taking that into account, that it seems to me to suggest that the simplest definition possible of it is the easy way out. Past that, it would seem to me that you are out of the ballgame in any case.

It is post-closure you have to be very worried about. So I would take the simplest definition and see if it comes close to being 1000 years at that time. That, it seems to me, is the easiest way out.

DR. STEINDLER: That is true if the argument holds that the disturbed zone is relatively small, a small fraction of that travel time.

DR. PARKER: That is what I would say.

DR. STEINDLER: If there is nothing to the contrary, I would say that is fine. But if the disturbed zone suddenly got to be an extremely large fraction of the total travel distance, then the argument is quite different. You haven't made that argument.

DR. PARKER: Even if it is a large fraction of the total travel distance, then you can say it is

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considerably higher.

MR. KNAPP: Let me be clear. While the disturbed zone is a small fraction of the total volume, depending on the rock properties it may not be a small fraction of the total groundwater traveling environment, and one of our concerns is that we would be very uncomfortable for DOE to select a site where the preponderance of their credit for groundwater travel time were to come within a few tenths of meters of the implaced waste because they happened to find some very tight, very impermeable rock units which were adjacent to some very permeable ones.

Essentially, they would be taking a lot of credit for a very close-in, and they wouldn't be taking credit for the bulk of the geologic setting.

DR. PARKER: Post-closure, they can't do that.

DR. MOELLER: And you are saying, Frank, that the flow rate in the disturbed zone may be slower?

DR. PARKER: No, faster.

DR. MOELLER: Well, generally you might think of it as faster, but you might think of it as slower because of the backpack and canister and all that.

DR. PARKER: Disturbed goes with nothing in it.

MR. KNAPP: One of the concerns again -- I don't know if this perspective will help, but the purpose of the criteria on groundwater travel time is to give us

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increased confidence that the EPA standard will be met. Again, it is a quantitative measure compared with the geologic setting.

Absent that, it might be argued that the EPA's standard could be met by saying we are going to have a 10,000 package. What we are interested is some way to make sure that the geologic setting --

DR. PARKER: Say a 1000-year travel time. I didn't say to strike that. The question is where do you start to count from? Do you start at the centerline or do you start 50 meters out?

MR. KNAPP: That is where -- if we were to start at the centerline and get most of that 1000 years within the first 15 meters, I would become concerned about what the merit of the setting would be beyond that.

DR. STEINDLER: That is a valid point. The question is whether or not the post-implacement analysis, in the absence of this definition, wouldn't also cover that point.

MR. KNAPP: That is right.

DR. STEINDLER: If you could explain it in some fashion or another, that would help. But you obviously don't want DOE to get away with pre-implacement in permeable zones, that they then blast away when they start digging the holes.

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DR. MOELLER: There is one other comment for me. On page 6, the last full paragraph. Of course, it is out of my field, but I found in Section 3.0, the second paragraph within that section, I had trouble:

"An increases in effective porosity" -- the third line -- "will increase the groundwater travel time."

Is that because the rock is soaking the waste up and holding it?

MR. CODELL: No. It is just that for the same flux of water through that area of rock, if you increase the size of the pores the water naturally has to slow down -- if you are putting the same amount of water through a small tube and a big tube.

DR. MOELLER: Okay.

Now, the next sentence says: "For the purposes of evaluating the extent of the disturbed zone at a given site, the staff considers that a change in porosity of a factor of about 2, which in general would be associated with a change in permeability by an order of magnitude, and that constitutes a significant adverse effect."

Now, if the porosity goes up by a factor of 2, does the permeability go up by an order of magnitude?

MR. CODELL: Yes. That is what we are saying.

DR. ORTH: They assume a cube relationship actually.

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DR. MOELLER: Thank you. That helps me some.

Other detailed comments on this draft?

I guess you have heard from us, in essence. If you have accepted it, it could require quite a bit of work to recast, and you will just have to think about it.

Any other comments on this proposed technical --

DR. PARKER: You don't want them to talk about the fluid, yet you talk about dissolution. Dissolution is a function of the fluid.

DR. FOSTER: Is the groundwater travel time yet to come?

DR. MOELLER: Yes, that is yet to come.

DR. PARKER: So you only want to talk about the effect on rock? When you are talking about dissolution, which is a function of the effect of the groundwater --

MR. CODELL: The calculations performed for the dissolution of silica were rather conservative. We picked large values.

DR. PARKER: I am just saying there is a logical inconsistency.

DR. MOELLER: Okay. Let's break for lunch now, with the comment that we have still got to do the draft technical position on the groundwater flow time. So in terms of the agenda, that takes us till 2:30 or 3:00.

Is the Division of Waste Management, the

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Research Group, and the Office of Nuclear Regulatory Research going to be content to begin about 2:30, about 2:00 or 3:00 o'clock?

Is Nick here?

We may do those just here in executive session.

Is Nick here? Is that going to be all right if we start with you about 2:30?

We are, as you see, somewhat behind schedule.

Let's break for lunch.

(Whereupon, at 12:50 p.m., the subcommittee was recessed, to reconvene around 2:00 p.m., this same day.)

AFTERNOON SESSION (1:50 p.m.)

DR. MOELLER: The meeting will resume.

We're going to pick up now where we left off with a discussion of the technical position on groundwater travel time.

Richard, the floor is yours.

(Slide.)

MR. CODELL: Now that we're all clear on the definition of the disturbed zone, this slide shows the disturbed zone surrounding the underground facility, the accessible environment and the path of groundwater flow. The object is to calculate the travel time from the disturbed zone to the accessible environment, along the path.

(Slide.)

The concept of groundwater travel time includes the following processes, all of which are related to movement of groundwater and of water, in general. These are advective flow, molecular diffusion and mechanical dispersion.

Primarily, we're interested in advective flow. These other processes are a little more vague, but where they do show up, it's important to allow that whoever is doing these calculations is taking them into consideration, so they are part of the position.

(Slide.)

Our approach to satisfying the groundwater travel time criteria is the following:

First, we identify the prewaste emplacement environment of the repository. We identify likely paths of the gradient of travel from the disturbed zone to the accessible environment.

Next we calculate the groundwater travel time along those paths, and finally pick the shortest groundwater travel time.

(Slide.)

Prewaste emplacement is summarized on this slide. What we mean by prewaste emplacement is, before any major disturbances to the site from construction activities or major site characterization activities, such as exploratory shafts or major well tests. Furthermore, we mean the degree of site characterization that we can make, based on the present day information, not going back many thousands or millions of years or projecting forward for any great length of time.

Usually we mean here a few tens of years of hydrologic and hydrologic data that might be available at the site.

And finally, we do not mean large-scale changes to the site, such as global climatic changes, changes in

surface morphology or major changes in land and water use, such as diversions of large rivers.

DR. MOELLER: What is the reasoning behind not including those items.

MR. CODELL: It's basically an argument for simplicity. We don't want to have to make projections on things which we have no way of making good predictions for or measuring, making what amounts to guesses about what was likely to have been the situation in the ground before there were records.

DR. MOELLER: Would those events fall within the probability limit that we were given earlier today? 1 chance in 10 to the 4th in 10,000 years? Are they all less than that?

MR. KNAPP: Yes. Again, this is separate from the EPA. This would be our preemplacement.

What Dick is talking about is almost a snapshot of what's going on.

DR. MOELLER: But what is the justification for what must be considered and need not be considered? I'm just not with you. I don't understand.

We were given the definition. The similarity of the word, that if it's unanticipated, it's unlikely. Then as you say, in the EPA standards, it's stated that if it had a probability of 1 in 10 to the 4th in 10,000 years, it need

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not be considered.

My presumption was, your definition of unlike.
fell in that probability range.

Now you're naming some things that you're not going to include, and you didn't say to me, my justificaiton is because we can excuse or exclude these on the basis of what we told you previously. You haven't told me that.

MR. FLEGEL: This is Mike Flegel.

What we're trying to do is just expand a little bit upon what preemplacement means. Preemplacement simply means that you want to be clear that it doesn't mean what was at 4:00 o'clock yesterday, it well, now is on the order of the kinds of changes that you might see over years, but not over thousands of years.

That's the only thought we're trying to get across here. Large-scale climatic changes are things that happen over periods of time longer than years. And they really don't mean present day.

That's all we're trying to do.

DR. MOELLER: Then after having to find and confirm the preemplacement conditions, are you then going to tell me, well, now that I know those, I will now calculate or estimate the impact of various unlikely events on these conditions?

MR. KNAPP: That will have to be done, including

projections of groundwater paths and travel times over the first 10,000 years, as a part of determining whether or not we've reached compliance with the EPA standard. That's 60.11.2.

For this performance objective, no, we're not going to be estimating how the groundwater travel time might be in the future. We're simply looking at preemplacement conditions. In fact, the reason we're looking at preemplacement conditions is for the purpose of this objective, to avoid having to get into some of these projections of what will happen.

DR. MOELLER: Then, what do I do with the results after you've finished? In other words, I know the preemplacement conditions. Then can I, with comfort, say to myself, well, these conditions will probably apply in the undisturbed zone for the next 1000 years or the next 600 or 400 or what? And then what do I do to give myself or provide someone else estimates for beyond 1000 years?

MR. FLEGEL: Again, the objective here is to determine whether or not groundwater travel time exceeds 1000 years under present-day conditions. That's all we're trying to do. That is a measure of the geologic goodness of the site.

DR. MOELLER: As it exists.

MR. FLEGEL: As it exists now.

DR. KERR: This seems to be saying, then, that what we're making is not a prediction of whether the groundwater will travel a certain distance over 1000 years, but rather, given that the current conditions prevail for the next 1000 years, this is what will happen.

DR. CARBON: I don't understand why the third goal is there then. It usually doesn't, talking about current goals. What does that mean then?

MR. CODELL: What we're talking about is large-scale, long duration -- or long-duration changes.

DR. CARBON: In the past?

MR. CODELL: It could be in the past or the future. In other words, we're not asking for long-term predictions of such things as global climate or glaciation.

DR. CARBON: I thought this referred to the past. He just tapped in and up to today. Maybe assume the future, but that, to me, it seems way in the future, and I'm confused.

MR. KNAPP: In talking about preemplacement groundwater travel time, one could interpret that in a number of ways.

How long is preemplacement? Is it a snapshot from 4:00 o'clock yesterday afternoon, or are we talking about further than that? The message that we should be conveying is, we're talking about the very recent past,

years or tens of years, and not going back through large-scale changes, pluvial cycles. That's not what we've asked to be done. That get's into this more complex modeling in estimating what was happening.

What we're really interested in here is looking at where we've got reasonable data over the last few years.

DR. CARBON: So the third bullet refers to that past.

MR. KNAPP: That's right.

(Slide.)

MR. CODELL: The first bullet on the previous slide as identifying the fastest path. What we mean here by paths may not be what everybody would automatically think. What we're talking about is their microscopic paths, such paths as aquifers, fracture zones. These are conduits, which are capable of carrying significant quantities of water.

Secondly, these paths must carry significant quantities of water from the area of the disturbed zone to the accessible environment.

And thirdly, the alternative paths may be defined by different models you have for the site. So this gets into the argument for either picking conservative, conceptual models of your site or having your data collection program ensure that you haven't overlooked paths

that are faster.

DR. STEINDLER: Why did you not identify specifically that the paths must carry significant fractions of water flowing by the waste package?

MR. CODELL: Because this is coupled very closely to the disturbed zone essentially.

DR. STEINDLER: I can see that.

My question is, why?

DR. MOELLER: I guess I maybe just thought it was a typo.

Does it mean by the disturbed zone, meaning, not through the disturbed zone but around it?

DR. STEINDLER: I didn't get that far. I'm not prepared to buy the disturbed zone, so I didn't address the question.

DR. MOELLER: So you'd certainly want to know water that is passed by, through, around or under the waster.

DR. STEINDLER: Isn't the waste the issue?

MR. CODELL: Yes, but we're taking no crdit for the quantity of rock within the disturbed zone. That's the idea of the disturbed zone. Once you accept that premise, it's clear

DR. MOELLER: What does it mean "flowing by the disturbed zone"? Does that mean above, below or around?

MR. CODELL: In the next couple of slides, it'll become a little clearer, but what I mean is, that the paths do not have to necessarily intersect the disturbed zone for them to be considered in our analyses.

Let me just show you on the next slide.

(Slide.)

This is a simple depiction of a layered repository site in a saturated medium.

Consider, for the case of this discussion, that there are multiple interbeds, and these are the conductive zone, and the zones between them are relatively impervious, if this is the repository and the underground facility, that is, and the dotted line is the disturbed zone. Interbeds C and D intersect the disturbed zone and, therefore, would be considered likely paths. Interbed B also could be considered a likely path, because there's a connection between B and C by way of this fracture. Interbed A, however, is not connected and the only way for anything to get from the disturbed zone to this interbed would be thorugh the inpervious rock.

So that is thrown out from the discussion.

DR. MOELLER: Where is the water that I have considered flowing?

MR. CODELL: It's flowing from the boundary of the disturbed zone to the accessible environment, which is

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off the slide.

DR. STEINDLER: You're assuming that the stuff between the interbeds is impervious.

MR. CODELL: For the sake of this example.

DR. STEINDLER: Is that property also valid fo the disturbed zone?

MR. CODELL: We're not taking credit for the disturbed zone, so I can't say. It doesn't matter.

DR. STEINDLER: It doesn't matter?

MR. CODELL: It doesn't matter because we'rnot taking credit for any kind of inhibition of groundwater moving by the rock in the disturbed zone.

DR. STEINDLER: I'm still trying to figure out how the water gets contact with the waste in this model.

The assumption is that a disturbed zone is a homogeneous mixture of whatever rock happens to be there, and the waste.

DR. PARKER: And the water takes no time to travel.

MR. FLEGEL: This performance objective does not speak to the waste. It speaks to the travel time of the groundwater before emplacement of waste, and it's for a gross determination, again, of the geologic goodness of the site, so we're not considering waste at this point. We're looking at the loction of the waste, and we've discussed

before why we want a disturbed zone around the waste. So we don't take any credit for the material right adjacent to where the waste would be.

This is looking at the rest of the geology.

DR. STEINDLER: I hear what you're saying. In light of the fact that you're argument presumably centers around some fairly fundamental and generally agreed on notions of transport from the waste out, by contact with water with the waste, you can argue that this is an artifact, because the waste isn't there. But the real world says it's only applicable or useful if the waste were there.

If you're going to pick a path that has no wayof contacting the waste, I guess I find the thing somewhat artificial.

DR. PARKER: That's not what were saying, because it's below the water table, everything naturally gets resaturated. So you're water -- you get water throughout the hole, in this case, and even after the wastes are there. Using order of magnitude arguments and saying in the intact rock, the flow is so slow you're going to ignore it, because the only thing that really counts is in the high flow regions.

DR. STEINDLER: I guess I assume that to be a generic diagram, and I have trouble translating it to basalt

and tough.

DR. MOELLER: Carson?

DR. MARK: These are layers, these interbeds, which could carry water. At this moment, I guess, it's irerlevant whether there is water in those or not.

MR. CODELL: It would be in this case. We're talking about saturated mediums. The water table is up here, and these would all be saturated with water.

DR. MARK: But also you said they had to carry a significant amount of water.

Is that like the significant water source in the early part of the rules?

MR. CODELL: I don't know whether I can draw that parallel or not. What we mean by "significant" is, that there is, hypothetically, a very direct, fast pathway that carries just a few drops of water. We don't want to eliminate this site on that basis. It's a little bit subjective at this point what we mean by significant, but that's basically it.

MR. PARRY: If the underground facility were in such a place that the disturbed zone did not cross an aquifer and interbed, then you would have no likely path?

MR. CODELL: It's just that you would probably look for a situation like that in which to build your repository, recognizing that nothing is totally impervious.

You're calculate the groundwater travel along the most pervious part of the rock.

MR. FLEGEL: We'd still have paths.

MR. PARRY: In a salt dome?

MR. CODELL: If you could demonstrate that, you're fine.

MR. PARRY: You mean I'd have to demonstrate that there wasn't one.

MR. KNAPP: If there isn't one, there isn't one. It might be worthwhile to say let's consider a salt dome, which is large, with respect to the disturbed zone we're defining. Let's presume it's an ideal salt dome that is completely isotropic.

MR. CODELL: At that point, then I think the applicant would be in pretty good shape because we're going to have very minimal water flow and I think it would probably be fairly straightforward to show that there wasn't much of a gradient. If it's isotropic, then, as we've said in the position, what we would call the path would be

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identical with the gradient, at which point I think it would be probably pretty easy to say yes, you've easily got over a thousand in your travel time.

There might be some questions about whether or not the salt was in fact that uniform or whether or not there might be clay interbeds, and that sort of thing. But, presuming that ideal case.

DR. MARK: He could cover this fact in two or three lines, in one paragraph? Or would he have to write a voluminous report to say how impervious the salt was?

MR. KNAPP: I don't know if he'd need much arithmetic from the viewpoint of a hydrologist. From the viewpoint of the geologist to whom he's going to have to demonstrate that he has high confidence that there are no interbeds and fractures.

DR. MARK: That part is separate. He's got to do that.

MR. KNAPP: My presumption is that, presuming he's made this demonstration of uniformity, I think it would be fairly straightfoward and he could certainly, in my view, entertain a simple calculation; because under those circumstances, a simple, one-dimensional calculation could balance this thing and show rather easily that you have a thousand-year groundwater travel time.

Again, this is an ideal situation where you've

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got a lot of salt.

MR. CODELL: I'd like to move on to the next slide, which is for the case of a repository in an unsaturated medium.

(Slide.)

This case is slightly different. Here the direction of groundwater flow is likely to be predominantly downward on the basis of the imperical hydrolic gradient and the most likely path would be straight down. And once it reaches the regional water table, we would go from that water table to the accessible environment.

However, one would also have to consider such phenomena as an increase in the recharge of the region because of, say, a few wet years in a row and possible perched water at bedding plains in the medium; also representing paths.

Here I've shown a few likely paths down along this bedding plate to the accessible environment through the perched water and perhaps an interconnection along saturated fractures in this fracture zone.

But there's be little if any possibility that would transport vertically to this pathway. This would be an unlikely pathway.

DR. MARK: What's perched water? Is it not a body of water that isn't flowing?

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MR. CODELL: Perched water could flow.

DR. MARK: But it doesn't get perched unless it doesn't flow.

MR. CODELL: I don't know about that. I think you can have perched water in any kind of an interbed in an unsaturated medium.

DR. MARK: I'm familiar with perched water along around where I live. That's hardly an aquifer. It's a little puddle that's been sitting there for a thousand years.

MR. CODELL: There are probably examples of perched waters that do flow. After all, when we're building the site, we want to build the site where there wouldn't be water that flows. What's not flowing to one person might be flowing very slowly, but still flowing, to another person.

MR. WEBER: My name is Mike Weber.

A standard definition of standard practice in hydrogeology is to use perched water to describe a saturated zone that's underlain by rock that's not saturated, or porous media that aren't saturated.

You can still have a local flow system entirely occurring within a perched water lens.

DR. MARK: So it's really an aquifer with an impermeable bottom?

MR. WEBER: Don't look at the unsaturated zone

as impermeable. It might be very impervious compared to saturated material, but you can't exclude flow through the unsaturated zone.

MR. CODELL: Thank you, Mike.

(Slide.)

Once the paths are identified, the next step is to calculate the groundwater travel time along each one of those paths. Now, this groundwater travel time is not going to be a single value number. It's going to be a distribution. That's for the following reasons.

Firstly, the disturbed zone and accessible environment are surfaces and if you consider that there are multiple releases from the disturbed zone and that the accessible environment is a surface, you can see that there is not going to be a single travel time for a particle leaving the disturbed zone and reaching the accessible environment.

DR. MOELLER: What do you mean by "surfaces"?

MR. CODELL: The disturbed zone is defined simply as 50 meters from the underground facility and any opening in the underground facility. So it would be...

DR. MOELLER: An odd-shaped sphere, or something? An envelope?

MR. CODELL: An envelope, yes.

DR. MOELLER: You're talking about insurface and

the accessible environment is some surface.

DR. MARK: It's a cylinder five kilometers away.

MR. CODELL: There is data uncertainty. Episodic recharge, diffusion and dispersion. I have some pictures which illustrate this better.

(Slide.)

Here's the point I was trying to make about the distributed nature of the disturbed zone and the accessible environment. So if you pick up the particles of water leaving your area as an arrival time distribution, the second point is episodic recharge. If you consider you have several wet years in a row, this will change the flow situation for a few years perhaps.

So part of the time that you can foresee, the groundwater will move quickly; the rest of the time, it will move very slowly. So that causes a distribution of the travel times.

(Slide.)

The next point is diffusion. Here's an example of one case where diffusion might be important. That's an example of matrix diffusion. If you consider particles of groundwater moving as they are in discrete molecules, there could be some diffusion into and out of pores in the matrix. So this diffusion into and out will cause a spreading of travel times for releases at this fracture,

reaching the accessible environment.

The last point is multiple realizations of the data. If you have sparse data, which you almost certainly do in any kind of groundwater situation, you, with the same data, try to apply to, say, a computer model to calculate travel time; you would come up with different realizations which would satisfy the same data because of uncertainty in the data, and sparseness in the data.

And for the release of a particle at the same point, each one of these realizations would give you a different travel time.

(Slide.)

Therefore, groundwater travel time is a distribution here represented as a cumulative distribution. This is actually taken from a computer simulation on travel times, here showing all of the fracture; a hundred percent of the simulations fall within this curve.

This is a cumulative probability distribution. Now, the point that's important to make is that when we're trying to characterize the groundwater travel time, since it is a distribution, it's hard to think of a distribution. So what we're doing is we're picking as our groundwater travel time criteria a certain percentile of the distribution.

This is only an example. We'll take for the sake of the example 15 percent, as shown on this curve. It's

about 5,000-6,000 years. That would be the groundwater travel time for this particular site, as we define it.

The reason we choose something that is a small percentile will be shown in the next several slides.

DR. FOSTER: Dick, while you're on that particular one, you've chosen, say, the 15th percentile or 85, whichever one you want to look at.

Do you feel that would come within the definition of "reasonable assurance"?

MR. CODELL: That would only be one of the factors. I think you'd want to have reasonable assurance of any of the calculations you do because you have such grave uncertainties about doing calculations based on insufficient data, and that's pretty much the situation we find ourselves in.

So that is one of the reasons for picking a small rather than a large percentile.

DR. FOSTER: But aren't these other uncertainties incorporated into this overall curve somehow or other?

MR. CODELL: All of the uncertainties are incorporated into this curve. We're not denying that there are uncertainties, they've just been incorporated into this curve.

DR. FOSTER: If I were faced with the problem of deciding whether or not the Department's objective of 1,000

years would be met with reasonable assurance, where would I draw my line here?

MR. CODELL: You would pick some point on here. You wouldn't pick zero or a hundred. And you probably don't want to pick 50, for reasons that I'll go into. But if you pick the zero, the problem is that certain computational models, for example, convective diffusion equations that you might solve, would predict wrongly that particles released could travel a finite distance in zero time.

This is the kind of problem we want to avoid by taking a non-zero criterion on this curve. So we're saying pick a small number. We haven't nailed it down to a specific number. But, say, a few percent, 15 percent, and use that as your criterion for satisfying the thousand-year groundwater travel time.

DR. STEINDLER: You said all the uncertainties are incorporated in that curve. Yet, that curve is a very sharp curve. Let me see if I have it backwards.

I see here, rather than having the uncertainties incorporated in the curve, what I see here is a series of different calculations, that with different kinds of models that are giving you different probabilities for particular travel times, but each of those is very precise the way you've got it drawn.

Is that correct?

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MR. CODELL: I'm not sure I completely understood, but let me tell you how this curve was calculated. This curve was calculated for looking at a finite difference model, looking at the time that it takes for a particle release at a particular point to cross a boundary.

Now, this calculation was repeated several hundred times, changing the data that went into the model randomly each time according to certain rules. All of the travel times were summed up in the travel time for the cumulative distribution.

DR. PARKER: This is one scenario and you'd have to pick one of these for each different scenario. That's how it's incorporated.

DR. STEINDLER: If that's one scenario, the scenario is precise.

MR. CODELL: This is for the occurrence of random realizations.

DR. PARKER: The scenario is the same in each one of them. It includes the changes.

MR. CODELL: I'm sorry. I don't know what you mean by "scenario" but the data in this case, the hydrolic-conductivity in the field changes for each run.

MR. KATHREN: Could you show me like an error

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band?

MR. CODELL: The error band is incorporated into this curve. I could show you on another slide, which is coming up.

DR. STEINDLER: What you're saying is -- I don't know what that number is. Suppose it's a fixed thousand-year travel time, that the cumulative probability is exactly .15 with no uncertainty attached to it.

MR. CODELL: Let's say we're choosing as our criterion 15 percent. Then the groundwater travel time would be 5,000 years, yes.

I think I will go to this slide because it may help clarify what we're talking about here.

(Slide.)

If you look at a distribution and say that this is a narrow distribution, this is a wide distribution with lots of uncertainty in it, and you integrate under those curves, you get these S-shaped curves.

This is the curve with little uncertainty. This is the curve with a lot of uncertainty. But they both contain the uncertainty. The curve that's more uncertain is wider. That's what I mean by incorporating all the uncertainty into the distribution.

DR. MARK: There's only one likely path that you could still develop a curve of that sort by arbitrarily

changing the porocity.

MR. KNAPP: I wouldn't say you arbitrarily change it because along this path will be the scattering data. And that's going to contribute to most of the distribution.

DR. MARK: And if I have two paths, then I add up the corresponding numbers to come up with each --

MR. KNAPP: Actually, each one --

MR. CODELL: Actually, we develop one of these curves for each path.

DR. MARK: And this has little to do with the carrying capacity of the path, only the spread in times that I get when I did this computer run.

MR. CODELL: That's correct.

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DR. PARKER: Before you take that off, one more factor of 10 to make sure that you get everything incorporated.

MR. CODELL: This I might point out was done by DOE.

DR. MOELLER: I hope that before that is printed and you report that 15 is put halfway between 1 and 2, it seems to me it ought to be in the middle. And I also looked at if you had taken the 50th percentile, if you estimate this is 5,000 for the 15th percentile, it's not much more than 10,000 for the 50th percentile.

So, you know, it's a factor of 2.

Well, let's move along because we do have to wrap it up.

(Slide.)

MR. CODELL: Since the point came up of using the median or 50th percentile travel time, you wouldn't necessarily want to do this. That's because you could have, say, at a particular hypothetical site, you would have an early characterization phase where you have poor data or few data; then, later on, the site would be well-characterized.

You may not have any bias in your measurement program, in which case, the medians could be the same for both situations. If that were so, there wouldn't be an incentive. If you chose as your criterion the 50th

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percentile, there wouldn't be any incentive to better characterize the site for the sake of the groundwater travel time determination.

However, if you choose a small percentile, such as 15 percent, then there's a distinct advantage to better characterizing your site, because that allows you to state that you have a longer ground ter travel time for a better characterized site.

DR. MOELLER: Here, again, these are nits, but your 15 is not in the right place.

MR. CODELL: These were drawn just for this presentation, freehand.

(Slide.)

The advantage of picking a nonzero criterion for groundwater travel time is illustrated on this slide for the case of a phased distribution that was covered in one of the other slides.

Another hypothetical example: Suppose you had two similar experiments. One would be groundwater travel time -- well, let's say flow of a tracer through a fracture, an identical fracture, except one is in impervious rock and the other is in a porous rock. You are likely to see curves like this.

In the case where there is impervious rock, the tracer will come out at the end of the fracture and the

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concentration will immediately go up; whereas, in the porous rock, you're likely to see more of a spreading because of the diffusion into and out of the rock matrix.

If you chose zero percentile, in other words, the first molecule tracer in your criterion in both cases, it would come up with the same groundwater travel time. And that's not what we intend because, clearly, the one case is better than the other. In the case with the matrix, diffusion is a more desirable situation.

By choosing a nonzero, in this case, the 15th percentile for your groundwater criterion, you give proper credit to the case where it's due.

(Slide.)

So, to wrap up NRC's position on the groundwater travel time is the following:

Determine the paths of likely radionuclide travel from the disturbed zone to the accessible environment.

Determine the preinplacement groundwater travel time along those paths; and select the path with the fastest groundwater travel.

In conclusion, I'd like to reiterate that we have defined the disturbed zone as the zone of significant changes to the intrinsic properties. And this is about 50 meters or so from any opening exclusive of shafts and boreholes.

I've gone over how we would define likely paths of radionuclide travel and how we calculate the travel time and the criteria for evaluating the travel time on these paths.

The groundwater travel time is part of the multiple barrier approach to high level waste isolation and is a measure of the hydrogeologic value of the site. It does not, however, supercede or obviate the need to comply with the EPA criteria.

Thank you. Any questions?

DR. MOELLER: Why don't we have general comments? Go ahead, Martin.

DR. STEINDLER: I have one practical question.

Has the staff collected some data on groundwater travel time from some site that may have nothing to do with the repository?

It would seem that, after the exercise that you're going to lay on DOE, does it come out the way, in fact, you indicated?

MR. CODELL: I can't admit to personally running through these calculations on a large scale because there's quite a bit of work involved for a simple procedure.

However, DOE has done at least two evaluations, employing most of the concepts I've talked about here. We can follow those pretty well.

DR. STEINDLER: Was the result pretty much what you anticipated, considering the comments you have made to us today? Were they in fact able to provide a reasonably coherent probability distribution? Did the pegging of some value at .15, 15 percent, seem like a sensible thing from the data that you saw? Or haven't they gotten that far yet?

MR. CODELL: They performed calculations. Now, we have not spent any time evaluating them. One of them is only out and has not been officially submitted to NRC. I've seen bits and pieces of it.

The other was done for BWIP and was included in the environmental assessments. They did not apply the criteria such as 15 percentiles because we haven't promulgated any guidance to this effect yet.

What they've done has made sense. We need to evaluate the assumptions they've used in doing their calculations to see if those are correct.

DR. MOELLER: In that regard, Martin, it seems to me the question is: Not only have they tested it to see if it works, but it seems to me this was a very prescriptive guide. It doesn't allow...it sets down every step they must take, at least it seemed to me.

DR. STEINDLER: I don't have that much trouble with that part of it. I think they allow for models to be determined by the applicant rather than specifying what

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models must be used. That, in itself, struck me as giving them an adequate amount of leeway.

DR. MOELLER: Dick is next. Then, Frank.

DR. FOSTER: If memory serves me, one of the particular reasons for doing these generic technical positions is to provide some guidance to the applicant, DOE, on the important things to look at and how they're going to be looked at. So when they come into NRC, they've got the right kind of information.

Between these two generic technical positions, you're laying out quite well where the starting blocks are as far as the disturbed zone, and you're laying out where the accessible environment is.

And you're prescribing here a system for generating a curve that shows the distribution and probability of what the travel time is going to be. Since you are generating this curve which covers in your example here two or three orders of magnitude, it seems to me that the missing part that DOE needs is where on that curve you're going to pick your point.

You've got a performance objective of a thousand years. You've got a curve year here which shows anywhere from perhap a hundred years for the low probability up to 10,000 years or more somewhere on the curve.

But you don't say where on this thing we're going

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to make your judgment.

MR. CODELL: I agree with you. I think something like that would be a good idea to just arbitrarily pick 15 percent. I think that problems arise when, because it is arbitrary, I'm not sure exactly why. But we've run into quite a bit of trouble in an earlier version of the draft, which actually said 15 percent.

We tried to make that clear that it was arbitrary, but we had to pick something. This is the sort of point you've raised.

DR. FOSTER: It seems to me that you haven't finished your job until you tell them what percentage it's got to be.

MR. CODELL: I'd like to take that as a recommendation from ACRS.

MR. LINEHAN: We agree it has to be done. Not necessarily by the NRC. Possibly, that's something DOE should be looking into. It can't be arbitrary. There's got to be a point. There's got to be some justification for it.

DR. KERR: If DOE should tell you what you would find acceptable.

MR. LINEHAN: No. There's a number of different points that could be considered. It's going to be a difficult exercise determining what point that is, and

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coming up with a good basis for it.

DR. MOELLER: You're saying whatever they recommend to you.

MR. LINEHAN: Not whatever they recommend.

DR. MOELLER: Whatever they select?

MR. LINEHAN: They'd have to come up with a proposal to justify it. They may want to look at a range of different points, and that curve is going to vary as they get the data on each site. You know, 15 on one curve may look okay and make sense, but on another, it wouldn't be the appropriate point.

DR. MOELLER: Frank.

DR. PARKER: It's a question of reasonable assurance. What percentage are you going to take as reasonable assurance?

Also, you have another option. You can use a bounding analysis to satisfy the requirement.

MR. CODELL: That's always an option.

DR. PARKER: It seems to me, in most cases, they'll be able to do that and they'll be better off.

MR. CODELL: It's an option in the position, too.

DR. KERR: They could also hire experts, apparently, to come in and tell the NRC we've seen this and this is okay. It seems to me they ought to have some

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guidance as to whether their heavy investment should be in calculation or experts.

DR. MOELLER: I found this slide and the text. This same thing is in the text on page 12. The last point says: "Select the path with fastest travel time." For what?

DR. PARKER: For the thousand year boundaries.

DR. MOELLER: Then they should have said the same thing. If they said examine the path with the fastest travel time and see if it meets the criterion -- they just said "select it". And your text on page 12 does the same thing, leaving me up in the air.

MR. CODELL: I think this was recognized when we were going over the presentation that this was not real clear.

DR. MOELLER: Okay. Other general comments on it? Yes, Frank.

DR. PARKER: On this last question, number three, one of the critical items will be the amount of matrix diffusion. It seems to me you don't offer any guidance at all as to how much matrix diffusion you'll be willing to give them credit for. Ten percent a meter penetration? How much are you going to allow? Or is it state of the art?

MR. CODELL: I don't think our position says anything about the models that may be used. Any kind of

transport model -- not transport model but any kind of model that would take matrix diffusion into account would certainly have to justify to us that it's a correct model.

DR. PARKER: It's a question of how much stuff they're going to allow.

MR. CODELL: I think that is really the job of DOE if they want to take credit for this phenomenon, proving to us that the parameters in the model are good ones.

Of course, if they want to, they can neglect the phenomenon and they can still demonstrate that thousand year groundwater travel time. That would be fine because we know that would be conservative.

DR. PARKER: If my memory serves me correctly, anticipating the next discussion on the Swiss analysis, they actually did a series of calculations with different penetration analyses and showed in that particular case that they could meet it with the lowest one that's reasonable.

MR. CODELL: It's a phenomenon that I anticipate won't show up very often. But if the DOE wanted to put this into their analysis, if they justified that their models were good, I think we would accept it.

DR. PARKER: You made a point both in the diagrams and in the text about distributed sources contributing to variability. It seems to me that's a very minor portion of the variability when you're talking about

travel time.

MR. CODELL: Maybe. May not. The reason I say that is that the distance to the accessible environment would be about 5 kilometers. Some of these repository designs have dimensions of a kilometer or so, or even more. If that's the case, they're of a fairly substantial size. And if you assume releases from different points along this --

DR. PARKER: It's a question of the permeability within the repository, which I would hope would be much, much higher than the permeability in the host rock. Otherwise, you'll be in trouble.

MR. CODELL: I think I know what you're saying. Let me put up a slide real quickly on the disturbed zone again.

(Slide.)

We would be mentioning groundwater travel times from points of release along this boundary and not necessarily from the nearest point to the nearest point.

DR. PARKER: Your distributed sources are contributing to your variability.

MR. CODELL: No, I think the slide was misleading. I should have showed a slide like this showing points along the disturbed zone.

DR. FOSTER: One general comment on GTPs as a whole. A year or more ago, we had an opportunity to look at several of these. This was at a time when it was pretty early on the learning curve for the Staff on writing such things. We found that some of those we looked at earlier were kind of far from the mark, in that they didn't provide much guidance as to what ought to be looked at. Some of them were so prescriptive that you didn't have any leeway of how the subject should be approached.

I found that these, in general, from my perspective anyway, were pretty much on target as to doing what I believe the GTP needs to do, as far as defining the issues and saying this is about the way we're going to look at it.

I personally would like to compliment the Staff on doing what I think is a pretty good job. I have some problems with the basic performance objective. It's already on the books in 10 CFR 60 on the 1000 years, and what not, but this is implementation of that, and I think it's a pretty good job.

DR. MOELLER: Coes that wrap it up?

Yes.

MR. LINEHAN: We had one question we'd like to throw out. We appreciate all the comments, and they're indeed very helpfu, and the kind of thing we're looking for

to give us guidance.

As we discussed the disturbed zone this morning, though, there was one issue we skirted around, which was really the basic approach we were trying to take, given the regulation, given the performance objectives and the definition of the disturbed zone we have in the regulations. The approach of trying to define the limit of 50 meters. Does that seem like a valid way to go, recognizing, you know, there were problems with the rationale we had in certain areas, but is the basic approach of trying to define something like that reasonable?

DR. MOELLER: Personally, I think you have to, because if you leave it to how far temperature increases have an impact, you could argue it for a long time. That's my own reaction. Some of the experts, Frank?

DR. PARKER: You're right. That's the only way to go. There needs to be a justification for the number, the exact number, but some means of setting the number is really needed.

DR. STEINDLER: Doesn't that depend strongly on the kind of stuff you're bearing on it?

DR. PARKER: We know that they won't be putting in 10-year-old stuff on the average.

DR. STEINDLER: The calculation for the performance of the waste package, for example, assumes short

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cooling, high burn-up fuel. That's the way you get that 300 degrees.

DR. PARKER: That's just another conservativism is what I'm saying.

DR. MOELLER: Okay. I think we need to move along.

Let me thank you. I had five or ten typos or editorials, but we'll give those to you, rather than take time now.

Let's move then to the next item, which is the discussion of waste management.

We're going to begin with modeling, the real-world assessment of future performance.

Nick Costanzi will introduce the subject, then Jay Randall will do the presentation.

Nick, you'll sort of chair or emcee this group.

Maybe we'll go through this first one and havae a break.

MR. CONSTANZI: Thank you, Dr. Moeller.

For those of you who don't know me, I'm Nick Constanzi, Chief of the Waste Management Branch in the Office of Research.

We certainly appreciate the opportunity to come down here and speak with you about some of the subjects of the research program. We really haven't had to much of an

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opportunity to focus on the specific programs. Looking into questions of modeling, alternatives to shallow land burial, our low level waste program, in general seems to always get short shrift.

High level wastes always seems to take up most of the time in the discussions.

DR. MOELLER: Would you, please, Nick, comment on the potential impact of this new Low Level Waste Act of '85.

MR. CONSTANZI: I'll try and do that. The agenda originally called for us to begin with low level waste; however, I'd like to beg your indulgence, shift it around a little bit and start with John Randall, who will talk to you about our waste management research program in the area of modeling for assesing performance in high level waste repositories.

DR. MOELLER: Although you're starting late, we don't want to keep you forever, but please take whatever amount of time is necessary to tell us what you want us to hear.

MR. RANDALL: Can you hear me? Is this working?

I'd like to thank you for letting me start first. I need to get away fairly soon after the talk, because my daughter, whom I've never met, will be coming to the airport. My wife and I are adopting a daughter, and

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today's the day that she comes to town.

DR. MOELLER: Congratulations.

(Slide.)

MR. RANDALL: The subject of the talk is Modeling Real-World Assessment of Future Performance.

What I'd like to be able to do in this talk is answer several questions. First of all, what's our high-level waste research program's perspective on modeling? And also other areas of waste management as well, but I'll be talking mostly about high level waste. Where does that fit into our research program and what do we think the state of the art is in modeling today, as applied to high level waste?

(Slide.)

The research program, as a whole, has as its objective identification and delineation of areas of controversy, uncertainty and ignorance with respect to phenomena that can influence the transport of radionuclides from emplaced high level waste to the accessible environment. Something we've already talked a lot about today.

In the Division of Waste Management, the modeling aspect of the research program fits in under the area of delineation, trying to take the identification and understanding its development by some of our projects and

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find ways to make predictions about repository performance, either qualitatively or quantitatively. We're trying to be as quantitative as we can, although we recognize that's not always possible.

So the modeling part of the research program contributes, along with other parts, to the development of the essential expertise in support of prelicensing and licensing activities in the commission of waste management. Also in this process of doing the research, understanding phenomena and trying to develop models, we recognize the need that both NRC and DOE will have to use simplified models of various processes.

So one of the things that the research program is trying to do is assess the price of simplification associated with this simplified model. And the modeling part of the program really depends on the rest of the program, the research program, to provide that information.

The next Vugraph shows a picture of where I think the modeling program fits in, the modeling part of the research program fits in with the rest of the projects.

(Slide.)

We're driven by the regulatory approach we chose to take. Part 60 of containment and controlled release of radionuclides. Ther are certain issues that the regulation dictates we look at -- groundwater contact with the

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canister, containment failure, radionuclide release. How does that occur? How does this travel through the far field? How do they get to the accessible environment?

And we've set up three categories of research projects to address these technical issues: materials and engineering, concentrating mainly on containment and release, sealing, backfitting of tunnels, hydrology and geochemistry having to do with natural barriers, transport through host rock and groundwater flow and compliance assessment and modeling, which I'm responsible for, which ties it all together.

Types of projects that we choose to do are dictated, to some extent, by what DOE has decided to do. For example, the fact that they picked BWIP as one of their candidate sites seems to me they need to know a lot about saturated cracked rock. The fact that they selected fractured tough, which is unsaturated, points in another direction.

We also have to expand our understanding to unsaturated rocks. We also need to know how waste will affect bedded salt, if it's possible for bedded salt to be breached in some way to allow transport of radionuclides to the accessible environment.

The program is strongest with respect to the fractured rocks and weakest with respect to sale.

DR. MOELLER: Why is that? Could that change?

MR. CONSTANZI: It's probably because we haven't had sufficient funding to develop the same level of effort that is needed at the same time. Basalt was the one which DOE over the last several years has been paying the most attention to, but the program has been shifting now away from basalt to tough and salt.

(Slide.)

MR. RANDALL: The reason why there's a modeling effort at all, I suppose is self-explanatory, but I'll say it again anyway. We've heard it many times. It's impossible to set up a prototypical repository the way you can built a car or locomotive and test it and see if it really works. So we are going to have to depend a lot on predictions. Predictions will be based on extrapolations of short-term tests, and we expect DOE to demonstrate compliance with our regulatory criteria, based on predictions that are somehow tied to short-term tests, site characterization activity, waste package activity.

And furthermore, as far as the integration of the tests go, that probably won't be possible either, and only the models will tell how well that information will fit together to test it, based on the repository components, very short-term tests of the repository components.

The point of the modeling program has been to

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try to figure out how all those pieces fit together, as a way of predicting overall repository performance.

My general modeling philosophy is given on the next slide.

(Slide.)

This shows our view of what the modeling process is. The hydrology and geochemistry and materials engineering projects help the modeling effort a lot by giving us information about understanding what the processes are and how they occur.

Ken Rice calls these qualitative models. They won't give you numbers. That's the limitation there. You can describe something verbally with a qualitative model, but you can't extract any numerical information. The translation equations and some other mathematical representation of those processes is usually done by those projects outside the modeling area. The actual integration of the models and finding ways to solve the equations is covered by the compliance assessment modeling projects.

Most of the equations are based on the assumption that the problems being solved are direct problems. A typical example is transport of radionuclides to the accessible environment governed by something like the investive dispersive equations. It's based on this assumption.

Given parameters like hydraulic conductivity and dispersion coefficients and given initial conditions, given boundary conditions, ideally, that's the way we'd like to be able to solve the problems. But we don't have that luxury.

Quite often when you go off into site characterization, it's easier to measure the dependent variables like concentrations of traces and to try to figure out what the parameters are, because the properties, such as hydraulic conductivity, it's hard to go to a system and say here's a boundary and here's what the conditions are, other than the ground surface where you can get some idea of recharge and discharge.

The underground boundary conditions are just about impossible to specific. So we're really confronted most of the time with what's called an inverse problem, a typical approach, both in toxic and radioactive waste applications is the calibrated models. In the community, calibration somehow adds truth to the model. It's not just an advanced curve fitting exercise. Lots of different combinations give the same measured results back, so there's a uniqueness problem with calibration, and it is a real problem that we face in our program.

DR. MOELLER: Will you say once again the difference in a direct problem and an inverse problem?

MR. RANDALL: Direct problem. If you want to

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find a dependent variable, say, pressure or concentration of temperature, given the boundary conditions, given the initial answer and given the space over which those things have been calculated and given all the properties, an inverse problem, you're given, say, it's the measure of a field, the values of the dependent variable, and you need to find the parameters. By parameters, I mean the boundary conditions, initial conditions and properties.

And that's quite difficult to do in a real world system. In an imaginary system, it's a lot easier.

MR. COSTANZI: The difficulty we have is what you measure in the field are the dependent variables of an equation that describe the physics of the situation. For example, the hydrology of a region. But you have to use that equation to predict what the future of the hydrology of that region is.

For different types of repository performance, the difficulty is going from the things that you measure in the field, which are dependent variables, to the initial conditions and the boundary conditions and the input to the equations, which you then calculate over time to try and extrapolate what the condition of the repository is going to be a thousand years, 5,000, 10,000 years hence. It is not a unique path.

The dependent variables that you measure today could arise from a whole set of boundary conditions. And if you change the boundary conditions to then do your calculation and extrapolation over time, you get again different answers.

So these various possible realizations, there's more than one way, more than one possible result for a set of values and initial conditions which are not measured that will give you, when you crank them through the equations again, that same set of dependent variables.

DR. STEINDLER: Aren't you just saying you don't

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understand the situation?

MR. COSTANZI: It's more than saying you don't understand the situation. You're saying that there are families of independent variables which will, depending on the model -- that is to say, the nature of the equation that you assume is describing the physics of the region -- will give you when you plug those back in and run the calculation, give you the measured values of the dependent variables.

DR. KERR: It's worse than not understanding. Rather, there are families of lack of understanding.

(Laughter.)

MR. COSTANZI: The model is not uniquely determined by what you measure in the field.

DR. KERR: Models are never determined by what you measure. Models come out of your head.

MR. COSTANZI: Exactly.

DR. KERR: So this problem is not unique.

MR. RANDALL: The parameter sets aren't uniquely determined.

MR. COSTANZI: But, you see, unlike a situation as Tom related to you earlier, where you build a car and you build an airplane and you can test it and change the variables, you can change the conditions and watch the system respond at will.

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You can't do that with a natural system; it's there. What you're talking about is the difference between a scientist and an engineer. Scientists are clever enough that they pick problems that they've understood and can be solved. You've got an engineering problem.

(Laughter.)

DR. STEINDLER: One other question.

On the previous slide, you talked about calibration and skirted what I thought was the issue that calibration was going to address.

So my question is: Where is it? Namely, there is a requirement to justify or qualify the model in some fashion. Is that in your list that you put up there on the previous slide?

MR. RANDALL: No. We put that under Validation.

DR. STEINDLER: Why is that not in fact an integral part of the modeling process?

MR. RANDALL: It is.

DR. STEINDLER: Well, then why wasn't it up there?

MR. RANDALL: I think that's a big enough issue that it ought to be on a separate slide.

DR. STEINDLER: You're just in time. I think you can go on.

DR. MOELLER: Frank, did you just want to say

something?

DR. PARKER: In cattle, you can measure any disease but you want to know what the effects are in humans. That's the inverse problem.

DR. MOELLER: Okay.

(Slide.)

MR. RANDALL: Part of our duties with the modeling problem in helping the Division of Waste Management are actually to take these models and get some values out of them. So we do worry a lot about solution procedures as to whether one wants to get the asymptotic or rose form solutions or numerical solutions, such as finite elements, spectral ladders.

We worry about that. We also do implement some solution procedures in computer programs. I don't want to leave you with the impression that we think that's the be all and the end all.

Computer programs I don't consider to be models. They're just implementation of the models and solution procedures. We shouldn't get hung up on whether the solution procedure is any better than a model or whether a model is any better.

The focus of the program is on the quality of the model. And when we get a model that we have a lot of faith in, then we'll worry about how to solve the problem and

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whether it's practical for licensing, or whether it should be put into a computer program.

DR. MARK: There was an extended experiment out in Nevada. There was an accumulation through some tens of meters at least that was measured. Could your models have predicted that?

MR. RANDALL: Probably not the ones that we have. The problem you're stating to me sounds like a three-phase.

DR. MARK: That's the kind of problem you're trying to talk about. Here's a lot of fission fragments with the water level known in a pool over here.

MR. RANDALL: We're working on problems like that. We're working on problems in unsaturated media.

DR. MARK: This is not a problem. This is a given test. If you don't fit it, I guess you go back and tinker with your model.

MR. RANDALL: It's possible to use such data in a test of the model.

DR. MARK: I don't have it as a reference at the moment.

MR. COSTANZI: That's very much an issue. Any set of measurements we can find.

DR. MARK: I think you would do well to look at these, with the question, of course: Are they or are they

not in good enough shape for you to make use of them?

Because, clearly, a failure to check that would be a strong warning that the model isn't doing what I really need it to do.

MR. COSTANZI: I guess so. Thank you.

DR. CARTER: Most of those even have a disturbed zone.

(Laughter.)

DR. CARTER: That's a factor of 10 meters and it was in TUF, which is a nonsaturated medium.

MR. RANDALL: You've touched on one of the hardest problems we're up against.

(Slide.)

DR. MARK: When they saw anything downstream, they had to pump like mad to get the water to move over there.

MR. RANDALL: I have talked a lot so far about mathematical models. I've talked about quantitative or qualitative models. But I don't want to leave the impression that we think only in terms of mathematical models. We're also looking at physical models.

I divide those into two areas. One is analogs, generally thinking of natural analogs; that is, there are some natural systems that, to some extent at least, are analagous to a high level waste repository.

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There's a major project in Australia using uranium ore bodies as analogs. They also have a project at Lawrence Berkeley Laboratory exploring the possibility of extrapolating or exploiting the possible analogy between high level waste repositories on the one hand and geothermal systems, hydrothermal systems on the other hand.

So we're trying to balance our perspective on the mathematical models with some real world observations of natural events that have occurred over a long period, with some idea of what we ought to be looking at in high level waste modeling.

The other type of physical model that we've looked at, and are looking at right now, is scale models. It's a project that we started up on the scale models of thermal hydrologic interactions.

I think, in that case, scale models are do-able, and give us some insight into whether mathematical models of the thermal hydrologic processes are going to work and give reliable results in high level waste applications.

I'm not too sure that controlling especially the chemical components of such scale models, we'll get much out of it, but quite a bit of the high level waste problem is the thermal hydrologic interactions.

But I still think it's very important to have a good scale model. That type of model, the physical model,

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is one of the things that we hope to depend on for validation.

(Slide.)

DR. KERR: Do you have a process in motion which attempts to decide how much you do need to know in order to do the modeling satisfactorily?

MR. RANDALL: I think that's one of the reasons why we like to look at physical models.

DR. KERR: Physical models can't tell you how much you're willing to accept in order to do the job.

MR. RANDALL: They can tell you what counts and what doesn't count. For example, in geochemical modeling there are two schools of thought. One is to do a very simple kind of model based on concentration ratios; that is, aqueous to solid concentration ratios.

The other concentrations are measured in the lab and then used as input models. But the other approach is to say, look, with anything measured in the lab, it probably isn't going to work too well in the field in that situation.

So you probably should be running a very detailed phenomenological model. There are all kinds of possibilities there, a lot of which may not be important.

DR. KERR: I am talking about a slightly different approach to the question. You said a thousand

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years. What sort of accuracies do you expect to get? Are you willing to accept an accuracy of plus or minus 200 years?

MR. RANDALL: You're asking me what reasonable assurance is.

DR. KERR: But, in order to have a research program, you have to have some idea of the accuracy you're trying to achieve. Otherwise, your investigations don't mean very much. You might be looking for a precision which is ridiculous and which is a waste unless you have some idea of what your objectives are.

MR. COSTANZI: I think it's fair to say that our research program has not evolved to the level where the question of precision --

DR. KERR: How can you even plan it if you haven't raised the question of significance?

MR. COSTANZI: What we're trying to do is to learn what is important. We're still at the stage of trying to understand.

DR. KERR: But things are going to be important if your accuracy is one year out of a thousand. Things are going to be important that may not be important if the accuracy is 200 years out of a thousand.

MR. RANDALL: We've done a little thought along these lines. Natural systems can give you anything from a

factor of 10. That's pretty good.

DR. KERR: During the process, there should be something that says: these are the kinds of accuracies we're looking for.

I'm not asking for details on it. But it seems to me you should be at least making a start towards that process.

MR. COSTANZI: I don't want to mislead you. I don't want you to think that we're smarter than we are. We really haven't set about to consciously apply a level of accuracy or a level of precision, number one.

Our program has been characterized more by taking opportunities to understand what phenomena are important and under what conditions. It's been pretty much of a relative judgment as you go sort of decision as to which paths the research ought to pursue.

DR. KERR: It seems to me it's almost as fundamental as deciding whether you're going to use a micrometer or a yardstick to make your measurement.

Until you make some decision about the accuracy you're trying to achieve --

MR. COSTANZI: But I think the difficulty, the problem we come up against, to take your analogy, is that we don't know whether there are micrometers or yardsticks to make the measurements that need to get measured.

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DR. KERR: But you know what is going to be acceptable to the NRC.

MR. COSTANZI: Reasonable assurance is not quantitative.

DR. KERR: But you have ultimately, eventually have got to decide what you're going to mean by "reasonable assurance". You can't make all the decisions today, but unless you begin the process of trying to make that decision, you'll never make it.

MR. COSTANZI: Reasonable assurance is and has been -- a reasonable assurance is a legal entity.

DR. KERR: But reasonable assurance, that sort of thing is determined by a jury. And every case is different. The jury finally decides what is meant by it. And the law works on the principle of compromise, it does not try to get the facts.

Now, if that's your approach, you don't care what the facts are. It's a question of what a particular board will decide in a set of circumstances. If that's what you're doing, you don't need scientific research.

MR. COSTANZI: I think we're perhaps confusing the role of NRC with DOE. The NRC is going to review DOE.

DR. KERR: NRC is going to have to make a decision. Unless some criteria for a decision-making process exists, the decision is going to be ad hoc every

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time.

MR. COSTANZI: There are criteria for making the decision, and that is that DOE has to demonstrate not only that --

DR. KERR: But what is it that DOE has to demonstrate? For example, the thousand years, do they have to demonstrate to a precision of one year out of 1,000? Or are you going to accept something like 200?

MR. COSTANZI: DOE needs to demonstrate what the uncertainty associated with that estimate of groundwater travel time is.

DR. KERR: But they won't know what the uncertainty is, and you won't either very accurately unless you define some way fairly early on of approaching this question. It seems to me, you're just going to be sort of groping both in your research program and in your regulatory program.

MR. COSTANZI: I think that, in terms of one of the things that the Division of Waste Management is trying to achieve with regard to guidance on groundwater travel time in taking positions like that, is to get DOE some guidance of what is accpeptable.

Ultimately, that is a judgment call, and it has to be.

DR. KERR: Of course it is. That's the reason I

think you ought to start out trying to make it because there'll be some iteration. But, unless you give some serious thought to this, it seems to me your planning is going to be based on sort of a vacuum.

MR. COSTANZI: We certainly have been giving serious thought to what the limits in terms of accuracy and precision of measurement techniques are for the various parameters, which we can measure and which will, we know, be important to performance.

And, basically, that is our point of departure, what can be done.

We're also very actively looking at performing research to try and determine is that good enough. That is to say, how badly off can you be by just going with techniques and models that go with these techniques that are currently in use today.

But we're still in an exploratory stage here and we're not at the point where we can say that this is where we want to be.

DR. STEINDLER: You're not suggesting that you're going to lay on DOE the requirement to do their measurements at the best, present state of the art whether they need it or not?

MR. COSTANZI: No.

DR. MOELLER: Let's go ahead.

MR. RANDALL: I think the research program, especially the modeling part of it, has gotten to a point where it needs to call its own bluff.

How good are the models we have and that exist in general that can be used in high level waste performance assessment?

How well do the existing mathematical models, ours or DOE's or someone else's, represent what really can happen in the repository situation?

That's what I mean by validation. Validation, in general, is taken by us to mean the addressing of the question how well does the model represent physical reality. And we do need to test a lot of the models that are out there. That's really quite a departure for our research department, as how far we would like it to go.

Along those lines, we're planning -- I'll get in a little plug here. We're planning a workshop later this month on this very issue. It's taking place at the Holiday Inn on Wisconsin Avenue in Bethesday, at 8120 Wisconsin Avenue. And it starts on January 27th, goes to the 29th, and I've got a few copies of the agenda up there on the table and a few copies of background information. You're all welcome to come to the workshop and hear all the speakers and all the discussions with respect to a lot of

things. There will be audience participation. It's not mostly a conference of presentations, it's mostly a workshop with a lot of give and take.

DR. CARTER: Is this going to be basically modelers?

MR. RANDALL: We're trying to balance it off between modelers and experimenters.

DR. MOELLER: How much more do you have?

MR. RANDALL: I wanted to run down very quickly through the state of the art, what we think the state of the art would involve.

(Slide.)

DR. PARKER: Is there a document that has all this detail?

MR. RANDALL: Yes, there is. There's a paper that Dr. Costanzi and I wrote. It's called Waste Management '85. In the area of the waste package, we've broken that down into two general categories.

(Slide.)

One is corrosion and the other is leaching or dissolution, the leaks of radionuclides from the waste form. DOE has taken a position quite often that uniform corrosion is the way that the waste package is going to fail.

Our research has shown that pitting corrosion is

quite likely. We've also discovered that current qualitative and quantitative models of pitting corrosion aren't very good, because they all concentrate on the base of the pit. They don't say much about how the pit opens up on the side.

So we're having quite a bit of work done at Battelle Columbus and the National Bureau of Standards, and at Brookhaven on the understanding of pitting corrosion, short-term pitting questions and the long-term results.

In the area of leaching and dissolution, the modeling there is in better shape but deficiencies still exist there as to how you handle high temperature things.

Also, there's still some controversy over whether leaching or dissolution helps you decide what mix of those mechanisms contributes to it.

DR. STEINDLER: You're saying the modeling for the release of nuclides is in better shape than corrosion?

I'm not sure you're saying a whole lot.

(Laughter.)

Are you referring to the release of the leaching from glass, or are you referring to leaching from fuel?

MR. RANDALL: Both.

DR. STEINDLER: The leaching from fuel information is zilch. That's in worse shape than pitting corrosion.

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MR. RANDALL: Maybe. I thought, from my discussions with Battelle --

DR. STEINDLER: There isn't any data that's worth anything.

MR. RANDALL: At least from what they think the mathematical parameters ought to be, they thought they had a better handle on that. I agree, the data situation isn't good, but I've been trying to visualize the process.

DR. STEINDLER: In the case of the waste package, are you making the assumption that you have to have a model for every phenomenon?

MR. RANDALL: I think we have to have a model for every phenomenon that is important to the regulation for the waste package.

DR. STEINDLER: That model was supposedly built up from some reasonably fundamental understanding of what goes on.

MR. RANDALL: Yes.

DR. STEINDLER: So it can't just be a phenomenological model.

MR. RANDALL: I can't just be an extrapolation of the data.

DR. STEINDLER: When do you intend to grant a license? In this century?

MR. RANDALL: That's not my decision. When you

say that, you remind me of the situation in Europe. The licensing dates aren't until around 2020. We want to do as much as we can before the license gets out.

DR. STEINDLER: Well, I've got to go back to Professor Kerr's comment. As much as [illegible] is different than as much as you have to. And unless and until you know what you have to, you're going to continue to drive a very fascinating science, but it isn't clear.

MR. RANDALL: I think as much as I can is controlled a lot by as much as I have to. It's also controlled by the schedule.

MR. COSTANZI: I think we ought to emphasize again the research program, the model which we might have for corrosion, for example, or dissolution may be a qualitative model. That may be all we can get by licensing.

At that time, the licensing review will be to check if the physics in the qualitative model is consistent with the physics in the model which DOE uses to calculate corrosion rates or dissolution rates.

And that may be the extent of our review.

DR. CARBON: Do you take all these models and put the models together into the system and model all the way through from corrosion and leaking of the package to leaching into the environment?

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And then do you look at the individual parts and say this is crucial here and we really need to know this well, and this over here, forget it?

MR. COSTANZI: We'd love to do that. Right now, I think that's beyond our ken. What we are trying to in lieu of that is look at the coupling of various processes in natural systems, geothermal systems, to see how heat/water chemistry and the properties of rock affect one another and how those would affect repositories, to look at the connections, the interfaces, if you will, between the various discrete models, which we will have a better idea of from any system model itself.

Modeling the repository, the whole system beginning to end, is probably something we're not going to be able to do. At this point, I have very little confidence that we can do that in any detail.

DR. PARKER: Have you looked at the Canadian system, the SIVAC?

MR. RANDALL: Not very closely. I frankly don't understand what they're trying to do. A white box is always going to be a white box.

DR. CARBON: I have difficulty though in seeing where you're going to put your emphasis unless you take some stab at trying to see where your major problems are.

MR. COSTANZI: This is why what we are doing is

just that. In terms of the modeling of the repository, we have kind of broken it up in three areas. One is the area which is affected by heat from the wastes themselves.

The other area is the area not affected by heat. And then the engineering is the waste package or the backpack, or whatever, realizing that the waste package essentially provides the source terms to the disturbed area, which provides the source term to the calculations in the far field.

We've tried to approach the modeling of repositories in that way, where there are still large uncertainties and questions arising, the interfaces, when you deliver this source term from one element in space and time to thermally disturbed areas. We're trying to approach that phenomenologically. We're essentially looking at geothermal systems where you do have heat and water flowing and chemical changes in the rock to see how those are affected, and how those boundaries occur in nature.

We hope to get some idea of are we missing anything when we take our waste package model to produce the source term which is used in the model for calculating radionuclide migration into thermally disturbed areas.

The result of that which is the source term for calculating transport from thermally undisturbed areas is excessive.

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DR. CARBON: Can I rephrase that and ask you if I'm correct? You're trying to get some of the basic information that you think you need to lay out a rough sketch of the model?

DR. MOELLER: Let's move along.

MR. RANDALL: Moving away from the waste package, I tried to move out to the source and I expect the major carrier of radionuclides is groundwater. And then it is sorted by geologic materials along the way.

We've spent a lot of time trying to understand the flow of groundwater through fractured systems. In connection with an earlier slide, the candidate repository, salt is highly permeable or in saturated or unsaturated fractured rocks.

We spent a lot of time and money trying to understand how the water and contaminants move through saturated and unsaturated fractured rocks. We have a program at the University of Arizona on saturated rocks which provided us with some results which suggest that it may be possible in a lot of situations to treat groundwater flow in saturated fractured rocks as a flow in an equivalent anisotropic porous medium.

By "anisotropic", I mean that the hydrolic conductivity is not just a constant value but it's a second or tensor; because of the fracture, it's possible to push

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water in one direction and have it slide off at an angle and get these defractions set up.

We had work done on that project both to show that the equivalent porous media approximation works, at least under some circumstances, and also how its properties would feel for that kind of model.

Another model that Sandia National Labs has implemented and has been tested as well experimentally is the dual porocity model. The dual porocity model is a nice conceptual model but nobody really knows how to get reliable data.

There were quite a few computer programs, but it's usually expressed in terms of a set of blocks. And in each block is a porous material which fractures bypass the block. That's why it's given the name dual porocity, because of the flow and the media interacting with each other. But no natural system looks like that.

That's the difficulty. We're having a new contract with a company called In Situ Incorporated to set up some test models like dual porocity to take a longer look at the equipment.

DR. MOELLER: We have a question.

DR. CARBON: On the specific point of the dual porocity model, do you look at this to see what's known and to determine whether you really need a model or whether

it's something of importance? Or whether you can take the outer limits and say, gee, this doesn't make any difference. We don't need to pay any attention to it?

MR. COSTANZI: Again, DOE is under the gun to demonstrate conformance with the repository. In order to do that, they're going to have to describe the hydrology of the system; they will have a model to do that. But what we need to be able to do is to be in a position to say, yes, that model is appropriate to the site and we conclude that because not only have they they characterized the site properly -- that is to say, being measured on all the right parameters, but they measured all the right parameters in the right way.

In order to do that, we have to understand what the physics of the situation is. That's really where the model comes in. So we have to know when is it appropriate to use the dual porocity model? When does it make sense and when doesn't it make sense? Or, when can we use the equivalent porous media model?

DR. CARBON: I'd certainly agree with you, in part, at least, but it would also seem that, in some of these cases, you could say, well, gee, I know there are limits that affect the dual porocity model. And even if I take the most extreme case, it isn't going to have any bearing on my overall answer.

MR. COSTANZI: I think, as part of what we are doing here, we will determine that. If we do reach a point where it looks like it's not going to make any difference, then we'll stop.

For example --

DR. CARBON: So then, in dual porocity case, you don't know enough to set those limits? Okay.

MR. RANDALL: We could accept the equivalent porous media model. That would close the issue in dual porocity. Also, next item on the list, discrete fracture. If we know what the fracture system actually looks like, we can go through the fractures.

Then, what may have to be done for large fractures and for small fractures is to put them together into one model and average them out. An area where we know this phenomenon occurs but we just don't know how to do a quantitative model for it is the alteration of flowpads due to thermochemical effects, like silica redistribution.

High level wastes generate an awful lot of heat. There are a lot of data and observations, but the mathematical models just aren't there. DOE will have to design around it.

If that had to be done today, that's the only way I see. It's not a very well-developed field, getting the right equations down and being able to solve them for

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licensing purposes.

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DR. STEINDLER: If you were to do calculations based on the first three you have up there, what sort of spread in results would you obtain if you attacked the same system?

What I am getting at --

MR. RANDALL: One big fracture would be the only way to go. You have had a lot of little fractures in the large picture. If you have dual porosity or some other kind of multiple interacting type model -- dual porosity is a typical example of that class -- that is not an area that outside of dual porosity is very well-known.

Everything I have said so far in connection with these models really relates to saturated media. Unsaturated media, there are mathematical models out there. There are quantitative models out there are qualitative models out there. There is a lot of disagreement over which ones are right, especially the qualitative models.

This is along the lines of saying, well, what water there is in the system moves in small fractures or, no, it doesn't, it is large fractures, or by surface tension and the transport is across the fractures between matrices. That is porous rocks on either side of the fracture.

Maybe both schools of thought might under certain circumstances -- there might be some way of deciding that. That hasn't proved out yet.

This is one of many topics that we are working on at the University of Arizona, and there is a whole session devoted to that topic, and everybody has his own ideas about which mechanism dominated, and nobody can talk to anybody else about their own point of view.

So there is no field data out there.

DR. PARKER: Within the NRC do you have the same views on these topics like you have just heard?

MR. RANDALL: NRC is trying to figure out which way to go. We are right at the stage now with our project with Sandia, which has the responsibility for pulling these models together. We are trying to decide which way do we go, adopt this school of thought that the water moves along the fractures or along the cross-fractures between matrices, and it really needs some kind of definitive test to answer the questions.

MR. COSTANZI: That is one of the research projects that we have now underway looking at that particular question. That is its aim. I hope it will be successful in getting the answer.

MR. RANDALL: The next slide pertains to transport of radionuclides.

(Slide.)

The major transport mechanism is flow, but along with that is dispersion, and these are, I think, the

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dominant transport mechanisms -- dispersion, geochemical effects, and possibly matrix diffusion.

That is something the Swedes are depending on a lot. It is also hard to measure in the field with the kind of diffusion coefficients that are believable.

In the area of dispersion, it is generally accepted that dispersion is an adequate description, far away from the source of contamination in the porous medium. The equivalent porous medium approximation holds up for fractures. It is probably okay with fractures as well. If the equivalent porous medium breaks down, it may not be a good model at all.

Nearer the waste, near any source of contamination, regardless of whether the medium is porous or not, the regular model isn't very good. It is very irregular, which suggests that the Vickian model just doesn't work.

I don't know how important that is with respect to repository performance.

Also, a fact that is left out of a lot of models is the fact that the dispersion coefficient tends to grow a distance from the contaminant source. We have looked into that problem at the University of Arizona, and the model predicts how dispersion coefficients grow based on statistical analyses of flow parameters.

We are also going to have In Situ, Incorporated in a new hydrology contract look at that question and look at other models as well.

Geochemistry. I alluded to that problem somewhat earlier. It is the distribution coefficient approach, the decay heat approach, to measure the concentration ratio in the laboratory, and I will plug it into my transport equation in the field, and I will believe the results.

That is essentially how it works, and a lot of people think it works pretty well. The numbers don't mean anything, but the alternative is detailed phenomenological code based on thermodynamics, modeling each of the individual absorption mechanisms such as ion exchange.

That at this stage is a very unwieldy type of model, and the data base isn't very complete. It is a very hard data base to put together, so it is a good idea in principle, but it has a lot of practical limitations.

We aren't doing too much about it right now. We are depending on other organizations, such as NEA, to provide us with information and with resources to attack the problem.

Matrix diffusion. We are still trying to figure out whether that really is a point that should be part of the model. We are having In Situ, Incorporated do some field tests to see if matrix diffusion can be measured in

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the field and divide it separately from other phenomena and see if it is possible to really stack up against the other transport mechanisms.

DR. MARK: Did you mention a new hydrology contractor?

You have had the University of Arizona for quite a few years. Did you find a lower bidder?

MR. RANDALL: We found a lower bidder. The Arizona contract ran out.

MR. COSTANZI: I might mention that that is a real problem, although in the ideal situation where we don't have the licensee -- in this case DOE -- competing for the same resource because they themselves were limited to begin with, contracting research by the competitive process is fine. It guarantees the taxpayers get the most for their money.

DR. MARK: No. It guarantees that he spends less money. It doesn't guarantee that he gets better results.

MR. COSTANZI: We will presume that we are only selecting competent contractors to begin with, but that is a real difficulty in expertise, once dropped, because somebody other than the University of Arizona is going to do it. That expertise will be picked up by DOE, and because of the conflict of interest considerations it is essentially lost to the NRC for all time.

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The NRC has a great deal of difficulty going back again to contractors who have worked on DOE high level waste projects because then they are in the position of developing the technical base, which the NRC will review and used to review for the submission which they originally worked with.

So we have a problem. We are trying to find ways around that problem.

DR. MOELLER: I think because of the time -- we have used up the hour -- I would ask that you read the conclusions and let's see if there are any additional questions.

MR. RANDALL: My conclusion is that we still have a ways to go. The research program has been overtaken by events, and sooner or later we are going to have to put out the best technical basis that we have to help the Division of Waste Management make as informed a decision as possible with the best possible models we can come up with.

DR. MOELLER: Okay. I think it is time we took a break.

DR. MARK: Can I ask one final question?

Very early in this discussion, Mr. Costanzi mentioned they were limited in funds and cut the work on basalt in order to bring up the work on salt.

MR. COSTANZI: Unfortunately, we had planned to

continue to complete the work on basalt at the same time we were bringing up the work on tuff and salt. I am afraid our preliminary -- we have prematurely stopped the basalt work.

DR. MARK: That was exactly -- I thought at one time you had asked for several number of millions in 1987 and were going to carry on basalt and bring the others up. You are now afraid you may have to take a cut in that and apply it mostly to basalt, but you are so far behind with the other media --

MR. COSTANZI: 70 percent.

DR. MARK: How much is it going to take to finish the work on basalt, or do you think it is at a stage where it can now safely be turned off?

MR. COSTANZI: I think to reach the point where we will not have clear questions on where to proceed next until DOE comes along and site characterization is well underway, that will be the next point when we review our programs, would be --

DR. MARK: On basalt. And at that time you would have acquired what you can on what you need or enough to go on?

MR. COSTANZI: Looking from today, yes.

DR. MARK: You have answered the question. This arises, of course, among some of the same people looking at the question of forecasts.

DR. MOELLER: Max?

DR. CARBON: Along that line, you don't have unlimited money. How do you prioritize? How do you decide what is most important?

I know you went from basalt to salt, but in terms of all the uncertainties.

MR. COSTANZI: Our research program is, quite honestly, taking a gamble. The gamble is that in the basalt we will have enough information that we will have pretty good coverage generally of all the questions and that we might be able to just pick up anything on a spot basis.

The tuff site is more likely to pay off in terms of our research dollars than studying basalt, and hence over the next -- beginning essentially in '87, the bulk of our research will be on tuff, with salt almost at the same level, about 60 percent of our tuff funding.

DR. CARBON: I see how you can decide that. Within tuff, how then would you decide where to put your money?

MR. COSTANZI: We realize now that it seems the most difficult problem we have in tuff is the behavior of groundwater and contaminant radionuclide transport in the unsaturated zone, a two-phased flow. The measurement techniques are going to be important to make transport predictions, and we know how to implement them correctly

and what models can mathematically describe this.

These are the areas of greatest concern. That has been the focus now.

The waste package, we are taking a lot from the basalt.

DR. CARBON: Excuse me. That is your greatest concern. What I am trying to understand is how you decide that.

Is that your judgment, collective judgment?

MR. COSTANZI: It is the judgment of the staff, the judgment of Research in this area. That is what we know.

There is a lot of controversy. For example, in the workshop we just had last week, we sort of dealt with those questions, and a good measure of that is how much agreement or disagreement there is. There were stimulating discussions in these workshops. It is a pretty good measure, as well, of course, as talking with people like yourselves.

DR. CARBON: What I was trying to get a feel for is discussion, judgment, or have you some particular technique or process by where you compare things and say, obviously, this one stands out?

MR. COSTANZI: It is, I guess, an unstructured process. We are in the process of continual discussion

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amongst the people who are working in the area, both within the Division of Waste Management and the people on the outside. They are continually asking questions of what is important and how do you know this is important.

This workshop we are having at the end of this month is just to identify what are the underlying assumptions on all these models and descriptions and qualitative events and what are going on the repositories.

How do people know if those assumptions are correct, and what tests have been done? What experiments have been done or have not been done, and what should be done to test those assumptions, to make sure we do know what we are talking about?

DR. CARBON: Let me also ask if these assumptions -- if it makes any difference what these assumptions are.

MR. COSTANZI: Absolutely.

DR. MOELLER: Let's take a break.

While we are in the break, I will ask, Nick, if you couldn't talk to the subsequent speakers and see if we perhaps can finish in an hour and 15 minutes or so.

Thank you.

(Recess.)

DR. MOELLER: The meeting will resume. We are altering our schedules or agenda's aspect. We will cover the Low Level Program and the Alternatives to Shallow Land Burial and the Natural Analogs. We are going to postone until a subsequent meeting the discussion of the International High Level Waste and Low Level Waste Programs, and the Cooperative Agreements.

I think that way we can finish at a reasonable time.

Okay, Dick.

MR. COSTANZI: I just wanted to start off talking about the alternatives, giving a bit of background of why there are lots of researchers looking at alternatives to conventional shallow land burial.

The political reality of the world right now is that the States and the State Compacts are essentially being driven to some sort of engineered enhancement of alternatives to shallow land burial. Despite the fact that shallow land burial of low level waste hasn't done anyone any harm, the fact that we're learning things about how the low level waste sites have performed differently from what we expect them to perform in the first place has cast a pall on the whole conventional way of disposing of these wastes.

I think perhaps some shoddy treatment of chemical wastes in the environment has just added to this, and the

public isn't really making the distinction between the two.

As a result, the States are going to be forced by political considerations to go with some sort of engineering to enhance, or as an alternative to shallow, conventional shallow land burial.

The difficulty is that there is really no clear articulation why or what the engineering is supposed to do with many of these alternatives. It's just there to provide some sort of confidence.

People apparently feel very good about concrete for some reason, but what it's really going to do from a regulatory or safety standpoint has not been clearly articulated. As a result of the understanding of this situation, representatives from a number of States -- Illinois, Pennsylvania, New York and Texas, for example the Southern States Energy Board, the DOE, EPA and the NRC-- have kind of formed an ad hoc coordinating committee for low level waste technology.

The idea is to try to disseminate information as to what are alternatives? What are reasonable alternatives or engineered enhancements to shallow land burial? What they can do? What the state of the art is? What the state of the engineering is? Whose doing what? And, hopefully, provide some sort of a rational way of proceeding and helping ultimately the states make their decisions as to

what kind of an alternative low level waste facility, what kind of engineering enhancements they want to go with.

(Slide.)

I might mention also that EPRI is involved in that program as well. In fact, they are doing a research project that Tim McCarkin, when he talks about our low level waste alternative program that we have going with INEL, will mention briefly.

DR. MOELLER: In other words, EPRI on their own are exploring alternatives?

MR. COSTANZI: They're exploring the economics and engineering feasibility of alternatives.

DR. MOELLER: Did you tell us roughly how much money we're talking about?

MR. COSTANZI: I don't know offhand. Vern Rogers of Rogers and Associates is doing it. They have come up with a scheme for classifying these various alternatives in terms of the functions of the various engineered components. We have used that classification scheme as a point of departure.

We estimate that, by using that and not having our own contractor come up with a classification scheme looking at alternatives as a first step, we probably could save on the order of $15,000-20,000. So at least it's that much. I suspect the contract is on the order of

100 to 150.

DR. CARBON: So the coordinating committee on your proceeding slide will utilize the EPRI work?

MR. COSTANZI: As well as our work, as well as work from DOE, from EPA, yes.

MR. EBERSOLE: Does engineering alternatives include volumetric reduction by any method whatsoever?

MR. COSTANZI: Not specifically. The volume reduction techniques are something which has been investigated again by EPRI as well as by NRC. That is a given. That's one of the necessary assumptions that you make looking at the performance of any low level waste disposal. You assume the wastes have or have not been volume-reduced.

MR. EBERSOLE: Even burned.

MR. COSTANZI: Also.

What our current program is looking at, the first program, Safety Assessment of Alternatives, that's what Tim McCarkin will talk about. That's ongoing right now.

At the end of this fiscal year, in FY-87, we're going to begin two other programs, developing siting criteria for alternatives. The alternatives that we're going to be looking at in the safety assessment and in the development of design criteria, the safety assessment is trying to focus on what are the safety implications of these

engineered features? What are they really doing for you? What happens when they don't do it for you?

The siting and design criteria are to make sure that the sites are compatible with designs and vice-versa, that you don't put the engineered low level waste disposal facility in a place in which you can't handle it and it won't work.

And what are the design criteria for those features to have some confidence that they will go for you what they are expected to do.

DR. MOELLER: I know this isn't in your realm, but when staff wrote 10 CFR 61, they hoped that it was universally worded so that any alternative would have been covered. It's obvious here though, from what you're doing, that there will be new information which may lead to a rewrite of 10 CFR 61.

MR. COSTANZI: In terms of the performance objectives of 10 CFR 61, those are universally applicable. The Division of Waste Management has a study going on with the Corps of Engineers to examine whether or not individual criteria for alternatives in terms of design might be appropriate.

That report has recently been published.

DR. MOELLER: What did it say, generally?

MR. COSTANZI: I'm afraid to speak on that. I

don't want to give you inaccurate information. But I believe there were some areas where they thought that information could be given in any case.

The recent amendments to the Low Level Waste Policy Act, which you asked me to comment on, provide that the NRC has to, within two years, issue some guidance on alternatives.

So this is a timely -- perhaps it's even a bit late, but we are starting this now.

DR. MOELLER: To interrupt again on that, I think the subcommittee should know that, although the ACRS has said, you know, heavy on high level waste, we could well be spending more time on low level waste over the next couple of years than on high level waste, because things are really happening.

MR. COSTANZI: I'd like Tim McCarkin to talk about the safety assessment alternatives program we have going at INEL.

DR. CARTER: Let me ask a question while we're waiting. Did I understand the organization you've got on your coordinating committee was a state orientation?

This is SSED?

MR. COSTANZI: SSED. We've been acting as the chairman and coordinator of the committee. We're principally chairing the group, keeping the minutes, setting

up meetings. It's completely informal. It's kind of a self-elected membership, but the information is disseminated very widely.

DR. MOELLER: How frequently do they meet?

MR. COSTANZI: Quarterly.

DR. MOELLER: For a day?

MR. COSTANZI: A day, generally. It was formed last May.

MR. MCCARKIN: Okay, the work currently funded in the safety assessment of alternatives has two main objectives. The first objective is to identify the engineering features important to the safety of a particular alternative. And try and get a handle on the ranking of these features.

The second objective is to actually quantify the consequences of these identified important features for each of the alternatives.

(Slide.)

The contractor we chose to do that is the Idaho National and Engineering Laboratory. We've got a two-year project. The first year, which we're currently in, is comprised of three tasks. The first task is a literature review to gather as much design information and operational experience on the five alternatives we're considering.

The five alternatives we are considering are:

Above-ground fault; below ground fault and earth-mounted concrete bunker; a mine cavity and augered holes.

DR. MOELLER: An augered hole? What specifically... is the waste in a concrete vault or something in that?

MR. MCCARKIN: No, it would be...well --

DR. MOELLER: It's a deep hole?

MR. MCCARKIN: It's less than 30 feet.

DR. STEINDLER: Less than 30 feet or meters?

MR. MCCARKIN: Feet.

For each alternative, you obviously can add a little more engineering. So, for a particular alternative, there will be a baseline alternative and then, depending on how the safety assessment goes, you may say, okay, we would like to add a concrete liner, or maybe a tile base or something to that feature which will bring its performance up X-relative figures of merit.

DR. MOELLER: A mine cavity. How deep are we talking about there?

MR. MCCARKIN: That there is no real depth that's envisioned as appropriate. Now, in terms of the literature review, if they find out certain things, okay, if the cavity is, say, in the saturated zone, you have these types of failures. Say, if you bored into the side of a mountain,

which could conceivably be looked on as a mine cavity.

MR. COSTANZI: I think, two examples of mine cavities for the disposal of low level waste, one is in Sweden. I'm not sure of the exact location but it's essentially underneath the North Sea. The access to it is on land, or the Baltic rather.

The other one has not yet been decided but it's in Switzerland.

DR. PARKER: Germany, too.

MR. COSTANZI: We're not looking in terms of mine cavities. We're not looking at anything which is medium specific.

MR. EBERSOLE: The cavity and the augered holes, I presume, don't have liners. Is that right?

MR. MCCARKIN: Yes, that's correct. However, the one thing that I'll get to a little later, that's the baseline definition of that particular alternative. For a mine cavity, I assume a liner probably would not be included. But for an augered hole, they may say, yes, we'll do the assessment with the baseline things.

However, if we add a liner, would we increase the safety on that particular alternative X-amount.

MR. EBERSOLE: So would those two types of alternatives critically depend upon the nature of a medium into which they're bored? You're not going to do it in a

swamp?

MR. MCCARKIN: Yes, that's correct.

MR. COSTANZI: There are some baseline criteria.

MR. MCCARKIN: We are assuming the site suitability requirements of pipe 61 are adherred to.

DR. ORTH: What constitutes the difference between an augered hole and a central ditch other than one is square and one is round? I don't understand.

MR. KATHREN: You use a backhoe for the trench.

(Laughter.)

DR. MOELLER: I'm with Martin. If you were talking about a 30-meter augered hole, then it means something. But if it's just a shallow hole, there's no difference.

DR. STEINDLER: A DOE study on a very similar thing stated, I believe, 30 meters for the augered hole.

MR. EBERSOLE: Isn't this a definition of the presumed mobility through the cavity wall? Isn't there a degree of that whatever you do?

MR. COSTANZI: Sure.

MR. EBERSOLE: So I should think a consideration should be to define that.

MR. COSTANZI: That's indeed what they're talking about.

DR. FOSTER: Do your mine cavities include

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existing mines that have been abandoned?

MR. COSTANZI: I don't think they're looking at any specific mine as such.

MR. MCCARKIN: We're interested in looking at why does it work? Why does someone want to choose an above-grade engineered vault? What features there make it a viable alternative? Of those features, which ones are the most important? Which ones do I not want to fail?

It's that type of thinking. And can I add the additional engineering feature to what alternative that would make it a lot safer?

MR. EBERSOLE: In any case, if you do everything, can it be moni'.ored so that you can fix it if it doesn't work, unlike the high level waste business?

MR. COSTANZI: The question of monitoring is not going to be addressed by this particular contract. Monitoring for performance during the operational period and monitoring during the operational period to collect data so that you can eventually close the thing, I suspect, is the subject of a program which we're developing now, which we will start funding late this fiscal year or in FY-87.

DR. CARPON: Presumably, deep ocean disposal is ruled out. Is that because of political or engineering considerations?

MR. COSTANZI: It's primarily political. In any

case, NRC does not have the authorization. It's DOE.

DR. MOELLER: Maybe you should push for it. Go ahead.

MR. MCCARKIN: The second task is identifying the design features that cause a particular alternative to be different than shallow land burial. And then identifying the enhancement or detriment that that particular design feature offers to the overall system.

Thirdly, we then go to a ranking of the design features in terms of their contribution to the system performance. That's the first year's funding.

The second year, we will then go and actually quantify the risks and benefits of the proposal. This ranking here will be done on a more qualitative and possibly some simple calculations. It won't be a real quantitative study.

DR. CARTER: Let me ask you a question about the number there. It seems to me, several years ago, when EPA was looking at alternatives in the process of developing the criteria for low level waste disposal, didn't they have seven or eight possible alternatives?

I just wondered how this list compares with theirs.

MR. COSTANZI: This is included in their list.

DR. CARTER: Weren't there some additional ones?

I guess the question was: why are you excluding them?

MR. COSTANZI: We haven't, really. These really turn out to be kind of a baseline set. The other ones are variations. Essentially, all those alternatives that people are seriously considering in the literature can be broken down into one of these five in terms of the schematic engineering concept.

DR. CARTER: Particularly when you have variations on each of them.

MR. EBERSOLE: What's the difference between a vault and a bunker?

MR. MCCARKIN: For the most part, the concrete bunker was put in that as part of the trench design for low level waste disposal as one of the larger low level waste disposal sites and one that has at least now operational experience, to some of the alternatives.

But, you're right, you can make some of these by adding the appropriate engineering design. You can make look exactly the same.

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DR. CARTER: Jesse, there's a simplistic answer to that question:

Bunkers keep things out; vaults keep things in.

MR. EBERSOLE: I've heard that a bunker was to keep people out and a vault was to keep things in.

But anyway, it's all concrete.

MR. MC CARTIN: Yes.

DR. ORTH: Among the various states that have come in and talked about things like that, have they expressed themselves, any preferences, or made any selections already?

MR. MC CARTIN: Not that I'm aware of.

DR. MOELLER: I guess you could say, though, the states are certainly trending away from shallow land burial. They don't like that. And they're hoping to find something else that they like better.

DR. ORTH: I was just wondering from the standpoint, if there were a couple of these things that nobody is interested in anyway --

MR. MC CARTIN: They were selected initially with the idea that all of these were reasonable alternatives and/or were being used.

MR. EBERSOLE: Isn't water the agent of mobility in every case? Wouldn't there be some sense in saying they need to consider wet versus dry storage?

MR. MC CARTIN: That certainly is a factor for an aboveground vault.

MR. EBERSOLE: Does it have roof on it?

MR. MC CARTIN: Yes.

MR. EBERSOLE: What about the others?

DR. MOELLER: Dick, you had a question too.

MR. MC CARTIN: If we can go to one more slide, and if you --

DR. MOELLER: Right. Let's see what Dick Foster has and then move on.

DR. FOSTER: Since this is a research study of alternatives, do you specify a particular waste package that says the curie content is going to be such-and-such at such-and-such a concentration, and the next matrix is going to be so-and-so, and it's got to last for so many years?

MR. MC CARTIN: We go with the waste form characteristics in 161.

MR. COSTANZI: 161 requires it in terms of both stability and the form of the waste and also the content. There are also a number of technical positions which Waste Management has reached on stability. We are presuming that those are being followed, in terms of the wastes themselves, the classification.

DR. FOSTER: It would be no worse than that. You're not making any sample package here. That's somewhat

different from that.

MR. COSTANZI: No. We're talking about waste.

DR. STEINDLER: We're not considering anything beyond Class C?

MR. COSTANZI: Not in this particular study. That is not to say that we aren't aware of the problem. The Department of Energy has a rather extensive program, looking at what they call greater confinement, dealing with their own above Class C wastes.

The question of alternatives for Class A, B and C wastes right now is on hold, because you can't do everything at once. We will, as need rises, turn our attention to above Class C, but so far, that's been handled on an ad hoc basis, and in fact, is being handled on an ad hoc basis.

DR. STEINDLER: My other question, if I may, ultimately this is to be a procedure that would involve the commercial sector, I assume, which is driven to a very large extent by economics.

At what point do you intend to factor in the role of economics in determining if the things you've studied are, in fact, sensible for acceptance by some customer?

MR. COSTANZI: That's where this coordinating committee is coming in very handily. Actually, on both these questions on above Class 3, we're getting information on DOE's research from that.

Also, the second part of the Rogers & Associates engineering study, funded by EPRI, is going to look at the economics of the various alternatives.

DR. STEINDLER: And those alternatives include the ones you're looking at here?

MR. COSTANZI: Absolutely. We're using the same logic, the same classification sequence.

DR. STEINDLER: And those alternatives include the ones you're looking at here?

MR. COSTANZI: Absolutely. We're using the same logic, the same classification sequence.

DR. MOELLER: We also need to know the comparison of the costs here to shallow land burial, not if it's acceptable, but just to know whether this is triple or how much more.

(Slide.)

MR. COSTANZI: Rogers & Associates identified four elements of any of these alternatives that are common to all in one form or another and what the functions are of each of those elements. From that, you can construct essentially all these alternatives people are talking about. We're going to be using that to do your economic assessment. We're going to be using this as a basis for our safety assessment.

The two programs, hopefully, are trying to mesh,

even to the point where we're trying to come out with kindred reports at about the same time.

So when you read the report from EPRI and the report from NRC Research, you can balance the picture of what's going on and what the safety and what the engineering and what the economic aspects are.

DR. STEINDLER: The final study of DOE is in its draft form, and it should be issued within the next six months, if you believe that kind of schedule. Have you had a chance to have a look to see what they're doing and how it relates to the kind of thing you're doing?

MR. COSTANZI: We have not seen the draft of the study; however, Mike Baranca from DOE in Idaho is essentially responsible for that program, and he has related to us through the coordinating committee what's going on, what sorts of things they are dealing with and what will be in the report, and I believe the next meeting of this coordinating committee is going to be in April out in Idaho. And at that point, I think that's on the agenda, and we'll find out what the results are.

MR. MC CARTIN: The only thing I'd like to add to this slot is that in terms of the structure, if you add a modifier to that, above grade, below grade, you can essentially, as Nick suggested, construct any alternative you want.

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DR. MOELLER: In each of these now the fill is what you, in essence, put around the package and the container, I understand, and the structure. What is the structure?

MR. MC CARTIN: The structure would be the walls and, say, the below-ground vault. And you can see, in terms of an alternative, you can have the structure and fill, both adding, assuring stability, to a particular alternative, and thereby, the structural component for an alternative, in terms of stability isn't as critical, because it has a backup in the fill. Those are the type of things we're trying to pull out of this study for a alternative, one of the important components.

MR. COSTANZI: I might mention that conventional shallow land burial is also covered under this scheme.

DR. MARK: Shallow land burial can be made safe enough and the cost impact numbers, which I hope you never have to develop, will all be negative. This engineering will cost more.

MR. COSTANZI: We have repeatedly in discussions with this coordinating committee emphasized that any way you want to dispose of low level waste -- shallow land burial or one of these alternatives -- you can make it as safe as you want, depending on how much you want to spend. So what we're trying to do here is identify what are the features

which you're relying on, what are the consequences of failure of these features?

We're not trying to say that you ought to spend money to make it a bit safer, but rather, if in the case of a vault, which is something that we'll take just frequently as a structure, where all the structural support is within the walls and within the floor, no inside fill, the consequences of a failure of that structure are greater than the consequences of the failure of a vault filled with concrete, because you might have differential subsidence and cracking that might rip open the waste package and have a different consequence.

The point is, all we're trying to look at is, what are you relying on in this alternative to make it safem and how reliable is it, and how much money do you have to spend to make it reliable?

Then the states can choose what they want to do. They can select whether they're a compact or an agreement state, whether they're to be licenses. The compact states will license ours. An agreement state will license somebody else, or NRC will license it. The choice will be made by them. Tell them what they're getting for the money. And what are you buying in terms of safety.

DR. STEINDLER: In the absence of a clear statement for the technical purpose, how do you determine

whether or not you're looking in the right direction, if you don't know what the problem is you're trying to solve?

The assessment might be interesting, but it might not be.

MR. COSTANZI: What we're trying to do is say that, given these alternatives, what are they doing? How are they going to work? Work means contain the radionuclides. Are you really getting what you think you're getting?

For example, relying on the concrete for containment is probably erroneous. Concrete is very porous. It also cracks and shrinks, which is not good for containment. You need a liner.

It's that sort of thing we're trying to bring out.

DR. MARK: Be careful you don't blow a hole in all our reactor containments with that statement.

(Laughter.)

MR. COSTANZI: I was thinking concrete, more like their subway tunnels. For example, the subway tunnels, the escalator at Dupont Circle down to the surface, you can see cracks all through that. We have to do something more than that, in order to use it as a structural containment.

MR. MC CARTIN: Having identified the alternatives and the components, we need a way to assess

the system performance.

(Slide.)

The way INEL decided to get at the system performance was to look at the performance objectives in Part 61 for their protection of the general population, the stability of the disposal site after closure, protection of individuals from inadvertent intrusion and protection of individuals during operations.

And as I mentioned a little bit before, the additional assumptions were site suitability requirements of Part 61 were met and the waste form characteristics are in compliance with Part 61 That was to focus the study on the engineering components.

MR. COSTANZI: I'd like to interject a point here. The last point, Item 4, protection of individuals during operations. One of the things that the states have been talking about is having some sort of retrievability option for the low-level waste. A number of these alternatives alone will require increased handling of waste. A retrievability option will probably magnify that many times over. Consequently, there may be some serious implications for occupational exposures in dealing with the disposal of low level waste in some alternative other than shallow land burial.

In the recent amendments to the Low Level Waste

Policy Act require the NRC to provide guidance and alternatives within two years. We have estimated that we're going to require some increased funding in the next two years.

The Office of Research is looking at that very question of occupational exposure in the form of alternatives to shallow land burial.

DR. CARTER: What's the reason for the interest in retrievability?

MR. COSTANZI: People are scared.

DR. CARTER: What's generated that?

MR. COSTANZI: I suspect people don't -- it seems to be a feeling on the part of the members of the state legislatures that they want to be able to go back in and correct mistakes if something goes wrong. They don't want the waste going out of their control. They don't want any Love Canals, especially with radioactive wastes.

It's an honest worry, perhaps not technically active, but certainly honest.

DR. MARK: Site suitability. Sites were thought of for shallow land burial in Part 61.

Is then a performance term rather than geological?

MR. COSTANZI: Yes.

(Slide.)

MR. MC CARTIN: With these performance objectives in mind, INEL identified five consequences of component failure:

direct radiation exposure;

release to the atmosphere;

release to the surface or groundwater;

repair or maintenance required; and

exposure of an intruder.

DR. MOELLER: How does the fourth one fit in? You mean something fails, so you have to go back and repair it?

MR. MC CARTIN: Right.

DR. MOELLER: I didn't see how that fits in with the other end of this grouping.

MR. MC CARTIN: The intent of Part 61 is that they do not want any long-term maintenance, so they had to go back and fix those.

MR. KATHREN: I'm a little confused, which is not too uncommon.

Go back to your performance objectives.

You have:

protection of the general public from releases of radioactivity;

stability of the disposal site after closure.

And you say as the difference, one is an

immediate sort of thing and the other one is a future sort of thing.

Is it just the time's the only difference?

MR. COSTANZI: Those are separate requirements in Part 61.

MR. KATHREN: I understand that, but how do you interpret those?

As time being the only difference?

MR. COSTANZI: The first one begins with the operational period and extends essentially till the wastes are gone.

The second one, of course, is just after closure, but it's a separate requirement in Part 61 as an insurance policy.

MR. KATHREN: I'm trying to understand in my own mind how the impact of the slide you just took off, shouldn't there be twos along with those ones in items 1, 2 and 3?

MR. COSTANZI: No, the reason is, you can have the loss of stability at the site, disposal facility, without having disposal.

For example, when you have loss of stability, you have loss of stability as a performance objective, but there hasn't been any exposure so far.

DR. MOELLER: Back on your occupational exposure,

as I recall, almost any data you look at, in terms of the annual doses to workers at a burial site are very high, relatively speaking.

MR. COSTANZI: Yes.

DR. CARTER: There's just very few of them.

DR. MOELLER: That's correct. They're a low number, but high exposures.

MR. COSTANZI: With increased handling, they could -- they could be substantial.

DR. MOELLER: And this intruder, is that a consequence of the component failure?

An intruder just intrudes. They can intrude into a site where nothing has failed.

MR. MC CARTIN: If someone wants to get in, they will indeed get in.

MR. COSTANZI: Class C wastes are buried in a configuration which protects against the inadvertent intruder. What we are looking at in this case, will the disposal system maintain that capability?

Maybe something just has to be designed in.

(Slide.)

MR. MC CARTIN: With that in mind, the failure mechanism analysis will for each design component identify failure mechanisms, and as I mentioned before, this is going to be primarily operational experience at some of the foreign low level waste sites that are alternatives and some simple calculations.

Once the failure mechanisms are identified, they will categorize them on how they may be mitigated, maybe adding an extra six inches of concrete to a particular wall. Maybe that eliminates a particular failure mechanism.

You have site selection, operations. Then, thirdly, we will have design enhancements.

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Let's say they look at 18 alternatives. Its overall system, of course, is not that good. However, if we add this one design feature, we can bring its figure of merit, if you will, up significantly.

They will tend to address some of those questions, and as you saw the four different components we had, you might want to add fill to this particular alternative, or you might want to add a high tech container, these type of things, and that should close out the first year's funding.

DR. MOELLER: Roughly, this was a one person-year effort, the first year, and two people the second. So you are talking 100,000 or so?

MR. MC CARTIN: About.

DR. MOELLER: Are there questions or comments on this?

(No response.)

DR. MOELLER: Personally, I am delighted to see it. It is a very important piece of work you are doing.

DR. CARTER: The only comment I have got is a philosophical one. I think we have sort of almost, from what I am hearing, come full cycle, sort of, from the AEC back in the old days. We know what is best and this is what we are going to do, and now what I hear to some extent, we are almost being driven by public fear and this sort of

thing rather than on the basis of some scientific and technical information and common sense. I hope that is not true.

MR. COSTANZI: I think the reality of it is that NRC isn't going to license or provide information to the agreement states.

What we are trying to do is to make sure that what does get licensed -- we are not going to dispose of the waste. Somebody else is, the licensee -- but that it gets done in a way that will make sense.

Obviously, people are turning away from shallow land burial. So we can't ignore it.

So it is really incumbent upon us to make sure that that is as sensible a choice as can be done, and the only way we are trying to do that is to provide information to people who are going to be making that choice, primarily the states with whom we have compacts, pointing out to them what they are getting for their money.

If they choose to throw their money away, that is their choice. But at least they will have been able to make their own decision. Hopefully, it will be a reasonable decision.

DR. CARTER: You mean when they throw their money away, not if?

MR. COSTANZI: I hope it won't be quite that

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bad.

One of the advantages of containment is that you can usually assess what is going on with engineering a lot more easily, with a lot greater confidence than you can with the natural world, natural systems.

Ultimately, you are going to have to also address the question of what happens when the containment fails, the vault cracks, or whatever, which is another aspect of the research, so that you can make some prediction and comments.

But at least during that initial period, the wastes are being disposed of and you can come to the question of, well, can I walk away with it, the engineering facility, and that kind of an assessment.

MR. EBERSOLE: In answer to that question, when it cracks, doesn't that really close the problem?

MR. COSTANZI: The question of fixing it, it may be possible and maybe not.

MR. EBERSOLE: But I think that is a critical point. If it is not fixable, then you are in a different problem.

So the first criterion, is it fixable?

DR. MOELLER: Do you have that as part of your criterion?

MR. COSTANZI: What we have is part of our

research. Beginning, as I say, late this year and early in FY '87, we will be looking at the question of how do you determine whether or not the thing is cracked before you see any radionuclide migration.

MR. EBERSOLE: Why would you want to do that?

MR. COSTANZI: Radionuclide migration from low level waste sites, trenches essentially, has been pretty much haphazard.

A case in point, Sheffield.

There was a tritium pool at Sheffield that was discovered by accident. There wasn't really a systematic look for it. People were drilling some wells, and they found it.

MR. EBERSOLE: But you are going to be systematic?

MR. COSTANZI: It would be nice if we could start being systematic, especially if it is an alternative, before anything starts to migrate. So at the time of closure, we have some positive indication that the concrete vault is still intact, that it hasn't cracked.

That is going to make you a lot more confident that you have closed the thing up than having to say, gee, we have been monitoring 50 feet away from the bunker in the vault and we haven't seen any nuclides yet. We have got a way of making the statement. Had this bunker cracked, I

would have already seen it now with a higher percentage of confidence.

Whether you can actually make that sort of statement or not is one of the things we are going to try and find out. There are ways of making those kinds of positive statements.

DR. CARTER: Well, you have got to ask other questions. If you have a tritium pool at Sheffield, is that necessarily bad in itself. It might sound bad.

MR. COSTANZI: It is far worse because you didn't know it was going to be there in the first place.

DR. CARTER: In terms of exposures or potential exposures, I would argue with you that it is a minuscule program.

MR. COSTANZI: I won't argue with you on that, but what I will say is because that was predicted to be there before it is worse in terms of confidence in disposal technology.

DR. CARTER: That means their ego was abused, that is all.

MR. COSTANZI: Not necessarily ego abused, but public confidence in what you are doing.

If you can say in 30 years after I close this facility up I expect to see a plume going off in this direction at this concentration and no more and don't worry

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about it because it is not going to be a health problem and in 30 years you see that, nobody is going to be surprised. Nobody is going to be alarmed.

But if you didn't say that and 30 years later, monitoring, you find it, then there is going to be a surprise and people get alarmed. That is what we are trying to avoid.

DR. MOELLER: Max?

DR. CARBON: I am glad to see you and NRC participating on this coordinating committee. I guess I have a little bit of a problem in seeing why the INEL had a two man-year with NRC.

Why didn't DOE?

MR. COSTANZI: DOE is not really -- it has been very reluctant to get into the area of alternatives to shallow land burial. I won't try and hazard a guess as to why that is, but essentially the fact of the matter is NRC is the only game in town.

DR. CARBON: It is not NRC's responsibility.

MR. COSTANZI: NRC does have the responsibility to provide the information to the states, and the amendments to the Low Level Waste Policy Act make that explicit.

DR. CARBON: Providing the information to the states is fine, but does it have the responsibility to provide the information on the quantification of risks from

the various alternatives?

MR. COSTANZI: I think to provide information on alternatives that what one needs to do to make that information meaningful is to give people who will be using it some idea of what the benefits derived from this alternative are in terms of the confidence that it is going to work.

That is what it is going to deal with. We are not going to look at the costs.

DR. MOELLER: Again, if NRC is licensing these facilities, I would like to know as an adviser to NRC whether they are licensing the facility, the types of facilities they are licensing. I want to know whether they are the best.

DR. CARBON: We don't do that with reactors.

DR. MOELLER: We certainly, though, compare the risks of different types, and I don't think we conclude that a BWR or PWR can be operated unless it met our goals, and if all of them meet the goal equally, fine.

DR. CARBON: But it seems to me this is different. It is obviously true that you don't do Westinghouse versus GE, but we don't compare with another and say here are the benefits.

MR. COSTANZI: What we are trying to do is not identify what the benefits are in the sense is one safer

than the other. What we are trying to do is say if you buy a BWR here is the safety problems you have to worry about; if you buy a PWR here is the list of safety problems you have to worry about; here is what you are relying on for safety. What are the important safety systems?

DR. CARBON: We really don't do that with reactors. The utility comes in and we say, yes, this reactor is safe. We don't say it is not safe.

MR. COSTANZI: But you see, we already have that information. We already know from our experience in licensing these plants what are the important safety features of the various plants and the various designs and the designs that have changed. We know how to compare that with past experience, past designs to make sure that we always in every case have picked out what is really important.

The states, who will probably be doing the bulk of the licensing, do not have that, and certainly the alternatives, we have no experience at all.

So that is what we are trying to do, is develop essentially, artificially if you will, the basis of licensing experience which doesn't exist by doing the studies.

DR. CARBON: If the NRC is charged by law with doing it, fine. But if they are not charged with doing

this, I don't think this is the NRC's responsibility.

MR. COSTANZI: The law specifically says that we are to provide all available guidance to the states in two years.

DR. MOELLER: I find -- and I fully understand your comments, Max -- I find them interesting, though, because I have for months now compared how the ACRS works on a nuclear power plant versus how they view high level waste.

Now, if I were a promoter and people would listen to me, you know, make some assumptions, I would set up different facilities to do separate effects tests on the high level waste repository. I would build a loft. I would spend a billion dollars, build a loft facility, a demonstration repository that the NRC would operate, and test different modes and different backfills, and so forth, and get integral data out of it.

I would have Sandia doing -- the mistake we make in high level waste is we don't call it the MARCH code, the MELCOR code, and all these things. We would have Sandia doing the source term and the corrosion of the container. We would have the next person, Argonne, doing the disturbed zone and Brookhaven doing the undisturbed zone, someone else doing the codes for here and another group for liquid and another group for vegetation, and we would have another

group, a multi-million per year, doing the integration of all of the codes to be sure they interface.

There is no difference here. Why don't we do this? You did that in the nuclear power plants.

We just missed the boat. We don't think big enough.

(Laughter.)

DR. CARBON: I think I am aiming at something else, though. To me, the low level waste danger is quite different than NRC's high level waste.

In the high level area you would say, yes, this is safe enough or it does or doesn't meet all the requirements, it does or does not meet EPA standards. That is what you are doing with high level waste.

This in the low level waste is a design effort. It is quite different, and again if that is what Congress has said to NRC to do, okay.

MR. COSTANZI: I agree there is some qualitative difference.

DR. CARBON: Quantitative.

MR. COSTANZI: In terms of quality, we are doing the problem differently in low level than high level waste. We are providing much more design sort of information and guidance.

But again, the reason is we started down this

road because we can see that there wasn't really anybody else to do it and consistently telling the Commission and being directed by the Commission to do this sort of work, to provide this sort of guidance to the states in light of the legislation. They told us to do it.

DR. CARBON: To do this kind of study?

MR. COSTANZI: I believe this is consistent, honestly, yes.

DR. MOELLER: Mel, then Carson.

DR. CARTER: I agree. I have got a little bit of a problem, Max, with what you are saying. I understand the theory of it, but I think in the background in low level waste this was very prominent. It did not have any advocate in the federal government. It just grew like topsy with very little planning or technical input in the process.

This to some extent created the problem that sort of permeates the whole atmosphere, but on the other hand, in the high level wastes, the roles are pretty well spelled out. You have the regulator. You have got somebody else to enforce the regulations. You have got somebody pushing the technology.

In this case you do not have that. So unless NRC and EPA fund this kind of thing I don't know who is going to do it, certainly not DOE.

DR. CARBON: I am not sure either, but when we

go back next week with our budget hats on and say, gee, the NRC research budget has been cut, I say to myself, fiscal year '87, here is a $200,000 man-year effort. It is not all that big.

DR. MARK: $200,000 is going to look appreciable next year.

(Laughter.)

DR. MARK: You said some things that I felt very good about. You will explain to the states what you buy for the extra cost. Either of them would be licensable. You have more confidence when you do it this way.

Now, that I think sounds just fine. What I don't like is on this last slide, where it is referred to subsequent cost-benefit analyses. I hope the NRC is determined, bound, and succeeds in keeping its hands completely clear of that garbage.

MR. COSTANZI: That is what EPRI will do.

DR. MARK: The states can do it if they feel like it.

MR. COSTANZI: Yes. But our discussions with EPRI -- that is what they ought to do.

DR. MARK: There is no reason why NRC should make a cost-benefit and say a $1000 man-rem, 10 to the minus 7th, at a distance of 50 yards.

DR. MOELLER: Martin?

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DR. STEINDLER: My comment is particularly in terms of a tight budget. The management of this problem strikes me as backwards, if at all sensible.

A comment was made that you are driven by the concern raised by the public at large because they are not interested in having new low level waste sites started up, et cetera, et cetera.

There was also a comment made -- I think it was perfectly accurate -- that there are no technical bases for the concerns. Yet we dive ahead in a particular area with some rather questionable long-term benefits, or at least not well-defined, on the naive assumption that the answers that we will get out of the INEL study, and heaven knows what else, in fact will do the job that was advertised to be the source of the problem; namely, alleviate the public fear.

I see no way -- if I interpret the public fear correctly, I see no way in which what is coming out of Idaho is going to do this job.

I also see no way in which the aid to the states that these three documents might possibly give -- and I am not sure they will -- are going to solve that same problem.

What I guess I am saying is that there is no doubt that there is a low level waste disposal problem, as related to the nuclear community by the public at large either by the Congress or, in fact, by the intervenors or

heaven knows who else.

We have got a lot of flack, but in the absence of some reasonable relationship between research results and the solving of that problem, I think 400,000 bucks or whatever it is going to cost by the time we are done are going to be of questionable value.

And that is particularly irritating -- if that is the right term -- at a time when the budget has gone to hell, and, as Carson correctly says, that kind of money is going to represent a nontrivial fraction of a dwindling resource.

I guess from the standpoint of managing the research program, if that is an issue which we are looking at -- and I assume it is -- I find the planning process to be at least not very clear if I want to be charitable.

That is the only comment I have.

DR. MOELLER: I think I agree with you, in the sense that this effort alone is not going to solve the problem or answer the state's questions or provide them what they want.

I guess the place where I am in favor -- or one of the reasons I am in favor of an effort like this is that I have not been personally satisfied with any shallow land burial facility that exists.

DR. STEINDLER: What has been the source of your

dissatisfaction, because they don't meet the 10 CFR 61?

DR. MOELLER: That may be it.

I am told that the Barnwell site is a pretty good site. I have never seen it. But certainly Sheffield, Maxey Flats have just been miserable -- you know, mistakes.

DR. CARTER: But for a whole variety of reasons -- poor selection, operation.

DR. MOELLER: But I guess I still need to be shown that shallow land burial is the way to go. I don't think that has been shown. I am willing to listen.

MR. PARRY: Dade, excuse me. I think I have mentioned to you -- I have mentioned to the committee and the subcommittee in general that I am planning to put out a summary of the three active sites in terms of their operational techniques and a study on high integrity containers.

It is my personal opinion that high integrity containers may be a more cost effective technique to ensure the safety of shallow land burial than of going to highly engineered concrete monolithic structures.

DR. STEINDLER: Jack, the impression that you are leaving by that statement is that safety is a major issue with the technical community.

MR. PARRY: Than perceived public safety.

DR. STEINDLER: Is that the place where the

public gets all bent out of shape?

MR. PARRY: That is my impression based on what I hear when I go up to Congress and listen to the people talk up there.

DR. STEINDLER: As Mel says, if there is a plume coming out of Sheffield, the safety issue may be absolutely trivial. As long as you have used the words "plume" and "tritium" in the newspaper article, all hell breaks loose.

DR. CARTER: Well, Jack, I don't know what your conclusion will be. Certainly mine, based on some familiarity with the present sites, the Dade site has been closed down for some pretty good reasons. On the other hand, the three that are still in operation are technically sound and have very few problems.

Nevada has had some problems, but that doesn't have anything to do with the technical quality of the particular site.

MR. PARRY: I would agree with you in your conclusion. From what I have read so far on the operational techniques, it is being handled pretty rigorously, and I have talked with our staff, too, in the Low Level Branch in the Division of Waste Management.

DR. CARBON: I think Marty expresses very well the points, along with Mr. Carter.

DR. MOELLER: Where do we stand?

MR. COSTANZI: I think we are finished with the alternatives to low level waste.

What is your pleasure?

DR. MOELLER: How long will the natural analogs take?

DR. MARK: It will take him 10 minutes.

MR. COSTANZI: I guess probably about half an hour.

We can always return.

DR. MOELLER: I think the subcommittee is probably pretty well washed out for today.

DR. MARK: Leached out.

DR. MOELLER: Why don't we say that will give us something to think about for next time?

We do have a long agenda tomorrow. I think the first thing I am going to have to do is ask people to be brief.

DR. CARBON: Would you like for some of us not to come?

(Laughter.)

MR. MERRILL: I hate to do this to you, but I am going to give you a quick quiz tomorrow. It is an open book, but the book is about a half inch thick.

What I have done is reproduced 10 CFR 20 out of the Federal Register and done you a favor by indexing it

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so you can find stuff in it.

I am sorry I wasn't able to get it done sooner, but I got that material and a couple of other handouts that related to 10 CFR 20. If you want to take a look at it tonight, I will hand it out now so you will have it.

DR. MOELLER: All right.

With that, let me thank all of our speakers today, and, Nick, you for bearing with us late into the afternoon, some two hours or more beyond what we had scheduled.

We will resume then in the morning.

(Whereupon, at 5:25 p.m., the subcommittee was recessed, to reconvene at 8:30 a.m., Thursday, January 16, 1986.)

CERTIFICATE OF OFFICIAL REPORTER

This is to certify that the attached proceedings before the UNITED STATES NUCLEAR REGULATORY COMMISSION in the matter of:

NAME OF PROCEEDING: ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

SUBCOMMITTEE ON WASTE MANAGEMENT AND
SUBCOMMITTEE ON REACTOR RADIOLOGICAL EFFECTS

DOCKET NO.:

PLACE: WASHINGTON, D. C.

DATE: WEDNESDAY, JANUARY 15, 1986

were held as herein appears, and that this is the original transcript thereof for the file of the United States Nuclear Regulatory Commission.

(sigt) David L. Hoffman

(TYPED)

David L. Hoffman

Official Reporter

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SUBCHAPTER F—RADIATION PROTECTION PROGRAMS

PART 191—ENVIRONMENTAL RADIATION PROTECTION STANDARDS FOR MANAGEMENT AND DISPOSAL OF SPENT NUCLEAR FUEL, HIGH-LEVEL AND TRANSURANIC RADIOACTIVE WASTES

Authority: The Atomic Energy Act of 1954, as amended; Reorganization Plan No. 3 of 1970; and the Nuclear Waste Policy Act of 1982.

Subpart A—Environmental Standards for Management and Storage

§ 191.01 Applicability.

This Subpart applies to:

(a) Radiation doses received by members of the public as a result of the management (except for transportation) and storage of spent nuclear fuel or high-level or transuranic radioactive wastes at any facility regulated by the Nuclear Regulatory Commission or by Agreement States, to the extent that such management and storage operations are not subject to the provisions of Part 190 of title 40; and

(b) Radiation doses received by members of the public as a result of the management and storage of spent nuclear fuel or high-level or transuranic wastes at any disposal facility that is operated by the Department of Energy and that is not regulated by the Commission or by Agreement States.

§ 191.02 Definitions.

Unless otherwise indicated in this Subpart, all terms shall have the same meaning as in Subpart A of Part 190.

(a) "Agency" means the Environmental Protection Agency.

(b) "Administrator" means the Administrator of the Environmental Protection Agency.

(c) "Commission" means the Nuclear Regulatory Commission.

(d) "Department" means the Department of Energy.

(e) "NWPA" means the Nuclear Waste Policy Act of 1982 (Pub. L. 97-425).

(f) "Agreement State" means any State with which the Commission or the Atomic Energy Commission has entered into an effective agreement under subsection 274b of the Atomic Energy Act of 1954, as amended (68 Stat. 919).

(g) "Spent nuclear fuel" means fuel that has been withdrawn from a nuclear reactor following irradiation, the constituent elements of which have not been separated by reprocessing.

(h) "High-level radioactive waste," as used in this Part, means high-level radioactive waste as defined in the Nuclear Waste Policy Act of 1982 (Pub. L. 97-425).

(i) "Transuranic radioactive waste," as used in this Part, means waste containing more than 100 nanocuries of alpha-emitting transuranic isotopes, with half-lives greater than twenty years, per gram of waste, except for: (1) High-level radioactive wastes; (2) wastes that the Department has determined, with the concurrence of the Administrator, do not need the degree of isolation required by this Part; or (3) wastes that the Commission has approved for disposal on a case-by-case basis in accordance with 10 CFR Part 61.

(j) "Radioactive waste," as used in this Part, means the high-level and transuranic radioactive waste covered by this Part.

(k) "Storage" means retention of spent nuclear fuel or radioactive wastes with the intent and capability to readily retrieve such fuel or waste for subsequent use, processing, or disposal.

(l) "Disposal" means permanent isolation of spent nuclear fuel or radioactive waste from the accessible environment with no intent of recovery, whether or not such isolation permits the recovery of such fuel or waste. For example, disposal of waste in a mined geologic repository occurs when all of the shafts to the repository are backfilled and sealed.

(m) "Management" means any activity, operation, or process (except for transportation) conducted to prepare spent nuclear fuel or radioactive waste for storage or disposal, or the activities associated with placing such fuel or waste in a disposal system.

(n) "Site" means an area contained within the boundary of a location under the effective control of persons possessing or using spent nuclear fuel or radioactive waste that are involved in

any activity, operation, or process covered by this Subpart.

(o) "General environment" means the total terrestrial, atmospheric, and aquatic environments outside sites within which any activity, operation, or process associated with the management and storage of spent nuclear fuel or radioactive waste is conducted.

(p) "Member of the public" means any individual except during the time when that individual is a worker engaged in any activity, operation, or process that is covered by the Atomic Energy Act of 1954, as amended.

(q) "Critical organ" means the most exposed human organ or tissue exclusive of the integumentary system (skin) and the cornea.

§ 191.03 Standards.

(a) Management and storage of spent nuclear fuel or high-level or transuranic radioactive wastes at all facilities regulated by the Commission or by Agreement States shall be conducted in such a manner as to provide reasonable assurance that the combined annual dose equivalent to any member of the public in the general environment resulting from: (1) Discharges of radioactive material and direct radiation from such management and storage and (2) all operations covered by Part 190; shall not exceed 25 millirems to the whole body, 75 millirems to the thyroid, and 25 millirems to any other critical organ.

(b) Management and storage of spent nuclear fuel or high-level or transuranic radioactive wastes at all facilities for the disposal of such fuel or waste that are operated by the Department and that are not regulated by the Commission or Agreement States shall be conducted in such a manner as to provide reasonable assurance that the combined annual dose equivalent to any member of the public in the general environment resulting from discharges of radioactive material and direct radiation from such management and storage shall not exceed 25 millirems to the whole body and 75 millirems to any critical organ.

§ 191.04 Alternative standards.

(a) The Administrator may issue alternative standards from those standards established in 191.03(b) for waste management and storage activities at facilities that are not regulated by the Commission or Agreement States if, upon review of an application for such alternative standards:

(1) The Administrator determines that such alternative standards will prevent any member of the public from receiving a continuous exposure of more than 100 millirems per year dose equivalent and an infrequent exposure of more than 500 millirems dose equivalent in a year from all sources, excluding natural background and medical procedures; and

(2) The Administrator promptly makes a matter of public record the degree to which continued operation of the facility is expected to result in levels in excess of the standards specified in 191.03(b).

(b) An application for alternative standards shall be submitted as soon as possible after the Department determines that continued operation of a facility will exceed the levels specified in 191.03(b) and shall include all information necessary for the Administrator to make the determinations called for in 191.04(a).

(c) Requests for alternative standards shall be submitted to the Administrator, U.S. Environmental Protection Agency, 401 M Street, SW., Washington, DC 20460.

§ 191.05 Effective date.

The standards in this Subpart shall be effective on November 18, 1985.

Subpart B—Environmental Standards for Disposal

§ 191.11 Applicability.

(a) This Subpart applies to:

(1) Radioactive materials released into the accessible environment as a result of the disposal of spent nuclear fuel or high-level or transuranic radioactive wastes;

(2) Radiation doses received by members of the public as a result of such disposal; and

(3) Radioactive contamination of certain sources of ground water in the vicinity of disposal systems for such fuel or wastes.

(b) However, this Subpart does not apply to disposal directly into the oceans or ocean sediments. This Subpart also does not apply to wastes disposed of before the effective date of this rule.

§ 191.12 Definitions.

Unless otherwise indicated in this Subpart, all terms shall have the same meaning as in Subpart A of this Part.

(a) "Disposal system" means any combination of engineered and natural barriers that isolate spent nuclear fuel or radioactive waste after disposal.

(b) "Waste," as used in this Subpart, means any spent nuclear fuel or radioactive waste isolated in a disposal system.

(c) "Waste form" means the materials comprising the radioactive components of waste and any encapsulating or stabilizing matrix.

(d) "Barrier" means any material or structure that prevents or substantially delays movement of water or radionuclides toward the accessible environment. For example, a barrier may be a geologic structure, a canister, a waste form with physical and chemical characteristics that significantly decrease the mobility of radionuclides, or a material placed over and around waste, provided that the material or structure substantially delays movement of water or radionuclides.

(e) "Passive institutional control" means: (1) Permanent markers placed at a disposal site, (2) public records and archives, (3) government ownership and regulations regarding land or resource use, and (4) other methods of preserving knowledge about the location, design, and contents of a disposal system.

(f) "Active institutional control" means: (1) Controlling access to a disposal site by any means other than passive institutional controls; (2) performing maintenance operations or remedial actions at a site, (3) controlling or cleaning up releases from a site, or (4) monitoring parameters related to disposal system performance.

(g) "Controlled area" means: (1) A surface location, to be identified by passive institutional controls, that encompasses no more than 100 square kilometers and extends horizontally no more than five kilometers in any direction from the outer boundary of the original location of the radioactive wastes in a disposal system; and (2) the subsurface underlying such a surface location.

(h) "Ground water" means water below the land surface in a zone of saturation.

(i) "Aquifer" means an underground geological formation, group of formations, or part of a formation that is capable of yielding a significant amount of water to a well or spring.

(j) "Lithosphere" means the solid part of the Earth below the surface, including any ground water contained within it.

(k) "Accessible environment" means: (1) The atmosphere; (2) land surfaces; (3) surface waters; (4) oceans; and (5) all of the lithosphere that is beyond the controlled area.

(l) "Transmissivity" means the hydraulic conductivity integrated over the saturated thickness of an underground formation. The transmissivity of a series of formations is the sum of the individual

transmissivities of each formation comprising the series.

(m) "Community water system" means a system for the provision to the public of piped water for human consumption, if such system has at least 15 service connections used by year-round residents or regularly serves at least 25 year-round residents.

(n) "Significant source of ground water," as used in this Part, means: (1) An aquifer that: (i) Is saturated with water having less than 10,000 milligrams per liter of total dissolved solids; (ii) is within 2,500 feet of the land surface; (iii) has a transmissivity greater than 200 gallons per day per foot, provided that any formation or part of a formation included within the source of ground water has a hydraulic conductivity greater than 2 gallons per day per square foot; and (iv) is capable of continuously yielding at least 10,000 gallons per day to a pumped or flowing well for a period of at least a year; or (2) an aquifer that provides the primary source of water for a community water system as of the effective date of this Subpart.

(o) "Special source of ground water," as used in this Part, means those Class I ground waters identified in accordance with the Agency's Ground-Water Protection Strategy published in August 1984 that: (1) Are within the controlled area encompassing a disposal system or are less than five kilometers beyond the controlled area; (2) are supplying drinking water for thousands of persons as of the date that the Department chooses a location within that area for detailed characterization as a potential site for a disposal system (e.g., in accordance with Section 112(b)(1)(B) of the NWPA); and (3) are irreplaceable in that no reasonable alternative source of drinking water is available to that population.

(p) "Undisturbed performance" means the predicted behavior of a disposal system, including consideration of the uncertainties in predicted behavior, if the disposal system is not disrupted by human intrusion or the occurrence of unlikely natural events.

(q) "Performance assessment" means an analysis that: (1) Identifies the processes and events that might affect the disposal system; (2) examines the effects of these processes and events on the performance of the disposal system; and (3) estimates the cumulative releases of radionuclides, considering the associated uncertainties, caused by all significant processes and events. These estimates shall be incorporated into an overall probability distribution of cumulative release to the extent practicable.

(r) "Heavy metal" means all uranium, plutonium, or thorium placed into a nuclear reactor.

(s) "Implementing agency," as used in this Subpart, means the Commission for spent nuclear fuel or high-level or transuranic wastes to be disposed of in facilities licensed by the Commission in accordance with the Energy Reorganization Act of 1974 and the Nuclear Waste Policy Act of 1982, and it means the Department for all other radioactive wastes covered by this Part.

§ 191.13 Containment requirements.

(a) Disposal systems for spent nuclear fuel or high-level or transuranic radioactive wastes shall be designed to provide a reasonable expectation, based upon performance assessments, that the cumulative releases of radionuclides to the accessible environment for 10,000 years after disposal from all significant processes and events that may affect the disposal system shall:

(1) Have a likelihood of less than one chance in 10 of exceeding the quantities calculated according to Table 1 (Appendix A); and

(2) Have a likelihood of less than one chance in 1,000 of exceeding ten times the quantities calculated according to Table 1 (Appendix A).

(b) Performance assessments need not provide complete assurance that the requirements of 191.13(a) will be met. Because of the long time period involved and the nature of the events and processes of interest, there will inevitably be substantial uncertainties in projecting disposal system performance. Proof of the future performance of a disposal system is not to be had in the ordinary sense of the word in situations that deal with much shorter time frames. Instead, what is required is a reasonable expectation, on the basis of the record before the implementing agency, that compliance with 191.13 (a) will be achieved.

§ 191.14 Assurance requirements.

To provide the confidence needed for long-term compliance with the requirements of 191.13, disposal of spent nuclear fuel or high-level or transuranic wastes shall be conducted in accordance with the following provisions, except that these provisions do not apply to facilities regulated by the Commission (see 10 CFR Part 60 for comparable provisions applicable to facilities regulated by the Commission):

(a) Active institutional controls over disposal sites should be maintained for as long a period of time as is practicable after disposal; however, performance assessments that assess isolation of the wastes from the accessible environment shall not consider any contributions from active institutional controls for more than 100 years after disposal.

(b) Disposal systems shall be monitored after disposal to detect substantial and detrimental deviations from expected performance. This monitoring shall be done with techniques that do not jeopardize the isolation of the wastes and shall be conducted until there are no significant concerns to be addressed by further monitoring.

(c) Disposal sites shall be designated by the most permanent markers, records, and other passive institutional controls practicable to indicate the dangers of the wastes and their location.

(d) Disposal systems shall use different types of barriers to isolate the wastes from the accessible environment. Both engineered and natural barriers shall be included.

(e) Places where there has been mining for resources, or where there is a reasonable expectation of exploration for scarce or easily accessible resources, or where there is a significant concentration of any material that is not widely available from other sources, should be avoided in selecting disposal sites. Resources to be considered shall include minerals, petroleum or natural gas, valuable geologic formations, and ground waters that are either irreplaceable because there is no reasonable alternative source of drinking water available for substantial populations or that are vital to the preservation of unique and sensitive ecosystems. Such places shall not be used for disposal of the wastes covered by this Part unless the favorable characteristics of such places compensate for their greater likelihood of being disturbed in the future.

(f) Disposal systems shall be selected so that removal of most of the wastes is not precluded for a reasonable period of time after disposal.

§ 191.15 Individual protection requirements.

Disposal systems for spent nuclear fuel or high-level or transuranic radioactive wastes shall be designed to provide a reasonable expectation that, for 1,000 years after disposal, undisturbed performance of the disposal system shall not cause the annual dose equivalent from the disposal system to any member of the public in the accessible environment to exceed 25 millirems to the whole body or 75 millirems to any critical organ. All potential pathways (associated with undisturbed performance) from the disposal system to people shall be

considered, including the assumption that individuals consume 2 liters per day of drinking water from any significant source of ground water outside of the controlled area.

§ 191.16 Ground water protection requirements.

(a) Disposal systems for spent nuclear fuel or high-level or transuranic radioactive wastes shall be designed to provide a reasonable expectation that, for 1,000 years after disposal, undisturbed performance of the disposal system shall not cause the radionuclide concentrations averaged over any year in water withdrawn from any portion of a special source of ground water to exceed:

(1) 5 picocuries per liter of radium-226 and radium-228;

(2) 15 picocuries per liter of alpha-emitting radionuclides (including radium-226 and radium-228 but excluding radon); or

(3) The combined concentrations of radionuclides that emit either beta or gamma radiation that would produce an annual dose equivalent to the total body or any internal organ greater than 4 millirems per year if an individual consumed 2 liters per day of drinking water from such a source of ground water.

(b) If any of the average annual radionuclide concentrations existing in a special source of ground water before construction of the disposal system already exceed the limits in 191.16(a), the disposal system shall be designed to provide a reasonable expectation that, for 1,000 years after disposal, undisturbed performance of the disposal system shall not increase the existing average annual radionuclide concentrations in water withdrawn from that special source of ground water by more than the limits established in 191.16(a).

§ 191.17 Alternative provisions for disposal.

The Administrator may, by rule, substitute for any of the provisions of Subpart B alternative provisions chosen after:

(a) The alternative provisions have been proposed for public comment in the **Federal Register** together with information describing the costs, risks, and benefits of disposal in accordance with the alternative provisions and the reasons why compliance with the existing provisions of Subpart B appears inappropriate;

(b) A public comment period of at least 90 days has been completed, during which an opportunity for public hearings in affected areas of the country has been provided; and

(c) The public comments received have been fully considered in developing the final version of such alternative provisions.

§ 191.18 Effective date.

The standards in this Subpart shall be effective on ~~September 19~~, 1985.

Appendix A—Table for Subpart B

TABLE 1.—RELEASE LIMITS FOR CONTAINMENT REQUIREMENTS

(Cumulative releases to the accessible environment for 10,000 years after disposal)

Radionuclide	Release limit per 1,000 MTHM or other unit of waste (see notes) (curies)
Americium-241 or -243	100
Carbon-14	100
Cesium-135 or -137	1,000
Iodine-129	100
Neptunium-237	100
Plutonium-238, -239, -240, or -242	100
Radium-226	100
Strontium-90	1,000
Technetium-99	10,000
Thorium-230 or -232	10
Tin-126	1,000
Uranium-233, -234, -235, -236, or -238	100
Any other alpha-emitting radionuclide with a half-life greater than 20 years	100
Any other radionuclide with a half-life greater than 20 years that does not emit alpha particles	1,000

Application of Table 1

Note 1: *Units of Waste.* The Release Limits in Table 1 apply to the amount of wastes in any one of the following:

(a) An amount of spent nuclear fuel containing 1,000 metric tons of heavy metal (MTHM) exposed to a burnup between 25,000 megawatt-days per metric ton of heavy metal (MWd/MTHM) and 40,000 MWd/MTHM;

(b) The high-level radioactive wastes generated from reprocessing each 1,000 MTHM exposed to a burnup between 25,000 MWd/MTHM and 40,000 MWd/MTHM;

(c) Each 100,000,000 curies of gamma or beta-emitting radionuclides with half-lives greater than 20 years but less than 100 years (for use as discussed in Note 5 or with materials that are identified by the Commission as high-level radioactive waste in accordance with part B of the definition of high-level waste in the NWPA);

(d) Each 1,000,000 curies of other radionuclides (i.e., gamma or beta-emitters with half-lives greater than 100 years or any alpha-emitters with half-lives greater than 20 years) (for use as discussed in Note 5 or with materials that are identified by the Commission as high-level radioactive waste in accordance with part B of the definition of high-level waste in the NWPA); or

(e) An amount of transuranic (TRU) wastes containing one million curies of alpha-emitting transuranic radionuclides with half-lives greater than 20 years.

Note 2: *Release Limits for Specific Disposal Systems.* To develop Release Limits for a particular disposal system, the quantities in Table 1 shall be adjusted for the amount of waste included in the disposal system compared to the various units of waste defined in Note 1. For example:

(a) If a particular disposal system contained the high-level wastes from 50,000 MTHM, the Release Limits for that system would be the quantities in Table 1 multiplied by 50 (50,000 MTHM divided by 1,000 MTHM).

(b) If a particular disposal system contained three million curies of alpha-emitting transuranic wastes, the Release Limits for that system would be the quantities in Table 1 multiplied by three (three million curies divided by one million curies).

(c) If a particular disposal system contained both the high-level wastes from 50,000 MTHM *and* 5 million curies of alpha-emitting transuranic wastes, the Release Limits for that system would be the quantities in Table 1 multiplied by 55:

$$\frac{50{,}000\ \text{MTHM}}{1{,}000\ \text{MTHM}} + \frac{5{,}000{,}000\ \text{curies TRU}}{1{,}000{,}000\ \text{curies TRU}} = 55$$

Note 3: *Adjustments for Reactor Fuels with Different Burnup.* For disposal systems containing reactor fuels (or the high-level wastes from reactor fuels) exposed to an average burnup of less than 25,000 MWd/MTHM or greater than 40,000 MWd/MTHM, the units of waste defined in (a) and (b) of Note 1 shall be adjusted. The unit shall be multiplied by the ratio of 30,000 MWd/MTHM divided by the fuel's actual average burnup, except that a value of 5,000 MWd/MTHM may be used when the average fuel burnup is below 5,000 MWd/MTHM and a value of 100,000 MWd/MTHM shall be used when the average fuel burnup is above 100,000 MWd/MTHM. This adjusted unit of waste shall then be used in determining the Release Limits for the disposal system.

For example, if a particular disposal system contained only high-level wastes with an average burnup of 3,000 MWd/MTHM, the unit of waste for that disposal system would be:

$$1{,}000\ \text{MTHM} \times \frac{(30{,}000)}{(5{,}000)} = 6{,}000\ \text{MTHM}$$

If that disposal system contained the high-level wastes from 60,000 MTHM (with an average burnup of 3,000 MWd/MTHM), then

the Release Limits for that system would be the quantities in Table 1 multiplied by ten:

$$\frac{60{,}000\ \text{MTHM}}{6{,}000\ \text{MTHM}} = 10$$

which is the same as:

$$\frac{60{,}000\ \text{MTHM}}{1{,}000\ \text{MTHM}} \times \frac{(5{,}000\ \text{MWd/MTHM})}{(30{,}000\ \text{MWd/MTHM})} = 10$$

Note 4: *Treatment of Fractionated High-Level Wastes.* In some cases, a high-level waste stream from reprocessing spent nuclear fuel may have been (or will be) separated into two or more high-level waste components destined for different disposal systems. In such cases, the implementing agency may allocate the Release Limit multiplier (based upon the original MTHM and the average fuel burnup of the high-level waste stream) among the various disposal systems as it chooses, provided that the total Release Limit multiplier used for that waste stream at all of its disposal systems may not exceed the Release Limit multiplier that would be used if the entire waste stream were disposed of in one disposal system.

Note 5: *Treatment of Wastes with Poorly Known Burnups or Original MTHM.* In some cases, the records associated with particular high-level waste streams may not be adequate to accurately determine the original metric tons of heavy metal in the reactor fuel that created the waste, or to determine the average burnup that the fuel was exposed to. If the uncertainties are such that the original amount of heavy metal or the average fuel burnup for particular high-level waste streams cannot be quantified, the units of waste derived from (a) and (b) of Note 1 shall no longer be used. Instead, the units of waste defined in (c) and (d) of Note 1 shall be used for such high-level waste streams. If the uncertainties in such information allow a range of values to be associated with the original amount of heavy metal or the average fuel burnup, then the calculations described in previous Notes will be conducted using the values that result in the smallest Release Limits, except that the Release Limits need not be smaller than those that would be calculated using the units of waste defined in (c) and (d) of Note 1.

Note 6: *Uses of Release Limits to Determine Compliance with 191.13* Once release limits for a particular disposal system have been determined in accordance with Notes 1 through 5, these release limits shall be used to determine compliance with the requirements of 191.13 as follows. In cases where a mixture of radionuclides is projected to be released to the accessible environment, the limiting values shall be determined as follows: For each radionuclide in the mixture, determine the ratio between the cumulative release quantity projected over 10,000 years and the limit for that radionuclide as determined from Table 1 and Notes 1 through 5. The sum of such ratios for all the radionuclides in the mixture may not exceed one with regard to 191.13(a)(1) and may not exceed ten with regard to 191.13(a)(2).

For example, if radionuclides A, B, and C are projected to be released in amounts Q_a, Q_b, and Q_c, and if the applicable Release Limits are RL_a, RL_b, and RL_c, then the cumulative releases over 10,000 years shall be limited so that the following relationship exists:

$$\frac{Q_a}{RL_a} + \frac{Q_b}{RL_b} + \frac{Q_c}{RL_c} < 1$$

Appendix B—Guidance for Implementation of Subpart B

[Note: The supplemental information in this appendix is not an integral part of 40 CFR Part 191. Therefore, the implementing agencies are not bound to follow this guidance. However, it is included because it describes the Agency's assumptions regarding the implementation of Subpart B. This appendix will appear in the Code of Federal Regulations.]

The Agency believes that the implementing agencies must determine compliance with §§ 191.13, 191.15, and 191.16 of Subpart B by evaluating long-term predictions of disposal system performance. Determining compliance with § 191.13 will also involve predicting the likelihood of events and processes that may disturb the disposal system. In making these various predictions, it will be appropriate for the implementing agencies to make use of rather complex computational models, analytical theories, and prevalent expert judgment relevant to the numerical predictions. Substantial uncertainties are likely to be encountered in making these predictions. In fact, sole reliance on these numerical predictions to determine compliance may not be appropriate; the implementing agencies may choose to supplement such predictions with qualitative judgments as well. Because the procedures for determining compliance with Subpart B have not been formulated and tested yet, this appendix to the rule indicates the Agency's assumptions regarding certain issues that may arise when implementing §§ 191.13, 191.15, and 191.16. Most of this guidance applies to any type of disposal system for the wastes covered by this rule. However, several sections apply only to disposal in mined geologic repositories and would be inappropriate for other types of disposal systems.

Consideration of Total Disposal System. When predicting disposal system performance, the Agency assumes that reasonable projections of the protection expected from all of the engineered and natural barriers of a disposal system will be considered. Portions of the disposal system should not be disregarded, even if projected performance is uncertain, except for portions of the system that make negligible contributions to the overall isolation provided by the disposal system.

Scope of Performance Assessments. Section 191.13 requires the implementing agencies to evaluate compliance through performance assessments as defined in § 191.12(q). The Agency assumes that such performance assessments need not consider categories of events or processes that are estimated to have less than one chance in 10,000 of occurring over 10,000 years. Furthermore, the performance assessments need not evaluate in detail the releases from all events and processes estimated to have a greater likelihood of occurrence. Some of these events and processes may be omitted from the performance assessments if there is a reasonable expectation that the remaining probability distribution of cumulative releases would not be significantly changed by such omissions.

Compliance with Section 191.13. The Agency assumes that, whenever practicable, the implementing agency will assemble all of the results of the performance assessments to determine compliance with § 191.13 into a "complementary cumulative distribution function" that indicates the probability of exceeding various levels of cumulative release. When the uncertainties in parameters are considered in a performance assessment, the effects of the uncertainties considered can be incorporated into a single such distribution function for each disposal system considered. The Agency assumes that a disposal system can be considered to be in compliance with § 191.13 if this single distribution function meets the requirements of § 191.13(a).

Compliance with Sections 191.15 and 191.16. When the uncertainties in undisturbed performance of a disposal system are considered, the implementing agencies need not require that a very large percentage of the range of estimated radiation exposures or radionuclide concentrations fall below limits established in §§ 191.15 and 191.16, respectively. The Agency assumes that compliance can be determined based upon "best estimate" predictions (e.g., the mean or the median of the appropriate distribution, whichever is higher).

Institutional Controls. To comply with § 191.14(a), the implementing agency will assume that none of the active institutional controls prevent or reduce radionuclide releases for more than 100 years after disposal. However, the Federal Government is committed to retaining ownership of all disposal sites for spent nuclear fuel and high-level and transuranic radioactive wastes and will establish appropriate markers and records, consistent with § 191.14(c). The Agency assumes that, as long as such passive institutional controls endure and are understood, they: (1) can be effective in deterring systematic or persistent exploitation of these disposal sites; and (2) can reduce the likelihood of inadvertent, intermittent human intrusion to a degree to be determined by the implementing agency. However, the Agency believes that passive institutional controls can never be assumed to eliminate the chance of inadvertent and intermittent human intrusion into these disposal sites.

Consideration of Inadvertent Human Intrusion into Geologic Repositories. The most speculative potential disruptions of a mined geologic repository are those associated with inadvertent human intrusion. Some types of intrusion would have virtually no effect on a repository's containment of

waste. On the other hand, it is possible to conceive of intrusions (involving widespread societal loss of knowledge regarding radioactive wastes) that could result in major disruptions that no reasonable repository selection or design precautions could alleviate. The Agency believes that the most productive consideration of inadvertent intrusion concerns those realistic possibilities that may be usefully mitigated by repository design, site selection, or use of passive controls (although passive institutional controls should not be assumed to completely rule out the possibility of intrusion). Therefore, inadvertent and intermittent intrusion by exploratory drilling for resources (other than any provided by the disposal system itself) can be the most severe intrusion scenario assumed by the implementing agencies. Furthermore, the implementing agencies can assume that passive institutional controls or the intruders' own exploratory procedures are adequate for the intruders to soon detect, or be warned of, the incompatibility of the area with their activities.

Frequency and Severity of Inadvertent Human Intrusion into Geologic Repositories. The implementing agencies should consider the effects of each particular disposal system's site, design, and passive institutional controls in judging the likelihood and consequences of such inadvertent exploratory drilling. However, the Agency assumes that the likelihood of such inadvertent and intermittent drilling need not be taken to be greater than 30 boreholes per square kilometer of repository area per 10,000 years for geologic repositories in proximity to sedimentary rock formations, or more than 3 boreholes per square kilometer per 10,000 years for repositories in other geologic formations. Furthermore, the Agency assumes that the consequences of such inadvertent drilling need not be assumed to be more severe than: (1) Direct release to the land surface of all the ground water in the repository horizon that would promptly flow through the newly created borehole to the surface due to natural lithostatic pressure—or (if pumping would be required to raise water to the surface) release of 200 cubic meters of ground water pumped to the surface if that much water is readily available to be pumped; and (2) creation of a ground water flow path with a permeability typical of a borehole filled by the soil or gravel that would normally settle into an open hole over time—not the permeability of a carefully sealed borehole.

[FR Doc. 85-20331 Filed 9-18-85; 8:45 am]

BILLING CODE 6560-50-M

RULEMAKING TO CONFORM PART 60

TO THE EPA HIGH-LEVEL WASTE STANDARDS

Daniel J. Fehringer

January 15, 1986

PURPOSES OF THE PROPOSED RULEMAKING

1) MAINTAIN CONSISTENCY BETWEEN PART 60 AND THE EPA STANDARDS AS DIRECTED BY SECTION 121 OF THE NUCLEAR WASTE POLICY ACT OF 1982.

2) CARRY OUT THE COMMITMENTS MADE IN SECY-85-272 REGARDING EPA'S "ASSURANCE REQUIREMENTS."

3) SIMPLIFY THE HIGH-LEVEL WASTE REGULATORY STRUCTURE.

--COMBINE REPOSITORY REQUIREMENTS IN ONE DOCUMENT.

--ELIMINATE DUPLICATIVE WORDING.

TYPES OF CHANGES

1) APPLICABLE SECTIONS OF THE EPA STANDARDS ARE BEING INCORPORATED DIRECTLY INTO PART 60.

2) SOME EPA TERMS ARE BEING CHANGED TO EXISTING PART 60 WORDING.

3) SOME REVISIONS TO PART 60 DEFINITIONS FOR CONSISTENCY WITH EPA DEFINITIONS.

4) SOME CHANGES FROM SECY-85-272.

5) NO SUBSTANTIVE CHANGES TO THE EXISTING PERFORMANCE OBJECTIVES OF PART 60.

SPECIFIC CHANGES

CONTROLLED AREA

"Controlled area" [~~means-a-surface-location,-to-be-marked-by-suitable monuments,-extending-horizontally-no-more-than-10-kilometers-in-any-direction from-the-outer-boundary-of-the-underground-facility,-and-the-underlying subsurface,-which-area-has-been-committed-to-use-as-a-geologic-repository-and from-which-incompatible-activities-would-be-restricted-following-permanent closure,~~] means: (1) a surface location, to be identified by passive institutional controls, that encompasses no more than 100 square kilometers and extends horizontally no more than five kilometers in any direction from the outer boundary of the underground facility, and (2) the subsurface underlying such a surface location.

PROPOSED WORDING IS IDENTICAL TO EPA'S EXCEPT THAT "UNDERGROUND FACILITY" REPLACES "ORIGINAL LOCATION OF THE RADIOACTIVE WASTES IN A DISPOSAL SYSTEM."

OTHER DEFINITIONS

SEVEN NEW DEFINITIONS ARE PROPOSED -- WORDING IS TAKEN VERBATIM FROM THE EPA STANDARDS.

--ACTIVE INSTITUTIONAL CONTROL

--COMMUNITY WATER SYSTEM

--PASSIVE INSTITUTIONAL CONTROL

--SIGNIFICANT SOURCE OF GROUND WATER

--SPECIAL SOURCE OF GROUND WATER

--TRANSMISSIVITY

--URANIUM FUEL CYCLE

USE OF "PERFORMANCE ASSESSMENTS"

PARAGRAPH 60.21(c)(1)(ii)(C) IS REVISED TO READ AS FOLLOWS:

(C) An evaluation of the performance of the proposed geologic repository for the period after permanent closure, assuming anticipated processes and events, giving the rates and quantities of releases of radionuclides to the accessible environment as a function of time; and a similar evaluation which assumes the occurrence of unanticipated processes and events. In making such evaluations, estimated values shall be incorporated into an overall probability distribution of cumulative release to the extent practicable.

THIS PARAGRAPH INCORPORATES THE SUBSTANCE OF EPA'S DEFINITION OF "PERFORMANCE ASSESSMENT" AND OF EPA'S REQUIREMENT TO USE PERFORMANCE ASSESSMENTS TO EVALUATE COMPLIANCE WITH THE STANDARDS.

REASONABLE ASSURANCE

PARAGRAPH 60.101(a)(2) NOW DESCRIBES THE COMMISSION'S INTERPRETATION OF "REASONABLE ASSURANCE" IN REPOSITORY LICENSING. THIS PARAGRAPH IS BEING SUPPLEMENTED BY ADDITION OF THE FOLLOWING WORDING, TAKEN LARGELY FROM APPENDIX B OF THE EPA STANDARDS.

Demonstration of compliance with the performance objectives of §60.112 will also involve predicting the likelihood and consequences of events and processes that may disturb the repository. Such predictions may involve complex computational models, analytical theories and prevalent expert judgment. Substantial uncertainties are likely to be encountered and sole reliance on numerical predictions to determine compliance may not be appropriate. In reaching a determination of reasonable assurance, the Commission may supplement numerical analyses with qualitative judgments including, for example, consideration of the degree of diversity or redundancy among the multiple barriers of a specific repository.

PRE-CLOSURE RADIATION PROTECTION

SECTION 60.111(a) IS REVISED AS FOLLOWS:

(a) Protection against radiation exposures and releases of radioactive material. The geologic repository operations area shall be designed so that until permanent closure has been completed[~~, radiation exposures and radiation levels, and releases of radioactive materials to unrestricted areas, will at all times be maintained within the limits specified in Part 20 of this chapter and such generally applicable environmental standards for radioactivity as may have been established by the Environmental Protection Agency.~~] :

(1) The combined annual dose equivalent to any member of the public outside the geologic repository operations area, resulting from (i) discharges of radioactive material and direct radiation from activities at the geologic repository operations area and (ii) uranium fuel cycle operations, shall not exceed 25 millirems to the whole body, 75 millirems to the thyroid, and 25 millirems to any other critical organ.

(2) Radiation exposures and radiation levels, and releases of radioactive materials to unrestricted areas, will at all times be maintained within the limits specified in Part 20 of this chapter.

CONTAINMENT REQUIREMENTS

SECTION 60.112 IS REVISED AS FOLLOWS:

The geologic setting shall be selected and the engineered barrier system and the shafts, boreholes and their seals shall be designed [~~to-assure-that releases-of-radioactive-materials-to-the-accessible-environment-following permanent-closure-conform-to-such-generally-applicable-environmental-standards as-may-have-been-established-by-the-Environmental-Protection-Agency-with respect-to-both-anticipated-processes-and-events-and-unanticipated-processes and-events.~~] :

(a) To assure that, for 10,000 years following permanent closure, cumulative releases of radionuclides to the accessible environment, from all anticipated and unanticipated processes and events, shall:

(1) Have a likelihood of less than one chance in 10 of exceeding the quantities calculated in accordance with section 60.115.

(2) Have a likelihood of less than one chance in 1,000 of exceeding ten times the quantities calculated in accordance with section 60.115.

INDIVIDUAL PROTECTION REQUIREMENTS

SECTION 60.112 CONTINUES WITH PARAGRAPH (b) AS FOLLOWS:

(b) So that for 1,000 years after permanent closure, and in the absence of unanticipated processes and events, the annual dose equivalent to any member of the public in the accessible environment does not exceed 25 millirems to the whole body or 75 millirems to any critical organ. For the purpose of applying this paragraph, all potential pathways from the geologic repository to people shall be considered, including the assumption that individuals consume 2 liters per day of drinking water from any significant source of groundwater outside of the controlled area.

NOTE: EPA'S TERM "UNDISTURBED PERFORMANCE" IS REPLACED BY "IN THE ABSENCE OF UNANTICIPATED PROCESSES AND EVENTS."

GROUNDWATER PROTECTION REQUIREMENTS

SECTION 60.112 CONTINUES:

(c) So that for 1,000 years after permanent closure, and in the absence of unanticipated processes and events:

(1) Except as provided in paragraph (c)(2), the radionuclide concentrations averaged over any year in water withdrawn from any portion of a special source of groundwater do not exceed:

(i) 5 picocuries per liter of radium-226 and radium-228;

(ii) 15 picocuries per liter of alpha-emitting radionuclides (including radium-226 and radium-228 but excluding radon); or

(iii) the combined concentrations of radionuclides that emit either beta or gamma radiation that would produce an annual dose equivalent to the total body or any internal organ greater than 4 millirems per year if an individual consumed 2 liters per day of drinking water from such a source of groundwater.

(2) If any of the average annual radionuclide concentrations existing in a special source of groundwater before construction of the geologic repository operations area already exceed the limits in paragraph (c)(1), the increase in the existing average annual radionuclide concentrations in water withdrawn from that special source of groundwater does not exceed the limits specified in paragraph (c)(1).

MULTIPLE BARRIERS

A NEW PARAGRAPH (d) IS PROPOSED FOR THE INDIVIDUAL BARRIER PERFORMANCE OBJECTIVES OF SECTION 60.113 AS FOLLOWS:

(d) Notwithstanding the provisions of (b) above, the geologic repository shall incorporate a system of multiple barriers, both engineered and natural.

THIS PARAGRAPH MAKES CLEAR THAT THE FLEXIBILITY PROVISION OF 60.113(b) DOES NOT ELIMINATE THE NEED FOR MULTIPLE BARRIERS IN A REPOSITORY SYSTEM.

INSTITUTIONAL CONTROL

A NEW SECTION 60.114 IS PROPOSED AS FOLLOWS:

§ 60.114 Institutional control.

Neither active nor passive institutional control shall be deemed to assure compliance with the overall system performance objective set out at § 60.112 for more than 100 years after permanent closure. However, the effects of institutional control may be considered in assessing, for purposes of that section, the likelihood and consequences of processes and events affecting the geologic setting.

THIS WORDING MAKES CLEAR THAT INSTITUTIONAL CONTROLS ARE NOT TO BE RELIED ON AS THE MEANS FOR ACHIEVING REPOSITORY SAFETY.

TABLE OF RELEASE LIMITS

A NEW SECTION 60.115 IS PROPOSED, CONSISTING OF EPA'S TABLE OF RELEASE LIMITS AND ACCOMPANYING NOTES FOR IMPLEMENTATION.

NATURAL RESOURCES

A NEW POTENTIALLY ADVERSE SITING CRITERION IS PROPOSED FOR SECTION 60.122(c) AS FOLLOWS:

(18) The presence of significant concentrations of any naturally-occurring material that is not widely available from other sources.

POST-CLOSURE MONITORING

A NEW SECTION 60.144 IS PROPOSED AS FOLLOWS:

§60.144 Monitoring After Permanent Closure

A program of monitoring shall be conducted after permanent closure to monitor all repository characteristics which can reasonably be expected to provide material confirmatory information regarding long-term repository performance, provided that the means for conducting such monitoring will not degrade repository performance. This program shall be continued until termination of a license.

THIS SECTION REFERS TO MONITORING OF SUCH PARAMETERS AS GROUNDWATER FLOW CHARACTERISTICS IN THE VICINITY OF A REPOSITORY, RATHER THAN MONITORING OF THE UNDERGROUND FACILITY OR WASTE PACKAGES.

SCHEDULE

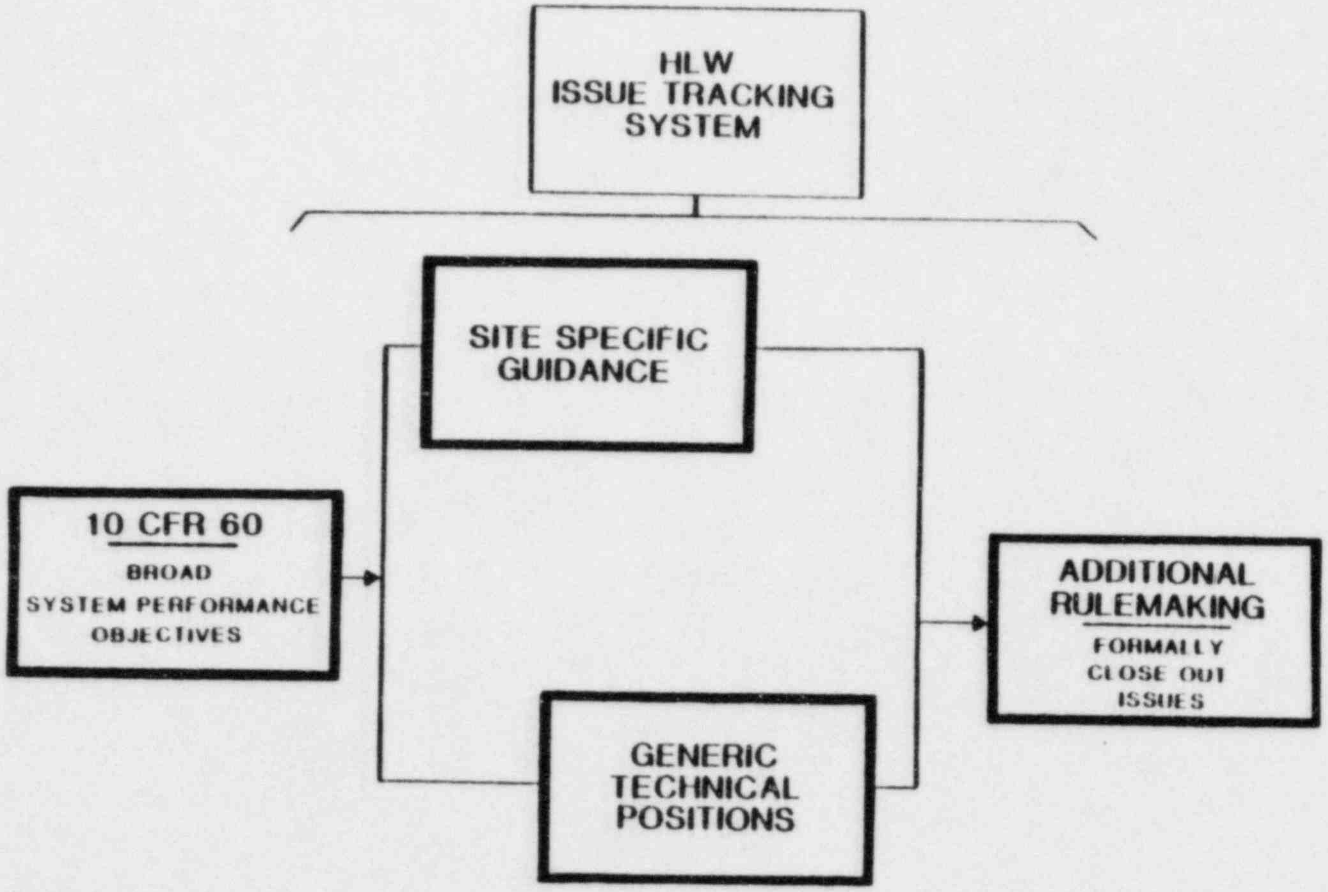
CIRCULATE FOR OFFICE CONCURRENCE	1/21/86
FORWARD TO EDO	1/31/86
FORWARD TO COMMISSION	2/14/86

(DATES BASED ON STAFF REQUIREMENTS MEMORANDUM FOR SECY-85-272)

GENERIC TECHNICAL POSITIONS ON
DISTURBED ZONE AND GROUNDWATER TRAVEL TIME

J. Linehan

ACRS SUBCOMMITTEE BRIEFING: 1/15/86



NRC HLW LICENSING GUIDANCE PROGRAM

POST-EMPLACEMENT PERFORMANCE OBJECTIVES

- WASTE PACKAGES WILL PROVIDE SUBSTANTIALLY COMPLETE CONTAINMENT FOR 300 TO 1.000 YEARS
- FOLLOWING CONTAINMENT, RADIONUCLIDE RELEASES FROM THE ENGINEERED BARRIER SYSTEM WILL BE LIMITED TO 1/100,000 OF 1,000 YEAR INVENTORY
- GROUNDWATER TRAVEL TIME TO THE ACCESSIBLE ENVIRONMENT WILL BE AT LEAST 1,000 YEARS
- LIMIT ON CUMULATIVE QUANTITIES OF RADIONUCLIDES RELEASED TO THE ENVIRONMENT OVER A 10,000 YEAR PERIOD (EPA STANDARD)

GEOLOGIC SETTING PERFORMANCE OBJECTIVE

"...PRE-EMPLACEMENT GROUNDWATER TRAVEL TIME ALONG THE FASTEST PATH OF LIKELY RADIONUCLIDE TRAVEL FROM THE DISTURBED ZONE TO THE ACCESSIBLE ENVIRONMENT SHALL BE AT LEAST 1,000 YEARS..."

TWO GENERIC TECHNICAL POSITIONS RELATED TO GEOLOGIC SETTING PERFORMANCE OBJECTIVE

- o INTERPRETATION AND EXTENT OF THE DISTURBED ZONE
  - WHAT IS EXTENT OF DISTURBED ZONE?
- o DETERMINATION OF GROUNDWATER TRAVEL TIME
  - WHAT IS AN ACCEPTABLE APPROACH FOR DETERMINING GROUNDWATER TRAVEL TIME?

DISTURBED ZONE

- THAT PORTION OF THE CONTROLLED AREA OF WHICH PHYSICAL OR CHEMICAL PROPERTIES HAVE BEEN CHANGED AS A RESULT OF WASTE EMPLACEMENT TO SIGNIFICANTLY AFFECT REPOSITORY PERFORMANCE

- INTENT
  - TO AVOID ANALYSES WHERE UNPREDICTABLE PHENOMENA WERE LIKELY
  - TO AVOID CREDIT WHERE POST-EMPLACEMENT DISRUPTION WOULD MAKE SUCH CREDIT MEANINGLESS

GROUNDWATER TRAVEL TIME

- o IMPLEMENT MULTIBARRIER APPROACH
- o QUANTITATIVE INDICATION OF WASTE ISOLATION POTENTIAL OF A SITE
- o ESTABLISHES A SIMPLE ROUGH SCREEN FOR HYDROLOGICALLY QUESTIONABLE SITES

DISTURBED ZONE AND GROUNDWATER TRAVEL TIME IN THE HIGH LEVEL WASTE RULE (10 CFR 60)

by

Richard B. Codell

U.S. Nuclear Regulatory Commission

Washington D.C.

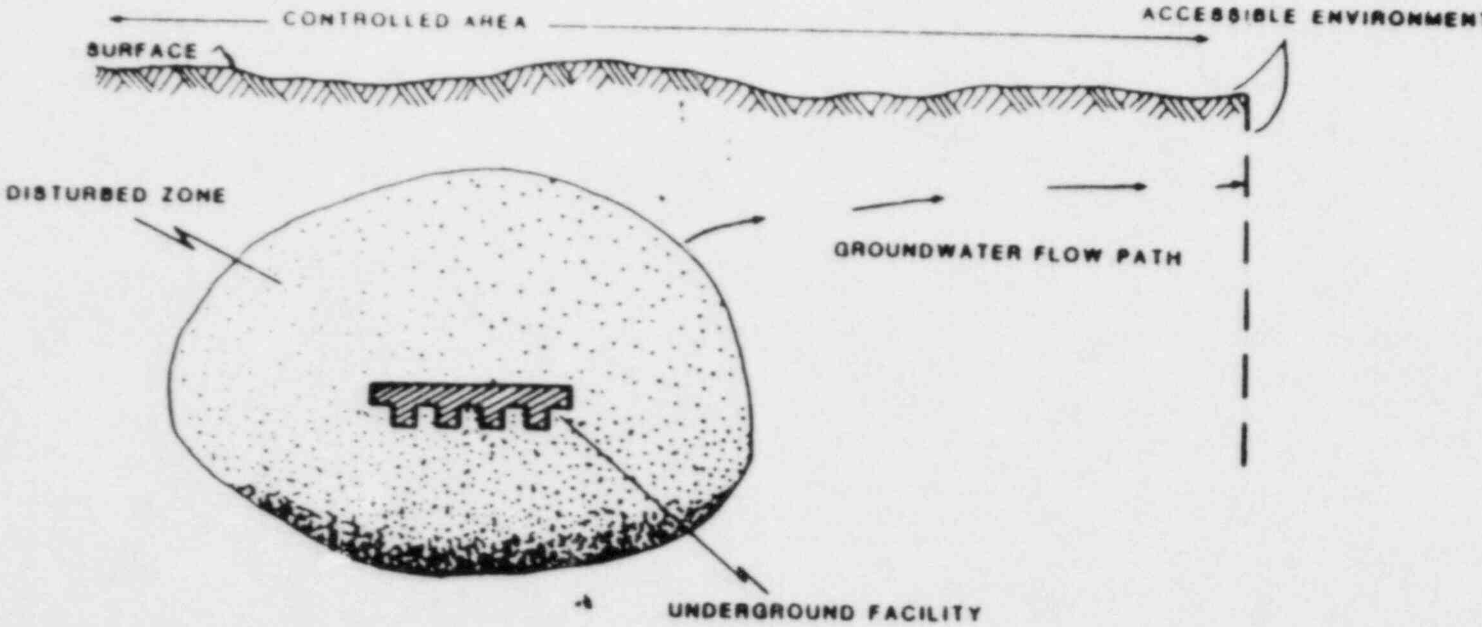
GROUNDWATER TRAVEL TIME

The geologic repository shall be located so that the **pre-waste-emplacement groundwater travel time** along the **fastest path of likely radionuclide travel** from the **disturbed zone** to the **accessible environment** shall be at least 1000 years or such other time as may be approved by the Commission

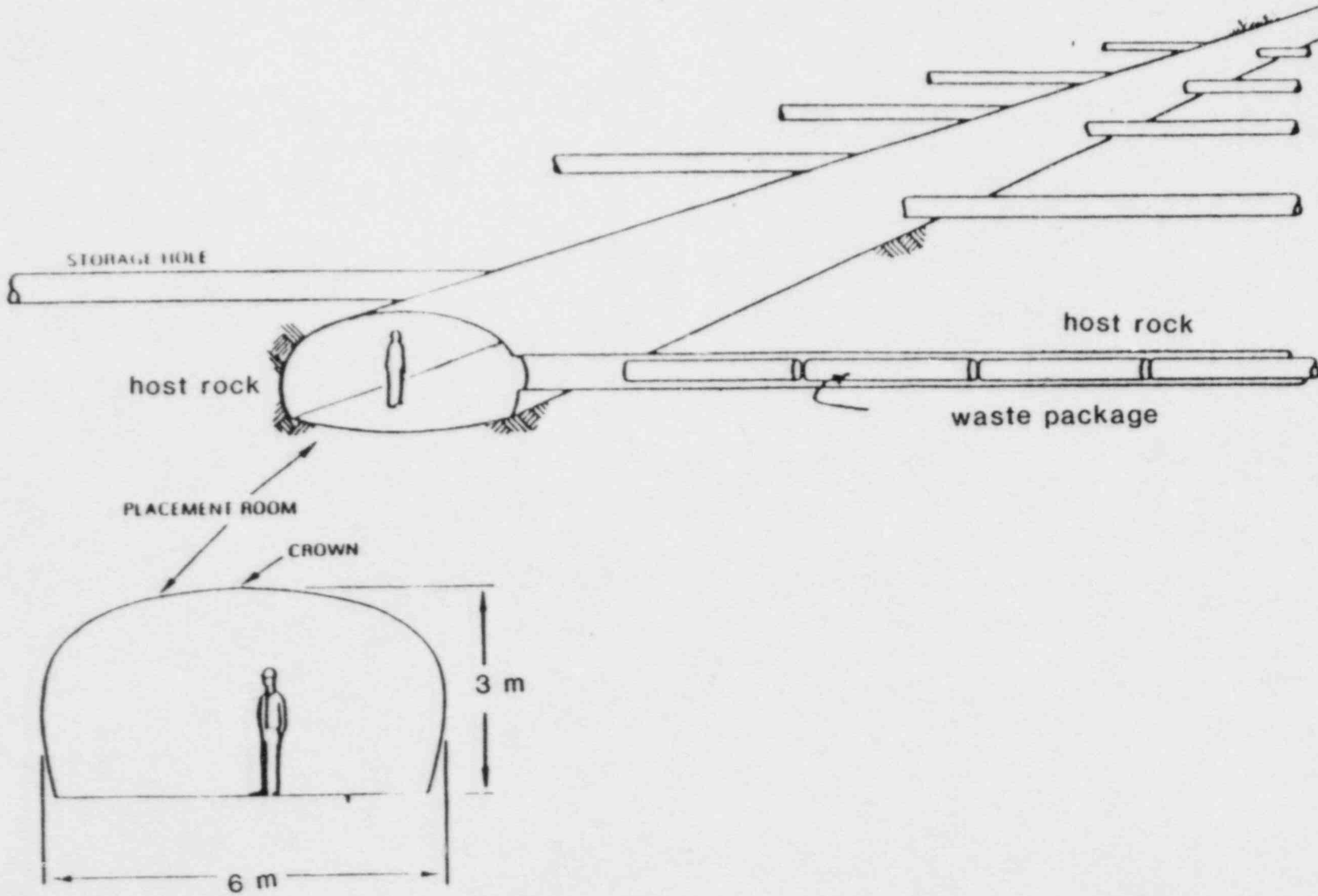
RATIONALE FOR DZ AND GWTT

- Quantitative measure of waste isolation potential of natural geologic setting
- Conceptually simple — avoids difficulties of predicting post—emplacement environment
- Prevents reliance solely on rock adjacent to the emplaced waste
- Takes into account near—field disturbance

ACRS S[illegible]MITTEE BRIEFING: 1/15/86



NOT TO SCALE


STORAGE HOLE
host rock
host rock
waste package
PLACEMENT ROOM
CROWN
3 m
6 m

INTERPRETATION OF DISTURBED ZONE

- Zone of significant changes to intrinsic properties of rock
- Change of porosity less than factor of 2
- Does not include buoyancy or viscosity of the ground water

Disturbed Zone size based on:

1. Stress redistribution
2. Construction and Excavation practice
3. Thermomechanical Effects
4. Thermochemical Effects

THERMOCHEMICAL EFFECTS

- o Phase change
- o Dissolution
- o Dehydration

STATEMENT OF POSITION ON DISTURBED ZONE

- Zone of substantial changes to intrinsic permeability and porosity
- Include rock adjacent to emplaced waste
- 5 diameters, room heights or 50 meters minimum. whichever is greatest
- Might extend further
- If less, must support

GWTT INCLUDES:

- Advective flow
- Diffusion
- Dispersion

APPROACH TO SATISFYING GWTT CRITERION

1. Identify pre-waste-emplacement environment
2. Identify likely paths
3. Calculate GWTT along each path
4. Pick shortest GWTT

PRE-WASTE-EMPLACEMENT ENVIRONMENT

- Pre-disturbance
- Present-day environment
- Not large-scale, duration changes

IDENTIFYING THE FASTEST PATH

1. Paths are macroscopic; e.g. fractured zones, aquifers

2. Paths must carry significant fraction of water flowing by the disturbed zone

3. Alternative paths may be defined by different conceptual models

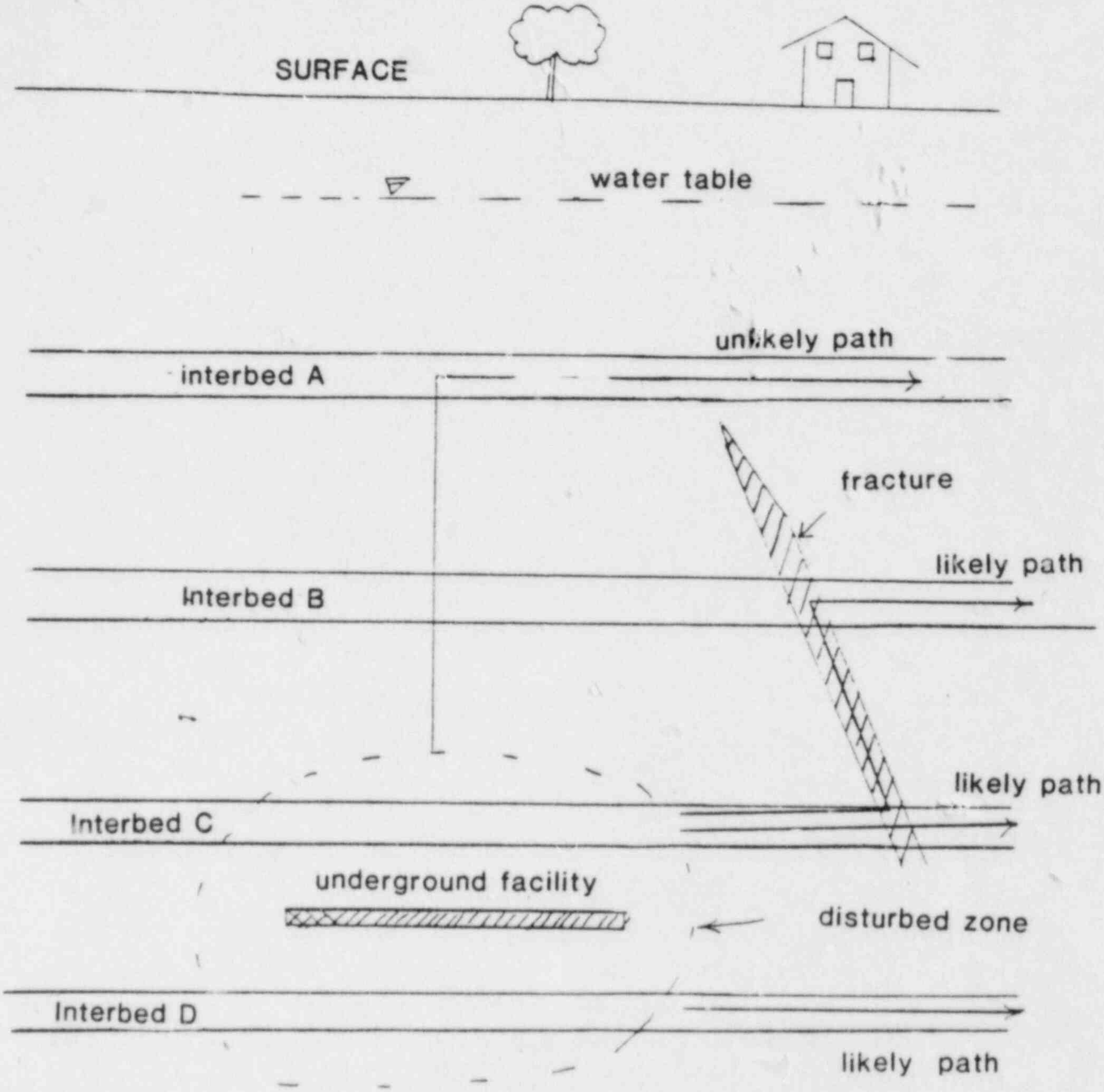


Figure B.1 - Definition of Paths in Saturated Media

ACRS S[...]MITTEE BRIEFING: 1/15/86

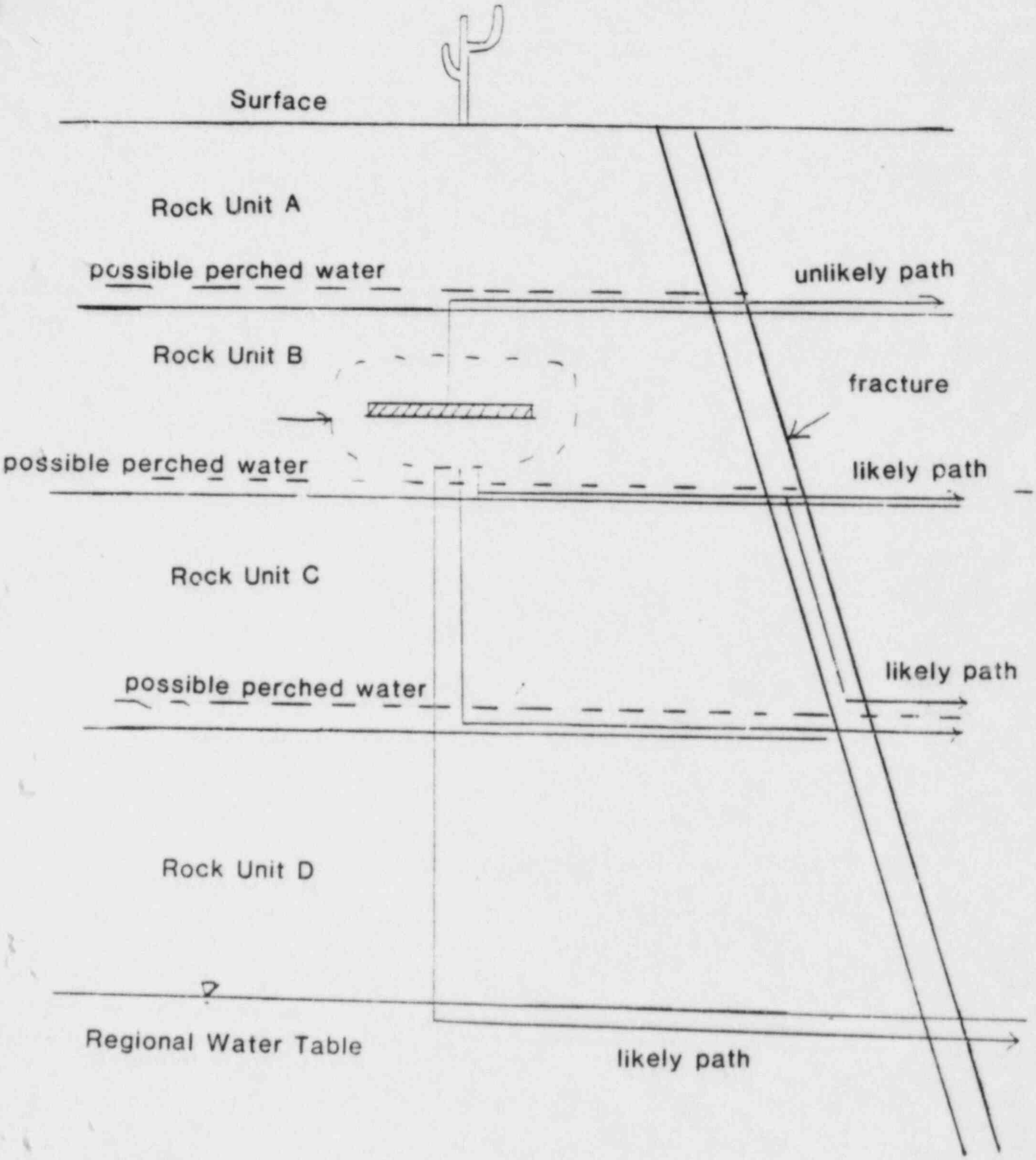


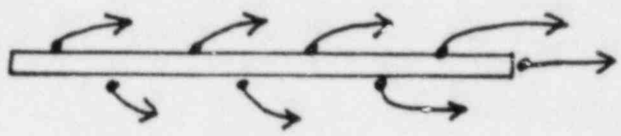
Figure B.2 - Definition of Paths in Unsaturated Media

GWTT Represented as a Distribution

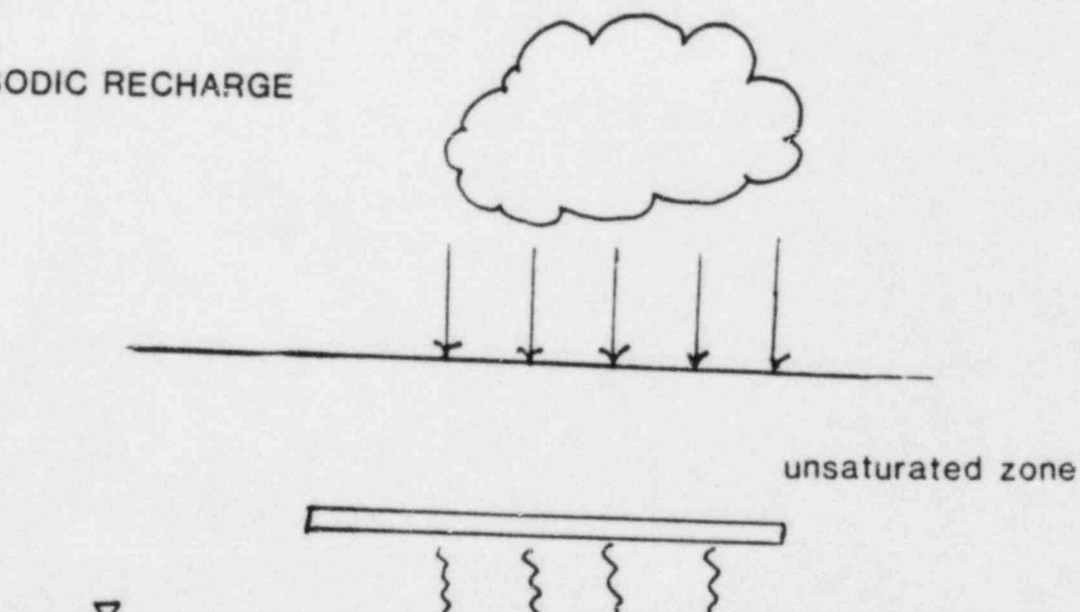
- DZ and accessible environment are surfaces
- Data uncertainty
- Episodic recharge
- Diffusion and dispersion

CAUSES OF DISTRIBUTED TRAVEL TIME

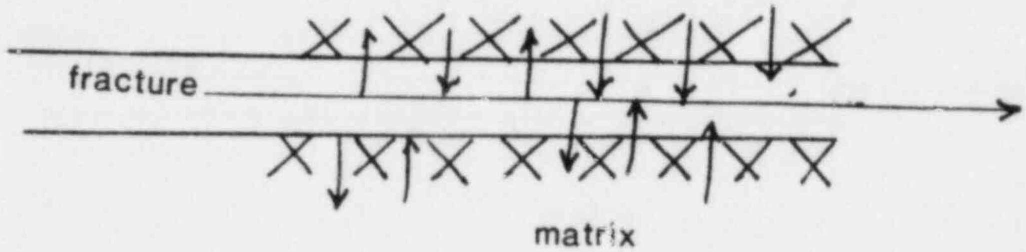
DISTRIBUTED SOURCE AND ACCESSIBLE ENVIRONMENT



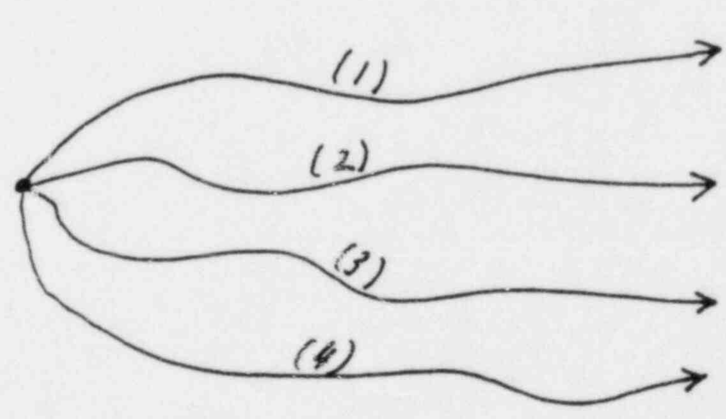
EPISODIC RECHARGE

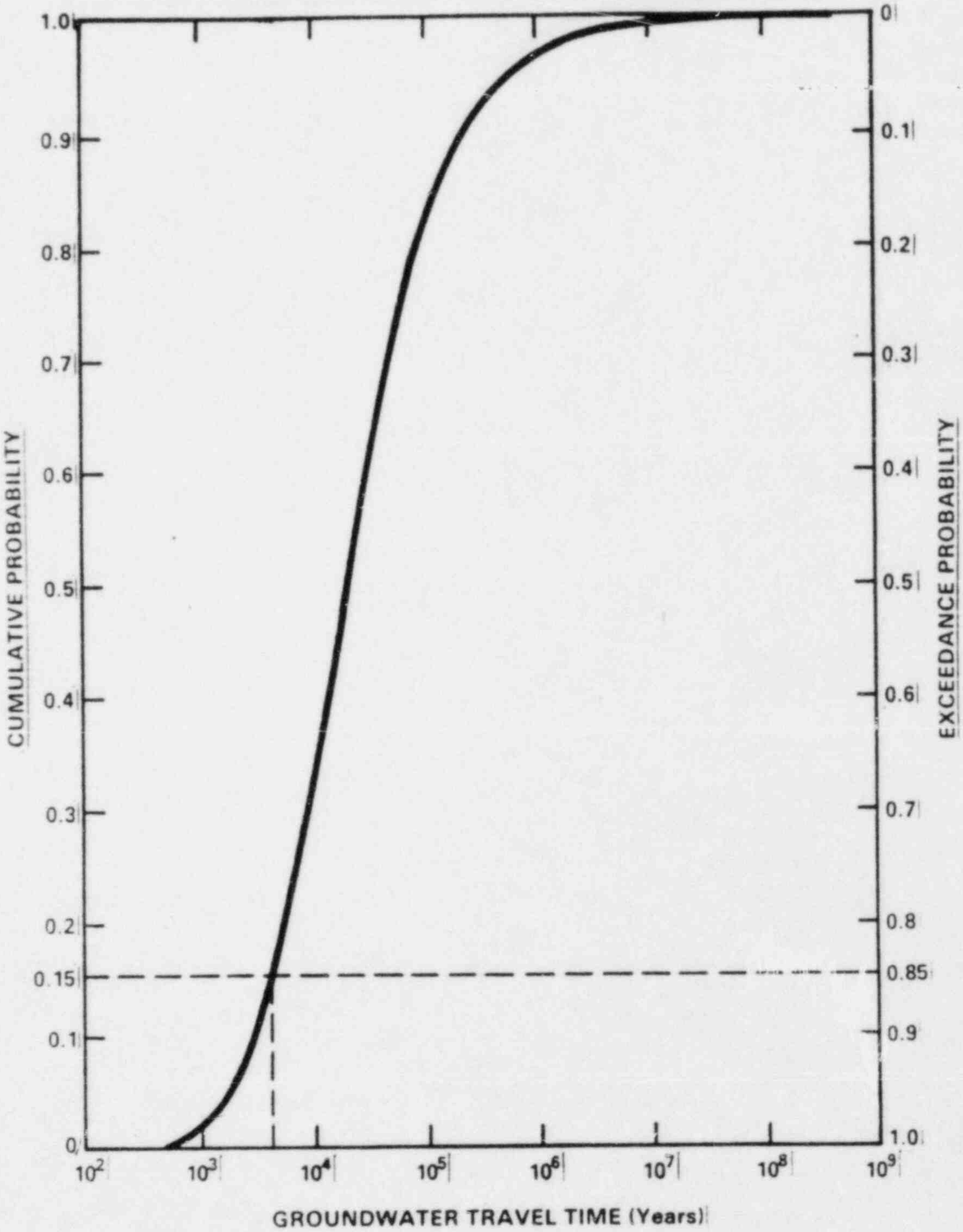


MATRIX DIFFUSION



MULTIPLE REALIZATIONS OF DATA





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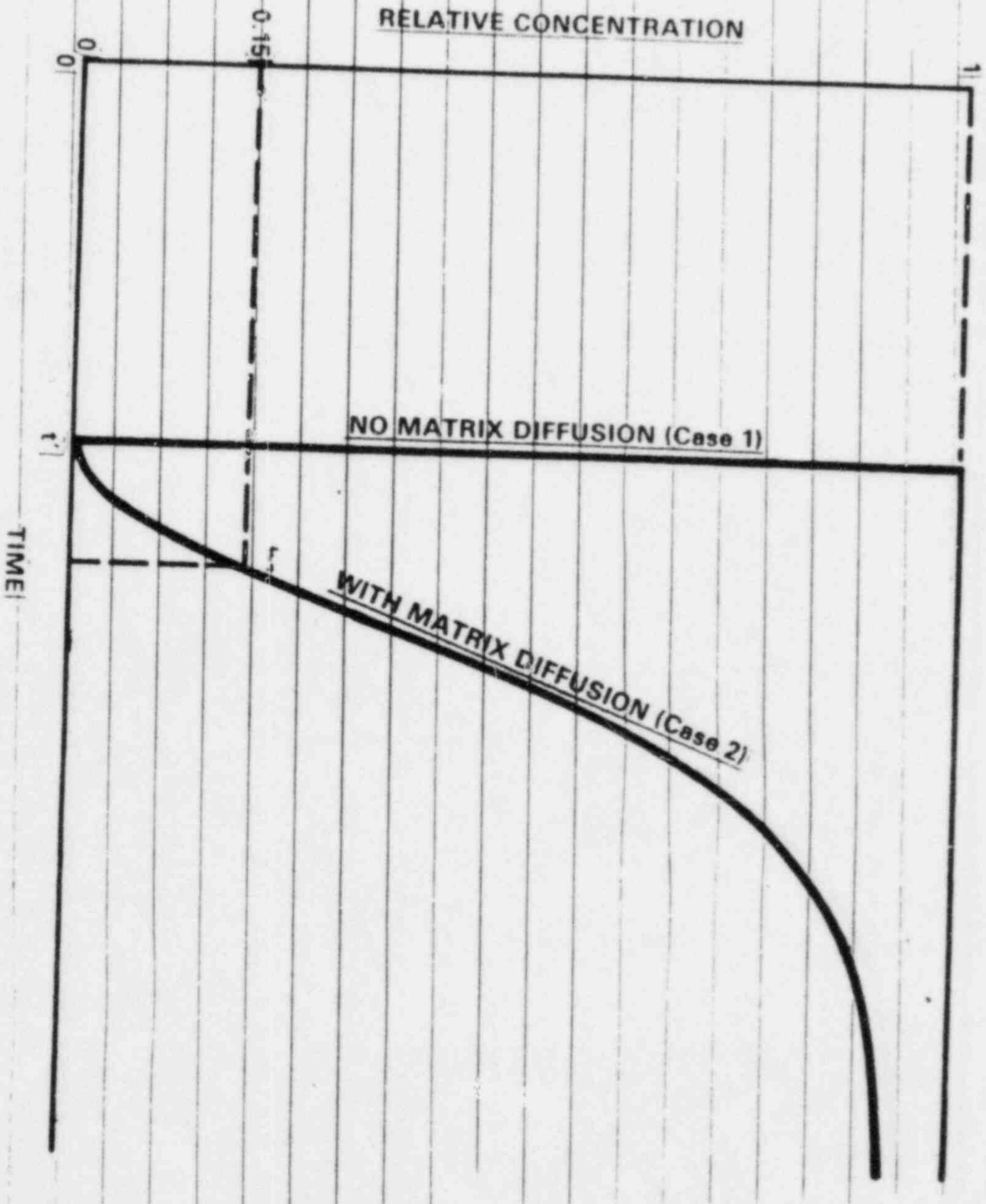
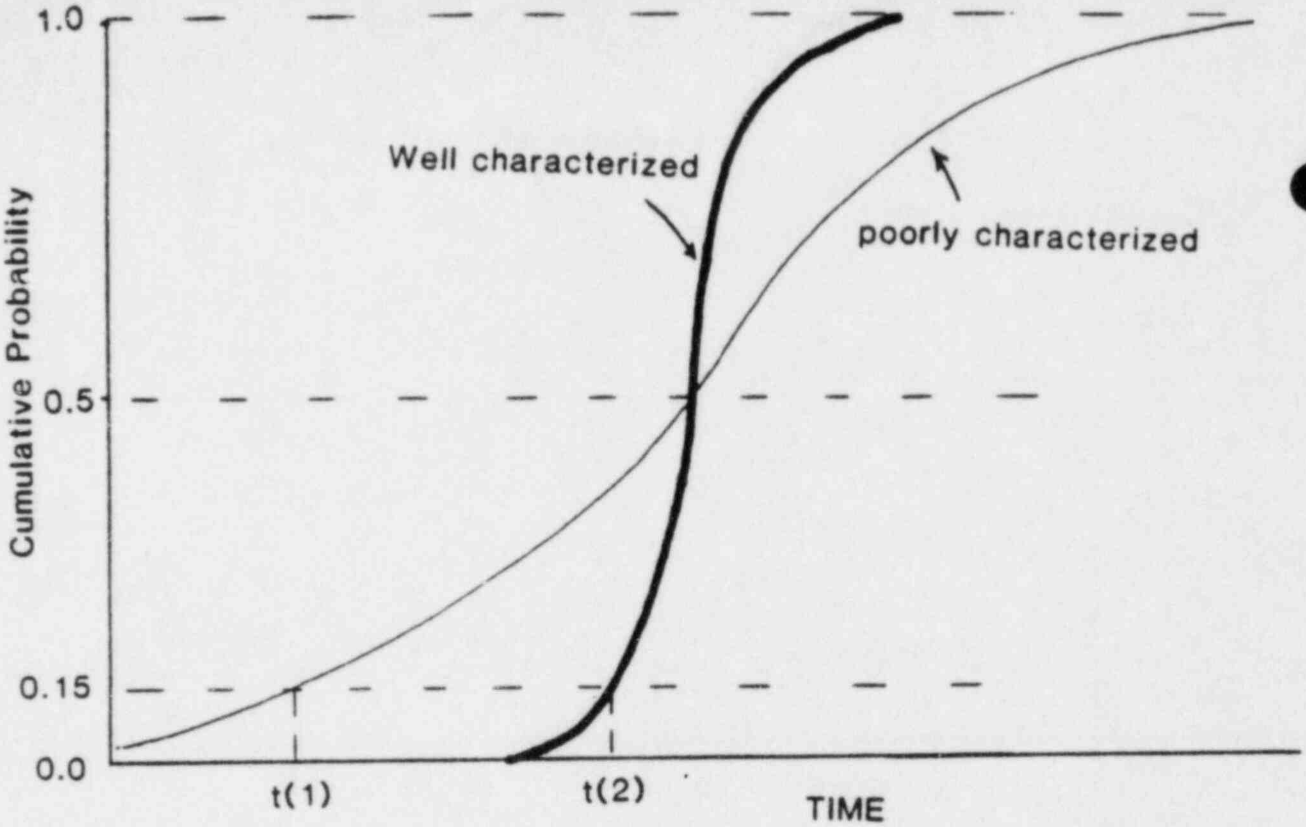
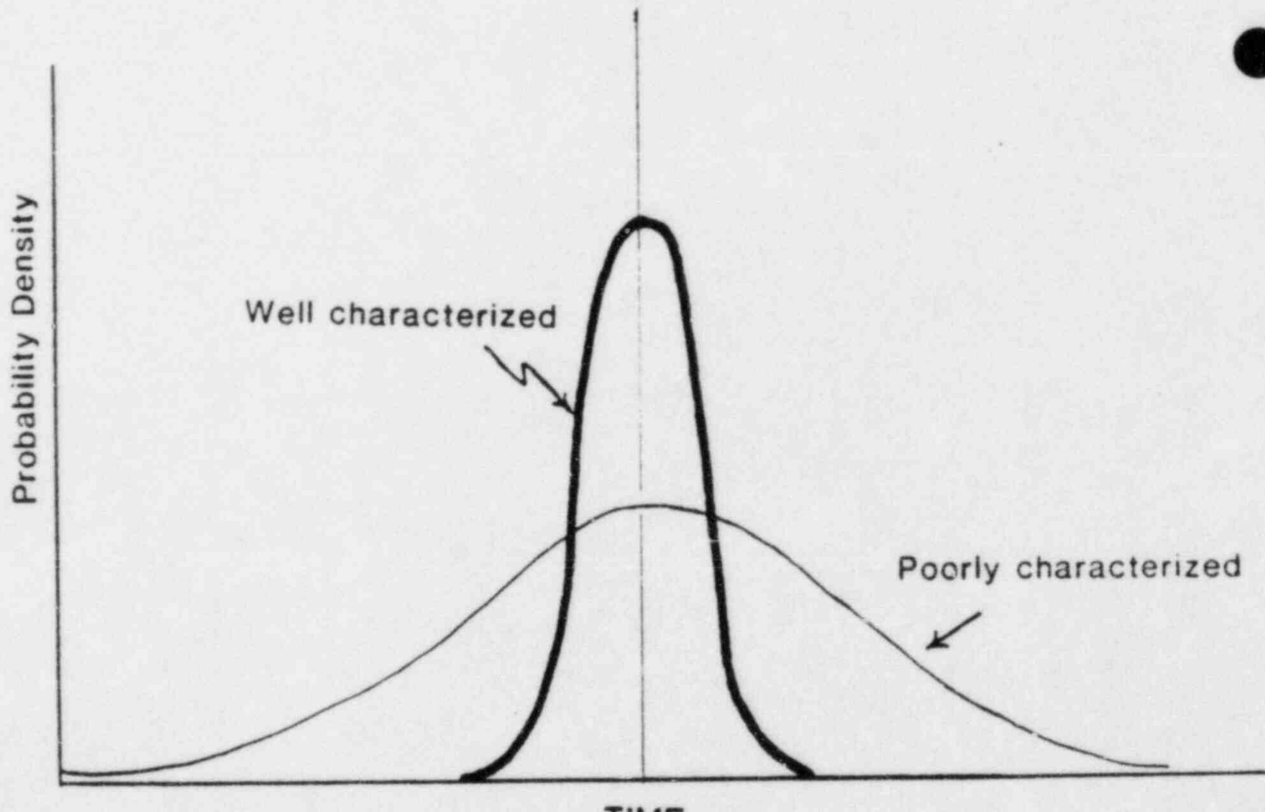

RELATIVE CONCENTRATION
0
0.15
1
NO MATRIX DIFFUSION (Case 1)
WITH MATRIX DIFFUSION (Case 2)
TIME
t'





CHOICE OF FRACTION FOR GWTT CUMULATIVE DISTRIBUTION

STATEMENT OF NRC POSITION ON GROUNDWATER TRAVEL TIME

1. Determine paths of likely radionuclide travel
2. Determine the pre-emplacement GWTT for the paths
3. Select path with fastest travel time

PERFORMANCE ASSESSMENT MODELING

NRC's HLW Research Program

OBJECTIVES

IDENTIFICATION AND DELINEATION OF AREAS OF

CONTROVERSY

UNCERTAINTY

IGNORANCE

WITH RESPECT TO PHENOMENA THAT CAN INFLUENCE THE TRANSPORT OF RADIONUCLIDES FROM EMPLACED HLW TO THE ACCESSIBLE ENVIRONMENT.

DEVELOPING ESSENTIAL TECHNICAL EXPERTISE TO SUPPORT NRC'S PRELICENSING CONSULTATIONS WITH DOE AND LICENSING REVIEWS.

ASSESSING THE PRICE OF SIMPLIFICATION ASSOCIATED WITH THE SIMPLIFIED MODELS THAT WILL BE USED IN PREDICTING REPOSITORY PERFORMANCE.

Implementation of EPA standard by NRC

|------------------- NRC HLW Regulation-------------|

Regulatory Approach		Containment of radio-nuclides	Controlled release of radionuclides	Ground water travel time	EPA HLW Radiological Standard
Major Technical Issues	Ground water contact with HLW canister	Containment failure	Radionuclides released to and through near field	Radionuclides travel through far field	Radionuclides released to accessible environment
Research Project Categories		Materials and Engineering Projects	Hydrology and Geochemistry Projects		

|----------------- Compliance Assessment and Modeling Projects -------------------|

Host Materials Under Consideration by DOE	Fractured basalt (BWIP)	Fractured tuff (NTS)	Bedded salt (Deaf Smith)

|--------------------- All NRC HLW Research Projects ------------|

WHY MODELING?

ONE CAN NOT CONSTRUCT AND TEST FULLY A PROTOTYPICAL GEOLOGIC REPOSITORY OVER ITS ISOLATION PERIOD TO PROVIDE A COMPLETE SET OF EMPIRICAL INFORMATION ON HOW IT WILL WORK.

DEMONSTRATIONS OF COMPLIANCE WITH REGULATORY CRITERIA WILL CONSIST OF EXTRAPOLATIONS OF SHORT-TERM TESTS TO LONG-TERM SITUATIONS.

THE TESTS UPON WHICH THE EXTRAPOLATIONS ARE BASED WILL BE CONDUCTED ONLY FOR VARIOUS COMPONENTS OF A REPOSITORY.

THE MODELING PROCESS

Qualitative models and limitations

Quantitative models and limitations

Direct problems

Inverse problems

- Calibration and uniqueness

EXTRACTING NUMBERS FROM QUANTITATIVE MODELS

Solution procedures

Role of computers

ALTERNATIVES TO MATHEMATICAL MODELING -- PHYSICAL MODELS

ANALOGUES

SCALE MODELS (PRINCIPLE OF SIMILARITY)

VALIDATION

In HLW applications, rigorous validation of models is not possible.

STATUS OF MODELING FOR DEEP GEOLOGIC DISPOSAL OF HLW

Waste Package

- Corrosion - uniform vs. pitting
- Release of radionuclides from waste form - leaching and dissolution

FLOW OF GROUNDWATER

- EQUIVALENT POROUS MEDIA
- DUAL POROSITY
- DISCRETE FRACTURE
- ALTERATION OF FLOW PATHS DUE TO THERMOCHEMICAL EFFECTS
- SATURATED AND UNSATURATED MEDIA

Transport of radionuclides

- Dispersion
- Geochemical effects
- Matrix diffusion

CONCLUSIONS

MUCH SCIENTIFIC WORK NEEDS TO BE DONE BEFORE THE CONTROVERSIES, UNCERTAINTIES, AND IGNORANCES ASSOCIATED WITH PREDICTING THE BEHAVIOR OF PHENOMENA AFFECTING HLW REPOSITORY PERFORMANCE ARE RESOLVED, REFINED, AND REMOVED.

LICENSING DECISIONS WILL HAVE TO BE MADE BEFORE THIS STATE OF AFFAIRS IS REACHED; THE ROLE OF JUDGMENT WILL BE VERY STRONG IN MAKING LICENSING DECISIONS.

THE TECHNICAL BASE SUPPORTED BY NRC'S HLW RESEARCH PROGRAM WILL BE USED TO REVIEW DOE'S LICENSE APPLICATIONS AND FORMULATE AND APPLY JUDGMENTS SO THAT CONFIDENT LICENSING DECISIONS CAN BE MADE.

WATER ENTRY INTO DISPOSAL UNITS

ACCOMPLISHMENTS:

- CURRENT CAPPING TECHNOLOGY HAS LED TO COVER SUBSIDENCE AND WATER ENTRY INTO DISPOSAL UNITS
- THE USE OF VEGETATION, SLOPES, AND CAREFUL CROPPING METHODS CAN EFFECTIVELY ELIMINATE DEEP PERCOLATION OF WATER BUT ONLY UNDER OPTIMAL CONDITIONS
- EXPERIMENTAL TESTS IN SMALL SCALE LYSIMETERS INDICATE THAT A BIOENGINEERED SYSTEM USING VEGETATION AND ENHANCED RUNOFF CAN ELIMINATE DEEP PERCOLATION THROUGH DISPOSAL UNIT COVERS

NEW WORK

- FIELD EXPERIMENTS WILL BE USED TO ASSESS THE EFFECTIVENESS OF TRENCH CAPS OF VARIOUS DESIGNS FOR CONTROLLING DEEP WATER PERCOLATION INTO DISPOSAL UNITS

VARIABILITY OF THE SOURCE TERM

ACCOMPLISHMENTS:

- REDUCING CONDITIONS DOMINATE IN TRENCHES WITH STANDING WATER

- ABUNDANT H_2S, NH_3, FERROUS IRON, DISSOLVED ORGANICS ARE COMMON TO TRENCHS WITH STANDING WATER

- MANY OF EPA POLLUTANTS PRESENT IN TRENCHES WITH STANDING WATER

PERFORMANCE ASSESSMENT

ACCOMPLISHMENTS:

- INFORMATION TO SUPPORT GEOCHEMICAL MODELS
    - GREATEST CHEMICAL CHANGES OCCURRED WITHIN 1 METER OF DISPOSAL UNITS
    - ORGANIC COMPLEXANTS, A COMMON COMPONENT OF WASTE, MOBILIZED RADIONUCLIDES
    - TREE ROOT EXUDATES MOBILIZE RADIONUCLIDES

NEW WORK:

- CONTINUE TO IDENTIFY CHEMICAL SPECIES OF MIGRATING RADIONUCLIDES

PERFORMANCE ASSESSMENT

INFORMATION TO SUPPORT HYDROLOGIC MODELS

ACCOMPLISHMENTS:

- DEVELOPED METHODS FOR STOCHASTIC REPRESENTATION OF SPATIAL VARIABILITY OF UNSATURATED HYDRAULIC SOIL PROPERTIES

- DEVELOPED METHODS FOR TESTING THE VALIDITY OF THE STOCHASTIC THEORY

NEW WORK:

- CONDUCT FIELD EXPERIMENTS TO VALIDATE STOCHASTIC APPROACH

PERFORMANCE ASSESSMENT (CONTINUED)

- INFORMATION TO SUPPORT ENVIRONMENTAL MONITORING
  - TRITIUM UPTAKE IN TREES AND GRASSES CAN INDICATE RADIONUCLIDE MOVEMENT MISSED BY CONVENTIONAL MONITORING WELLS
- INFORMATION TO SUPPORT MODELABILITY OF LLW SITES
  - FIRST PART OF AN ASSESSMENT OF THE CURRENT STATE OF MODELING TECHNIQUES AT A LLW SITE HAS BEEN COMPLETED

LLW WASTE FORM AND PACKAGING

ACCOMPLISHMENTS

- 0 IDENTIFIED KY PROCESSING PARAMETERS AND NECESSARY CONDITIONS TO SOLIDIFY LIQUID LLW IN CEMENT, BITUMEN, AND VINYL ESTER STYRENE.
- 0 IDENTIFIED FREE WATER PROBLEM ASSOCIATED WITH UREAFORMALDEHYDE WASTE FORM.
- 0 ESTABLISHED TEST PROCEDURES FOR LLW WASTE FORMS LEACHABILITY, COMPRESSIBILITY, AND RADIATION STABILITY.
- 0 ESTABLISHED RELATION BETWEEN SPECIMEN SIZE AND LEACHABILITY OF CEMENT WASTE FORM.
- 0 ESTABLISHED THE EFFECT OS WET-DRY CYCLING ON LEACHABILITY OF CEMENT WASTE FORM.
- 0 INVESTIGATED THE MECHANICAL STRENGTH OF HIGH DENSITY POLYETHYLENE (HDPE) MATERIALS FOR USES IN HIGH INTEGRITY LLW CONTAINERS.

NEW WORK

- 0 INVESTIGATION OF PROPERTIES OF NEW WASTE FORM SUCH AS POLYMER IMPREGNATED CEMENT AND GYPSUM CEMENT.
- 0 INVESTIGATION OF CONTAINMENT PROPERTIES OF ENGINEERED FEATURES OF SLB ALTERNATIVES (E.G., SURE-PACK WASTE CONTAINERS).

NRC RESEARCH - ENGINEERED ENHANCEMENTS

AND

ALTERNATIVES TO SHALLOW LAND BURIAL

BACKGROUND

- 0 STATES BEING DRIVEN TO ALTERNATIVES
- 0 NO CLEAR STATEMENT OF TECHNICAL PURPOSE FOR ALTERNATIVE
- 0 COORDINATING COMMITTEE FOR LLW DISPOSAL TECHNOLOGY

LLW-ALTERNATIVES RESEARCH

- O SAFETY ASSESSMENT OF ALTERNATIVES
- O DEVELOPMENT OF SITING CRITERIA FOR ALTERNATIVES
- O DEVELOPMENT OF DESIGN CRITERIA FOR ALTERNATIVES

SAFETY ASSESSMENT OF ALTERNATIVES TO SHALLOW LAND BURIAL OF LOW LEVEL WASTE

OBJECTIVE:

1) IDENTIFICATION OF THE ENGINEERING FEATURES IMPORTANT TO SAFETY OF THE ENGINEERED ENHANCEMENTS/ALTERNATIVES TO SHALLOW LAND BURIAL

2) ESTIMATION OF THE CONSEQUENCES (I.E., RELEASE OR RADIONUCLIDES) OF FAILURE OF THE ENGINEERED FEATURES IDENTIFIED AS IMPORTANT TO SAFETY

CONTRACTOR: INEL

FY 1986 WORKSCOPE (ONE MAN YEAR EFFORT)

TASK 1: ALTERNATIVE METHODS REVIEW

LITERATURE REVIEW OF THE CONCEPTUAL DESIGNS OF THE FOLLOWING FIVE ENHANCEMENTS/ALTERNATIVES TO SHALLOW LAND BURIAL: MINED CAVITY, ABOVE GRADE ENGINEERED VAULT, BELOW GRADE ENGINEERED VAULT, AUGURED HOLES, AND CONCRETE BUNKERS

TASK 2: IDENTIFICATION OF IMPORTANT DESIGN COMPONENTS

IDENTIFICATION OF SIGNIFICANT DESIGN FEATURES THAT CAUSE AN ENHANCEMENT/ALTERNATIVE TO DIFFER FROM SHALLOW LAND BURIAL AND THE RELATIVE ENHANCEMENTS AND/OR DETRIMENTS ASSOCIATED WITH THE IDENTIFIED FEATURES

TASK 3: RANKING OF IMPORTANT DESIGN COMPONENTS

RELATIVE RANKING OF THE DESIGN FEATURES ACCORDING TO THEIR CONTRIBUTION TO THE OVERALL DESIGN PERFORMANCE

FY 1987 WORKSCOPE (TWO MAN YEARS EFFORT)

QUANTIFICATION OF THE BENEFITS/RISKS ASSOCIATED WITH THE DESIGN FEATURES DETERMINED TO BE IMPORTANT TO OVERALL FACILITY PERFORMANCE

BASIS OF TECHNICAL APPROACH

- o IDENTIFICATION OF DESIGN COMPONENTS

  DERIVED FROM "SUMMARY CHARACTERIZATION OF LOW-LEVEL RADIOACTIVE WASTE DISPOSAL TECHNOLOGIES," ROGERS & ASSOC. ENGINEERING, TIM 8504/1-1, JUNE 1985.

- o DEFINITION OF PERFORMANCE OBJECTIVES

  FOLLOWS 10CFR61 "LICENSING REQUIREMENTS FOR LAND DISPOSAL OF RADIOACTIVE WASTE" SUBPART C - PERFORMANCE OBJECTIVES.

- o ANALYSIS OF ALTERNATIVES

  BASED ON FAILURE MODE AND EFFECT ANALYSIS (FMEA). FIGURES OF MERIT ARE CALCULATED FOR:

  - RELATIVE IMPORTANCE OF EACH COMPONENT WITHIN EACH ALTERNATIVE.

FUNCTIONS OF FOUR DESIGN COMPONENTS

COMPONENT	FUNCTIONS
COVER	- Bio-barrier - Diverts incident water - Prevents airborne release - Shields direct radiation
STRUCTURE	- Assures stability - Prevents release to air, water - Shields direct radiation
FILL	- Assures stability - Shields direct radiation
CONTAINER	- Assures stabiltiy - Prevents release to air, water - Shields during operations

PERFORMANCE OBJECTIVES (10 CFR 61)

1. PROTECTION OF THE GENERAL POPULATION FROM RELEASES OF RADIOACTIVITY. (IMMEDIATE SEPARATION FROM BIOSPHERE.)
2. STABILITY OF DISPOSAL SITE AFTER CLOSURE. (MINIMIZE FUTURE AVAILABILITY TO ENVIRONMENT.)
3. PROTECTION OF INDIVIDUALS FROM INADVERTANT INTRUSION.
4. PROTECTION OF INDIVIDUALS DURING OPERATIONS (ALARA PRINCIPLES).

ADDITIONAL ASSUMPTIONS (10 CFR 61)

- ALL SITE SUITABILITY REQUIREMENTS OF 10 CFR 61 ARE MET.
- ALL WASTE FORM CHARACTERISTICS ARE IN COMPLIANCE WITH 10 CFR 61.

THIS SAFETY ANALYSIS FOCUSES ON FIVE CONSEQUENCES OF COMPONENT FAILURE

CONSEQUENCE	RELATED PERFORMANCE OBJECTIVES
1. DIRECT RADIATION EXPOSURE	1,4
2. RELEASE TO ATMOSPHERE	1
3. RELEASE TO SURFACE OR GROUNDWATER	1
4. REPAIR OR MAINTENANCE REQUIRED	2,4
5. EXPOSURE OF INTRUDER	3

FAILURE MECHANISM ANALYSIS

- FOR EACH DESIGN COMPONENT, FAILURE MECHANISMS WILL BE IDENTIFIED (ENGINEERING ANALYSIS, HISTORICAL EVIDENCE, ETC.)

- FAILURE MECHANISMS WILL BE CATEGORIZED BY HOW THEY MAY BE MITIGATED (DESIGN, CONSTRUCTION QC, SITE SELECTION, OPERATIONS QC, ETC.)

- DESIGN ENHANCEMENTS WILL BE PROPOSED AND THE RESULTING INCREASE IN PERFORMANCE RANKING FACTOR WILL BE ESTIMATED WHERE APPROPRIATE. THIS WILL HELP IDENTIFY THE ALTERNATIVES FOR SUBSEQUENT COST/BENEFIT ANALYSES.

INTERNATIONAL WASTE MANAGEMENT RESEARCH

RESEARCH AGREEMENTS

- JAERI (JAPAN)
- CEA (FRANCE)
- NAGRA (SWITZERLAND - PROPOSED)

COOPERATIVE PROGRAMS

- AUSTRALIA - AAEC
- CANADA - AECL (POTENTIAL)
- HYDROCOIN
- INTERVAL (PROPOSED)

- 0 JAERI (JAPAN)
  - 0 RESEARCH AGREEMENT SIGNED NOVEMBER 1984 FOR 5 YEARS
  - 0 SCOPE OF COOPERATION
    - PERSONNEL EXCHANGE
    - RESEARCH INFORMATION EXCHANGE
    - JOINT EXPERIMENTS
    - ANNUAL TECHNICAL MEETING
  - 0 COOPERATION
    - JAERI STAFF ASSIGNMENT AT SNL AND BCL FOR ONE YEAR
    - JAERI STAFF ASSIGNMENT AT PNL FOR ONE YEAR
    - JAERI CONDUCTING 3 EXPERIMENTS FOR NRC
    - ACTIVE INFORMATION EXCHANGE UNDERWAY

JAERI EXPERIMENTS

- O FLOW-THROUGH TEST OF HLW GLASS
  - O MCC-4 TYPE LEACHABILITY TEST OF PNL 76-68 GLASS WITH BWIP WATER CHEMISTRY
- O SLOW-STRAIN RATE TEST OF CARBON STEEL UNDER IRRADIATION
  - O ASTM STP 665 TESTS UNDER IRRADIATION TO EVALUATE SUSCEPTIBILITY OF CARBON STEEL TO STRESS-CORROSION CRACKING
- O LLW MIGRATION STUDY
  - O CURRENTLY UNDER DISCUSSION

- 0 CEA FRANCE
  - 0 TECHNICAL EXCHANGE AND COOPERATION AGREEMENT SIGNED JANUARY 1984, FOR 5 YEARS
  - 0 SCOPE OF COOPERATION
    - PERSONNEL EXCHANGE
    - JOINT PROGRAMS AND PROJECTS
    - INFORMATION EXCHANGE
    - DEFINE SPECIFIC AREAS OF RESEARCH

- O NAGRA SWITZERLAND
  - O RESEARCH AGREEMENT UNDER NEGOTIATION
  - O PROPOSED SCOPE OF COOPERATION
    - PERSONNEL EXCHANGE
    - RESEARCH INFORMATION EXCHANGE
    - JOINT EXPERIMENTS (LABORATORY/NRC - FIELD/NAGRA)
    - ANNUAL TECHNICAL MEETING

NAGRA EXPERIMENTS (POTENTIAL)

- 0 NON ISOTHERMAL FRACTURE FLOW EXPERIMENT
- 0 INSITU HEATER EXPERIMENT
- 0 INTERGRATED WASTE PACKAGE EXPERIMENT

HYDROCOIN - HYDROLOGIC CODE INTERCOMPARISON

AN INTERNATIONAL PROJECT FOR STUDYING GROUND-WATER HYDROLOGY MODELING STRATEGIES

NOVEMBER 18-31, 1985 PARIS, FRANCE OECD/NEA

MAY 26-30, 1986 TOKYO, JAPAN JAERI

NOVEMBER 10-14, 1986 LEIDSCHENDAM, THE NETHERLANDS RIVM

PURPOSE: "TO OBTAIN IMPROVED KNOWLEDGE OF THE INFLUENCE OF VARIOUS STRATEGIES FOR GROUND-WATER FLOW MODELING FOR THE SAFETY ASSESSMENT OF FINAL REPOSITORIES FOR NUCLEAR WASTE."

MEMBERS: NRC, DOE, UNITED KINGDOM (BGS, HARWELL, ATKINS), FRANCE (CEA/IPSN) CANADA (AECL), W. GERMANY (TUF, GSF), JAPAN (JAERI, UOK, HAZA, OKUM) SWITZERLAND (NAGRA, UON), THE NETHERLANDS (RIVM), SWEDEN (SKB, SKI), FINLAND (VTT)

HYDROCOIN STUDY OBJECTIVES ARE TO DETERMINE:

(A) THE IMPACT OF DIFFERENT SOLUTION ALGORITHMS ON THE GROUND-WATER FLOW CALCULATIONS.

(B) THE CAPABILITIES OF DIFFERENT MODELS TO DESCRIBE FIELD MEASUREMENTS.

(C) THE IMPACT ON THE GROUND-WATER FLOW CALCULATIONS OF INCORPORATING VARIOUS PHYSICAL PHENOMENON (E.G. DENSITY VARIATIONS DUE TO THERMAL GRADIENTS, HYDRAULIC DISCONTINUITIES).

HYDROCOIN STUDY STRUCTURE

LEVEL 1	LEVEL 2	LEVEL 3
VERIFY NUMERICAL ACCURACY OF GROUND-WATER FLOW CODES	VALIDATION OF MODELS USING FIELD AND/OR LABORATORY EXPERIMENTS	UNCERTAINTY/ SENSITIVITY ANALYSES

LEVEL 1

PURPO[illegible] VERIFICATION OF THE NUMERICAL ACCURACY OF GROUND-WATER FLOW PROGRAMS VIA THE INTERCOMPARISON OF RESULTS BETWEEN PROGRAMS AND, WHERE POSSIBLE, WITH ANALYTICAL SOLUTIONS

PROBLEM TYPES: 7 TEST CASES WHICH INCLUDE

- THREE-DIMENSIONAL REGIONAL FLOW
- UNSATURATED FLOW
- FRACTURE FLOW
- COUPLED HEAT AND FLOW
- COUPLED BRINE AND FLOW

FINDINGS:

- SCALAR FUNCTIONS (PRESSURE AND TEMPERATURE) HAVE, IN GENERAL, COMPARED WELL BETWEEN THE VARIOUS PROGRAMS
- DIFFERENCES BETWEEN PROGRAMS WERE GREATEST WHEN COMPARING VELOCITIES AND PATHLINES
- NON-LINEAR PROBLEMS (I.E. UNSATURATED FLOW AND BRINE TRANSPORT) ARE EXTREMELY DIFFICULT FOR CURRENT PROGRAMS TO MANIPULATE

LEVEL 2

PURPOSE: VALIDATION OF MODELS AND ASSOCIATED COMPUTER PROGRAMS BY TESTING THEIR ABILITY TO DESCRIBE THE RESULTS OF LABORATORY AND/OR FIELD EXPERIMENTS

PROBLEM TYPE: 5 PROBLEMS

- THREE-DIMENSIONAL REGIONAL FLOW
- UNSATURATED FLOW (NEAR SURFACE FIELD STUDY)
- FRACTURE FLOW (SMALL-SCALE FIELD STUDY)
- COUPLED HEAT AND FLOW (SMALL-SCALE FIELD STUDY)
- COUPLED BRINE AND FLOW (LABORATORY SCALE)

LEVEL 3

PURPOSE: TO EXPLORE APPROPRIATE WAYS OF USING HYDROGEOLOGIC MODELS IN PERFORMANCE ASSESSMENTS, CONSIDERING THE UNCERTAINTIES IN PRESENT AND FUTURE HYDROGEOLOGIC CONDITIONS.

PROBLEM AREAS:

- SENSITIVITY OF RESULTS TO SITE CHARACTERISTICS WHICH ARE POORLY KNOWN OR COULD CHANGE WITH TIME
- ALTERNATIVE METHODS FOR SENSITIVITY/UNCERTAINTY ANALYSES
- ALTERNATIVE METHODS FOR CALCULATIONS OF PATHLINE VELOCITIES

INTRAVAL

PURPOSE: TO CREATE AN INTERNATIONAL FORUM FOR EXCHANGE OF INFORMATION BETWEEN EXPERIMENTALISTS AND MODELERS FOR EVALUATING THE VALIDITY OF NUCLIDE TRANSPORT MODELS.

STATUS: FORMATION OF AD HOC GROUP IN EARLY 1986 TO INVESTIGATE AVAILABLE EXPERIMENTAL DATA AND TO FORM A PROPOSAL FOR TECHNICAL CONTENTS OF INTRAVAL INCLUDING PROPOSALS FOR EXPERIMENTS SUITABLE FOR USE IN VALIDATION EXERCISES AT BEGINNING OF PROJECT.

INITIATION: FALL 1986

DURATION: 3 YEARS (OPTION FOR ADDITIONAL 3 YEAR PERIOD)

ORGANIZATION: TO BE DETERMINED (POSSIBILITY OF SKI ACTING AS MANAGING PARTICIPANT)

NATURAL ANALOG:

AN OCCURRENCE IN NATURE OF MATERIALS AND/OR PROCESSES WHICH ARE ANALOGOUS TO EXPECTED MATERIALS AND/OR PROCESSES IN A PROPOSED GEOLOGIC REPOSITORY.

EXAMPLES:

- IRON NAILS WHICH HAVE SURVIVED IN THE GEOLOGIC ENVIRONMENT SINCE ROMAN TIMES
- GEOTHERMAL CIRCULATION OF GROUND WATER ABOVE A DEEP HEAT SOURCE
- URANIUM DEPOSITS AT THE INTERFACE OF OXIDIZED AND REDUCED ZONES

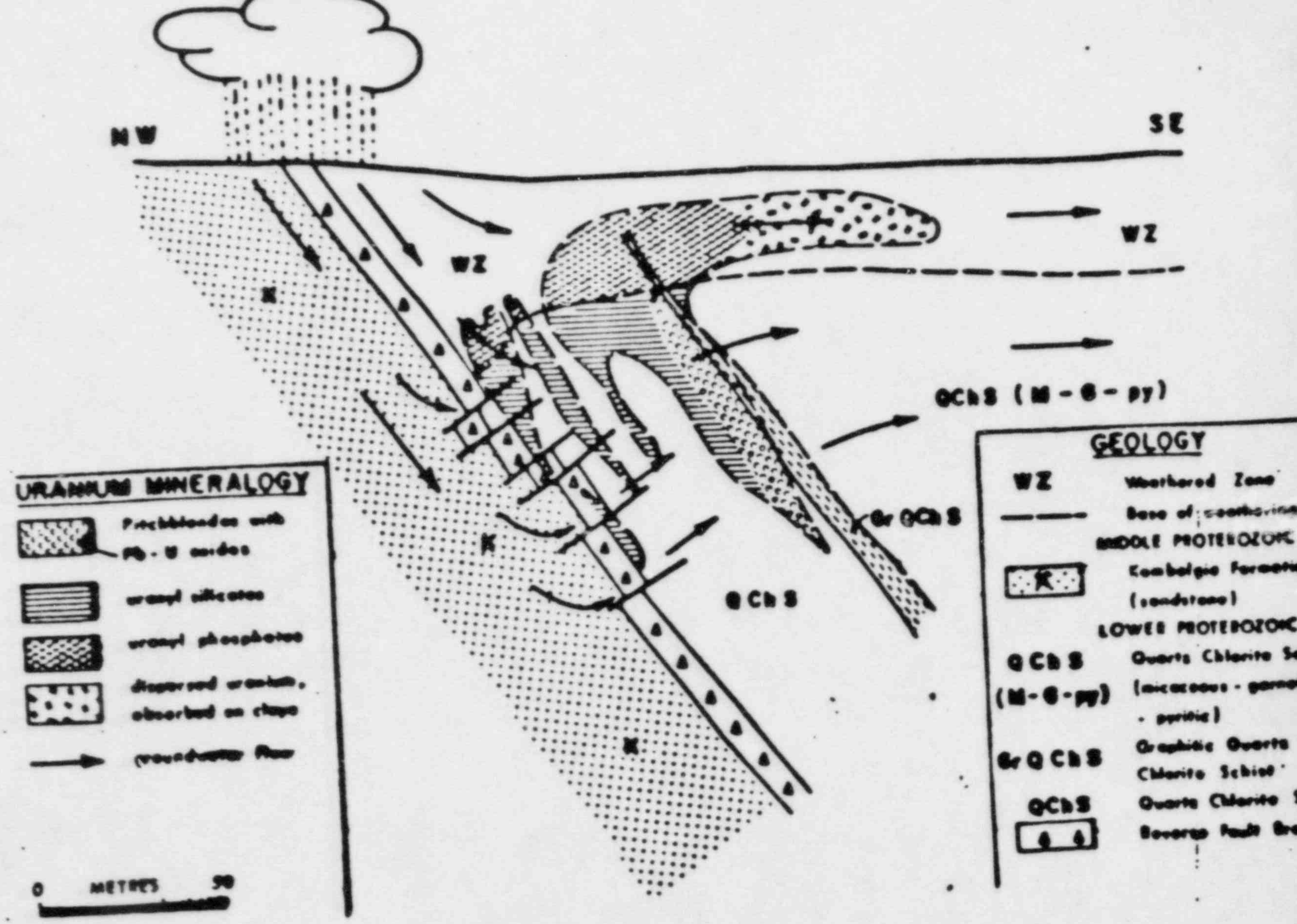
RESULTS OF AAEC LAB/FIELD STUDIES

THE EFFECTS OF TIME AND SCALE HAVE BEEN STUDIED

- CONDITIONS FOR WHICH COLLOID TRANSPORT MAY BE SIGNIFICANT FOR RADIONUCLIDE TRANSPORT HAVE BEEN IDENTIFIED

- PROCEDURES HAVE BEEN DEVELOPED FOR MEASURING ACTUAL RADIONUCLIDE MOBILITY IN THE FIELD

- LABORATORY PROCEDURES HAVE BEEN DEVELOPED FOR CONSERVATIVELY MEASURING RADIONUCLIDE MOBILITY



NW
SE
WZ
WZ
QChS (M - G - py)
Gr QChS
QChS
K
K
K
URANIUM MINERALOGY
Pitchblendes with
Pb - U oxides
uranyl silicates
uranyl phosphates
dispersed uranium,
absorbed on clays
groundwater flow
0 METRES 50
GEOLOGY
WZ
Weathered Zone
Base of weathering
MIDDLE PROTEROZOIC
K
Kombolgie Formation
(sandstone)
LOWER PROTEROZOIC
QChS
(M-G-py)
Quartz Chlorite Sch
(micaceous - garne
- pyritic)
GrQChS
Graphitic Quartz
Chlorite Schist
QChS
Quartz Chlorite S
Reverse Fault Bre

FIGURE 12

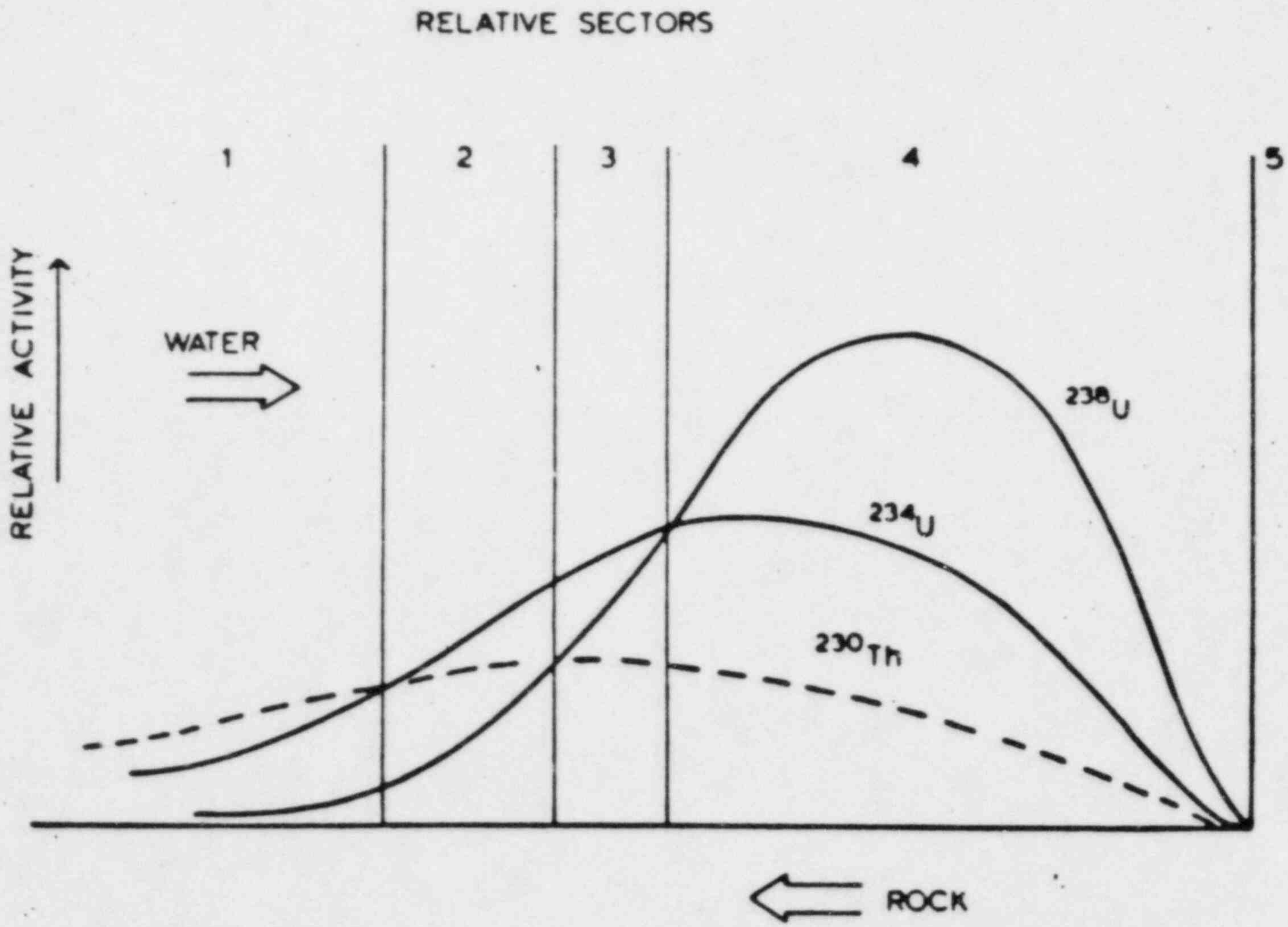


FIGURE 13 Relative distribution of ^{238}U, ^{234}U and ^{230}Th in a redox frontal system, assuming that ^{234}U is retarded relative to ^{238}U. The resulting radioactivity ratios define a sequence of sectors from up-flow (1) to down-flow (4).

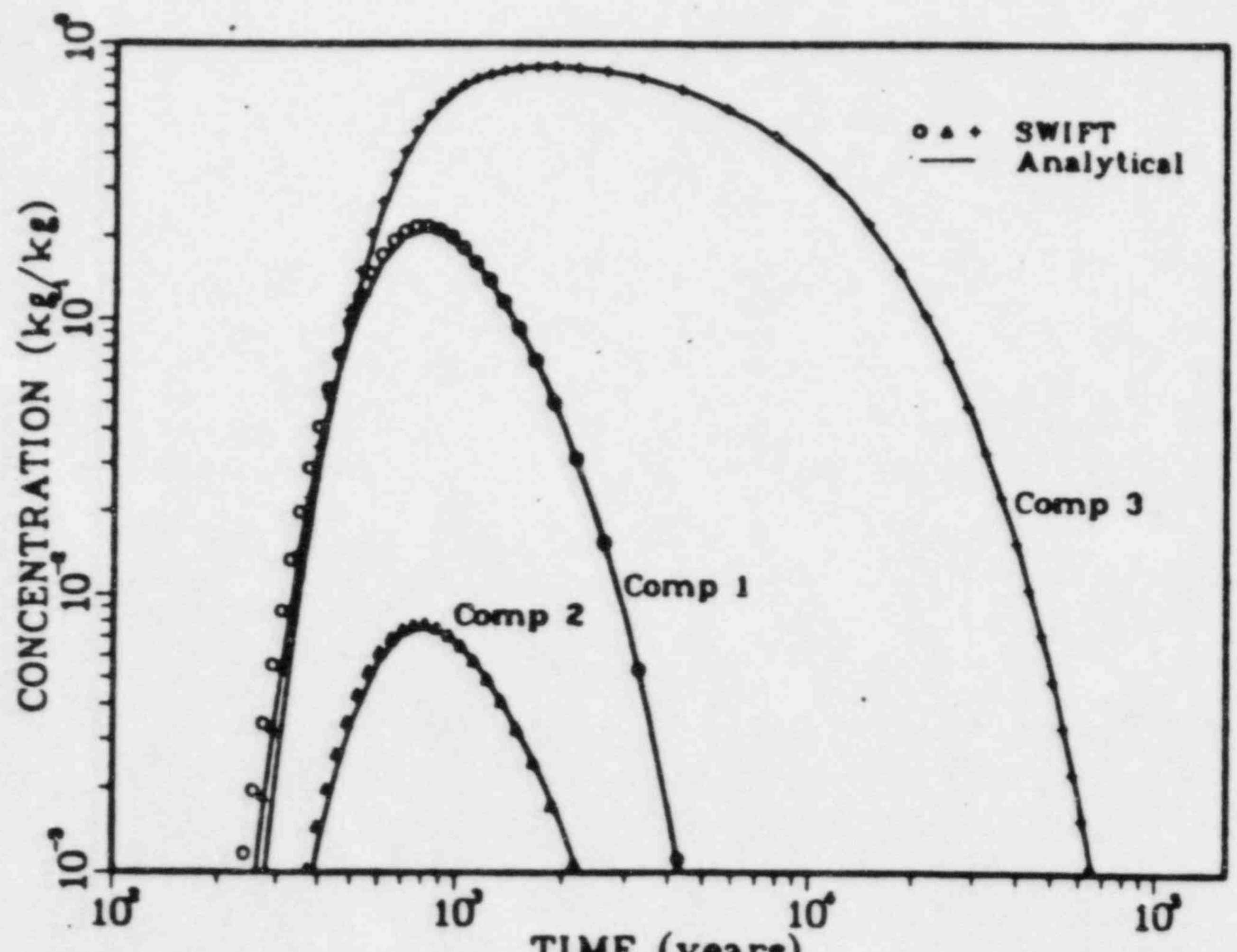


FIGURE 15 Radionuclide Discharge Concentration as a Function of Time.

POTENTIAL AREAS FOR FUTURE ANALOG STUDIES

- HYDROTHERMAL CONVECTION IN ICELANDIC BASALT
- HYDROTHERMAL CONVECTION IN NEW ZEALAND TUFF
- UNSATURATED ZONE HYDROTHERMAL EFFECTS IN TUFF SOUTHWESTERN - U.S. TUFF OR NEW ZEALAND TUFF
- STABILITY OF BENTONITE AT DIFFERENT TEMPERATURES IN MONTANA CLAYS
- HYDROTHERMAL CONVECTION IN WESTERN U.S. GRANITE

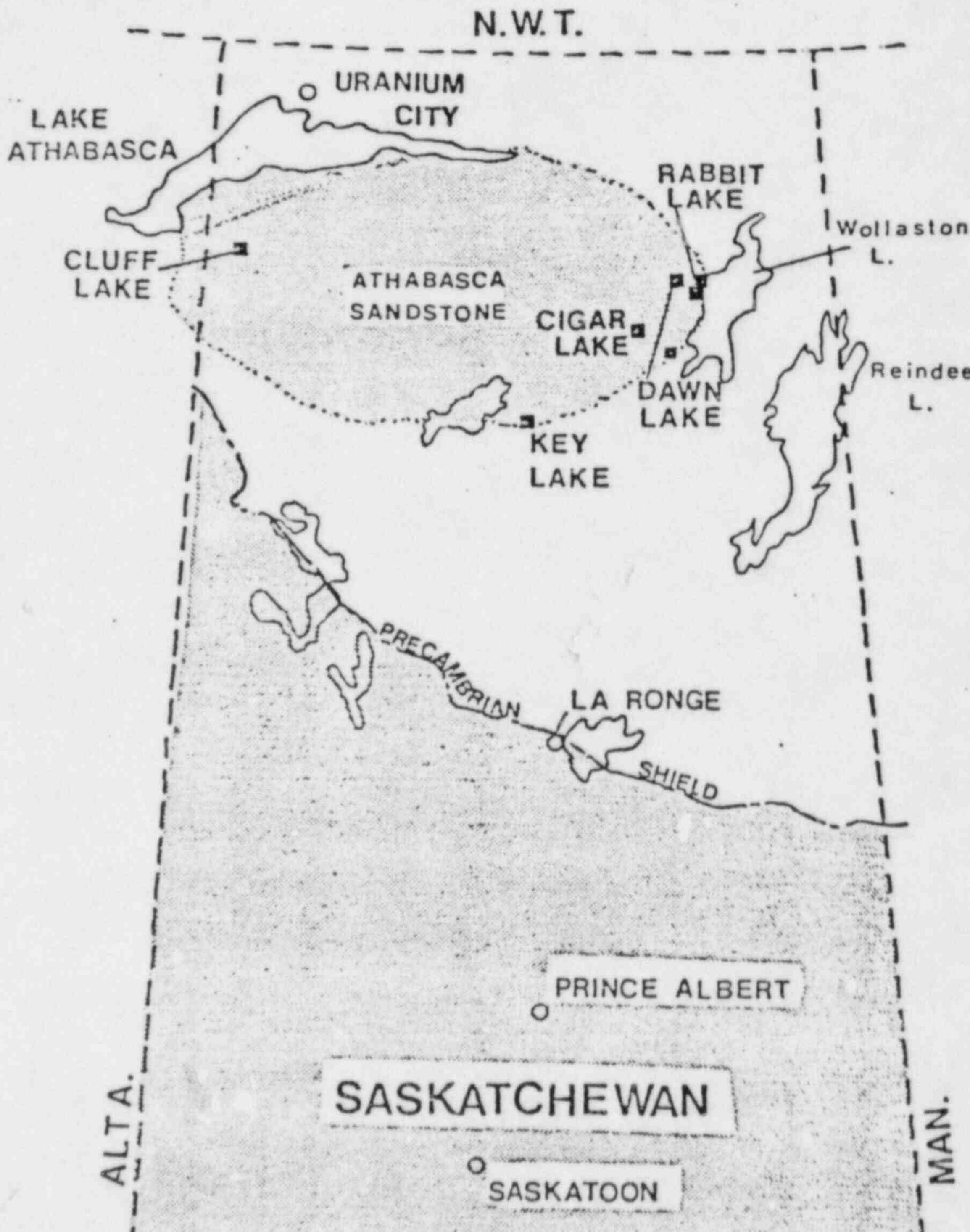


Fig 1

GURE 1: Location of Some Important Sandstone-Type Uranium Deposits in the Athabasca Sandstone Basin of Northern Saskatchewan

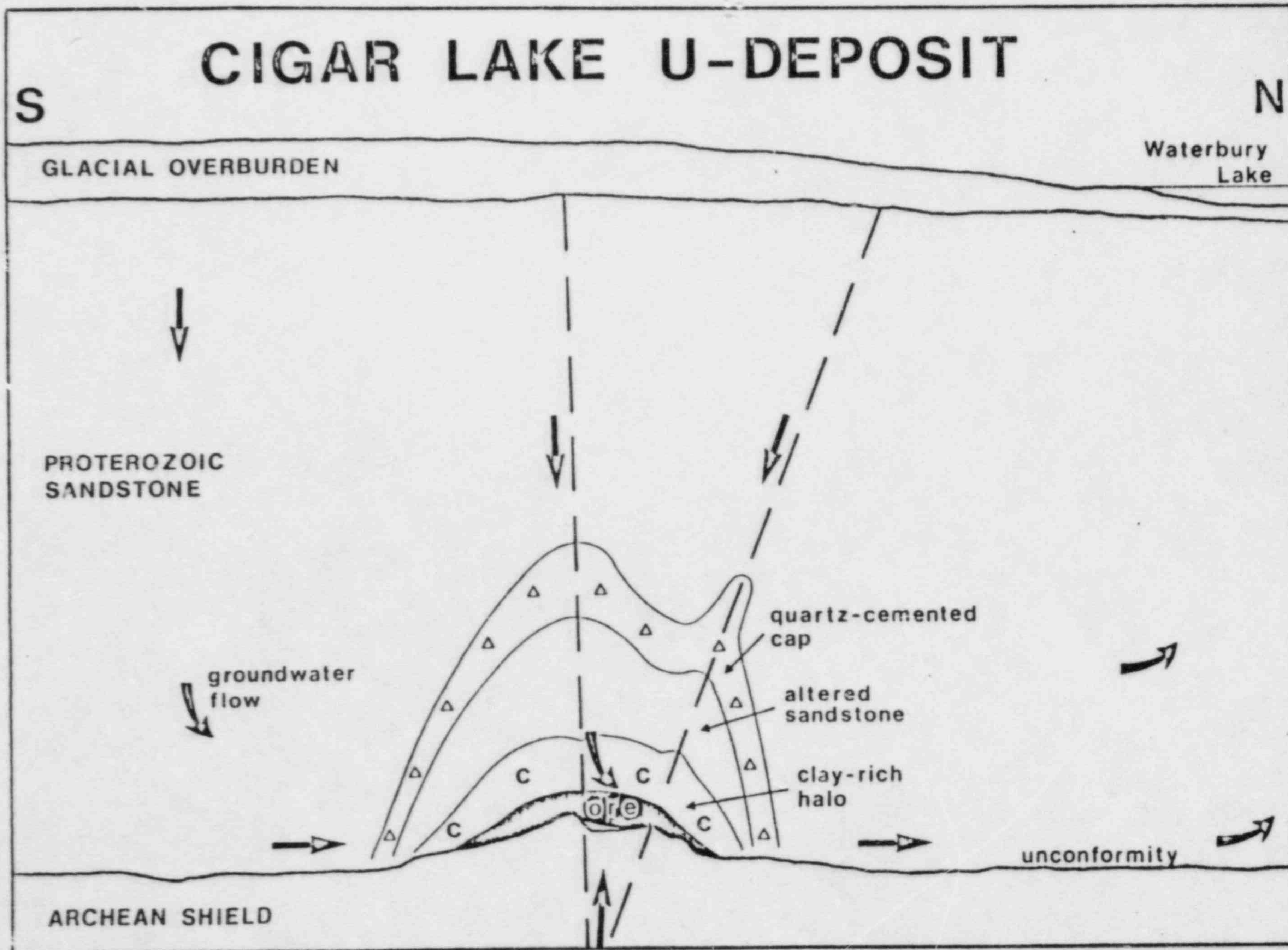

CIGAR LAKE U-DEPOSIT
S
N
GLACIAL OVERBURDEN
Waterbury Lake
PROTEROZOIC SANDSTONE
groundwater flow
quartz-cemented cap
altered sandstone
clay-rich halo
ore
C
unconformity
ARCHEAN SHIELD

Fig 2.