

UNITED STATES OF AMERICA NUCLEAR REGULATORY COMMISSION

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UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

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BRIEFING ON NRC RESEARCH PROGRAMS ON
HIGH-LEVEL WASTE

- - - -

PUBLIC MEETING

Nuclear Regulatory Commission
One White Flint North
Rockville, Maryland

Wednesday, October 27, 1993

The Commission met in open session,
pursuant to notice, at 10:00 a.m., Ivan Selin,
Chairman, presiding.

COMMISSIONERS PRESENT:

IVAN SELIN, Chairman of the Commission
KENNETH C. ROGERS, Commissioner
FORREST J. REMICK, Commissioner
E. GAIL de PLANQUE, Commissioner

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STAFF SEATED AT THE COMMISSION TABLE:

SAMUEL J. CHILK, Secretary

KAREN CYR, Office of the General Counsel

JAMES TAYLOR, Executive Director for Operations

ERIC BECKJORD, Director, Office of Research

ROBERT BERNERO, Director, NMSS

FRANK COSTANZI, Deputy Director, Division of
Regulatory Applications, RES

MELVIN SILBERBERG, Chief, Waste Management Branch, RES

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P-R-O-C-E-E-D-I-N-G-S

10:00 a.m.

CHAIRMAN SELIN: Good morning, ladies and gentlemen.

The Commission is meeting at this time to receive the latest in our series of briefings from the Research and Program offices on a major research area. Today's will be the high-level radioactive waste research program.

As I'm sure you know, the NRC has the responsibility of reviewing the Department of Energy's future application for a high-level waste repository. Although this is far in the future, there are a great number of things that have to be accomplished before we'll be in a position to do that and much of this activity is carried out under our high-level radioactive waste research program, which is designed to develop the licensing tools as well as the technical basis necessary to judge the adequacy of any license application to ensure sufficient independent understanding of the basic physical processes that would take place at a geological repository and, not incidentally, to maintain a limited but nevertheless robust independent confirmatory research capability under NRC's auspices.

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1 Commissioners, would you have any remarks?

2 Mr. Taylor, would you -- I'm sorry.

3 There's one other thing, Mr. Bernero. I
4 hope that during this discussion you're able to put
5 some of the research programs into the context of
6 timeliness and the appropriate level of effort that we
7 should be putting into the preparation for this
8 application given that its perspective date has
9 slipped considerably in the future since we first
10 started this program.

11 Mr. Taylor?

12 MR. TAYLOR: Good morning.

13 With me are members of the Office of
14 Research and NMSS.

15 As you mentioned, Mr. Chairman, there are
16 a number of technical issues in planning for the
17 ultimately licensing of the DOE geologic repository.
18 One of the unique things, of course, is the time span
19 considered for the repository and its performance is
20 unprecedented in our regulatory experience. So, I'm
21 meeting this challenge.

22 The high-level waste research program
23 involves a broad range of technical and scientific
24 disciplines, from metallurgy to rock mechanics, from
25 geochemistry to hydrology. As you're aware, most of

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1 the research is being carried out through the Center
2 for Nuclear Waste Regulatory Analyses and I believe
3 some of the members from there are here -- from the
4 senior staff are here today.

5 Frank Costanzi from the Office of Research
6 will start the formal presentation.

7 MR. COSTANZI: Thank you, Mr. Taylor.

8 As you stated, Mr. Chairman, the objective
9 of the high-level waste research program is to provide
10 the tools and data to support the licensing assessment
11 of DOE's demonstration of compliance against 10 CFR
12 Part 60 and the EPA high-level waste standard.

13 (Slide) May I have page 2, please?

14 The activities that the research program
15 is undertaking can be broadly categorized in three
16 areas. One is to address what the staff has
17 identified as the key technical uncertainties, to
18 provide technical bases of support for future
19 identification of uncertainties as DOE progresses in
20 its development of the repository, and to further
21 refine existing identified uncertainties, and of
22 course to provide the tools, models, technical support
23 and limited data for the development and use of
24 performance assessment, in particular the iterative
25 performance assessment process which is ongoing today.

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1 (Slide) Next slide, please.

2 With regard to performance assessment, I
3 wanted to mention particularly that that's kind of the
4 glue that holds the program together, that all the
5 programs, all the elements in this program are related
6 in one fashion or another to performance assessment.
7 Either they are developing models which will be used
8 in performance assessment or models in which we'll do
9 calculations to review DOE's demonstration of
10 compliance. Or they're developing the technical
11 support to choose among competing models for
12 describing various processes which should be ongoing
13 at the Yucca Mountain site, or they're developing
14 limited data sets against which we can test and
15 evaluate competing models.

16 COMMISSIONER ROGERS: Just before we leave
17 that, I wonder if you would say a little bit about the
18 iterative aspects of performance assessment.

19 MR. COSTANZI: The interactive performance
20 assessment is an exercise which the staff, under the
21 leadership of the licensing staff, is undertaking now.
22 It's essentially running through actual performance
23 assessment and to make sure that we have the
24 capability of -- not only the capability of doing the
25 performance assessment, but will we understand exactly

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1 what the pinchpoints are in a performance assessment,
2 what is going to be controlling in terms of the
3 repository performance over time, what particular
4 things we need to pay attention to in doing our
5 license review assessment.

6 I think the licensing staff probably would
7 be in a better position to answer any particular
8 questions in the IPA itself and where they are and the
9 like.

10 MR. BERNERO: Excuse me. If I could add
11 to that, we're actually on the second stage of the
12 performance, our second iteration, and we envision
13 several in the course of it. It's really the ultimate
14 licensing compliance assessment against what we expect
15 to be the EPA standard at the time, which will be part
16 of our regulations. What we learned from the
17 iterations is, as Nick said, the pinchpoints, what are
18 the key technical issues that have to be addressed and
19 resolved, whether it be carbon-14 emissions or some
20 geotechnical issue about solubility or rock retention
21 or fracturing or something like that.

22 We thereby get the information needed to
23 say more is needed here or there to focus site
24 characterization or site investigation. It is our
25 independent check of what DOE is doing. DOE now does

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1 and must do iterative performance assessment
2 themselves for the same reasons.

3 COMMISSIONER ROGERS: Well, I guess what
4 I'm curious about is just how the research and the
5 performance assessment are actually linked together,
6 how those two are working exactly as you say you'd
7 like to see them work. To what extent has the
8 research program thus far, for example, if we are in
9 the second iteration, in fact been influenced by the
10 fact that we're in the second rather than the first
11 go-around on that.

12 I'd like to see how that's working because
13 that seems to me very, very important that we, in
14 fact, have feedback from the performance assessment
15 iterations into the research program rather than the
16 research program somehow or other been initially
17 defined as important things to look at and then it
18 just runs on.

19 MR. BERNERO: Perhaps so.

20 MR. COSTANZI: Well, as Mr. Bernero
21 mentioned, the IPA is a continuing process. The
22 definition of the research program, the things that
23 the research is looking at, has both been shaped as
24 well as has helped to shape the identification of the
25 issues. As we run through and do performance

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1 assessments, it helps us further define what are the
2 important things to look at in terms of our research
3 program and where to focus our efforts.

4 There are certainly many more questions
5 than one could possibly dream up to ask than we would
6 have resources to focus on. So, the task of the IPA
7 is to make sure that we've identified those issues
8 which are critical to the performance and to those
9 which require research for addressing, that the
10 research program does indeed address it. It's an
11 ongoing process. It's a continual review and a
12 looking back of what we're doing and how we're doing
13 it.

14 I can't point to a specific task in the
15 program that says relate findings of IPA to research
16 program because there is no such specific task. It's
17 an ongoing effort. It's something that we can
18 continually do.

19 It occurs in large part because many of
20 the same people are doing both things among the
21 research staff. They're managing the individual
22 research projects. They're also participating in the
23 IPA exercise. Researchers at the center are doing the
24 same thing.

25 COMMISSIONER ROGERS: I have difficulty

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1 envisioning a continuous process.

2 MR. BERNERO: Okay. Let me suggest that
3 perhaps --

4 COMMISSIONER ROGERS: To me it's
5 inherently discontinuous.

6 MR. BERNERO: -- what you need is an
7 example. I believe in the second phase of performance
8 assessment one of the technical examples of program
9 guidance or program sensitivity that is coming out of
10 it is our ability to discern calculation of individual
11 risk on a limited pathway model. One of the
12 characteristics of a dry site is that although it
13 might be very good for overall release standards, that
14 is total curies released to the accessible biosphere,
15 it may have what few curies come out, coming out one
16 little rivulet of water.

17 That is a major issue in the National
18 Academy of Science consideration of should you have a
19 health risk-based standard or a release standard. I
20 believe there is an example where our own analysis is
21 able to focus on the calculation of individual dose,
22 what would be entailed and what would be the quantity
23 in that little rivulet, that one small stream. That
24 can be very significant to us now in the program.
25 That's just an example of a thing that can come out.

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1 The carbon-14 is another I mentioned earlier.

2 COMMISSIONER ROGERS: Well, why don't you
3 just proceed? I think I'd like to just see how it
4 seems to be shaping up.

5 MR. COSTANZI: All right.

6 (Slide) May I have the next slide,
7 please?

8 The way I would like to proceed this
9 morning with the presentation is first to identify the
10 issues of regulatory significance which the research
11 program is addressing and briefly describe what
12 research is that's addressing the issue, what end
13 products we anticipate from that research and how we
14 anticipate that those products will be used.

15 CHAIRMAN SELIN: Before you start, Mr.
16 Costanzi, you've got some engineering stuff at the end
17 that I'm quite interested in and you have a very large
18 number of issues and you have a fixed amount of time.
19 So you might take all that into account as you --

20 MR. COSTANZI: Okay.

21 CHAIRMAN SELIN: -- allocate those --

22 MR. COSTANZI: (Slide) All right. Okay.
23 The next slide.

24 I've divided this presentation into
25 dealing with issues related to the site, issues

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1 related to engineering. That's what's going to be
2 done at the site and finally what I call the source
3 term issues which really that's the mathematical
4 characterization of the in place waste that's used to
5 test the compliance against the Part 60 performance
6 objectives and EPA high-level waste standard.

7 The first group of site issues can be
8 described, I suppose, as reading the geologic record.
9 How do you do that? And the uncertainties that we're
10 focusing on there put in -- phrased as questions. The
11 first one, what measurement techniques are appropriate
12 for determining the geologic properties and parameter
13 values? Secondly, what measurement techniques are
14 appropriate in determining hydrologic properties and
15 parameter values?

16 (Slide) Next slide, please.

17 With regard to that first question, the
18 research that we've done and are doing, we've
19 conducted previous experiments and investigated
20 techniques such as down-hole tomography and core-
21 logging, and present experiments are examining other
22 methods of determining geologic properties and
23 parameters.

24 I might mention here that the bulk of this
25 work is being done at the center and, in fact, all the

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1 work in this presentation would be considered as being
2 done at the center unless it's explicitly noted
3 otherwise.

4 (Slide) Next slide, please. Page 7.

5 What we anticipate in terms of products or
6 evaluation of site characterization techniques that
7 DOE would be using at Yucca Mountain and we would
8 intend to use those, of course, in evaluating the
9 appropriateness of DOE's site characterization
10 program, whether they're using the right techniques to
11 go after the right data to get the right story.

12 (Slide) Page 8, please.

13 The related issue on hydrology, what
14 measurement techniques are appropriate for determining
15 hydrologic properties, again we have done some
16 previous field work that was done at Arizona to
17 determine local hydrologic properties. Current
18 research at Arizona is continuing measurements of
19 hydrologic properties of a site very similar to Yucca
20 Mountain. That's namely an unsaturated fractured
21 tuff.

22 (Slide) The product is field data which
23 has been developed using demonstrated techniques from
24 a well-characterized site. So, we will have done some
25 site characterization. We will understand what the

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1 successes and failures are of site characterization
2 and that will, of course, put us in a favorable
3 position to review the hydrologic data that DOE
4 develops at the Yucca Mountain site, techniques and
5 also the way they analyze that data.

6 (Slide) On page 10 we begin the second
7 part of the story. Now that we've read the geologic
8 record we need to understand what it means. What is
9 the nature of the processes, the tectonic processes
10 operating in the central basin and range? That's the
11 geological area in which the site is located. What
12 are the characteristics affecting groundwater flow at
13 Yucca Mountain? What are the characteristics
14 affecting radionuclide transport at Yucca Mountain?

15 (Slide) With regard to the tectonic
16 processes operating in the basin and range, we're
17 performing geodetic observations, those are being done
18 by Cal Tech, and analytical studies at the center
19 using existing data of tectonics in the central basin
20 and range. The outcome of this research will be
21 models with appropriate supporting data of what the
22 major tectonic processes and significant features are
23 of the Yucca Mountain area, in particular the
24 deformation rates which, of course, relate to the
25 stability at the site.

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1 CHAIRMAN SELIN: How is this different
2 from the research that DOE itself must be doing
3 because they have to answer the same questions?

4 MR. COSTANZI: Indeed, they are going to
5 be answering the same questions and doing the same
6 sort of research. This is part of the independent
7 base for evaluation of what they're doing.

8 CHAIRMAN SELIN: Are we ahead of them in
9 this or have they done much of this work and we're
10 confirming it? What's the relative timing of the
11 licensee's work?

12 MR. COSTANZI: That's my understanding,
13 it's parallel efforts. They're doing the same thing
14 now as we are doing. We have been trying to develop
15 the understandings of what's going on so that we can
16 interpret the results of their investigations.

17 CHAIRMAN SELIN: Is there a sharing of
18 information as we go along or do we wait for a certain
19 time and then disclose what we have found?

20 MR. COSTANZI: There are periodic meetings
21 which the licensing staff conducts with DOE for
22 exchanging of information. They're under the
23 agreement that we have with the Department of Energy.

24 MR. BERNERO: But we don't have a
25 coordinated plan.

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1 MR. BIRCHARD: I can answer this question
2 directly. The DOE is focused specifically --

3 CHAIRMAN SELIN: Would you identify
4 yourself for the record?

5 MR. BIRCHARD: Hello. I'm George Birchard
6 of the Office of Research.

7 The DOE is focused specifically on the
8 Nevada test site and is conducting geodetic
9 measurements on that test site. The Cal Tech program
10 is coordinated with the geological survey. It was
11 conducting those measurements for the test site, so
12 there is communication at the investigator level. We
13 are going from the test site across to the Sierra
14 Nevada range to understand the broader context to be
15 able to model the regional processes to make sure that
16 the DOE has not in some way overlooked some important
17 process.

18 CHAIRMAN SELIN: Okay. Thank you.

19 COMMISSIONER ROGERS: Could you just say
20 what you mean by model here? Is this a computer
21 model? Is this a conceptual model?

22 MR. COSTANZI: The first stage is
23 conceptual.

24 COMMISSIONER ROGERS: What is a model?

25 MR. COSTANZI: Yes. Well, all of the

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1 above. Initially it's a conceptual model, trying to
2 identify and understand what processes are operating.
3 To the point where we will actually assess the
4 information rates it will be a mathematical model, be
5 quantitative to allow us to do calculations.

6 COMMISSIONER de PLANQUE: I'd like to just
7 follow-up on the Chairman's question too. If where
8 you're headed is diverging or is different from where
9 DOE is heading in terms of results, how do you know
10 that? Do you know when you've reached a point where
11 your data tell you something entirely different from
12 what they're telling DOE?

13 MR. COSTANZI: Well, certainly we'd know
14 that when the license application comes in.

15 COMMISSIONER de PLANQUE: Yes. That's way
16 down the road.

17 MR. COSTANZI: Hopefully we'd know that
18 before.

19 COMMISSIONER de PLANQUE: I mean are there
20 any ways in which you find that out along the line?

21 MR. COSTANZI: The periodic exchanges, the
22 periodic meetings that we have with DOE we do tell
23 them what the results of our work is, and they also
24 tell us what the results of their work is. So, there
25 is a transfer of information back and forth and I

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1 think -- was it the matrix fracture fluid is a good
2 example of a case where we, through our research,
3 assess that fracture flow is very significant in the
4 type of rock that exists at Yucca Mountain. That
5 information was related back to DOE and they have
6 since focused their program more to examine fracture
7 flow than they had to that point.

8 MR. SILBERBERG: In fact, when DOE issued
9 its site characterization plan that the staff
10 reviewed, that in effect laid out their process of
11 what they were going to -- in effect their study
12 program, how they were going to proceed. They also
13 come out periodically with study plans which are more
14 details for the staff to look at on how they're
15 proceeding.

16 In the site characterization plan they
17 immediately came out with -- in there showed the
18 concepts they were using, except for models of the
19 hydrology, and the staff noted that very early on, as
20 Nick says from our own work, but the comments back to
21 DOE were put on record that, in fact, alternative
22 conceptual flow models would have to be looked at,
23 that what they had was not sufficient.

24 COMMISSIONER de PLANQUE: Okay. So
25 there's a good enough exchange that there shouldn't be

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1 some big surprises when the applications come in.

2 MR. SILBERBERG: Certainly.

3 MR. COSTANZI: That's our hope, yes.

4 (Slide) The next site issue is what are
5 the characteristics affecting the groundwater flow at
6 Yucca Mountain on page 13. The research that we're
7 doing there are analytical studies both at the
8 University of Arizona and primarily at the center
9 assessing the use of stochastic techniques to develop
10 large-scale hydrologic models of unsaturated flow in
11 fractured, porous tuff. What all that means really is
12 we're trying to determine how one takes into account
13 the tremendous variability in hydrologic properties
14 from location to location within the Yucca Mountain
15 region.

16 What the results of that research will be
17 is identification of appropriate modeling techniques,
18 which is essentially algorithms, computer algorithms
19 for taking into account the variability of hydrologic
20 characteristics. The use, of course, would be to
21 evaluate DOE's description of the hydrology at the
22 Yucca Mountain site and in particular how they treat
23 the spatial and temporal variations in those
24 hydrologic properties.

25 (Slide) On page 16 we ask a similar

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1 question with regard to the characteristics of
2 radionuclide transport. The field research, the
3 research that we're doing includes field research at
4 Peña Blanca Analogue and laboratory studies to
5 determine the controlling mechanisms of radionuclide
6 transport in tuffaceous rock. The result will be
7 kinetic and thermodynamic models and data of
8 radionuclide speciation and movement in the tuff and
9 the use again is evaluation of DOE's geochemical model
10 of the Yucca Mountain site. Of course, supporting
11 data and also DOE's use of natural analogues that they
12 intend to use as well to help support their evaluation
13 of the site.

14 (Slide) We've read the geologic record
15 and we think we've understood it. What does it tell
16 us about what's going to happen there in the future?
17 That's what the next four issues relate to. First is
18 how will the heat from the high-level waste that's in
19 place at the site affect the local hydrology and
20 geochemistry? What is the credible range of future
21 climates that may affect a repository? How likely are
22 volcanos at the site and what effect may they have on
23 the repository, the geology, the hydrology and, of
24 course, the emplaced waste?

25 (Slide) And lastly, on page 19, what

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1 effect does seismic activity in the region have on the
2 hydrology of the Yucca Mountain site.

3 (Slide) With regard to the heat from the
4 emplaced waste, the work we're doing in natural
5 analogue studies, primarily the Oklo study and
6 laboratory experiments in geochemistry and repository
7 thermal hydraulics. The products would be
8 identification of the key heat-driven mechanisms that
9 affect hydrology and transport close in to the
10 repository and a model of the effect of heating on
11 local geochemistry and hydrology.

12 COMMISSIONER ROGERS: How do you do those
13 studies without knowing what the expected design of
14 emplacement will be? I mean you don't know what the
15 heat sources are really going to be in that site until
16 that's been decided and it hasn't been decided yet.

17 MR. COSTANZI: Well, that's right. What
18 we are trying to do is right now understand how heat
19 affects these various elements, the local hydrology
20 and the geochemistry. The heat loading of the
21 repository will affect both the time duration and the
22 temperature that the repository will receive. So, the
23 objective is to have the understanding of the physics
24 of the situation so that when we know the parameters
25 of the situation we'll simply be able to evaluate the

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1 consequences using the same physical models.

2 Obviously the --

3 COMMISSIONER ROGERS: Well, my impression
4 is that some of these models are very complex.

5 MR. COSTANZI: They are extremely complex.
6 They also don't have -- many of them do not have
7 extremely broad ranges of applicability. So, we are
8 looking at a number of models to determine what their
9 limits of the applicability are over the various
10 ranges. Whatever the final internal parameters of the
11 repository might be, we will be able to select
12 appropriate models to again test what DOE's
13 demonstration of compliance is.

14 MR. TAYLOR: Did you want to say
15 something?

16 MR. BERNERO: Yes. I just wanted to add,
17 Commissioner Rogers, I believe you have heard the
18 briefing on the subject of the hot hole concept out at
19 Livermore. That concept is very strongly entrenched
20 in the DOE design right now. It focuses on the near-
21 field effect of having calibrated heat content keeping
22 the excavation right around the canister above the
23 boiling point of water for a very long time. But the
24 far-field or mid-field effect where the mountain could
25 turn into a heat pipe by starting some rather

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1 macroscopic flow condensation and capillary return,
2 that's extremely important because that could be an
3 issue that would have a very great impact on the
4 entire design of the facility from the outset.

5 COMMISSIONER ROGERS: Right.

6 MR. BERNERO: Very, very important, this
7 information. And frankly, from what I've seen so far,
8 I'm not sure that DOE's program has enough focus on
9 that.

10 MR. COSTANZI: The implications for the
11 performance of the repository of obtaining those high
12 temperatures the closer to the waste package are
13 pretty profound. The regional or the hydrology at
14 least on the scale of the repository itself could be
15 altered quite dramatically to what the amount of water
16 that was initially considered to be available for
17 dissolution and transport may increase significantly
18 owing to the fact that what we have observed appears
19 to be a concentrating of water near the dry-out zone
20 in some of our laboratory tests. If that's the case,
21 the hot dry repository might actually attract water to
22 it. Once the temperature starts to recede, then the
23 amount of water available may actually be more than
24 the current design anticipates.

25 But these are the sorts of questions which

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1 we're trying to examine in our program.

2 COMMISSIONER REMICK: Frank, how pertinent
3 is the Oklo study results to the local hydrology
4 studies and so forth? Is CEA still doing research at
5 Oklo?

6 MR. COSTANZI: Yes, CEA is still doing a
7 good deal of research there. With regard to the
8 hydrology, I don't know that we know an answer to that
9 right yet. I do know with regard to the geochemistry,
10 the transport, it's very clear. There is a -- close
11 to one of the reactors there is an intrusive dike that
12 occurred some time after -- I don't remember the exact
13 number of thousands of years, but the alteration of
14 the rock and the thermal effect is clearly visible
15 there in terms of what effect it has had on the
16 migration of the fission products and actonides from
17 the reaction.

18 COMMISSIONER REMICK: I could see where
19 maybe the geochemistry -- I wasn't quite clear how it
20 would help in the local hydrology studies.

21 MR. SILBERBERG: But the presence of a
22 dike is, in fact, one possible scenario that one might
23 have under potential volcanic conditions at the site.
24 So, looking at intrusion from a volcanic source is
25 something that's looked at within performance

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1 assessment.

2 MR. COSTANZI: One of the things, the real
3 benefits of doing the IPA exercise is that when you
4 take a piece of a model there, the piece that talks
5 about geochemistry and the piece that talks about
6 hydrology and the piece that talks about engineering
7 and combine them altogether you start to get a
8 limiting set of parameters. It starts to constrain
9 the problem and you have to start looking for
10 consistencies. We found that, in fact, in studying
11 the natural analogues that the conglomerate deposit is
12 a good example of how we were able to learn a lot
13 about the hydrology from the geochemistry just by
14 demanding consistency of the models and we would
15 anticipate that that kind of thing will just continue
16 as we keep doing these performance assessments. It
17 will help constrain and give us a more realistic
18 picture of what's going on because -- to avoid
19 internal contradictions.

20 MR. SILBERBERG: I would just also note,
21 Commissioner Remick, that the CEA is doing that in
22 conjunction with the Commission on European
23 Communities and along with us in the field of
24 countries.

25 COMMISSIONER REMICK: Good.

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1 COMMISSIONER de PLANQUE: There was some
2 discussion of a natural analogue site in Mexico. Is
3 that being used at all?

4 MR. COSTANZI: Peña Blanca?

5 COMMISSIONER de PLANQUE: Yes.

6 MR. COSTANZI: Yes. Oh, yes, very
7 definitely.

8 COMMISSIONER de PLANQUE: Oh, I didn't
9 remember the name of it.

10 MR. COSTANZI: I believe we'll talk a bit
11 more about that later.

12 COMMISSIONER de PLANQUE: Okay.

13 MR. COSTANZI: (Slide) I'd like to turn
14 to page 22 now. The next question we wish to address
15 is what is the credible range of future climates.
16 This largely has to do with precipitation, water
17 infiltration, how much water could get into the
18 repository. Methods to assess water infiltration
19 field side have been examined and future work will
20 focus on a possible range of climates at Yucca
21 Mountain. We've done some work in that area already.
22 We've, in fact, had an expert elicitation exercise
23 that NMSS conducted with regard to the climates.

24 What we will be doing in terms of the
25 product is that we will evaluate the methods of

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1 treating infiltration that have been developed and
2 looked at by the University of Arizona and this would
3 be work be done at the center. We'll address the
4 consequences of range of potential climates as well.
5 If water balance increases by a factor of two or a
6 factor of four, how does that -- given our current
7 understanding of what the repository looks like, how
8 will that affect the performance? And again, all this
9 is to evaluate DOE's treatment of future climates.

10 The last or, I guess, an ultimate question
11 in this set is how likely are volcanos at the site and
12 what affect may they have on the repository, the
13 geology, the hydrology and, of course, the emplaced
14 wastes themselves.

15 We're doing analytical studies of using
16 field observations, assessing volcanism in the basin
17 and range. We're anticipating to developing a model
18 which will give us an idea of the likelihood as well
19 as the characteristics and the consequences of all
20 that volcanic eruptions in the repository area.

21 Again, the use will be to develop
22 interpretations of the regional data that DOE is now,
23 of course, developing at the site and interpretations
24 of the likelihood and the location and characteristics
25 and consequences of volcanoes.

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1 The last site issue that we'll address is
2 what effect will the seismic activity in the region
3 have on the hydrology of Yucca Mountain? The work
4 we're doing to -- analysis and interpretations of
5 existing historical and field data relating to changes
6 in the regional hydrology to seismic activity. This
7 is being done at the University of California in a
8 site out in California where there is some large --
9 the seismic activity is fairly frequently and fairly
10 large magnitude and work that has been done and is now
11 in the final process of analysis at the center, field
12 work at the Lucky Friday Mine.

13 We will be developing a model which
14 relates regional hydrologic changes to the seismic
15 events. In particular, the kinds of things that we
16 have observed is that the local core pressures change
17 and they change in odd ways as a result of seismic
18 event. First of all, there are some cases where there
19 are delays. The seismic event precedes the changing
20 core pressure or pressure in a fracture by some time.
21 In some fractures pressure goes up as a result, in
22 some fractures pressure goes down. Sometimes some
23 observations it's taking a long time before pressure
24 goes back to its ambient state and sometimes it's
25 taken a very, very long time. Sometimes it's rather

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1 quick. We don't really understand all the mechanisms.
2 Obviously it has to do with the opening and closing of
3 fractures. But to relate that kind of information as
4 to what will happen in a repository is what we're
5 trying to do now.

6 Again the use of this will be to review
7 DOE's treatment of potential perched water zones as
8 well as some of the steep hydraulic gradients which
9 appear to be near the Yucca Mountain site, will an
10 earthquake essentially end up flooding the repository
11 and delivering a lot of water into the waste
12 emplacement area.

13 (Slide) Now I'd like to turn to the
14 engineering questions. I have two sets of questions
15 related to the repository engineering itself. One,
16 will the waste emplacement drifts and boreholes at
17 Yucca Mountain remain open during the retrieval period
18 and will they be stable in the post-retrieval period?
19 And secondly, how long will the shafts in the
20 boreholes remain sealed at the site?

21 (Slide) With regard to the first
22 question, the research that we're doing consists of
23 field and laboratory experiments, as well as
24 analytical studies evaluating the efficacy of rock
25 mechanics models that are used for predicting tunnel

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1 stability, actually reviewing the models and doing
2 some laboratory experiments in testing the predictions
3 of the models against what's observed.

4 (Slide) What we will end up with as a
5 product are, of course, a review of several of the
6 rock mechanics codes against field observations, both
7 the University of California and the center work, and
8 laboratory observations of rock joint behavior. This
9 is being done at the center, as I mentioned.

10 (Slide) The use of this product will be
11 the development of methods for the review of DOE's
12 assessment of repository response to earthquakes,
13 stability, the opening themselves and thermal
14 mechanical stability of underground excavations. Of
15 course when DOE places the wastes in the repository
16 the heat is going to put thermal stresses on the rock
17 itself and will change the -- the change in the stress
18 fields will, of course, be reflected in the -- could
19 be reflected in stability of changes in the stability
20 of the excavations themselves.

21 (Slide) The next engineering issue is how
22 long will the shafts and the boreholes remain sealed?
23 We've had a laboratory program investigating the
24 effectiveness of various techniques for sealing the
25 shafts and boreholes. This was done at the University

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1 of Arizona. The product is data on the effectiveness
2 of various techniques and designs for sealing shafts
3 and boreholes and unsaturated fractured tuff. We have
4 a pretty good idea at this point of what the design
5 parameters for a good seal are. Good in this case
6 however is defined only to what makes the seal hold
7 right now. The long-term performance is something
8 which we really don't have a good handle on and that
9 would be the subject of future research. The use, of
10 course, of the work from this program is to assess the
11 suitability of DOE's sealing program at the site.

12 (Slide) The next set of engineering
13 questions focus on the waste package itself, in
14 particular how long will the waste package contain the
15 high-level waste, and the next question being how
16 confidently can you extrapolate the short-term tests
17 that are being conducted in the laboratory today to
18 the long-term performance of the waste package. We
19 have in the laboratory, at best, and opportunity for
20 maybe a few decades of experiment. Certainly field
21 observations of the behavior of various metals gives
22 us maybe a century or so worth of data, but the waste
23 package themselves don't maintain themselves from the
24 order of tens of centuries. So, the question is how
25 confidently can you extrapolate the short-term data to

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1 the long-term performance?

2 (Slide) With regard to how long will the
3 waste package contain waste, expect a performance in
4 the waste package. We have an experimental program to
5 identify the corrosion mechanisms of the various
6 metals that DOE has been examining in the repository
7 environment. The product has been correlation of
8 dominant corrosion types and rates with environmental
9 parameters. We've looked at pitting corrosion. We've
10 just about finished our work on that. The question of
11 internal corrosion, that's the interaction of the
12 waste itself on the waste package or canister. We're
13 now in the midst of looking at stress corrosion
14 cracking of the waste materials, waste package
15 materials.

16 (Slide) The use, of course, will be to
17 assess whether DOE has identified the controlling
18 waste package failure mechanisms, employed
19 appropriately conservative models in assessing the
20 waste package performance, and confirm the suitability
21 of waste package material to meet the containment
22 requirement.

23 (Slide) The next question of engineering
24 issues is how confidently can a short-term laboratory
25 test be used to predict long-term performance. The

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1 research that we have underway is continuing
2 laboratory program of testing waste package materials
3 under a range of potential repository conditions. We
4 had planned to supplement this with observation of
5 buried metal objects at the Akrotiri site, which is an
6 archeological site, and also long-term observation of
7 waste package materials. We still have not yet
8 formulated exactly what we're going to do on that, but
9 we have been considering the possibility of burying
10 the waste package materials in tuffaceous rock,
11 heating it and just letting it sit and cook in the
12 laboratory for a couple of decades.

13 COMMISSIONER ROGERS: How long have those
14 metal objects been buried at Akrotiri.

15 MR. COSTANZI: Thirty-five hundred years.

16 COMMISSIONER ROGERS: Thirty-five hundred
17 years.

18 MR. COSTANZI: (Slide) The product of
19 this research will be an assessment of the mechanistic
20 corrosion models for correlating the short-term
21 laboratory tests, long-term in situ tests and field
22 observations. The use, of course, will be to review
23 DOE's demonstration of compliance with the containment
24 requirement in 10 CFR Part 60.

25 (Slide) The last issue --

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1 CHAIRMAN SELIN: Before you come off this,
2 Mr. Costanzi --

3 MR. COSTANZI: Yes.

4 CHAIRMAN SELIN: The other topics really
5 have to do with the site or some sort of major civil
6 engineering around which there aren't a huge number of
7 alternatives. But when you get to waste packages, the
8 number of different kinds of materials that might be
9 used seems quite large. Is this a continuing process?
10 Are we going to be looking at ceramics as well as
11 metals or some other --

12 MR. COSTANZI: Well, what we are doing
13 generally -- well, what we have been doing is
14 following DOE's lead. The metals that -- DOE has been
15 investigating metals. They have looked at titanium,
16 carbon steel, mild steel to a certain degree, copper
17 to a certain degree, nickel alloys which seems to
18 be -- right now they're their favorite candidate
19 material and we've essentially been following them,
20 looking at materials which they have been observing
21 and trying to determine what are the degradation
22 mechanisms characteristic of that material in
23 repository environment and trying to understand how we
24 could ascertain over the short-term what the long-term
25 performance might be.

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1 CHAIRMAN SELIN: The license application
2 would assumably be amendable later on if they decided
3 after the observation period to change the materials
4 or is that fixed for once and for all? What's the --

5 MR. COSTANZI: I assume that it's
6 amendable until they actually start putting the waste
7 in and even then I suppose they could pull it out.

8 MR. BERNERO: One of the things that has
9 a potentially very great impact on this is this
10 concept of multipurpose canister that is now afoot
11 where among other things DOE might be able to some
12 degree to uncouple the waste package from the spent
13 fuel package and just use the concept of an over pack,
14 that you have a handling package that comes along,
15 maybe an alloy steel or something, and then have a
16 pure and simple waste package sleeve that goes over it
17 and really have two packages in one and thereby
18 uncouple and be able to handle a variety of things
19 within it.

20 DOE also has other waste forms than just
21 spent fuel and there are a variety of spent fuel forms
22 and waste forms that they have to deal with. This
23 might give them greater flexibility. But therein also
24 lies a much more difficult problem for us. Many of
25 the concepts like the multipurpose canister can and

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1 may very well make the shaft bigger, the seals bigger
2 and so we really need to have a good knowledge of how
3 that would affect the reliability of the repository.

4 MR. SILBERBERG: And about five years ago
5 DOE had a much larger candidate selection, a number of
6 array of candidates which they have narrowed down in
7 the last five years and I think they need to narrow it
8 down within again the next few years, narrow it down
9 further as well as select the design with regard to
10 the thin canister or the more robust design, as Bob
11 Bernero noted.

12 But nevertheless, the licensing process
13 allows for what they call a license application design
14 that they will have to come up with. I think it's
15 like 96. They have a process that they're going over
16 now, what they call the alternative conceptual
17 designs. I think by 96, as I recall, they're supposed
18 to fix on the license application design, as I
19 understand it.

20 MR. BERNERO: Something of that order.

21 MR. SILBERBERG: Something like that.

22 MR. BERNERO: That's part of the issue I
23 want to say a few words about, about the program
24 progress and what happens when.

25 MR. COSTANZI: (Slide) The last issue

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1 relates to the source term, simply at what rate will
2 radionuclides enter the -- be released from the waste
3 package and be available to enter the groundwater
4 system. Here again our national analogues come into
5 large play, those field observations of the actinide
6 and fission product migration at Oklo and Peña Blanca
7 where we're looking at the actual transport of
8 material away from the ore bodies, the reactors at
9 Oklo and the ore body at Peña Blanca.

10 The data which will be product in the
11 models, spent fuel leaching and radionuclide
12 speciation and transport in an actual geologic
13 environment. That's what we're going to get out of
14 these studies and their use, of course, will be to
15 confront the results of laboratory experiments on
16 radionuclide speciation and mobility.

17 I might mention that some of the things
18 that we've already determined is that under an
19 appropriate set of potential repository conditions
20 iron makes a great getter for uranium. It likes to
21 bind up with the uranium and that also we've
22 identified under what conditions the leaching of
23 radionuclides from a waste glass would be controlled
24 by essentially silicon chemistry which makes the
25 problem of demonstration compliance a bit more

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1 tractable. It makes the geochemical modeling a bit
2 simpler.

3 That concludes my prepared remarks.

4 CHAIRMAN SELIN: Thank you.

5 Should we go on to Mr. Bernero's remarks
6 and then questions?

7 MR. BERNERO: Yes. Let me just say a few
8 words about program approach and resources and what's
9 going on in the program today.

10 I'm sure the Commission recalls that we
11 have divided the work in the program for a long time
12 into reactive and proactive work, reactive work being
13 reacting to what they find in site characterization,
14 that that rock is different than you expected or
15 there's more water here than you expected or something
16 like that, that also is reactive to design. I mention
17 the multipurpose canister. That is an extremely
18 important piece of reactive work that's now on the
19 table because it can have such a profound effect on
20 the entire repository approach, the hot hole, whether
21 or not they can manage or control the thermal loading
22 precisely and so forth.

23 The proactive work is something -- well,
24 in fact, Nick Costanzi used a very good example of
25 scientific proactive work, that fracture flow may be

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1 far more important than people envisioned, you know,
2 based on some research. Or proactive work can be
3 quite specific in what does it take to make a
4 licensing finding about containment or package
5 lifetime, something like that.

6 We have had for quite some time a strategy
7 for characterization and for regulation, licensing,
8 that we would focus early on the most important issues
9 whether reactive issues like carbon-14 release or
10 proactive like what is substantially complete
11 containment or what is a 1,000 year package when
12 you're talking about 15,000 or 20,000 packages and
13 each holding different materials.

14 Now when we look at what's going on in the
15 program today, the DOE Yucca Mountain program, there
16 is a lot of talk. They haven't announced yet, but
17 there is a lot of talk that they'll do what they did
18 in 1989 and move the date out, and we ought to look
19 very carefully at what that date movement means. Is
20 it simply rescheduling a previously well-known thing
21 or is it recognizing that the critical path takes
22 longer than you left time for?

23 The Nuclear Waste Technical Review Board
24 has been criticizing the DOE program for some time now
25 for not having within their planning horizon enough

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1 time to complete or to conduct sufficient span of
2 geologic testing. Certain testing aspects should take
3 longer according to that.

4 I think what we will see in the three
5 months or four months is, you know, perhaps a mission
6 plan amendment that may indeed do what happened in
7 1989, a several year change in overall schedule, but
8 I think it will be more in the character of what the
9 Nuclear Waste Technical Review Board was saying, that
10 you haven't recognized that the critical path will
11 take longer than you now have in your books.

12 Nevertheless, a program like the High-
13 Level Waste Program, all you have to do is listen to
14 the regulatory utility commissioners or anyone else
15 that watches the cash flow. If you have large
16 resources going out year after year after year for
17 decades, the numbers are mind boggling. You can just
18 pile up billions of dollars and the only way you can
19 deal with that is by careful planning. And remember
20 what the focus is. If it's not a good site, find out
21 early. Get the important issues on the table early.

22 Now DOE has a very great responsibility in
23 their mission plans, in their site characterization
24 plans, in their study plans, to iterate those, to do
25 those again and again, to review those again and

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1 again, and I presume they're doing that right now and
2 that will be the basis of whatever reschedule they
3 come out with.

4 At the same time, we have to do the same
5 thing here. At the NRC we have an internal management
6 plan for the High-Level Waste Program. We have a
7 high-level waste research plan and we must look at
8 those, in my view, every budget cycle, and certainly
9 now when we're taking a fresh look at the five year
10 plan. We've got to look at those to say, "Do we
11 really need to do this now? Do we really need to have
12 these resources now?" It's a difficult issue, but you
13 have that tension and I think it's very important to
14 understand. If in past years it slipped from 1989 to
15 1998 to 2001 and now the application may slip another
16 several years, is that a simple rescheduling of a
17 predictable thing or is it recognition that you
18 couldn't get there from here?

19 I think the program has to focus on a
20 responsible use of resources in doing what needs to be
21 done this year, next year and the year after, so we
22 are doing that and we will come to the Commission
23 certainly in the five year planning process that we're
24 going to be doing this winter, but our management plan
25 has to reflect a very careful look at that issue.

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1 CHAIRMAN SELIN: Well, that's a discussion
2 with which one cannot differ. It's interesting,
3 because at least for me a couple of things have fallen
4 into place.

5 One is I'd like to congratulate you, Mr.
6 Costanzi, and your team on putting together really a
7 very nice bottom-up discussion of what you're doing
8 and why you're doing it and in smaller sessions
9 different Commissioners might want to follow-up on how
10 you're doing it, but that's clearly a much greater
11 level of detail, but some feeling for the lead times
12 there and the fruitful interaction between the
13 licensing people, the preapplication people and the
14 research people to identify the topics.

15 So clearly you've put your finger on a
16 number of long-term objects. On the other hand, we
17 could get so far ahead in the licensing part that
18 every time DOE changes the program a little bit we've
19 wasted a fair number of resources and have to go back
20 and do that and we clearly don't want to do that. I'm
21 not thinking so much of research resources as program
22 resources.

23 Commissioner Rogers?

24 COMMISSIONER ROGERS: Well, a couple of
25 observations.

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1 One is I didn't see in the briefing slides
2 and, although you did say some words about it, I don't
3 really see exactly how it is that you're making
4 decisions on research topics that essentially
5 duplicate an area that DOE is dealing with, just
6 exactly how you manage that question of are you simply
7 repeating something that somebody else has done, what
8 do you expect to get out of it that is going to be of
9 assistance in the future. I think that that really
10 isn't clear from your presentation today. I think
11 it's very important that be done.

12 You've said all the right words about the
13 philosophy of your research and so on and so forth,
14 but I guess what I'm uncomfortable about is how you're
15 arriving at very difficult decisions as to essentially
16 repeating a piece of research to get a kind of feeling
17 about whether -- what the problems are and what the
18 expertise is that one must have to make judgements on
19 that particular subject as distinct from what are the
20 difference -- you know, what can you really add to
21 this, in a certain sense, that's helpful for us other
22 than a general level of comfort in our ability to make
23 decisions.

24 I wonder if you can go one more step
25 beyond the sort of general arguments in favor of a

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1 particular piece of research to more specifics with
2 respect to what extent particular uncertainties are
3 dealt with or questions are raised about the validity
4 of a particular approach, something of that sort. I
5 don't get any feeling about that from what I've seen
6 so far and it seems to me that there is a question of
7 resources. There is a question of how you make your
8 research decisions and of course the extended time
9 frame of this whole project makes those things very
10 difficult decisions to make.

11 But I personally don't feel I've gotten
12 much help in my concerns about how you do this from
13 the presentation today or from what I've seen so far
14 and it seems to me that these are absolutely
15 fundamental to justification for anything that we do,
16 in a certain sense. We can't just do something
17 because it has some pretty good-- it gives us sort of
18 a good feeling that we've done that and we have some
19 comfort level.

20 Now I'm being a little bit superficial
21 here in this, but I think you understand what I'm
22 saying, that somehow you've got to go one more step
23 beyond that as to the justification for particular
24 pieces of work as to how far to go and when to stop.
25 These are very tough questions. They're not easy

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1 questions at all and they fly somewhat in the face of
2 the natural inclination of researchers to pursue
3 things because they do fit together in some way and
4 they represent a considerable intellectual challenge,
5 and so this is a very difficult area to deal with in
6 managing applied research and I guess I haven't really
7 gotten a feeling from what I've heard today of how
8 you're doing that and what the level of resources are.

9 These are all interesting topics and yet,
10 when I look here and what I've heard so far, I don't
11 know how much you're getting a lot of resources and
12 how much you're getting a little resources and how
13 expensive and what the time frames are in which some
14 of these things are being done, so I don't have any
15 feeling about that.

16 In other words, I don't have a context, a
17 framework on which to hang this program that gives me
18 some feeling about relative importance and how
19 priorities are being set with respect to the
20 assignment of resources, financial and FTE type of
21 resources. That wasn't part of today's briefing.
22 Maybe it was by design not to be, because maybe you
23 didn't think it was appropriate. But I think it is
24 appropriate, so I'd like to get a better feeling about
25 how this whole thing fits together from that point of

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1 view.

2 MR. COSTANZI: Let me address your
3 question by, one, giving an example with regard to
4 what we look at. We have been aware for some time
5 that DOE had been pursuing in the area of geochemical
6 modeling the so-called "KD approach" or "partition
7 coefficient approach," a very simple geochemical
8 model. We undertook to examine the thermodynamic
9 database for various mineral species and their action
10 with actinides -- uranium, neptunium, for example --
11 to determine just how good an approach that would be,
12 how robust it would be, where it would work and where
13 it wouldn't work. We have to a large extent finished
14 that geochemical program and we're just wrapping it up
15 now and we do have a very good idea of under what
16 conditions how complex a geochemical model really does
17 need to be to give us adequate comfort in the
18 geochemical description of the site that DOE may
19 derive.

20 What we do in the future we're not sure
21 yet. Clearly the temperature is still a large unknown
22 and the possibility of the hot dry or the hot hole
23 model would require us to do some additional thinking
24 as to what kind of geochemical model is appropriate.
25 The mechanism by which we do this really inputs from

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1 several areas.

2 One, of course, is just knowing what the
3 DOE program is and keeping track of that.

4 The other one is, in collaboration and
5 consultation with the users, the licensing office as
6 to what they view as being the critical things which
7 they will be looking at from this vantage point in the
8 licensing assessment, those have recently been
9 articulated in the set of uncertainties called "key
10 technical uncertainties" which we're now using, I
11 would guess, as our most prominent assessment tool for
12 assessing our program, and this is the identification
13 of those things which must be resolved or addressed
14 some time between now and the actual granting of the
15 license or the license review. Some of those have
16 been identified as requiring research, either to
17 develop models or data or both, and that is what the
18 licensing staff has indicated to us also in terms of
19 their priorities and so we reflect, given our own
20 judgement as part of that input, in our research
21 program.

22 With regard to -- I can show you a cartoon
23 which gives you kind of an idea of where everything
24 kind of fits together.

25 (Slide) If I can have the 1-B backup,

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1 please, this is kind of a complicated chart and I was
2 kind of hesitant to put it up because a lot of lines
3 at least confuse me.

4 But I think the essence of this --

5 COMMISSIONER ROGERS: Have you ever seen
6 the severe accident closure program?

7 MR. COSTANZI: Yes, as a matter of fact,
8 I have.,

9 MR. BERNERO: There are no heads on the
10 arrows.

11 MR. COSTANZI: I think the essence of this
12 is that it is a complex process. It's an iterative
13 process with a lot of feedback. It's a loop in which
14 the staff is actively involved to try continually, as
15 Mr. Bernero said, review our priorities and the
16 direction of our program every budget cycle.

17 MR. BERNERO: I wonder if I could
18 interject here. There is a rather simple and to me a
19 significant example that Nick covered in the briefing
20 on pages 24 and 25, volcanism.

21 I think you've all been on Yucca Mountain.
22 You just look around and you see volcano cones. From
23 a program point of view, I can't envision licensing a
24 repository at Yucca Mountain without dealing with the
25 question, can those volcanos effect it. But you get

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1 into some very simple pragmatic issues. Is there
2 something we can realistically do? Can we even get
3 volcanology specialists? How much would it cost?
4 What could we do?

5 And so really what we're looking for is a
6 sufficient degree of independent judgement to be able
7 to judge the bulk of the work which DOE has to do, and
8 Research has a modest but I think realistic and
9 sufficient program to develop that degree of
10 independence. It's certainly not an example of
11 research sufficient to support licensing of Yucca
12 Mountain. It's not a replacement or a redundancy for
13 the DOE program, but it's what we need because here's
14 a program issue I can't walk away from. I can't
15 ignore those cones.

16 COMMISSIONER ROGERS: Well, it seems to me
17 you're touching on something I wanted to mention and
18 didn't, and that was that it seems to me that what we
19 need to be able to do is to be able to ask the right
20 questions and we have to also be in a position to be
21 able to evaluate whether the answers are reasonable or
22 not, not to supply the answers but to know whether an
23 answer is a reasonable answer or not. Now, you know,
24 that's a fair level of sophistication.

25 One level is to be able to ask the right

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1 questions. That's pretty high. But then there's a
2 second level that's even deeper, to know whether those
3 answers are reasonable answers or not without having
4 done all the work ourselves. We can't do that. And
5 so it's that kind of a judgement that has to be made
6 as to where to stop, how far to go, to know that you
7 can ask the right questions, what they are, what the
8 right questions are to ask, and then what's the basis
9 on which you can judge whether an answer you get to
10 those questions is a reasonable answer or not from a
11 technical point of view. And so it seems to me that's
12 what has to drive our approach here. Once we feel
13 that we can do that, then that may change, of course,
14 because the questions may change because of the
15 iterative nature of this business, but that's what I'd
16 like to have some feeling about, how that works.

17 I don't want to pursue this too much
18 further, but I would like to ask you if you could
19 comment on the recent DOE decision to not emplace
20 waste in WIPP because they didn't feel that this --
21 well, what I've read is they didn't feel that they
22 would learn as much by doing this as they would from
23 laboratory experiments. I don't know the WIPP
24 situation that well, but, to me, I was a little bit
25 surprised by that rationale because there's nothing

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1 like hard data about a specific site and, you know, a
2 laboratory experiment is not the same thing as working
3 on a site with all of its dirty aspects.

4 I'm not familiar enough with the
5 particulars of the WIPP project to be able to comment
6 on it in any way, but, I wonder -- that question of
7 laboratory studies versus on-site studies it seems to
8 me is something that's important for our judgements
9 here as well and, if you could, comment very briefly,
10 or if you choose not to that's fine, on what was the
11 basis for DOE deciding that actually doing studies on-
12 site at WIPP with some waste emplaced as an experiment
13 are not -- would not yield as much information as
14 doing laboratory studies. And I understand that there
15 was some question from advisory committees that this
16 was a better way to go, and so--

17 MR. BERNERO: Well, Commissioner Rogers,
18 the WIPP tests when they were originally postulated,
19 the bin tests or you might call them "package tests,"
20 they became a subject of discussion about a year and
21 a half or two years ago in the Yucca Mountain Program
22 as, is there anything to, you know, test emplacement
23 in the strategic planning sense and there was
24 discussion at that time.

25 I think the essential question that the

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1 technical commenters commented on and which led to the
2 decision is the tests were really focused on bins and
3 the waste reaction with the bin rather than the waste
4 reaction with the salt and the repository WIPP was
5 providing simply an environment to hold the bin and
6 therefore you could do that under just as well a
7 control in a laboratory, and I think that was the
8 essential thing.

9 In all of our dialogue on the strategic
10 planning, we did not see relevance of those tests.
11 Remember, they have what is essentially unprocessed
12 waste, unpackaged waste, and so it's a different issue
13 they're looking at.

14 MR. TAYLOR: Commissioner, continuing in
15 your line of questions, Nick has a slide here on the
16 distribution of resources. It gives you a rough idea
17 and we can give you actual numbers.

18 MR. COSTANZI: May I have the bar graph,
19 please?

20 MR. TAYLOR: Not that one. The other one.

21 MR. COSTANZI: May I have the bar graph?

22 (Slide) This is a further breakdown of
23 our program in terms of the various technical
24 disciplines in which we're working.

25 Just to draw your attention to two things,

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1 the bulk of the work that we're doing is in the area
2 of hydrology, geochemistry and geology. Those, of
3 course, are the things which deal directly now with
4 site characterization, which is what DOE is doing.

5 We're doing a little bit of work on
6 containment and engineered systems.

7 We're not doing anything on what we call
8 controlled release, which is really the waste form
9 studies. At this point DOE is -- well, one, has not
10 selected a waste package material, so our containment
11 study is kind of an overview sorts of studies right
12 now. It's ongoing sorts of things. Just due to
13 budgetary limitations we feel that it's more
14 appropriate to put our resources in those areas in
15 which DOE is now conducting activities, namely site
16 characterizations. So, the site-related properties
17 are the ones in which we're putting the bulk of our
18 money.

19 COMMISSIONER REMICK: I'd just like to say
20 that I share Commissioner Rogers' observation that it
21 was not clear to me either how we make the research
22 decisions and it came to mind to me in a specific
23 example when you were talking about we're doing
24 research on borehole sealing because my memory tells
25 me that 12, 15 years ago a considerable amount of

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1 effort was done by international experts on borehole
2 sealing and a lot was published and so forth. The
3 thought went through my mind, and I realize we use the
4 term "research" very loosely. Are we doing
5 independent research or are we evaluating a lot of
6 that work that has been done and has been in journals
7 and so forth, done for DOE admittedly and so forth?
8 But are we doing independent borehole sealing or are
9 we doing evaluation of research that has been done and
10 reported in the literature and so forth?

11 MR. COSTANZI: The work that I discussed
12 here is independent work and not been done before.
13 The material is unsaturated fractured tuff. It's
14 material which -- it's rock which usually doesn't host
15 anything of resource value. So, there is not a whole
16 lot of interest in looking at it, certainly not in
17 sealing it. It's not a typical material in which you
18 drill holes to -- through which you drill holes to
19 obtain oil or water or other resources that then
20 require sealing.

21 So, there was really no body of directly
22 applicable literature on sealing fractured tuff and
23 what work we had done was to determine what kinds of
24 designs and what kinds of procedures that you can
25 develop competent seals in this kind of material.

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1 That just had not been done before.

2 MR. OTT: I'm Bill Ott, also from the
3 Office of Research. One other aspect is that the
4 regulations require us to seal according to the
5 permeability of the rocks in place. A lot of
6 traditional sealing work was just done to make certain
7 that there was not gross leakage, but we had to seal
8 those things to essentially very tight, very high
9 permeability work. So, it really is state-of-the-art
10 work which has not been traditionally done in the
11 past.

12 COMMISSIONER REMICK: So you're saying the
13 work that was done over a decade ago and so forth,
14 quite extensive, had no applicability to the tuff?

15 MR. OTT: There may have been some work
16 that was done, but there's a large body of knowledge
17 of work on sealing in the industry and petroleum
18 industry and places like that, which was not really
19 applicable.

20 COMMISSIONER REMICK: No, I'm referring to
21 work that was specifically done for Department of
22 Energy.

23 MR. OTT: I'm not certain whether that was
24 done to seal to the permeability. The individual that
25 we have working or had working on the program, Jack

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1 Daemen, is an internationally recognized expert and is
2 thoroughly familiar with the field. We're confident
3 that what he is doing did not essentially -- just
4 looking at other work, it was new work that hadn't
5 been done before. He had also done work in salt and
6 in basalt before and his latest work was in the tuff
7 area itself.

8 COMMISSIONER REMICK: Yes. I was
9 referring to some of the work, I think, that Russ Roy
10 did and I think work at University of Arizona and so
11 forth in the past is quite extensive.

12 MR. OTT: Yes, Jack Daemen was at the
13 University of Arizona and he was aware of Russ Roy's
14 work as well.

15 COMMISSIONER REMICK: Okay. Good. Okay.

16 Those that are looking at the hot hole
17 concept, are they also looking at what effect this
18 might have on the waste form? Because I also remember
19 a decade or so ago the findings that borosilicate
20 glass at elevated temperatures and pressures fragments
21 quite easily, increasing the surface area for leaching
22 and therefore if a canister fails, why there's a
23 concern. Are they looking at those aspects? Is there
24 a coupling between those who are looking at the
25 hydrology and so forth and those that are looking from

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1 leaching from waste form and --

2 MR. COSTANZI: I don't know that there is.
3 There may be. I'm not aware that there is any cross
4 talk there. In fact, you point out something which is
5 a very concern to us that it's not simply drying out--
6 the effect is not to simply dry out the area next to
7 the waste package. The effects of high temperatures
8 in the repository are far reaching. They change the
9 local mineralogy, they change the local hydrology and,
10 as you point out, they change the leaching
11 characteristics of the waste form.

12 We are not addressing yet in an integrated
13 fashion that question. We're still trying to attack
14 this problem in terms of the pieces.

15 MR. SILBERBERG: The center has done some
16 initial modeling actually starting with NMSS and
17 something that we can use that we'll be looking at in
18 the research program. Given the fact that there might
19 be this dryout effect, there also can be locally a
20 concentration of minerals and minerals which, in fact,
21 being left behind could attack the waste package. So,
22 the modeling in terms of how it might impact the waste
23 package, we've started looking at that at the center.

24 COMMISSIONER REMICK: Good.

25 MR. BERNERO: I wonder if I could add to

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1 it, Commissioner Remick. Our program in the research
2 program is not spending any significant resources on
3 waste form and there's a major regulatory reason why.
4 Originally in the high-level waste program there was
5 going to be a form specification because it was
6 presumed all would be reprocessing waste and it would
7 be vitrified to some specified process and to certain
8 waste form performance criteria. What we have now
9 instead is a need for DOE to characterize what the
10 form of the waste is and the forms are many. Some is
11 vitrified waste, some is ordinary power reactor spent
12 fuel, some is N reactor spent fuel, some will -- you
13 know, whatever it might be.

14 So, we're in the mode of expecting and
15 telling DOE that they have to characterize it and they
16 do have to consider that in order to understand what
17 credit, if any, can be attributed to the waste form.

18 In our present licensing requirements, we
19 have overall performance. The package should not leak
20 for about a thousand years and then when it does leak
21 it shall leak slowly, very slowly. So, that's when
22 you would take into account the waste form. But I
23 don't know of any specific work that DOE has right
24 now.

25 COMMISSIONER REMICK: Yes. Okay.

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1 One other observation. I agree with
2 Chairman Selin when he said that the presentation was
3 a good explanation of what you're doing and why you're
4 doing it. The one area that I thought was missing
5 would have been of interest and I hope sometime we
6 hear and that is results. You must be getting some
7 results and we have not talked about results of what
8 we are doing, and that obviously is missing from the
9 presentation and would be of interest, realizing some
10 of this is ongoing research, but some of it's been
11 going for some time. We must have some things that --
12 being an engineer, that always stimulates me rather
13 than plans.

14 MR. SILBERBERG: In fact, annually in the
15 Office of Research we collect for Mr. Beckjord a
16 listing of, if you will, peer reviewed products,
17 amongst others, that are done in the research
18 programs. But we have actually compiled that this
19 past year for the high-level waste program and with a
20 large preponderance of the products coming from the
21 center. I think it's a rather impressive list of
22 products and that in itself will, I think, make
23 another presentation. So, what have we learned so
24 far?

25 COMMISSIONER REMICK: Okay. Thank you

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1 very much.

2 CHAIRMAN SELIN: Commissioner de Planque?

3 COMMISSIONER de PLANQUE: Yes. I would
4 agree with Commissioner Remick. Researchers also
5 yearn for what's the bottom line, what do you know.
6 But we realize the constraints on the timing for this
7 briefing.

8 I have a couple general questions. Can
9 you tell us if and how you're interacting with the
10 National Academy of Sciences on their work right now?
11 Are you going to these meetings? Are you plugged into
12 what they're doing?

13 MR. BERNERO: We're actually -- we have an
14 observer representative, Margaret --

15 COMMISSIONER de PLANQUE: For Research?

16 MR. BERNERO: No, no, no, from the NRC.
17 Margaret Federline is actually, if you could say, an
18 NRC representative or liaison with that activity and
19 we have tracked that activity very closely. I expect
20 to attend their December meeting which is here in
21 Washington and speak to them at that meeting. But we
22 are doing it collegially, as an agency, not separately
23 as Research.

24 COMMISSIONER de PLANQUE: But Research is
25 in the loop on what's going on?

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1 MR. BERNERO: I believe so.

2 COMMISSIONER de PLANQUE: Okay. It's
3 obvious that a lot of work is being done in the
4 international community on waste and I didn't hear too
5 much about that other in the analogue studies, the
6 natural analogue studies. Could you just give us
7 briefly some of the ways that the NRC staff is plugged
8 into the international work? Not necessarily
9 contractors, but the NRC staff, in research.

10 MR. COSTANZI: Okay. In anticipation of
11 my answer, my colleague has put on the slide. This is
12 a list of groups with whom we're involved in
13 international research in the waste area. It spans
14 everything from looking at hydrologic and transport
15 models and methods to gain confidence in the
16 appropriateness of those models, doing what they say
17 they're supposed to do, looking at the thermal
18 response and mechanical response of the host rock to
19 the emplaced waste. That's the DECOVALEX, so-called
20 THMC, thermal mechanical chemical, hydrologic
21 couplings.

22 Of course the Oklo study itself, which I
23 talked about earlier and the CEC-run organization,
24 National Analogue Working Group, which looks at the
25 suitability and opportunity to use natural analogues

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1 throughout the world in again assessing processes and
2 models describing processes operating in a repository.

3 We estimate that -- I think
4 conservatively, that in our interactions in the
5 international community looking at this problem
6 probably in effect doubles our resources.

7 MR. SILBERBERG: I would just add that if
8 you look at the lower set of bullets, if you look at
9 each one of those multi-national programs, we have a
10 staff member in the branch who is intimately involved
11 in every one of those programs, either serving on the
12 managing board or the advisory committee within the
13 program and our staff are in attendance at all of
14 those principle meetings. And in fact, I have an
15 impact, important impact on the international
16 programs, while also receiving peer review from them.

17 COMMISSIONER de PLANQUE: Okay.

18 MR. COSTANZI: I also might mention that
19 the nature of the agreements run from cooperative
20 research -- we give you our results, you give us your
21 results -- to international exercises where we're
22 sitting down and working problems and each member
23 country has problems they work on and then we compare
24 the answers that we get by employing various
25 techniques that try and get some feels. Again, the

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1 range of application of -- perfect range of
2 application of various models that are out there that
3 people are exploring to try and assess performance of
4 a repository.

5 COMMISSIONER de PLANQUE: I don't know all
6 the acronyms up there and you don't need to tell me,
7 but any IAEA work that you're plugged into?

8 MR. BERNERO: Actually, the way it works
9 out in high-level waste, the OECD has a radioactive
10 waste management committee. I'm the NRC member of
11 that committee and they have subcommittees such as the
12 performance assessment advisory group and things like
13 that. The IAEA has participated with that activity.
14 Also, the IAEA has its own RAWs, radioactive waste
15 standards, and we have some direct interaction with
16 them on that. But that's not focused as much on high-
17 level waste as it is more on low-level waste.

18 COMMISSIONER de PLANQUE: Yes, I know.
19 Yes. Okay.

20 You talked about resources earlier and I
21 think the budget calls for a reduction in FTEs in this
22 area. How are you going to deal with that? What
23 impact is that going to have?

24 MR. BERNERO: Which budget are you
25 referring to?

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1 COMMISSIONER de PLANQUE: Well, you've got
2 something like seven in '93, four in '94 listed in
3 this area.

4 MR. BERNERO: We have had the '95 budget
5 is up now and then the future ones are the ones I was
6 referring to where we're in that agonizing reappraisal
7 as part of the management plans, the research plans
8 and the five year plan.

9 CHAIRMAN SELIN: He's talking most about
10 NMSS.

11 COMMISSIONER de PLANQUE: Yes.

12 MR. BERNERO: Yes. Well, if you look at
13 the budgets, remember that the high-level waste
14 budget, the nuclear waste fund origin budget includes
15 OGC, LSS, Research, ourselves. It's a whole program.
16 It has to be looked at integrated.

17 COMMISSIONER de PLANQUE: Okay.

18 MR. BERNERO: But I can't tell you right
19 now how those cuts will be taken.

20 MR. TAYLOR: More to come on that.

21 COMMISSIONER de PLANQUE: Right. Okay.

22 I want to ask you a big picture question.
23 It's obvious that a lot of the kinds of research that
24 you're doing should yield results eventually, should
25 yield answers eventually. But are there any key

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1 issues where it looks difficult, if not impossible, to
2 get the answers that you think you'll need? Are there
3 any issues in that category?

4 MR. COSTANZI: I think that certainly some
5 areas the answers are more difficult than others. I
6 think in terms of modeling, for example, it's very
7 difficult to deal successfully with the variability of
8 the hydrologic parameters at a site. But to say that
9 we don't think that we're going to get an answer, I
10 don't think I can say that. I think we are pretty
11 confident that the lines of research we're pursuing
12 are going to pay off. We've had some successes. We
13 are chipping away at some of these major
14 uncertainties, but I can't say, "Yes, everything's in
15 the bag." But on the other hand, I have no reason to
16 be pessimistic.

17 COMMISSIONER de PLANQUE: There's nothing
18 that you go to bed at night saying, how are we ever
19 going to get this answer given the requirements that
20 you're anticipating?

21 MR. COSTANZI: No. DOE may go to bed at
22 night saying that since they ultimately do have to
23 supply the answers and we, as Commissioner Rogers
24 pointed out, have to make sure that the answer makes
25 sense. But no, I don't see anything like that.

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1 DOCTOR BECKJORD: Yes. I think that the
2 predictions about performance far into the future get
3 extremely difficult. The legislation calls for this
4 kind of thing. I just don't feel myself that you can
5 say that this is going to do this over the next 10,000
6 years with high confidence. The further out that
7 people want to know the performance, the less the
8 confidence will be and I think we have to face that.

9 COMMISSIONER de PLANQUE: Are we facing
10 that?

11 DOCTOR BECKJORD: Well, a lot of it has to
12 do with legislation, Commissioner.

13 COMMISSIONER de PLANQUE: I know.

14 DOCTOR BECKJORD: I think that the
15 technical people are facing that. I think if you have
16 a face to face discussion with the people who are
17 working on the job, they recognize the problem.

18 MR. TAYLOR: Bob, do you want to --

19 MR. BERNERO: I think there's something
20 that should be added here. It's not so much a
21 question of can you get an answer, but can you get the
22 right answer or an acceptable --

23 COMMISSIONER de PLANQUE: Or the
24 acceptable uncertainty.

25 MR. BERNERO: An acceptable answer and

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1 perhaps carbon-14 is the most dramatic current example
2 of that. There has been a lot of work on modeling and
3 analysis of carbon-14 released from Yucca Mountain and
4 on its face it appears that it constitutes a release
5 in excess of the EPA standard. So, yes, we can get an
6 answer, but what do we do with that answer and that is
7 one of the crucial issues the National Academy is
8 looking at, a release standard where there is no
9 individual risk ever with the high confidence to say
10 that and yet it's an exceedance on its face. It
11 appears to be an exceedance of the standard. So, one
12 can have many cases perhaps where the answer is
13 obtainable, but then the question is what do we do
14 with it.

15 COMMISSIONER de PLANQUE: Doesn't match
16 with the requirements.

17 MR. BERNERO: Yes.

18 COMMISSIONER de PLANQUE: Yes. Okay.
19 Thank you. Excellent briefing.

20 MR. TAYLOR: That concludes it. Thank
21 you.

22 (Whereupon, at 11:31 a.m., the above-
23 entitled matter was concluded.)
24
25

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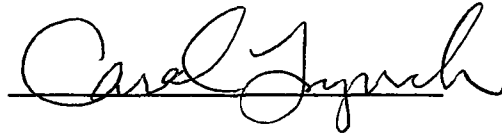
This is to certify that the attached events of a meeting
of the United States Nuclear Regulatory Commission entitled:

TITLE OF MEETING: BRIEFING ON NRC RESEARCH PROGRAMS ON
HIGH-LEVEL WASTE

PLACE OF MEETING: ROCKVILLE, MARYLAND

DATE OF MEETING: OCTOBER 27, 1993

were transcribed by me. I further certify that said transcription
is accurate and complete, to the best of my ability, and that the
transcript is a true and accurate record of the foregoing events.



Reporter's name: Peter Lynch

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**STAFF BRIEFING ON THE
HIGH LEVEL RADIOACTIVE WASTE
RESEARCH PROGRAM**



OCTOBER 27, 1993

FRANK A. COSTANZI

**Contact: Frank A. Costanzi
Phone: 492-3760**

HIGH LEVEL WASTE RESEARCH PROGRAM

OBJECTIVE

**PROVIDE TOOLS AND DATA TO SUPPORT LICENSING ASSESSMENT
OF DOE COMPLIANCE WITH 10CFR PART 60 AND EPA HLW
STANDARD**

HIGH LEVEL WASTE RESEARCH PROGRAM

ACTIVITIES

ADDRESS KEY TECHNICAL UNCERTAINTIES

**PROVIDE TECHNICAL SUPPORT FOR FURTHER
IDENTIFICATION/REFINEMENT OF KEY TECHNICAL
UNCERTAINTIES**

**PROVIDE MODELS, TECHNICAL SUPPORT,
AND LIMITED DATA FOR
DEVELOPMENT AND USE OF
ITERATIVE PERFORMANCE ASSESSMENT**

HIGH LEVEL WASTE RESEARCH PROGRAM

**PERFORMANCE ASSESSMENT
IS THE INTEGRATING ELEMENT OF
THE NRC'S HLW PROGRAM**

**EACH ELEMENT OF THE HLW RESEARCH PROGRAM IS TIED TO
PERFORMANCE ASSESSMENT THROUGH THE DEVELOPMENT OF:
MODELS, TECHNICAL BASIS FOR THE SELECTION OF MODELS,
OR LIMITED DATA TO TEST AND EXERCISE MODELS**

OUTLINE OF PRESENTATION

- ▶ **TECHNICAL ISSUES OF REGULATORY SIGNIFICANCE**
 - ▶ **RESEARCH ADDRESSING ISSUES**
 - ▶ **ANTICIPATED PRODUCTS**
 - ▶ **ANTICIPATED USE**

SITE

KEY TECHNICAL UNCERTAINTIES RELATED TO SITE CHARACTERIZATION METHODS

- **WHAT MEASUREMENT TECHNIQUES ARE APPROPRIATE FOR DETERMINING GEOLOGIC PROPERTIES AND PARAMETER VALUES?**
- **WHAT MEASUREMENT TECHNIQUES ARE APPROPRIATE FOR DETERMINING HYDROLOGIC PROPERTIES AND PARAMETER VALUES?**

**SITE ISSUE--WHAT MEASUREMENT TECHNIQUES ARE
APPROPRIATE FOR DETERMINING GEOLOGIC PROPERTIES AND
PARAMETER VALUES?**

- ▶ **RESEARCH PREVIOUS EXPERIMENTS INVESTIGATED
TECHNIQUES SUCH AS DOWN-HOLE TOMOGRAPHY
AND CORE-LOGGING (U OF AZ, ETC.)**

**PRESENT EXPERIMENTS ARE EXAMINING
OTHER METHODS OF DETERMINING GEOLOGIC
PROPERTIES AND PARAMETERS, SUCH AS
AGE DATING FAULT OFFSETS**

**SITE ISSUE--WHAT MEASUREMENT TECHNIQUES ARE
APPROPRIATE FOR DETERMINING GEOLOGIC PROPERTIES AND
PARAMETER VALUES?
(CONTINUED)**

- PRODUCT EVALUATION OF SITE CHARACTERIZATION
TECHNIQUES BEING USED BY DOE AT YUCCA
MOUNTAIN (CY 96)**
- USE ASSESS DOE'S GEOPHYSICAL SITE
CHARACTERIZATION PROGRAM**

**SITE ISSUES--WHAT MEASUREMENT TECHNIQUES ARE
APPROPRIATE FOR DETERMINING HYDROLOGIC PROPERTIES AND
PARAMETER VALUES?**

- ▶ **RESEARCH PREVIOUS WORK FIELD TESTED METHODS TO
DETERMINE LOCAL HYDROLOGIC PROPERTIES
(U OF AZ)**

**CURRENT RESEARCH (U OF AZ) IS
CONTINUING MEASUREMENTS OF HYDROLOGIC
PROPERTIES OF A SITE VERY SIMILAR TO
YUCCA MOUNTAIN--UNSATURATED FRACTURED
TUFF**

**SITE ISSUES--WHAT MEASUREMENT TECHNIQUES ARE
APPROPRIATE FOR DETERMINING HYDROLOGIC PROPERTIES AND
PARAMETER VALUES? (CONTINUED)**

- PRODUCT HYDROLOGIC FIELD DATA DEVELOPED USING
DEMONSTRATED TECHNIQUES FROM A WELL-
CHARACTERIZED SITE (U OF AZ, FY 94)**

- USE EVALUATE METHODS DOE EMPLOYS TO
INTERPRET REPOSITORY-SCALE HYDROLOGIC
PROPERTIES FROM LOCAL MEASUREMENTS**

SITE

KEY TECHNICAL UNCERTAINTIES RELATED TO QUALITATIVE AND QUANTITATIVE DESCRIPTION OF THE YUCCA MOUNTAIN SITE

- **WHAT IS THE NATURE OF THE TECTONIC PROCESSES OPERATING IN THE CENTRAL BASIN AND RANGE?**
- **WHAT ARE THE CHARACTERISTICS AFFECTING GROUND WATER FLOW AT YUCCA MOUNTAIN?**
- **WHAT ARE THE CHARACTERISTICS AFFECTING RADIONUCLIDE TRANSPORT AT YUCCA MOUNTAIN?**

**SITE ISSUES--WHAT IS THE NATURE OF THE TECTONIC
PROCESSES OPERATING IN THE CENTRAL BASIN AND RANGE?**

- ▶ **RESEARCH** **GEODETIC OBSERVATIONS (CAL TECH), AND
ANALYTICAL STUDIES USING EXISTING DATA, OF
THE TECTONICS OF THE CENTRAL BASIN AND
RANGE**

- ▶ **PRODUCT** **MODELS WITH SUPPORTING DATA OF: MAJOR
TECTONIC PROCESSES, SIGNIFICANT
FEATURES, AND DEFORMATION RATES OF THE
YUCCA MOUNTAIN AREA (CY 96)**

**SITE ISSUES--WHAT IS THE NATURE OF THE TECTONIC
PROCESSES OPERATING IN THE CENTRAL BASIN AND RANGE?
(CONTINUED)**

► USE

**EVALUATION OF DOE'S ASSESSMENT OF
TECTONIC PROCESSES AND RELATED
VOLCANISM AT THE YUCCA MOUNTAIN SITE**

**SITE ISSUES--WHAT ARE THE CHARACTERISTICS AFFECTING
GROUND WATER FLOW AT YUCCA MOUNTAIN?**

- ▶ **RESEARCH ANALYTICAL STUDIES (U OF AZ AND CNWRA)
ASSESSING THE USE OF STOCHASTIC
TECHNIQUES TO DEVELOP LARGE-SCALE
HYDROLOGIC MODELS OF UNSATURATED FLOW IN
FRACTURED, POROUS TUFF**

**SITE ISSUES--WHAT ARE THE CHARACTERISTICS AFFECTING
GROUND WATER FLOW AT YUCCA MOUNTAIN? (CONTINUED)**

- ▶ **PRODUCT** **IDENTIFICATION OF APPROPRIATE
TECHNIQUES FOR MODELING GROUND WATER
FLOW AT THE YUCCA MOUNTAIN SITE (CY
95) AND DEFINING THE RANGE OF
HYDROLOGIC MODELS THAT WOULD BE
CONSISTENT WITH THE MEASUREMENTS TAKEN
AT THE SITE (CY 97)**

**SITE ISSUES--WHAT ARE THE CHARACTERISTICS AFFECTING
GROUND WATER FLOW AT YUCCA MOUNTAIN? (CONTINUED)**

► USE

**REVIEW OF DOE'S QUANTITATIVE
DESCRIPTION OF YUCCA MOUNTAIN
HYDROLOGY, DOE'S TREATMENT OF SPATIAL
VARIATIONS OF THE HYDROLOGIC
PROPERTIES OF THE SITE, AND DOE'S
ASSESSMENT OF THE EVOLUTION OF YUCCA
MOUNTAIN HYDROLOGY OVER TIME**

**SITE ISSUES--WHAT ARE THE CHARACTERISTICS AFFECTING
RADIONUCLIDE TRANSPORT AT YUCCA MOUNTAIN?**

- ▶ **RESEARCH** **FIELD (PEÑA BLANCA NATURAL ANALOGUE) AND
LABORATORY STUDIES TO DETERMINE THE
CONTROLLING MECHANISMS OF RADIONUCLIDE
TRANSPORT IN TUFF**

- ▶ **PRODUCT** **KINETIC AND THERMODYNAMIC MODELS AND
DATA OF RADIONUCLIDE SPECIATION AND
MOVEMENT IN TUFF (CY 95)**

**SITE ISSUES--WHAT ARE THE CHARACTERISTICS AFFECTING
RADIONUCLIDE TRANSPORT AT YUCCA MOUNTAIN? (CONTINUED)**

- ▶ **USE** **EVALUATE DOE'S GEOCHEMICAL MODEL OF THE
YUCCA MOUNTAIN SITE, SUPPORTING
GEOCHEMICAL DATA, AND DOE'S USE OF
NATURAL ANALOGUES IN DEVELOPING ITS
GEOCHEMICAL MODEL**

SITE

KEY TECHNICAL UNCERTAINTIES RELATED TO FUTURE STATE OF YUCCA MOUNTAIN SITE

- **HOW WILL THE HEAT FROM THE HLW AFFECT THE LOCAL
HYDROLOGY AND GEOCHEMISTRY?**
- **WHAT IS THE CREDIBLE RANGE OF FUTURE CLIMATES AT
YUCCA MOUNTAIN (PRECIPITATION AND WATER
INFILTRATION)?**
- **HOW LIKELY ARE VOLCANOS AT THE SITE AND WHAT EFFECT
MAY THEY HAVE ON THE REPOSITORY (GEOLOGY,
HYDROLOGY, AND EMPLACED WASTES)?**

SITE

KEY TECHNICAL UNCERTAINTIES RELATED TO FUTURE STATE OF YUCCA MOUNTAIN SITE (CONTINUED)

- **WHAT EFFECT WILL SEISMIC ACTIVITY IN THE REGION
HAVE ON THE HYDROLOGY OF YUCCA MOUNTAIN?**

**SITE ISSUES--HOW WILL THE HEAT FROM THE HLW AFFECT THE
LOCAL HYDROLOGY AND GEOCHEMISTRY?**

- RESEARCH NATURAL ANALOGUE STUDIES (OKLO--CEA) AND
LABORATORY EXPERIMENTS IN GEOCHEMISTRY AND
REPOSITORY THERMOHYDRAULICS**

- PRODUCT IDENTIFICATION OF THE KEY HEAT-DRIVEN
MECHANISMS THAT AFFECT HYDROLOGY AND
TRANSPORT CLOSE TO THE REPOSITORY, AND
A MODEL OF THE EFFECT OF HEATING ON
LOCAL GEOCHEMISTRY (CY 96) AND
HYDROLOGY (CY 94)**

**SITE ISSUES--HOW WILL THE HEAT FROM THE HLW AFFECT THE
LOCAL HYDROLOGY AND GEOCHEMISTRY? (CONTINUED)**

► USE

**DATA AND MODELS TO TEST DOE'S
ASSESSMENT OF THE ANTICIPATED WASTE
PACKAGE ENVIRONMENT OVER TIME**

SITE ISSUES--WHAT IS THE CREDIBLE RANGE OF FUTURE CLIMATES AT YUCCA MOUNTAIN (PRECIPITATION AND WATER INFILTRATION)?

- ▶ **RESEARCH METHODS TO ASSESS WATER INFILTRATION HAVE BEEN EXAMINED (U OF AZ)**
 - FUTURE WORK WILL ADDRESS EFFECT OF CHANGING CLIMATE ON YUCCA MOUNTAIN REGION**

SITE ISSUES--WHAT IS THE CREDIBLE RANGE OF FUTURE CLIMATES AT YUCCA MOUNTAIN (PRECIPITATION AND WATER INFILTRATION)? (CONTINUED)

- PRODUCT** **METHODS OF TREATING INFILTRATION AT YUCCA MOUNTAIN HAVE BEEN IDENTIFIED-- THESE WILL BE EVALUATED ON REGIONAL AND SUB-REGIONAL SCALES--MODELS ADDRESSING THE CONSEQUENCES OF A RANGE OF POTENTIAL CLIMATES WILL BE DEVELOPED (CY 96)**

- USE** **EVALUATION OF DOE'S ASSESSMENT OF THE EFFECTS OF FUTURE CLIMATES AT YUCCA MOUNTAIN**

SITE ISSUES--HOW LIKELY ARE VOLCANOS AT THE SITE AND WHAT EFFECT MAY THEY HAVE ON THE REPOSITORY (GEOLOGY, HYDROLOGY, AND EMPLACED WASTES)?

- ▶ **RESEARCH** **ANALYTICAL STUDIES USING FIELD OBSERVATIONS ASSESSING VOLCANISM IN THE BASIN AND RANGE**
- ▶ **PRODUCT** **MODELS OF THE LIKELIHOOD, CHARACTERISTICS, AND CONSEQUENCES OF VOLCANIC ERUPTIONS IN THE CENTRAL BASIN AND RANGE (CY 96)**

SITE ISSUES--HOW LIKELY ARE VOLCANOS AT THE SITE AND WHAT EFFECT MAY THEY HAVE ON THE REPOSITORY (GEOLOGY, HYDROLOGY, AND EMPLACED WASTES)?

► USE

DEVELOP ALTERNATIVE INTERPRETATIONS OF REGIONAL DATA, AS TO THE LIKELIHOOD, LOCATION, CHARACTERISTICS, AND CONSEQUENCES OF VOLCANOS IN THE YUCCA MOUNTAIN REGION, TO EVALUATE DOE'S ASSESSMENT OF THE POTENTIAL FOR AND EFFECTS OF VOLCANISM AT YUCCA MOUNTAIN

**SITE ISSUES--WHAT EFFECT WILL SEISMIC ACTIVITY IN THE
REGION HAVE ON THE HYDROLOGY OF YUCCA MOUNTAIN?**

- ▶ **RESEARCH** **ANALYSES AND INTERPRETATIONS OF EXISTING
HISTORICAL AND NEW FIELD DATA RELATING
CHANGES IN REGIONAL HYDROLOGY TO SEISMIC
ACTIVITY (U OF C AND CNWRA)**

- ▶ **PRODUCT** **MODEL RELATING REGIONAL HYDROLOGIC
CHANGES TO SEISMIC EVENTS (CY 95)**

**SITE ISSUES--WHAT EFFECT WILL SEISMIC ACTIVITY IN THE
REGION HAVE ON THE HYDROLOGY OF YUCCA MOUNTAIN?
(CONTINUED)**

► USE

**REVIEW DOE'S TREATMENT OF POTENTIAL
PERCHED WATER ZONES AND STEEP HYDRAULIC
GRADIENTS NEAR THE YUCCA MOUNTAIN SITE**

ENGINEERING

KEY TECHNICAL UNCERTAINTIES RELATED TO REPOSITORY ENGINEERING

- **WILL THE WASTE EMPLACEMENT DRIFTS AND BOREHOLES AT YUCCA MOUNTAIN REMAIN OPEN DURING THE RETRIEVAL PERIOD, AND WILL THEY BE STABLE POST RETRIEVAL PERIOD?**
- **HOW LONG WILL THE SHAFTS AND BOREHOLES REMAIN SEALED?**

ENGINEERING ISSUES--WILL THE WASTE EMPLACEMENT DRIFTS AND BOREHOLES AT YUCCA MOUNTAIN REMAIN OPEN DURING THE RETRIEVAL PERIOD, AND WILL THEY BE STABLE POST RETRIEVAL PERIOD?

- ▶ **RESEARCH** **FIELD AND LABORATORY EXPERIMENTS AND ANALYTICAL STUDIES EVALUATING EFFICACY OF ROCK MECHANICS MODELS USED FOR PREDICTING TUNNEL STABILITY AND RESPONSE TO EMPLACED WASTES AND TO EARTHQUAKES**

**ENGINEERING ISSUES--WILL THE WASTE EMPLACEMENT DRIFTS
AND BOREHOLES AT YUCCA MOUNTAIN REMAIN OPEN DURING THE
RETRIEVAL PERIOD, AND WILL THEY BE STABLE POST RETRIEVAL
PERIOD? (CONTINUED)**

- ▶ **PRODUCT** **REVIEW OF SEVERAL ROCK MECHANICS CODES
AGAINST FIELD (U OF C CY 96, CNWRA CY
94) AND LABORATORY OBSERVATIONS OF ROCK
JOINT BEHAVIOR (CNWRA CY 94)**

**ENGINEERING ISSUES--WILL THE WASTE EMPLACEMENT DRIFTS
AND BOREHOLES AT YUCCA MOUNTAIN REMAIN OPEN DURING THE
RETRIEVAL PERIOD, AND WILL THEY BE STABLE POST RETRIEVAL
PERIOD? (CONTINUED)**

- USE DEVELOPMENT OF METHODS FOR REVIEW OF
DOE'S ASSESSMENT OF REPOSITORY RESPONSE
TO EARTHQUAKES, AND THERMOMECHANICAL
STABILITY OF UNDERGROUND EXCAVATIONS**

ENGINEERING ISSUES--HOW LONG WILL THE SHAFTS AND BOREHOLES REMAIN SEALED?

- ▶ **RESEARCH** **LABORATORY PROGRAM INVESTIGATING EFFECTIVENESS OF VARIOUS TECHNIQUES FOR SEALING SHAFTS AND BOREHOLES (U OF AZ)**
- ▶ **PRODUCT** **DATA ON THE EFFECTIVENESS OF VARIOUS TECHNIQUES AND DESIGNS FOR SEALING SHAFTS AND BOREHOLES IN UNSATURATED FRACTURED TUFF (CY 94)**
- ▶ **USE** **REVIEW OF DOE'S SHAFT AND BOREHOLE SEALING PROGRAM**

ENGINEERING

KEY TECHNICAL UNCERTAINTIES RELATED TO CONTAINMENT PERFORMANCE OF WASTE PACKAGE

- **HOW LONG WILL THE WASTE PACKAGE CONTAIN THE HLW?**
- **HOW CONFIDENTLY CAN SHORT TERM LABORATORY TESTS BE
USED TO PREDICT LONG TERM PERFORMANCE?**

**ENGINEERING ISSUES--HOW LONG WILL THE WASTE PACKAGE
CONTAIN THE HLW?**

- ▶ **RESEARCH** **EXPERIMENTAL PROGRAM TO IDENTIFY WASTE
PACKAGE CORROSION MECHANISMS THAT CAN BE
EXPECTED IN REPOSITORY ENVIRONMENT**

- ▶ **PRODUCT** **CORRELATION OF DOMINANT CORROSION TYPES
AND RATES WITH ENVIRONMENTAL PARAMETERS
(PITTING CORROSION-CY 93, INTERNAL
CORROSION-CY 95, AND STRESS CORROSION-
CY 95)**

**ENGINEERING ISSUES--HOW LONG WILL THE WASTE PACKAGE
CONTAIN THE HLW? (CONTINUED)**

► USE

**ASSESS WHETHER DOE HAS IDENTIFIED
CONTROLLING WASTE PACKAGE FAILURE
MECHANISMS, EMPLOYED APPROPRIATELY
CONSERVATIVE MODELS IN ASSESSING WASTE
PACKAGE PERFORMANCE, AND CONFIRM
SUITABILITY OF WASTE PACKAGE MATERIAL
TO MEET CONTAINMENT REQUIREMENT**

**ENGINEERING ISSUES--HOW CONFIDENTLY CAN SHORT TERM
LABORATORY TESTS BE USED TO PREDICT LONG TERM
PERFORMANCE?**

- ▶ **RESEARCH** CONTINUING LABORATORY PROGRAM OF TESTING
WASTE PACKAGE MATERIALS UNDER A RANGE OF
POTENTIAL REPOSITORY CONDITIONS WILL BE
SUPPLEMENTED WITH OBSERVATION OF BURIED
METAL OBJECTS AT AKROTIRI NATURAL ANALOGUE
SITE, AND LONG TERM (YEARS) OBSERVATION OF
WASTE PACKAGE MATERIALS

**ENGINEERING ISSUES--HOW CONFIDENTLY CAN SHORT TERM
LABORATORY TESTS BE USED TO PREDICT LONG TERM
PERFORMANCE?**

- ▶ **PRODUCT** **ASSESSMENT OF MECHANISTIC CORROSION
MODELS FOR CORRELATING SHORT TERM
LABORATORY TESTS, LONG TERM IN SITU
TESTS, AND FIELD OBSERVATIONS**

- ▶ **USE** **REVIEW DOE DEMONSTRATION OF COMPLIANCE
WITH CONTAINMENT REQUIREMENT**

SOURCE TERM

KEY TECHNICAL UNCERTAINTIES RELATED TO RELEASE OF WASTES FROM WASTE PACKAGES

- **AT WHAT RATE WILL RADIONUCLIDES ENTER THE GROUND
WATER SYSTEM?**

SOURCE TERM ISSUES--AT WHAT RATE WILL RADIONUCLIDES ENTER THE GROUND WATER SYSTEM?

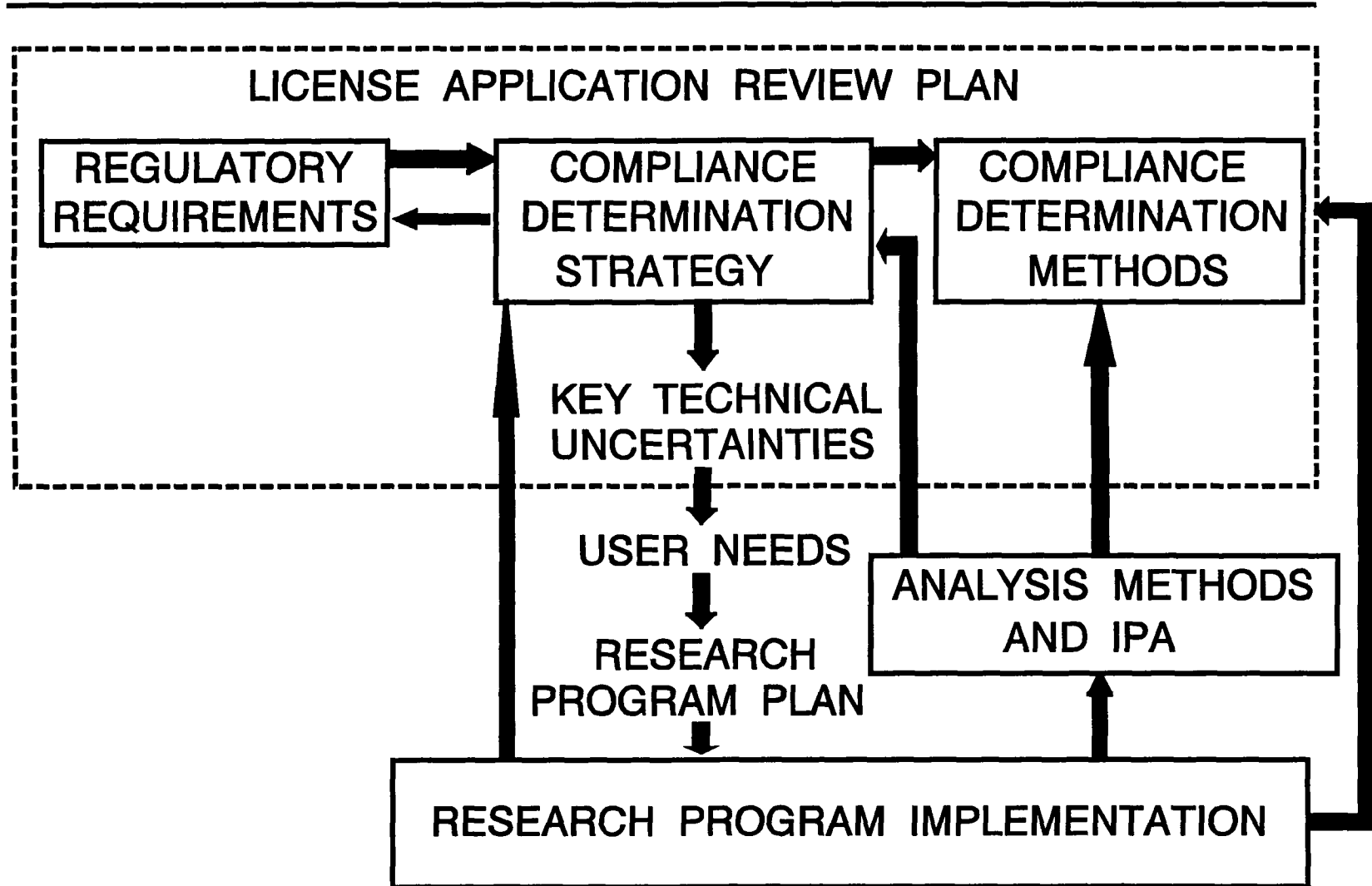
- ▶ **RESEARCH** **FIELD OBSERVATION OF ACTINIDE AND FISSION PRODUCT MIGRATION (OKLO AND PEÑA BLANCA NATURAL ANALOGUE STUDIES)**
- ▶ **PRODUCT** **DATA ON AND MODEL OF SPENT FUEL LEACHING, AND RADIONUCLIDE SPECIATION AND TRANSPORT IN A GEOLOGIC ENVIRONMENT (CY 95)**
- ▶ **USE** **CONFIRM RESULTS OF LABORATORY EXPERIMENTS ON RADIONUCLIDE SPECIATION AND MOBILITY**

NRC HLW RESEARCH INTERNATIONAL INTERFACES

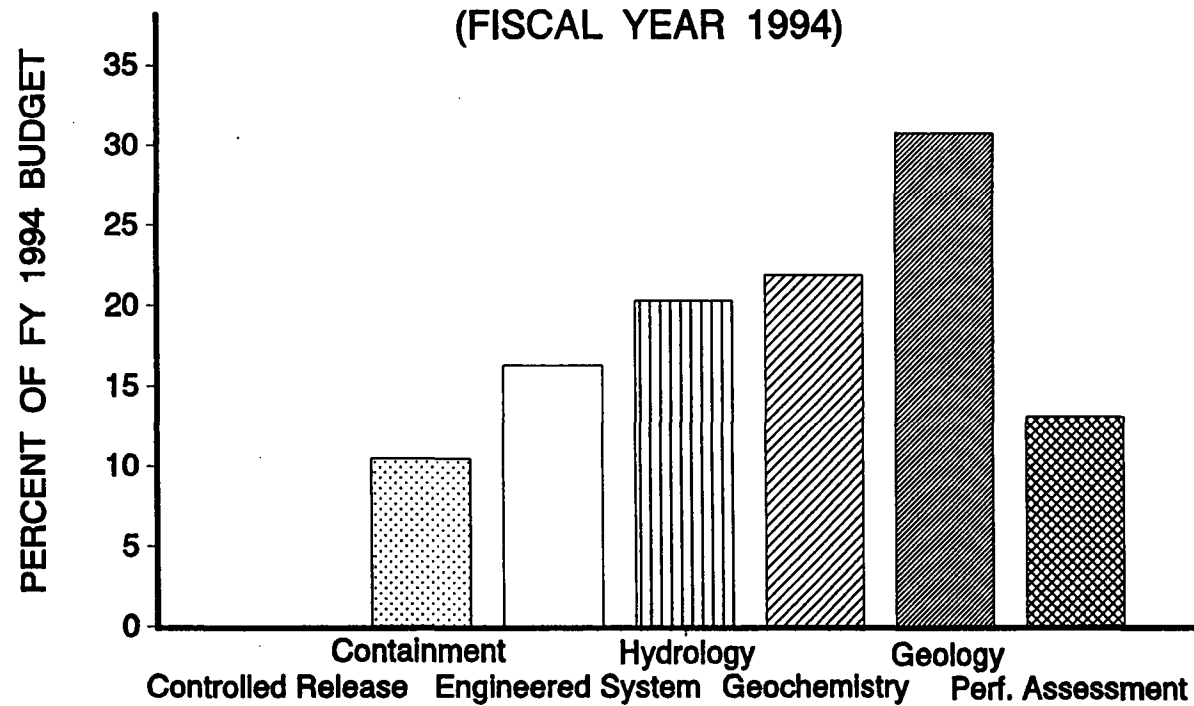
- **Bilateral Agreements**
 - **Switzerland (NAGRA)**
 - **France (CEA)**
 - **Sweden (SKI)**
 - **Japan (JAERI)**

- **Multi-National Programs**
 - **INTRAVAL**
 - **ARAP/ASARR**
 - **DECOVALEX**
 - **Oklo (CEC/CEA)**
 - **NAWG (CEC)**

RELATIONSHIP OF NRC HLW RESEARCH TO LICENSING PROGRAM



**DISTRIBUTION OF HLW RESEARCH FUNDING
(FISCAL YEAR 1994)**



PLANNED DISTRIBUTION OF FY94 FUNDS