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NUCLEAR REGULATORY COMMISSION

In the matter of:

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

SUBCOMMITTEE ON WASTE
MANAGEMENT

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UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

Subcommittee on Waste Management

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

Thursday, April 21, 1983

The Subcommittee on Waste Management met at 8:30 a.m., pursuant to notice, Dade Moeller, chairman, presiding.

PRESENT FOR THE ACRS:

D. Moeller, Member
R. Axtmann, Member
D. Orth, Consultant
M. Steindler, Consultant
R. Thompson, Consultant
S. Philbrick, Consultant
R. Foster, Consultant

R. C. Tang, Designated Federal Employee

Audience Participants:

M. Frei
D. Squires
L. Fitch
S. Price
S. Baker
D. Turner
M. Smith
H. Miller

Audience Participants (continued):

W. Ives
R. Baca

arljoyl

P R O C E E D I N G S

MR. MOELLER: The meeting will now come to order. This is a meeting of the Advisory Committee on Reactor Safeguards, Subcommittee on Waste Management.

I am Dade Moeller, the Chairman of the Subcommittee, and joining us shortly will be Dr. Robert Axtmann, the other ACRS member who will be present today. Also we have with us R.C. Tang, who is a Staff engineer for us for this Subcommittee, and we have a team of consultants with us, beginning on my left with Don Orth, Martin Steindler, George Thompson and Richard Foster. We also expect to have joining us shortly Mr. Philbrick.

The purpose of this meeting is to review and comment on the Department of Energy's Site Characterization Report for the basalt waste isolation project, and we will also, of course,as part of that exercise be reviewing the NRC's draft analysis of DOE's Site Characterization Report.

In addition to these two topics, tomorrow we will be hearing on the status of NRC's research project on the long-term performance of high level waste packaging materials.

With regard to today's meeting I might mention that this Subcommittee recently reviewed the proposed DOE guidelines for selecting a site for a repository, and for the information of the Subcommittee members, those remarks that we jointly developed were presented to the Full Committee at the April

monthly meeting. They were approved for forwarding. They were not read in detail and approved word by word, but the Full Committee approved the forwarding of those officially to NRC and DOE, so your work did prove most fruitful.

Having met today and tomorrow -- today, again, with DOE and tomorrow with NRC, with both parties being present on both days -- on Saturday the Subcommittee will meet to formulate a report on what we have heard. We, of course, are not sure at this time what our report will say, but we certainly want to address the issues; and some of the questions that I hope we can deal with include: is the Site Characterization Report a good guide; have any major points been missed; is the scope of the report adequate or are there loopholes in it; are the assumptions and conclusions justified;and what are the uncertainties associated with these assumptions?

Similarly, we will be asking: Is the NRC asking the right questions; are their challenges to the SCR justified; and what should be the mechanisms they use to make value judgments in determining whether the NRC criteria in the EPA standards are being met? I think also of importance to us in our deliberations is the timing on the availability of answers to our various questions.

Mr. Philbrick in his written comments which he shared with us has pointed out that this is indeed a long-term project. In fact,the way he addressed it is he said it is a

three-generation project: one generation of people will build it, one generation of people will fill it, and one generation of people will decommission it. It is not exactly in that scheme, but it gives us an impression and I think we have to look then at each of the questions and say do we need the answer to this today or can it wait until tomorrow?

Our goal, then, will be to prepare on Saturday morning a digest of our comments and to bring to the attention of the Advisory Committee on Reactor Safeguards our thoughts and to discuss these things with them, at the moment tentatively scheduled for our June 1983 meeting. Now, hopefully within the next three days we can accomplish at least a first-stage review of the various items. However, if we find we need additional subcommittee meetings to address specific points, we will certainly schedule them. Indeed,the DOE representation has already offered to return for additional discussions if we desire them, and we may very well take them up on that point, and I'm sure the NRC Staff would have the same attitude.

To throw in a little personal comment here in terms of the NRC Site Characterization Analysis, I found Appendix E to be particularly helpful. This is the one in which they listed the various issues and then rated them as to importance and the ease with which they foresee their resolution, and I am hoping that during the next two or three days we will have time to talk about that particular portion of the

SCA.

This meeting is being conducted in accordance with the provisions of the Federal Advisory Committee Act and the Government in the Sunshine Act. Seated on my right is R.C. Tang, who is the Designated Federal Employee for the meeting.

A transcript of the meeting is being kept and it is requested that each speaker first identify himself or herself and speak with sufficient clarity and volume so that they can be readily heard, and we would ask that every speaker first identify yourself -- well, first go to a microphone and then identify yourself and give your comments, and we don't want the meeting to be so formal that people are inhibited about getting up and commenting, and I would encourage the DOE and contractor representatives that if we ask a question and a subject comes up that you would like few minutes or over the lunch hour to discuss it before you present an answer or before you enter an answer into the record, by all means just ask for a caucus. We can even suspend for a few minutes and let you discuss it because you don't have to respond to every question the instant we ask it. We would rather have a thoughtful answer than a hasty answer.

The rules for participation in today's meeting have been announced as part of the notice previously published in the Federal Register on April 5, 1983. We have not received any request for oral statements by members of the public, nor

have we received any written comments from representatives of the public.

I would ask at this time if there is anyone here who might today want to offer comments as a representative of the public or some organization. Is there anyone who desires to do that?

(No response)

Seeing no hands, then we will assume that no one wants to comment.

Do any members of the Subcommittee have comments before we begin our questions?

(No response)

Okay. There being none, we will now proceed with the meeting, and we hope that everyone has the agenda. The first item on the schedule is an overview of the project, and I gather that Mark Frei will do that presentation representing DOE headquarters.

Mark.

(Slide)

MR. FREI: Thank you, Dr. Moeller.

Good morning. I am Mark Frei, the Team Leader for the Basalt Waste Isolation Project with DOE headquarters here in Washington, D.C. Lee Olson was to make the introductory remarks this morning but he was detained on some project business back in Richmond and sends his regrets.

Today we would like to present the Site Characterization Report for the Basalt Waste Isolation Project. In my remarks I would like to cover two areas, background and run through the agenda.

As far as the background is concerned, as many of you know, the SCR was issued on November 12th of last year to NRC in accordance with 10 CFR 60. The SCR was based on work conducted at the Hanford site since 1976 as part of the National Waste Terminal Storage Program.

The documents were done in the areas of geology, hydrology, performance assessment and other critical areas of the project, as well as laying out the decision process of how we got to the referenced repository location on the Hanford site. It also identifies the issues that we have with respect to site suitability and then describes the plans to resolve those issues as part of our detailed site characterization effort.

Since the report was issued in November, the Nuclear Waste Policy Act of 1982 was passed and signed into law by the President and lays out the process and schedule for the development of repositories,and as part of that process requires the site characterization plan as a prerequisite to starting site characterization.

As it turns out, the Site Characterization Plan is in fact more of a document in terms of the SCR in terms of content, and therefore the Project is in the process of

preparing the Site Characterization Plan. As we envision it, this plan will update the SCR information from November and will meet, of course, the content requirements that are stated in the Act and will, to the maximum extent possible, address the concerns stated by NRC in their draft SCA.

In addition, any feedback that the Advisory Committee can provide us today or in the future would be much appreciated so we can have the best document we can.

We expect to issue the Site Characterization Plan sometime this fall.

(Slide)

Now, as far as today's agenda goes, those of you who have seen the document realize it is a very lengthy document, on the order of 1800 pages. In the course of one day what we would like to do is give you a summary of the contents. In fact, some of the material in your handout today was provided for your information and as backup, and if you desire more information in any critical area, like hydrology or whatever, we would be happy to arrange a separate discussion later at your convenience.

MR. MOELLER: I think for the matter of the record, Mr. Frei, let me point out that all of the Subcommittee members and all of our consultants have received the full three-volume report, and indeed, in preparing for this Subcommittee meeting we assigned specific chapters to various

consultants to be reviewed and critiqued in detail, and many of them have been critiqued by two and three people, so I think that is important for you and for others to realize.

MR. FREI: Very good. Let me walk through the agenda now.

Following my remarks here, David Squires, who is with the DOE Richland Operations Office, will run through an overview, and following that we have a series of presentation by Rockwell-Hanford, who is the technical management organization in charge of the project.

The first speaker will be Mr. Larry Fitch, who is Manager of Research and Licensing with Rockwell, and he will present the approach to the SCR planning efforts. That will be followed by Performance Assessment by Dr. Robert Baca, who is Manager of Performance Assessment, followed by Geology by Dr. Sue Price of the Geosciences Group, Hydrology by Dr. Steve Baker, Site Analysis Department Manager. Dave Turner will be presenting the Repository, the Engineering Development Manager, and finally, Dr. Mike Smith will be presenting the Waste Package portion of the SCR. He is Manager of the Waste Package Department.

We will be happy to take questions as we go through each presentation and at the end of each presentation.

At this time I would like to turn it over to Dave Squires with the Richland Operations Office.

MR. MOELLER: Any questions for Mr. Frei?

(No response)

There being none, thank you.

MR. SQUIRES: Thank you, Mark and Dr. Moeller.

(Slide)

What I would first like to do is give you a brief overview of the National Waste Terminal Storage Program in our organization. In addition, we will be talking about those areas in the United States that we are covering in terms of areas that we are looking at for geologic storage.

There are actually four operations offices involved in terms of where the work is being done on the NWTS Program. In the Richland office we are looking at the basalt waste isolation. The technical operator is Rockwell-Hanford Operations. The Chicago operations has two project offices, one being the project office at Columbus. Their prime contractor is Battelle Memorial Institute. The prime responsibility is looking at bedded salt sites and dome salt sites.

In addition to the project office at Columbus they also have the crystalline project office in Chicago to look at crystalline rock structures throughout the United States for geologic storage.

The Nevada operations office has responsibility for looking at the Nevada test site. NNWSI stands for Nevada Nuclear Waste Storage Program. The prime contractors are

Sandia, LASL, Lawrence Livermore Laboratories and the USGS. The one office that we also have within the program is the Albuquerque Operations Program, who has responsibility for the seabed program, and their prime responsibility is to look at sub-seabed areas for potential geologic storage for radioactive waste.

Now, this program, of course, is a low-funded program, but it is one that we are looking at in terms of the future.

(Slide)

Areas that we are looking at in terms of the continental United States for potential storage of radioactive waste: of course, the basalt project within the south central state of Washington; the site in Nevada; the bedded salt deposit in Utah in the Paradox Basin, and the bedded salt site in the Permian Basin in northern Texas.

In addition to those two sites, which are being managed by the Columbus office in Columbus, Ohio, is the dome sites in Louisiana and Mississippi.

The Crystalline Project Office is primarily looking at the northeastern states.

(Slide)

Now what I would like to do is just give you a brief overview of what you are going to hear about in fair amount of detail today from a number of the people from Rockwell.

You can see here the State of Washington, and what we have done here is we have pulled out the Hanford site to blow it up a little bit so you can see a little better some of the activities going on here.

Of course, most of the activities are along the Columbia River and have been shut down, except the N Reactor, which is still in operation. We have the chemical separations going on in the 200 West areas. We have the 300 Area Laboratory down here and it also identifies the WPPPS reactors, the FFTF, and then the area identified in white here is the referenced repository location.

In addition to that, we have also identified the exploratory shaft site, and you will hear a fair amount of that in terms of the discussions today from the Rockwell people on what is going on relative to this location.

(Slide)

One of the things I would like to point out here are the key factors in the siting of a repository or those areas that we consider prime areas or areas of concern. One is the hydrology area. A number of people perceive that you have a layered media, you have fractured rock, and of course the perception is with the Columbia River running nearby, can you resolve this? This is one we are taking a hard look at and one you will hear a lot about today from Dr. Steve Baker.

The geology area is an area that -- how stable is

the site? Past evidence indicates that the basalts have been fairly stable; however, how do you model a very fractured media in terms of determining that the geology will continue to remain stable? Rock mechanics. That is one of the areas we are looking at here and are concerned about, the high-intensity stresses at depth. Engineered barriers. How many barriers do you need in terms of placing waste in a canister? Waste form, package around the waste forms. Some kind of a backfill material and, of course, some kind of overpack around that. So there are a number of barriers that we are looking at, and this is also an area in which additional research needs to go on.

Transportation is always one of those that from the overall standpoint of any waste repository, when you locate a repository in one part of the country and you are transporting waste from another part, the public perceives that -- what do we have to do to resolve the problem in terms of shipping materials around the country? The long-term commitment. The fact that you are going to place the waste in the deep geologies and dispose of it by definition is long-term commitment, so it is one of these things you have got to consider. Also you have got to consider the institutional factors involved for long-term commitment.

Socioeconomics. Of course, the political, the public perception, how well they perceive this, how well they accept

it is one that we need to consider. It is one that we need to continue to educate the public on, and we are trying to do that.

(Slide)

What I would like to do now is talk a little bit about the organization within the Department of Energy. As Mark mentioned, since the Nuclear Waste Policy Act was passed for 1982,this is the organization that was set up. Mr. Robert L. Morgan is the project manager and has four different groups that report to him. However, the groups that we work with mostly in the geologic area is Bill Bennett's organization in the Geologic Repository. He has five different offices that report to him, and we in the Richland Operations Office work mostly with Mark Frei.

(Slide)

The organization at the Richland Operations Office, Mr. Alex Fremling is the manager of the office. He has five different assistant managers that we work with in terms of different organizations and support. The office that we work closely with, of course, Mr. John Anttonen, and my boss Mr. Lee Olson is the project manager of the Basalt Waste Isolation Project. We work very closely with Bill Bennett's operation. However, the guidance flows from Bill Bennett to Alex Fremling.

Our day-to-day operations work between Bennett's office and Lee's office. Our prime contractor is the Rockwell-

Hanford operations. We also have Kaiser Engineers. We also have the Construction Project, Morris-Knudsen, Incorporated, and a number of subcontractors that provide a great deal of support to us.

(Slide)

I would like to point out the Rockwell organization, who is the technical manager of the project, the Basalt Waste Isolation Project, is headed up by Dr. Raul Deju, who is the Project Manager for Rockwell. His associate manager is Mr. Ralph Gimera, who has dual responsibility within this project. In addition to Mr. Gimera, we also have Dr. Richard Gerly, who is the Manager of the Systems Integration Assessment Group. You will hear from Dr. Robert Baca today in terms of what they are doing.

Larry Fitch is the Manager of Research and Licensing, who will follow me. He has responsibility for the geology, hydrology area, the waste package chemistry and the licensing office, and you will hear from a number of speakers in the site area on the waste package area today.

(Slide)

Just very briefly I would like to talk a little bit about what the schedule looks like as a result of the Nuclear Waste Policy Act that was passed in 1982. Mainly what I would like to point out is the fact of what was prior to the legislation and what was after the legislation.

arljoy15

What I think really jumps out at you here is as a result of the legislation, the program has been accelerated. If you look at the licensing activity, it goes on and it has been accelerated about 18 months. That is the most key thing on this whole entire schedule, the fact that the licensing of the repositories has been accelerated.

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(Slide)

A lot of these milestones apply to other projects as well. I think the thing I would like to point out here, on P with is what Mark said. The site characterization report was completed and delivered in November of 1982. We also issued a NEPA environmental assessment in that time frame.

I think what I would like to indicate here is what we are working towards is the number of activities that are going on in the project in terms of R&D, the engineering, those things that are leading up to what we need to put together the site recommendation report and environmental impact statement which we hope to submit to Congress in March of '87 with the license submission in August of '87 to NRC.

I think as you go on out, if that happens in August of '87, which is the schedule we're working towards, we would hope then to obtain license application or permit to move ahead with construction in 1990 with construction to follow thereafter.

MR. MOELLER: Excuse me a second, Mr. Squires. When was the environmental impact statement to be issued?

MR. SQUIRES: As I indicated here --

MR. MOELLER: Oh, I see it. Okay.

MR. SQUIRES: -- it is to be submitted to

Congress in March of '87 and from that all three projects will feed into one SRR and one EIS, and from that there will be one site selected to move ahead with licensing in August of '87.

MR. MOELLER: Okay. Thank you.

(Slice)

MR. SQUIRES: And finally, just to give you a very brief overview of the budget on the salt waste isolation project, to date we have spent about $175 million, $150 million in terms of operating, about $12 million in capital equipment and about $13 million in construction.

This year our budget is about $55-56 million, and our congressional request for '84 is about $60 million.

And with that, if there are no questions --

MR. MOELLER: Let's see, I had a couple, and I should have asked them as you were moving along. On the map of the United States where you identified -- it was about your third slide -- when you identified the various structures in which a repository might be located. The tuft is at the Nevada test site, which has the slant lines. Now, it doesn't mean to imply that there is tuft all on the eastern U.S., or does it?

MR. SQUIRES: No, no, it does not. Going back some time ago -- and this chart should have been revised --

at one time when we were first screening in the United States, looking at different geologies, there were plans to look at some of the different geologies over here -- limestones, salt deposits, and so on. But that is not happening now.

MR. MOELLER: I guess the other question I had was for me to understand a little better where Rockwell ends or where DOE ends and Rockwell begins.

Now, the organization chart that you show for the Rockwell organization is clear. Now, the project management organization, I guess at that level there is an interweaving, is that correct?

(Slide)

MR. SQUIRES: Primarily, what we have here is we have the management, administrative management of the project, DOE does; and Rockwell has the technical management of the project. And I think that's the split between what DOE's responsibilities and what Rockwell's is.

MR. MOELLER: When you said Olson was your boss, is he a DOE employee?

MR. SQUIRES: Lee Olson is the project manager at Richland, yes, sir.

MR. MOELLER: Any other questions? Dick?

MR. FOSTER: Is Dr. Deju still there at the moment? It seems to me I recall he was going to be on

leave.

MR. SQUIRES: Right now in fact I think he's supposed to be back in town on Sunday. He has been gone for the last four weeks, I think.

MR. FOSTER: Somewhere I thought maybe he was going to be gone for about a year or something of that sort.

MR. SQUIRES: Not that I know of, sir.

MR. MOELLER: Other questions?

(No response)

MR. MOELLER: Okay. Thank you, David.

We will move now to Larry Fitch.

(Slide)

MR. FITCH: My name is Larry Fitch. What I would like to do this morning is to try to set the stage for what the BWIP project in DOE and Rockwell think the SCR is and is not relative to the basalt waste isolation project.

In listening to your comments and the questions you are putting forth on what you would like to get out of this review, I think it's important to note a couple of things. First, the SCR --

(Slide)

-- in all of its beauty, clearly is not a final document. It is not the essence of all planning that the project needs to do. It is not sufficient to

administratively or technically manage the program and make sure that all the concerns that the technical community, including ourselves, think need to be addressed, but it is a first attempt of the project to stack up, based on the criteria as we know them today, what are the pieces of work that need to be done so we can get the information in order to show either compliance or lack of compliance on any one technical subject.

It took us about 19 months to prepare, about 1,800 pages long. It is a rather thorough document relative to in some kind of an evenhanded manner trying to touch base with all of the technical disciplines within the project.

And I guess you would call it a top-down document based on criteria, not based on concerns.

(Slide)

The document used up about 20-some man-years of effort, maybe a little more than that, and we had input basically from every project -- or excuse me, every department and group within BWIP. It was reviewed by every facet of the NWTS prorgram before it was submitted, including all of our overview committees.

And it is, I think, a good first effort of planning at a rather high level, but it clearly is not sufficient, nor was it ever intended to be, the final

answer of all the technical information we need to get. It clearly is not that, and I think when you read the SCR and the draft SCA that's been prepared by the Nuclear Regulatory Commission, it's clear that while we touch bases on most of the issues, it is not obvious how the work we are going to do makes all of the issues go away.

It was not intended to do that. There are other documents within the program, what we call test plans that are basically written by each of the functions, that really are the second-tier documents that help you understand exactly what the technical work is that needs to be done and how that work will focus at addressing the issues, the technical issues that both the NWTS program has raised and the NRC has raised, and the committee I am sure will raise some themselves.

MR. AXTMANN: I have a curiosity. How much contact did you have with DOE during this campaign, and how much, if any, with the NRC staff?

MR. FITCH: I have a slide on the NRC a little later of the interfaces we had with them during the time that it was being prepared. I would guess, simply contact with DOE was at least on a daily basis. We had an intensive effort late in the project after all of the drafts had been initially prepared where Mark and some of his people from headquarters came out and spent a couple of weeks with us

and we read and reread and we did a virtually line-by-line review making sure that what we were saying, one, technically made sense and, two, was supported by the rest of the NWTS program.

So I would say a lot of input, we had a lot of day-to-day goings-on, primarily with Department of Energy in Richland, in sharing with them what we're writing and why we said what we said and taking their comments.

MR. AXTMANN: So there were people in DOE that were assigned to this task, the daily consultation?

MR. FITCH: Yes. If you recall, the organization chart that Dave Squires just put up --

MR. AXTMANN: I just arrived.

MR. FITCH: The Department of Energy has a basalt waste isolation project. Their manager is Lee Olson. Lee has a staff of some six or seven people who provide technical interface with each of the departments within the BWIP project.

Dave Squires happens to be the contact for licensing and has had an overview capacity in everything that we've been doing. There are some new people within the Richland project office that monitor what waste package does, what the site department does, what the engineering groups are doing, and that kind of thing.

So there is a one-to-one correlation between the

Richland operations office project and the Rockwell technical people.

MR. AXTMANN: Thank you.

MR. FITCH: Today you are going to hear, as Dave had said, Bob Baca in the area of safety -- or, excuse me, in systems and performance assessment, and he is going to talk about what the project's approach to performance assessment is.

I think there will be a lot of interest in that area because performance assessment basically ties everything together for us. And the other people -- Mike Smith is department manager for waste package. You will hear from him. And out of the site department we have Sue Price. And Steve Baker will be talking about geology and hydrology. And Dave Turner, who is the manager of engineering development, will go over that part of the program.

(Slide)

There is a real quick overview. I hope we will not spend much more than a couple of seconds.

This is simply part of the table of contents which shows that about two-thirds of the SCR is status as we knew it about a year ago. There is some information that is more recent than that. But the lion's share of the information that's in it is about a year old now. I think

that's why you heard Mark state that when we respond with a site characterization plan as required by the Nuclear Waste Policy Act, there will be an update to the information that's in the SCR because it is dated information.

I think it will also help us get a better understanding of what the planning efforts are. I think that the dialogue we will have with the committee and the dialogue that we are having with the NRC will help us to focus on and look at things a little bit differently than we do simply by ourselves, and I think that will be beneficial.

(Slide)

I would like to look at the SCR primarily for the third volume of the document, which is really issues and plans. It's an exceedingly difficult, or it was an exceedingly difficult thing to write.

It's the first time that the project had really tried to undertake a very detailed and all-encompassing look at what is it we need to know, how much of it do we currently know, what have we yet there to find out, and to tie those needs directly to the criteria, not simply questions that everyone has raised that technically have some merit but it's not obvious how those might tie in to address particular criteria.

As you are well aware, the 10 CFR 60 technical

rule is still in draft. The EPA regulations are still in draft. And you will see that when those documents come out in final, it will probably impact what's in the SCR. It will make it obsolete, but I think the lower planning documents which are really trying to address the issues and the concerns that the technical community has will not. At least that is our hope. If it does, it means we don't know how to manage the program very well.

(Slide)

MR. AXTMANN: What's your guess on the timing of those final regulations, EPR and 10 CFR 60?

MR. FITCH: I wouldn't hazard a guess. I would pass the one on 10 CFR 60 to NRC. I think curent schedules call for it happening sometime this year. From the project standpoint, the sooner the better, but it's not quite that simple, I am afraid.

MR. MILLER: I am Hubert Miller of the NRC. The 10 CFR 60 final regulation is, I believe, up for affirmation vote by the Commission today. So it is days away.

(Slide)

MR. FITCH: Those of you who have looked at the site characterization report issues and plans chapters remember seeing this flow chart, I am sure. And the reason I made a slide of it was simply to show that really the

basis of everything that's in the SCR issues and plans goes back directly to the criteria as we understood them some several months ago.

There is a little decision box here which basically allows us to come to the conclusion whether there are issues in any particular area, but we really did not try to structure the work that comes out here as work elements to address the issues. We really structure these work elements to address the criteria.

We did that on purpose, and the reason we did that was because we knew there was a continuing dialogue between ourselves and the NRC. Some of it has taken place, and much more, I hope, will take place in the future.

We have had, and continue to have, dialogue with our overview committee, with other members of the NWTS program, and we knew that you could not write a list, a complete list of issues. We can write them today based on what we know, but it is with that new information those issues are going to change.

We did not want the document to quickly become obsolete because we have come up with a new set of issues and we thought that basing it on criteria gave us a base that was a little longer-standing than simply what it is we knew.

When we come out to the end, if we have

addressed all the criteria, we make it. If we don't, we have got to go back and look at it again or we walk away from the site. And that was the approach.

(Slide)

I think we also looked and found there was something new called key technical issues within the program. We found three of them. I think they probably apply to any site in the United States as well BWIP. And really the first one addresses simply the EPA criteria. You have to be able to have a site and repository design that allows you to have an acceptable release or less than some release at an acceptable -- excuse me -- at a location.

The second one is whether or not you can build a safe repository. Is it going to be safe to have miners and placers down there for 50, 60, 75 years? You are going to have rock falls. Is it going to be a dangerous mine? You clearly don't want to have that kind of problem.

And the last one really is related both to the stability of the openings and the ability to meet the limits. And that is, can I go back and seal the repository shafts and tunnels such that you can meet the EPA criteria?

And I think if the answer to those are no, you cannot meet them, you quickly come to the conclusion you do not have an acceptable site.

That's why we call them "key." They can

basically make you walk away from the site.

(Slide)

That's kind of what we did in the SCR. I would guess that in today's light, 18 months after we underook that effort or nearly 2 years after we undertook that effort, I would say that we did a fair job. i think today we could do a lot better joo, and I think we have matured a great deal over the last 2 years. It was an extensive effort to put that document together and understand how you do it.

And it was clearly a first-of-a-kind effort. And I think the work elements that are defined in the SCR are the right work elements. They are not of sufficient detail that someone like yourself or the NRC can review it and say, no, I don't agree because it doesn't tell you how many bore holes we're going to have, but it does tell you what kinds of information I need to get on a bore hole testing.

So what we need to do now is to take that kernel of the technical program, which is a summation of all of those work elements and in a continuing manner feed into that the results of the work that's currently going on, because as work goes on you get smarter and realize what it is you don't know and you change that program based on the results almost in a real-time mode.

In addition, we have had and will continue to

have, I hope, an open dialogue with the NRC on their understanding of our program. And it has really been very beneficial for us to have a dialogue with the NRC. I think not only are they getting up to speed with what the project is, but their technical expertise has given us a lot of good ideas. It has given us a different look at ourselves, and I think that's very beneficial.

Not only should I say NRC, but the bottom box is basically the other part of the NRC, if you will. It's our overview committee, our peer review groups, U.S.G.S., other national labs which have a view of the program constantly are asking questions that we haven't come to yet. And those kinds of things help us develop what this program is.

Out of that program from a regulatory nature, we were required, one, to issue the SCP, and on a semi-annual basis update the information the program has been able to generate that goes to the NRC as SCR updates. And it has allowed us to have a basis for focusing on what these test plans are that are going to be the subtier of the SCR, if you will, that give you a little more detail as to really what you need to do to show that you have addressed all of the work elements.

And this is going to be ongoing. I think it's going to take us a long time before we have a real stable program. But I think we're getting there.

(Slide)

Dr. Axtmann asked a question about what our interface with the NRC has been in support of getting the NRC in a position that they could do a very speedy review of the SCR and issue their SCA. We had a series of workshops, which are the first three here, that we had with the Michigan. You see some of them lasted as long as a week, and some of them were simply a couple of days, going over the various technical areas within the program so they could get a better understanding of what it was we thought we knew, so they could have a better understanding of BWIP.

The first one was on hydrology. The second was on waste package and geochemisry. Third was repository design and what we intend to do in the exploratory shaft. And last week we had one on geology. We were a little late getting that one done.

And I see that the issuance of the NRC's SCA will be the focus for yet more rounds of these kinds of meetings where we take hopefully smaller parts of the program, discuss them in detail with the staff and make sure that we have an agreement with one another as to where the program is going.

I think we have been doing a good job on that in the past, and I hope we can continue it in the future.

I guess, in summation, I would like to say that

we do not believe that the site characterization report in any way reflects a licensing document. It is a high-level focusing document that the project produced at one point in time. it would look different if we were to do it today. It will be modified as time goes on to our semiannual updates and reviews with the staff.

But I think it's a very important first step for the program. We are looking forward to being able to follow up on the concerns that have been raised by the NRC in their SCA. I think it was a very good effort. We have not reviewed it in detail yet, especially myself. I have been in Richland about 5 hours since we received the document. I have not given it much review, but we will. And I hope it will be the basis for future dialogue.

With that, I would like to turn the podium over to Dr. Bob Baca, who - I am sorry.

MR. MOELLER: We have some questions. Martin Steindler.

MR. STEINDLER: Let me take you back to your technical issues slide.

(Slide)

Is it significant that the only criterion you elected to address is the EPA criterion? There are some additional criteria in draft form the NRC has put out.

MR. FITCH: That's right. And we believe, as the

NRC has stated, that the subsystem criteria in 10 CFR 60 is their way of making sure that the applicant meets EPA's criteria, in having, as a case in point, a thousand-year waste package and groundwater travel times and fractional release rates and those sort of things. I don't want to be speaking for the staff, since they're here. But our understanding is that is the NRC's way of assuring that a site will meet the EPA criteria.

And I think, depending on which site you're looking at, you may view those subsystem criteria slightly differently. So we're saying here that really what the NRC is after is the same thing we're after, and that is to show that we really have assurance that we can meet EPA's criteria and the regulation. And that does not mean that the subsystem criteria are not of concern to the project, but there are a step to get us so we can assure that we meet the EPA criteria.

Does that address your concern?

MR. MOELLER: Don Orth.

MR. ORTH: A comment on the integration and revision, the integration program. First of all, not all elements take the same time to resolve, and not all of them are of equal importance, and not all of them are due at the same time. So have you got somebody in there working on what amounts to critical path, making sure you get what you

need or start what you need in time?

MR. FITCH: Yes. We have two organizations within the program that do that. We have the technical people, who are our critical path schedulers, and the technical people who understand the needs for all that is in our systems integration department Bob Baca, who is up next, is from that department, but his particlar expertise is in performance assessment.

But indeed, the systems department charter is indeed that integration and helping us prioritize the work so we can take the dollars that are available to the program and in essence get the biggest bang for the buck in any one calendar year.

MR. ORTH: Then somebody has a schedule somewhere that could be sent out as part of the review process, a schedule of these things showing how you have really --

MR. FITCH: Yes. Yes, and the detailed schedule, I guess, is more appropriate to what I was addressing earlier as test plans. There are schedules and logic diagrams in the SCR, but they are clearly high-level schedules and not of very much detail.

And other more detailed schedules are within the program, and indeed they are updated on a monthly basis under the Department of Energy.

MR. MOELLER: I think if I hear Don correctly, he

is asking also if perhaps today we are going to hear from you on each of the various topics -- geology, hydrology, and so forth? Are we going to hear from you an interpretation of the issues raised by NRC and the sequence in which you plan to address those?

MR. FITCH: No, that is not what we had intended to do. We could do that on another meeting. What we had intended to do is related but different. What we intended to do is have each of the presenters after myself basically go over waht we have said in the SCR in a very cursory fashion. We have got an hour and 15 minutes per person, so we can't give it a heck of a lot of depth, but to go over briefly what was in the SCR and what our planning efforts have been since we issued it.

And you will see that we clearly understand that there are concerns from the NRC and our overview committee and the task force on hydrology. Lots of concerns have been raised. What we would like to show you is, one, an overview here, the kinds of concerns being raised, here is our program, here is how you can interrelate the programs that we have under way with the issues and concerns that are being raised.

And that is by no means to say that we know what all the issues are. If I were to write them all down today, I know that within a year they would be a completely

different set, or at least a longer set if not a different one.

MR. MOELLER: Well, what you have said will be very helpful.

Dick Foster.

MR. FOSTER: Same subject on overall scheduling. You mentioned that the Waste Act speeded up your program by something like 18 months.

MR. FITCH: Yes, sir.

MR. FOSTER: Do you consider at the present time that you were on track timewise relative to the requirements of that act? And if there are areas of special concer, can you share with us what those particular areas would be?

MR. FITCH: I really don't have a complete answer for that, sir. As you are well aware, the act has been out now since January. We have studied it. It does have an impact on the program. What that impact is finally going to be we are not in a position to say today. We are doing the best that we can to meet all of the requirements on the scheaule that's in the act. Whether or not we are going to be completely successul in doing that or not, I couldn't tell you which ones we'll miss and which ones we'll hit. We are going to do our best.

MR. MOELLER: Well, thank you, Larry Fitch. Thank you.

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MR. MOELLER: We will move on, then, to Dr. Baca.

(Slide)

MR. BACA: My name is Robert Baca, Manager of the Performance Assessment and Analysis Group. In my talk this morning what I would like to do is first start out by defining the terms for you.

Performance assessment, or more specifically, performance analysis, is a systematic evaluation process by which we estimate how well the repository system and its subsystems isolate the nuclear waste. The role of performance assessment in the BWIP is basically to guide the data collection efforts and to support the repository design as it relates to selection of engineered barriers.

The performance assessment studies which have been conducted to date have primarily emphasized the post-closure phase as opposed to the pre-closure. In my presentation this morning I am going to deal specifically with the post-closure studies.

(Slide)

In the presentation I intend to deal with three topics. First I will cover some introductory information as it relates to the proposed standards and criteria and go over some definitions and give you some background on the hydrologic aspects of basalt. Secondly, I would like to review the performance assessment study results that are in Chapter 12 of

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the SER, and third, I would like to give you an update on some of the more recent work, and I will try to make a comparison between what we presented in the SCR and what we are finding to date.

(Slide)

I would like to start out by making a few points here. First of all, as Larry mentioned before regarding SCR, the results we presented there were based on information that was available at that time. The studies that we have conducted in the interim still basically support the conclusions that we drew, although there are certainly limitations on the strengths of those conclusions, but basically I would like to make the statement that it appears at the present time that the geologic system itself can provide significant isolation, although there are uncertainties with regard to certain characteristics, and I will go into specifics on that.

What we intend to do is to, of course, design the engineered systems, the multiple barriers and the repositories so that they accommodate the residual uncertainties that will always exist in any geologic system for the estimation of their performance. And then thirdly, we are not done in carrying out these performance assessments. We have a lot of data to collect. We will go through an interative process of taking new data from the field and the lab, updating our estimation of how well the system will perform, and --

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MR. MOELLER: We have a question. Martin Steindler.

MR. STEINDLER: Do you want to let him go through and then ask questions?

MR. MOELLER: No, let's ask them as we go.

MR. STEINDLER: Other than a fairly trivial aspect, I don't understand the significance of your point number one. It seems apparent to anybody that there will always be some uncertainty. Is there another message under your point number one that I missed, or is that just kind of an obvious statement?

MR. BACA: Well, I'm glad you see it is obvious, but the point I want to make, though, is that we acknowledge the uncertainties, and a little later in the presentation I am going to explain to you how we are quantifying those uncertainties, and particularly how the uncertainties in data propagate into the uncertainties in predictions; and what we intend to do is quantify performance not only in terms of an outcome, a calculation of performance measure, but also a statement of its likelihood of occurrence and a peak probability number.

MR. STEINDLER: Can I translate that significant point into one that says yes, there are uncertainties but we think we are able to quantify them to a significant extent so that at least their measure is possible?

MR. BACA: Yes.

MR. MOELLER: As a comment, Marty, I had somewhat

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the same thought. I interpreted the first bullet as a response to the NRC's comments. You know, one of their major comments was DOE says that the natural barriers can take care of everything, and the NRC says, well, what are the uncertainties? So they are acknowledging that.

MR. STEINDLER: I see.

MR. MOELLER: Go ahead.

MR. BACA: So we are not done in our performance assessment studies. The studies that we do conduct, either both in-house and by outside organizations, will be published in reports which will support the site recommendation report and PSAR which will be issued in the 1986 and later timeframes.

(Slide)

Now, the starting point are the proposed standards and criteria. If we look at the EPA draft standard and the NRC standards, we can kind of group them into two categories, one that applies to the entire system, the engineered repository system and the natural system, and then those that apply to its components.

Basically the EPA standard says that we will count or we will make a prediction of releases at a given boundary over a 10,000-year period. We will compare those cumulative releases to specified numerical values. Table 2 of 40 CFR 191. In particular, it stresses that we will look at the first

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10,000 years. We will certainly do that.

In addition, however, we are looking at periods in excess of 10,000 years.

The subsystem criteria require that we set a pre-waste-emplacement or that we have at least a 1,000-year travel time. Those are natural groundwater travel times.

The next requirement is the actual release rates be 10^{-5} per year or less. We must maintain containment of the waste in the engineered system for 1000 years, and the current draft of that regulation provides or allows a provision for other numerical values here for a 1000-year release rate and a 1000-year containment as approved or specified by the NRC.

(Slide)

MR. AXTMANN: What does the engineered system now mean/ I seem to remember originally the package had to last 1000 years but then that got relaxed. Is that right?

MR. BACA: That's right.

MR. AXTMANN: The engineered system, then, means the package and the cavern about it and so forth/

MR. BACA: That's right. It includes the backfill material which would surround the canister and some portion of rock.

MR. AXTMANN: And what is the criteria for the package now?

MR. BACA: The package itself is basically a

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containment time, that it contain the waste for 1000 years. In other words, zero release out of the canister.

MR. AXTMANN: Well, wait a minute, now. So the container, the capsule is the same as the engineered system?

MR. MOELLER: Could the NRC Staff help us on that, because I'm with Bob Axtmann. I had understood it had been changed.

MR. MILLER: This is Hubert Miller.

Maybe the next slide, the diagram that you have, at least in the handout, would help.

(Slide)

That would help for discussion purposes, at least. The engineered barrier system is, in the version that is before the Commission right now for the final vote -- the boundary is at the face of the excavation. In the diagram that is shown here, the rock that provided structural support would also be part of that, but in the current version, it is the face of the excavation so it would include backfill around the waste package and backfill in rooms.

Now, the waste package includes the canister and then the discrete backfill or packing materials that are in the emplacement wall out to the face of the excavation, so that if you are talking about the horizontal emplacement configuration shown here, the boundary for the waste package and the boundary for the fractional release are the same.

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They would differ if you are talking about transport of waste or to move horizontally out into a room. Then you would have the engineered barrier system being a bit more in extent than the waste package.

Does that answer the --

MR. MOELLER: Do you understand that, Bob?

MR. AXTMANN: No, I don't.

MR. MOELLER: I don't either.

Can you give it to us in just simple terms? I guess our question is -- and Bob, stop me if I don't raise it right -- we don't know whether the -- first, I don't even know if the 1000-year number is still the number. Number two, I don't know, whatever the number is, whether it applies to the waste within the canister or the waste in the canister with the backfill and with the disturbed zone around it.

(Slide)

MR. MILLER: Mike Bell would have been here but he is out of town, so I will stand in his place.

MR. MOELLER: Talk real loud, if you will.

MR. MILLER: This diagram shows the boundary, and your question was about boundaries if I detected it right: what is the extent of the waste package, what is the engineered barrier system? Let me make sure I have got the question right.

MR. AXTMANN: My question was: Which limits apply to

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which lines, and did they change, and if they changed, what changed?

MR. MILLER: All right. The current version of the rule, there is still a limit placed upon the lifetime of the performance of the waste package, and also there is a limit placed upon the allowed release from the engineered barrier system in addition to the overall allowable releases of the accessible environment, which is the thing that is controlled by the EPA standard.

First with regard to the waste package, for which there is a lifetime requirement specified, the current version of the rule specifies a period of between 300 and 1000 years as the current lifetime performance objective.

MR. AXTMANN: Is that the canister, now?

MR. MILLER: This is the waste package, the waste package meaning the canister itself, which is shown by this -- the waste form and the waste canister and any barriers, let's say clay or any other natural sort of backfill that would be placed in close proximity to the waste package within the emplacement cavity. The definition of the waste package has been extended from the draft version of the rule to include that small amount of backfill around the waste package.

The fractional release from the engineered barrier system boundary applies at the face of the excavation, the face of the rock wall, the interface between the rock wall and

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any packing that may be placed around the waste package if there is packing material.

The lifetime requirement is such that the Commission would not accept less than 300 years and would not require more than 1000 years, and the exact number would be one that would be proposed by the DOE in licensing, considering such factors as the heat load, the temperatures in the respository, other things that would lead to uncertainty in assessing repository performance, particularly in the near field. I'm not sure if that answered your --

MR. AXTMANN: Now, the canister could be many canisters; is that right?

MR. MILLER: Yes, sir. It will definitely be many canisters.

MR. AXTMANN: But there has been no limit on the canisters on this release.

MR. MILLER: There is no release limit, that's right. The concept is to get good performance from a waste package during the period of high radioactivity and high heat, high heat flux rates, and the idea is to specify that performance in terms of a lifetime.

MR. AXTMANN: An aside to this chairman here. The Battelle contract on the package, I wonder if that has been adjusted for this.

MR. MOELLER: I don't know, and that will be

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presented tomorrow; but you are correct. That contract is mainly to look at the canister, as I understand it, and what the NRC is now doing is requiring certain things for the system, so to speak.

George?

MR. THOMPSON: May I ask: is the sealing of bore holes in shafts part of the engineering barrier?

MR. MILLER: No. There are separate requirements on the bore hole and shaft seals because -- you are rightfully concerned about their performance, but the requirement is such that they have to be designed in such a fashion that the overall system performance requirements as specified in the EPA standard are met, that you seal the holes well enough that you have got reasonable assurance that they will not be preferential pathways.

MR. THOMPSON: What about the sealing of natural fractures that you may run into that you don't expect until you get down to the details of the storage site? These are really engineered barriers that may be very important. Are we somehow excluding those from the present discussion?

MR. MILLER: I think DOE has to decide how to deal with any fractures or other things that might be determined to cause a connection between the repository and the accessible environment, and you just have to in some fashion, if they were there, decide whether you could pay the money to fill

such fractures or whether it would be feasible or not.

MR. MOELLER: Does that answer it, George?

MR. THOMPSON: I get confused on the meaning of ordinary English words here.

MR. MILLER: The definition of waste package and engineered barrier system have been one of the more difficult things to settle in this process of finalizing the rule, and there has been a lot of debate on those terms. I think that what Mike and the folks have come up with is their best definition weighing all things. But I think the thing that is underlying your concern here is how do we apply limits to other engineered barriers such as the -- are the seals, which are, of course, engineered, and they are not selected out for separate numerical performance objectives as are the waste package, the backfill in the near vicinity of the waste packages.

MR. THOMPSON: Yes, that is roughly my concern. It would seem to me that one of our major functions today and tomorrow is to look at where there might be bottleneck problems in this process outside of just formally weighing these rather impressive documents. I think that may be one of them, that there is going to be fracture systems that either have to be engineered for or maybe cannot be engineered for, and I want to make sure that somehow we give those the emphasis that is needed.

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MR. MILLER: I think what you will see in Rockwell's presentation, and certainly our comments on the SCA, is great attention to the question of how will you engineer, how will you develop a good engineered system, including shaft and bore hole seals.

MR. THOMPSON: Thank you.

MR. MOELLER: Thank you.

Dr. Baca, why don't you continue.

MR. BACA: We started out addressing a question about uncertainty, and one of the uncertainties that we have had to deal with is the uncertainty in these proposed standards and criteria, which have been changing as these definitions have been slightly unclear.

MR. MOELLER: You are going to have to deal with the uncertainty in the criteria and standards are --

MR. BACA: That is one of the uncertainties we have been dealing with, primarily in proposed in draft form.

MR. MOELLER: Okay, I see what you mean, plus the uncertainties in the factors that go into assuring compliance with whatever the criteria and standards ultimately are.

MR. BACA: That is correct.

(Slide)

I would like to go back to one of my earlier slides here. Let's go back to these proposed criteria. They are written in such a manner that they specify fixed values, which

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kind of presumes that we will be in a position to make precise numerical predictions which will compare to these numbers. What the regulations currently do not state is to what degree of confidence or what probability do we have to achieve to get an agreement that we have complied with that criteria.

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Okay. To go back to our little sketch here, those performance measures -- at least the ones that I will be addressing -- have to do with the pre-waste emplacement groundwater travel times, and they would be measured from this disturbed zone boundary out to 10 kilometers. Then the cumulative mass flux, integrated mass flux across this boundary also at 10 kilometers from the repository.

(Slide)

The purpose of the background here, I would like to say a few things about the characteristics of the basalt. My colleagues will be giving you a lot more detail on the subject in their presentations.

Basically what we have here is a layer geology. We have a sequence of basalt flows. We have three major formations with the candidate horizons, the basalt flows that we are looking at for a possible repository: the Cohassett flow, which is referred to as the Middle Sentinel Bluffs on the SCR, the regional change in nomenclature, McCoy Canyon, and the Umtanum Flow.

In this layered sequence basalt, the groundwater moves primarily through the flow tops -- flow contacts, as they were called in the SCR -- which are interfaces between basalt flows, and from our field measures of the hydrologic properties, we assigned, for example, the median permeability of a flow top as about 10^{-7} meters per second. The measured permeability

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of the interiors, the median value is like 10^{-13} meters per second. So there is a very large contrast in permeability.

So the water as it moves through this geologic system basically follows the path of least resistance, and so the major water zones are these interfaces, and that layered sequence is an alternating pattern of flow top and flow interior, and it has a significant impact on the patterns of groundwater flow and transport. I will be showing you some specific examples.

MR. FOSTER: Question.

MR. MOELLER: Yes.

MR. FOSTER: While you have that slide on, your report mentions that some of the basalt areas do have some pretty big aquifers, especially important for current use as irrigation, and potentially for irrigation on the reservation. Is that particular one in the Mapton Interbed, is that the main strata that provides a good aquifer there?

MR. BACA: The Mapton certainly is a very transmissive zone. It is one of the major aquifers. There are also some transmissive zones in the lower part, and a little later Dr. Baker will be giving you a lot more detail on the characteristics, hydrologic characteristics.

MR. FOSTER: All right. I will hold off on that until we get more detail.

MR. BACA: Okay.

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(Slide)

MR. BACA: Next what I would like to do is review some of the information that was presented in Chapter 12 on performance assessment.

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Basically Chapter 12 had a certain set of objectives: first, identify the performance issues that really relate to the proposed standards and criteria. Secondly, we described the analytical approach, the predictive methodology that we are using to calculate or to estimate long-term performance. We reviewed previous studies that had been done by Rockwell and other independent organizations regarding the hydrologic flow system in the Pasco Basin, and we did a specific long-term performance analysis for the SCR which looked at the performance of the Middle Sentinel Bluffs, and I will be showing you specific results from that.

(Slide)

First I would like to start with the groundwater travel time prediction. Groundwater travel times are one of the important performance measures. We basically had five studies conducted from 1979 to 1982, our initial work done by our Hydrology Group, the second study performed by Los Alamos Technical Associates and Intera Environmental Consultants. They were at that time our risk assessment subcontractor.

There was a study performed by Pacific Northwest

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Labs as part of their Aegis Project, and then later on as we had more field data, we updated the '79 analysis, and there was a subsequent analysis done by the Analytic Science Corporation.

What was done in these studies was basically to look at the large-scale flow patterns and to take the available data, most of which was in the center of the Hanford site, and to try to develop a prediction of the three-dimensional flow system in the Pasco Basin, which encompasses about 1500 square kilometers.

The results that were obtained were quite different. As you can see here, the calculated path length varied from 8 kilometers to about 65 kilometers, and travel times ranged from 13,000 to as high as 7 million. And basically what these results were telling us is that there was not sufficient field information to develop a unified or a single interpretation of the hydrologic model.

MR. MOELLER: Were all of these field studies or theoretical studies?

MR. BACA: All of these are theoretical studies. They took into account the available field measurements, field data. However, in dealing with such a large system in three dimensions, you basically have to specify everything that is happening on that periphery of that system, and to obtain that kind of information, it required a lot of judgment, a lot of

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extrapolation.

MR. MOELLER: Martin Steindler.

MR. STEINDLER: Are you suggesting by this list that prior to 1979 there were no studies done at the Hanford site that would lead you to travel time estimates?

MR. BACA: To my knowledge, these were the major studies that were published and released, yes.

MR. MOELLER: That is somewhat difficult to believe, that there was nothing done before 1979. Certainly I read estimates of how long it would take for the water to reach the Columbia River, but perhaps that was in a different medium.

Dick?

MR. FOSTER: Well, I know Bob was involved in some of those earlier ones himself. You should answer this, but my guess would be that you are talking here about the very deep lower strata as contrasted with the aquifers.

MR. MOELLER: That could very well be true.

(Slide)

MR. BACA: Yes, that is an important point. There were hydrologic studies, both field and theoretical analyses, that go back many years, but those studies have been of the sedimentary zone in the upper part of the column here. One other point I would like to make about this particular table here is that all of these theoretical calculations were based on deterministic models. They did not take into account the

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variations of the properties in any kind of probabilistic way, and many of them were intended to make a calculation of expected conditions as opposed to analyzing a broad range of conditions and so therefore did not look at the extreme types of situations.

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This is primarily the philosophy we used in the work that we conducted for the site characterization report, again looking at mean values, trying to make estimates of the expected travel times and releases. This particular diagram here is a result from a computer model calculation, and it shows you a vertical cross-section through the Grande Ronde formation. So where it is 700 meters below ground, looking at the Middle Sentinel Bluffs, and in this analysis we take into account the coupled effects of heat transfer, fluid flow and radionuclide transport, what this little diagram shows you is a depiction of the flow paths assuming that you have a release of a water molecule at these points at 1000 years after closure.

The dashed lines here refer to the interfaces between basalt flows and the basalt sequences, and what we find is that the flow paths tend to retract as they go through these series of layers. You have the low permeability rock, the transmissive rock, the low permeability rock. You can see that we have an upward movement here which is primarily caused

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by the buoyancy effect, the thermal effect. That was a rather surprising observation. And basically the reason for that is that the thermal field around the repository creates change in density inducing gradients and driving forces that are larger than the natural hydraulic fields.

As the water moves through the sequence, it eventually gets out of that thermal field and it gets into one of these more transmissive units and is carried horizontally as a result of the natural hydraulic forces. So you see a stratum or a predominant horizontal movement once the water would get outside of that thermal field.

The dark portions here refer to the separate sections of the repository. The shaft would be placed right here in the middle. So these results again, as I said earlier, were based on the data that we had at that time. They are preliminary results. They are an estimate of expected conditions as opposed to attempting to look at extremes, and if we take this kind of information and then superimpose it on what radionuclides might do if released at 1000 years, we obtain results which are shown in this diagram.

(Slide)

We looked at carbon-14 primarily because it is non-absorbing, highly soluble, and would move with the water unretarded by chemical effects and therefore would give us an indication of the spread, the extent of any other contaminant.

What we found is that the flow field basically pushed that contaminant up 200 meters above the repository sections, and as indicated by the flow paths earlier, it is contained in these flow contacts and would transport horizontally.

MR. AXTMANN: What chemical form is Carbon-14?

MR. BACA: I would assume it would be in a carbonate.

MR. MOELLER: And when you say MPCs, you are referring to permissible concentrations in drinking water?

MR. BACA: Yes, Table 2.

MR. MOELLER: Fine. Thank you.

MR. BACA: That limit is specified here.

MR. FOSTER: Just for clarification here, though, when you draw a line that you put a 1 MPC on it, that is just an arbitrarily chosen number, isn't it, to show the relationship between concentrations versus space and distance? It's not a real concentration that you are going to expect at that particular location at a particular time? Or is it?

What I am trying to get at is whether this is a reflection of what you actually expect to be happening or whether this is just a diagrammatic presentation of the relative concentrations with space.

MR. BACA: It is based on a calculation, a theoretical result, okay? For example, we assume that after 1000 years, all the waste form or all the canisters fail, putting the waste

form in contact with the water, a very conservative kind of assumption as far as the source term treatment; and then the model basically calculates through time a sequence of pictures of distribution of that radionuclide as it is moved by the groundwater. So this is a snapshot in time. This is that 10,000 years and this is what the model would predict regarding the extent of the plume. The limits that I have picked here were selected mainly to give you an idea of the spread.

MR. PHILBRICK: Now, is this after you have completed the repository and you have pumped it out and put all the stuff in it and you started out with a dry hole?

MR. BACA: Yes. This is post-closure. This is 1000 years after they have decommissioned the facility. It's a closed system. We have assumed that the repository is fully saturated with water, and that right at 1000 years --

MR. PHILBRICK: That was not the condition when you finished emplacing the waste.

MR. BACA: That is correct.

MR. PHILBRICK: It was a dry hole, wasn't it?

MR. BACA: That's correct.

MR. PHILBRICK: How long did it take to get the water in it?

MR. BACA: We are assuming that that was instantaneous.

MR. PHILBRICK: You know it wasn't.

MR. BACA: That's right. It would take some time before the water would resaturate the rock, and we have done analyses which indicate that that resaturation time might be somewhere on the order of tens of years to a few hundreds of years.

MR. PHILBRICK: So then all the things should shove to the left or the right, shouldn't it?

MR. BACA: To the left or the right?

MR. PHILBRICK: Yes. You have a -- where is the time?

MR. BACA: The time is 10,000 years.

MR. PHILBRICK: There is no time plot on that, is there?

MR. BACA: This is not a time variation. This is one point in time. So what I have not shown you is the sequence of how the flow would spread at different time points.

MR. PHILBRICK: So as a matter of fact, this is a much more pessimistic picture than really exists.

MR. BACA: I would expect it to be, yes.

MR. PHILBRICK: Have you got an indication of how much water you are going to pump out of the repository? What was the yield?

MR. BACA: Pump out of the repository?

MR. PHILBRICK: Right.

MR. BACA: I guess I would defer that question to

maybe a little bit later. My presentation really deals with post-closure as opposed to pre-closure and the conditions during the time of emplacement.

MR. PHILBRICK: What I am looking at is the thing that was mentioned before: how much of this is based on actual observation?

MR. BACA: Okay. That very question is going to be answered in Dr. Baker's presentation. He is going to go over these specific data items and the specific measurements which have been used in this kind of analysis. And basically, to answer your question at least to a limited degree, the thicknesses of these layers come from borehole observations, okay? The geologists take core samples and so they get an estimate of these thicknesses, okay? The field testing program, the hydrologic testing, what they do is they obtain measurements of hydraulic properties for selected zones or horizons, so each one of these little dashed lines here, which indicate a hydrologic unit, has a specific set of values in terms of its hydraulic properties. Also from these field measurements we have an idea as to the --

MR. PHILBRICK: Do they have the same head?

MR. BACA: No, they don't.

To explain that question, basically what we are looking at here is a regional flow from left to right. The water is moving this way induced by a gradient of 10^{-3} meters.

That horizontal flow is interrupted or altered by the conditions around the repository: namely the thermal effects would change the rock property, which changes the driving forces, and that was reflected in that previous Vu-graph which showed you the trajectories of the water particles leaving the repository.

MR. MOELLER: Bob Axtmann had a question.

MR. AXTMANN: I somehow got lost in 10 CFR 60 at the beginning of this slide. I'm confused about the Carbon-14 concentration being characteristic of what. It's the transport of carbonate ion, and what else does it say? Is that all it says? Or can that be related to the transport of water, the velocity of the transport of water?

MR. BACA: Right. Now, the various radionuclides in the inventory move at different rates, different velocities different to each other and different to the groundwater. They are attenuated by chemical effects such as absorption. We selected carbon because it is a non-absorbing nuclide and therefore would give us an indication of the maximum rate -- the upper limit on the rate of transport and the areal extent of transport. It's kind of an upper bound for the other nuclides.

MR. AXTMANN: I would expect carbonate chemistry to be much more complicated than that. That is the deposition and the redissolution in the transport of carbonate is what you

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are looking at rather than something else.

MR. BACA: Okay. What we are modeling here is a radionuclide which is in a dissolved phase, which is not precipitating or undergoing chemical reactions, and I'm sure --

MR. MOELLER: Go ahead, Bob.

MR. AXTMANN: Carbonate is a pretty insoluble substance.

MR. BACA: Yes, I agree, and I think your questions will be answered a little later by Dr. Smith who is the geochemist.

MR. AXTMANN: Okay.

MR. MOELLER: Martin Steindler has been patiently waiting.

MR. STEINDLER: I initially asked some questions about the uncertainties, and what you have drawn here is a diagram and t he lines are exceedingly sharp. The implication is that there is no uncertainty in the calculation. The question I have is what is the uncertainty of your calculation; and more specifically, what relationship exists between the model that you are using and the real world, and where is that documented?

END T 4

MR. BACA: That is a rather broad question. Could you break it up into little parts for me? I think it would be easier to answer.

MR. STEINDLER: Let me ask the last question first. This is obviously based on a fairly complicated analytical model of what you perceive that situation to be both thermally and hydraulically.

MR. BACA: That's correct.

MR. STEINDLER: To what extent have you been able to qualify this model by showing that in fact has some relationship to the real world at the repository?

MR. BACA: Basically, your question deals with the question of the validity of the model.

MR. STEINDLER: The first part of the question, right.

MR. BACA: The theory of the model was presented or described in the SCR. We stated the assumptions. It really is based on first principles, congregation of mass, energy, momentum. The work that we have done with regard to verification and validation has been primarily in-house work where we have compared the model against other known exact theoretical solutions.

We also have done some comparisons with other computer codes, such as the NRC SWIFT computer code, which analyzes a very similar problem.

We have also done some comparisons between the model and some lab experimental data. And so that has been part of the validation phase. Most of that or all of that work will actually be documented in a report which will be released later this fiscal year, and the report will be in a computer code called POREFLOW, which is a numerical model, and that will be in the public domain here, like I said, at the end of this fiscal year.

MR. STEINDLER: Let me just comment that the comparison of one model to another doesn't do very much for me personally. I am much more impressed by laboratory comparisons, and I would be even more impressed by field comparisons.

Originally, the first part of the question deals with the uncertainty that you are projecting to the data that you currently show on the viewgraph. Do you have some measure of how precise you expect the information to be based on the uncertainty of the impact data?

MR. BACA: As I mentioned earlier, the work that was done for the SCR was a deterministic calculation, which means it's really single value. You take some instrument of the properties, input them into the model, and calculate a single result.

MR. STEINDLER: Let me stop you there. The question I am asking is you have had some kind of physical

properties of the world at large, and none of those are precise.

MR. BACA: That's correct.

MR. STEINDLER: You have to estimate some kind of uncertainty for each one of those. Have you done a sensitivity analysis to determine which of the values that you used are most important and which don't make a great deal of difference, and then having focused in on those, it makes some real difference in your answers? Have you tried to estimate how uncertain those are and how that reflects back to the contours that you have shown on the board?

MR. BACA: That's a little bit expanded question. I will try to answer all those points or all those questions in there. First of all, for this particular calculation there was no attempt to estimate or bound the uncertainty in the calculation. The hydraulic properties that were used were primarily mean values, geometric mean based on the available data.

There was some conservatism incorporated in here in terms of the characterization of the mode and the release rate of the waste form, but we did not attempt in this calculation to address the uncertainty question.

I will be showing you a set of results a little later on based on recent calculations where we have addressed the uncertainty, and I will be showing you some

probability curves in specific regard to the groundwater travel times.

MR. MOELLER: So you have done it, and you will tell us about it later?

MR. BACA: Yes. But in the SCR we did not address the question of uncertainty in this calculation.

MR. MOELLER: Dick Foster.

MR. FOSTER: A brief comment, back to the selection of carbon-14. If I understand what you are doing here, you might well have selected tritium, shall I say, instead, except in relation to the waste that tritium would have been all decayed by the tima that you ran your calculations.

MR. BACA: Precisely.

MR. FOSTER: So since tritium was decayed, you said maybe carbon is the next best nuclide to use because it is going to behave more like water than the actinites and other things which we have in there. The MPC which you show in here is merely one which turned out to be for the carbon, and it has no relationship to what that might have been for the technitium or for the plutonium or any of the other items, and it's not combined and this is merely a snapshot of the concentration. Am I correct?

MR. BACA: Correct.

MR. MOELLER: But to follow that up further then,

you are saying to us that you have assumed the carbon moved as rapidly as the water. And in answer to Dr. Axtmann, you should have said that yes, indeed, you realized that chemical reactions will be taking place, but for the purposes here you have ignored them. Is that correct?

MR. BACA: That's correct.

MR. MOELLER: And that isn't the answer you gave. But also, then you are saying to us that plutonium and perhaps other things possibly would not move as rapidly as you have assumed the carbon is moving.

MR. BACA: That's correct. In the analysis that we did for the SCR we looked at a single nuclide which we assumed is dissolved in the groundwater and did not precipitate out and did not absorb.

MR. MOELLER: Well, you may as well have taken the proton. Why did you choose carbon-14?

MR. BACA: We looked at the absorption that we had for the other nuclidse, and none of them in a 10,000-year time frame would get out of the emplacement horizon. We did not want to create the impression that that was a reflection of the overall performance of this geologic system. So we tried to select a nuclide and tried to make the appropriate conservative assumptions that would give us some bounds, some upper bound on the rate of transport and the spread, the extent.

Does that answer your question?

MR. AXTMANN: No. I am more bewildered than ever. I cannot imagine these calculations. What chemical form is the carbon-14 in?

MR. BACA: I think we said it is carbon-8.

MR. AXTMANN: But then you ignored all the reactions?

MR. BACA: That's right.

MR. ORTH: Just an arbitrary assumption, that carbon, it was going to move with water.

MR. MOELLER: All right, let's move on, but do try to answer our questions as crisply as you can.

MR. BACA: Okay, I will certainly try.

(Slide)

What I would like to do next is to go over the conclusions that we presented in the SCR. First of all, based on the calculation for carbon-14, which we assumed wet with water, we found that it had very limited travel. It went up 200 meters above the repository, a few kilometers horizontally, in a 10,000-year time frame.

Secondly, the releases across the reference boundary appear to be well below the EPA draft regulations. At least the values that we have addressed that was available to us at that time.

And it was primarily because the post-waste

emplacement traveltimes that we estimated were greater than 10,000 years. So obviously, if the water cannot reach the boundary, there would be no releases.

The next conclusion that we drew was that the general trend that the groundwater movement is horizontal. It was restricted to that deeper formation, primarily controlled by the more transmissive units, and for the solubility estimates that we have available, the fractional release rates that we calculated for such nuclides as technitium, americium, and plutonium were below that 10 to the 5 per year release rate.

Now, in making these conclusions --

MR. MOELLER: We have a question.

MR. STEINDLER: Before you leave that, those are clearly critical conclusions to the whole report. Am I correct in assuming that those conclusions are based, in essence, entirely on calculations of mathematical -- derived from mathematical models that attempt to start at fundamental principles and incorporate what you know about how the system behaves?

MR. BACA: Correct. They are based on the use of theoretical models and available field laboratory measurements, yes.

MR. STEINDLER: When you use flow top groundwater flow, you gave us the difference between the flow on the

top in the middle of the formation that appeared to be six different orders of magnitude, roughly, 10 to the 7, 10 to the 13. Then you gave us average values and somebody made the comment or perhaps you made the comment that water really is likely to flow through the path of least resistance, which struck me as correct.

What is the lowest limit of that flow top permeability?

MR. BACA: The lowest permeability?

MR. STEINDLER: And why did you use the average -- I am sorry, the highest permeability?

MR. BACA: The highest permeabilty that we have measured in one of these flow tops is like 10 to the 4 meters per second, and later on I am going to be showing you a graph which shows the distribution of these permeabilities.

MR. STEINDLER: But you did use averages in your calculations?

MR. BACA: That's correct, and that's because we were attempting to make an estimate of the expected transport as opposed to examining extremes. There was no sensitivity analysis and no projection or estimate of uncertainty.

MR. MOELLER: Are the NRC criteria applicable to averages?

MR. BACA: Well, I guess I would pass that question to the NRC.

MR. MOELLER: Well, why don't we hear? Was your criteria 10-5 and so forth, are those applicable to average values?

MR. MILLER: The rule does not go into the level of detail that specifies the exact method of assessment. And in fact, as we have already said, and I am sure Mike Bell in presentations before the committee has mentioned, that we looked forward to this process of interaction with DOE and the technical community to establish what would be acceptable methods.

But certainly, with regard to traveltime, which is sort of the measure of critical flow path, one of the options that will have to be considered is not using the average, not averaging things out, but looking at fracture permeabilities, looking at what one might term I guess the critical path for the point of closest approach. But that's something that we are looking to establish in this period of prelicensing consultation.

MR. MOELLER: Okay. Thank you.

MR. FITCH: Can I interject a comment here for a second? We did not intend in the SCR to submit a calculation on overall performance that's appropriate to make a licensing finding or even guide as to how good we

think the site is. That's not why we did the calculation. Why we did the calculation, and one is presented here by Bob, is to show where does the project need data? We are not here to tell you that we think it's approrpiate to use mean value or maximum or minimum value; it's to simply tell you here is what we did and not to defend that that means the site is either acceptable or unacceptable.

And I think we need to keep in mind that we are not after a construction authorization or even a pre-look at that. What we are really saying is, based on what we know today, here is what we think it looks like, and it helps us very much to draw and focus on what we need to do in the future. And that's the context in which those calculations were presented.

MR. MOELLER: That is helpful.

Martin.

MR. STEINDLER: Let me point out, however, that in order to try and understand the validity of the consequences of the conclusions that you have drawn, we have to have some measure of information on how you arrived at these values as they relate to either the licensing process or the draft standards about which some confusion remains.

MR. MOELLER: Go ahead, Dr. Baca. Can you finish up in the next 10 minutes or so, please?

MR. BACA: I sure will.

(Slide)

In addition to stating those conclusions we stated the uncertainties, or at least we outlined those factors that contributed to the uncertainties in those calculations, and also the limitations.

MR. MOELLER: Excuse me. Now, where have you done this? Because you just told us you had not done it.

MR. BACA: What I am saying here is that we identified the things that would contributed to unceratinty. That's different from actually analyzing their effects.

MR. MOELLER: Okay, I see the distinction.

MR. BACA: The things we identified was limitations for the amount of information on the hydraulic heads which determined the directions and rates of groundwater flow, particularly in the periphery of the Pasco Basin.

Secondly, we had a limited amount of hydraulic conductivity for flow contact. We had a lack of -- we had single porosity measurement and we had no flow estimate of vertical hydraulic conductivity.

The last factor was that there were large-scale geologic structures in the basin which we felt would have an impact on the large-scale groundwater flow system which

we have not taken into account in which additional information was needed.

(Slide)

Okay. Very quickly here. In the interim or subject to the SCR, we had collected additional data in the RL location. We had additional bore holes. We had developed new analytical techniques, particularly with regard to the calculation of the probabilities of certain outcomes. We focused our analysis of the 3D flow field to the Cold Creek syncline. And so what I will do is quickly run through some of these results.

(Slide)

MR. MOELLER: Now, when you say "additional data," those are beyond the SCR?

MR. BACA: That's correct.

MR. MOELLER: Thank you.

(Slide)

MR. BACA: We did an analysis where we looked at a variety of radionuclides. Those nuclides which we felt were of most concern, either because of their solubility or their absorption characteristics, we took the most conservative interpretation of the EPA standard, in that we looked at releases at the boundary for the worst 10,000-year time frame, and we're looking at a waste isolation period greater than 10,000 years.

We used the conservative values for our Kds provided to us by our geochemist and assumed an instantaneous release and took no credit for the emplacement horizon, and then looked at the impact of the release rates at 10 kilometers as a function of the groundwater traveltime, and then sequentially superimposing the effects of absorption and solubility.

In this curve which is depicted here -- this first curve indicates the reduction in the release rate if we were only counting on groundwater traveltime. And it says even at long groundwater traveltimes you would still have a problem meeting EPA, which is 10 to 0 here. And so there is a relatively small effect, basically about a little less than 3 orders of magnitude.

Now, if you take into account the actual chemistry that we expect in basalt, if we looked at solubility absorption superimposed, there is a rather large reduction of those releases, basically about 5 orders of magnitude.

And it shows you the distinct characteristic here, and that is that the release curve here begins to flatten out. And that is related to the fact that certain nuclides now start to dominate the releases, basically, carbon-14, if it does not precipitate out, and the iodine-129. And if we then impose a constraint of 10 to the

5 release rate on top of those chemical effects, you would rather not stay in that release curve, and again you basically have the same controlling nuclides, and you are below the EPA.

And as the C-14 would die off, then iodine would control. And this thing starts to asymptote down. And so I think this kind of diagram gives you a good perspective of the effects of these various processes: first, the groundwater traveltime and the solubility, absorption, and release rate.

MR. STEINDLER: Is your source material spent fuel?

MR. BACA: That's correct.

(Slide)

None of the performance measures that we are concerned with is the groundwater traveltime, particularly in pre-waste and post-waste emplacement traveltimes.

We recently completed an analysis, which will be documented here in a few months. And what we did is look at the most uncertain hydrologic parameter; namely, the permeability of the salt flow tops.

We have seen deterministic values for our porosity and boundary conditions which establish the hydraulic driving forces and used basically a MONTE CARLO approach, which is a standard probabilistic method that is

being used. And then we calculated a sequence of path lines and traveltimes and then determined the distribution of that sequence.

(Slide)

Now I would like to show you some of the data that goes into characterizing that kind of analysis. We currently have about 11 measurements of the hydraulic conductivity of the vents interiors, the low permeability measurements. This is a probability curve. The dots and the data points on the straight line is a theoretical fit to those, and the degree of fit basically indicates that the field data is log-normal distributed.

From this curve you can pick off the median, which says that the value is like 10 to the -13 meters per second, also calculate the standard deviation. And with that information we can now carry out this MONTE CARLO simulation.

(Slide)

Before I show you the results, I would like to show you the data that characterized the flow tops. As I mentioned earlier, the median avalue was 10 to the -7. This is the logarithm hydraulic case. These are hours, 10 raised to this power.

Again we have a very good fit, suprisingly good fit, between the measured data points and that theoretical

curve, then reflective of a log-normal distribution.

(Slide)

MR. PHILBRICK: Where did you get all those point?

MR. BACA: From in situ field measurements.

MR. PHILBRICK: How many points have you got there?

MR. BACA: We have got a total of 50 measurements of flow top permeability.

MR. PHILBRICK: You have 50 wells?

MR. BACA: No, sir. We have 50 measurements, different elevations in a series of bore holes.

MR. PHILBRICK: How many wells are you working from?

MR. BACA: Approximately eight, I believe, seven or eight.

END 7.5

Tape 6

Any further questions?

(Slide.)

Okay, if we take that kind of information and calculate out the statistical properties, we come up with an accumulative probabilistic curve for the groundwater travel time.

This is the probability that the travel time is greater than some value in this axis. So this is travel time in powers, in various powers. If we look at the 50 percent probability, which corresponds to the median value, and this is for the Cohasset flow, we basically get about 62,000 years.

The probability that the travel time exceeds 10,000 years is 92 percent. The probability of the 95 percent probability corresponds to a travel time of about 7,000 years.

Okay, so this kind of curve gives us a lot more information than we were able to provide in the SCR. It gives us a better perspective of the likelihood of specific flow paths and travel times.

(Skide.)

We have done these kinds of calculations for the other two candidate horizons and those results are similar as to this table here.

Again, here are the median values, the Cohasset

62,000/35,000 for McCoy Canyon, 37,000 for Umtanum. These are the travel times corresponding to a 95 percent probability and then these are the probabilities associated with a 10,000 year travel time.

(Slide.)

So I think that gives you ---

MR. MOELLER: Excuse me. Help me with the last column. If it is .92 that peak travel time is greater than 10,000 years, is that better than .85? I guess it is.

MR. BACA: Yes.

MR. MOELLER: And one would be perfect?

MR. BACA: Yes.

MR. MOELLER: Martin, does this make you more happy?

MR. STEINDLER: Yes. I was delighted to see data. Is it all six factors and eight percent probability that the cohesive is the travel time of less than 10,000 years?

MR. BACA: That is correct.

MR. STEINDLER: What is the -- well, can you -- do you have enough data to carry that to the illogical extreme of asking what is the probability that the travel time is say 100 years? I mean it gets so fuzzy up there that you don't really want to ---

MR. BACA: That is the hardest part of the probability curve to estimate. From the numerical

simulation here one could actually get a number, but it is in that kind of gray zone.

MR. MOELLER: Dick Foster.

MR. FOSTER: I don't recognize these names Cohasset and McCoy Canyon. Where are those in relationship to ---

(Slide.)

MR. BACA: The Cohasset flow is about 900 meters below ground. Here it is about 72 meters think. McCoy Canyon, which is just above the Umtanum.

MR. FOSTER: And the Untamum is ---

MR. BACA: It is the lower most flow here. It is about 1,100 meters below ground.

MR. FOSTER: Okay. I am a little surprised that the lower flow has the shorter travel time.

MR. BACA: Okay, the reason for that is that the Cohasset and the Umtanum have about the same permeability, but the Cohasset is much thicker. It is almost twice as thick. So it takes a considerable amount of time for the water to get out of the emplacement horizon before it moves horizontally in that flow top. That is the reason for the longer travel time.

MR. FOSTER: But doesn't the lower flow have to get up into the upper one before it begins moving?

MR. BACA: No, sir. The water would be driven

upwards to the emplacement horizon as a result of the thermal driving forces. Once that water particle would reach the flow top, it would primarily be moved laterally by the regional forces.

MR. FOSTER: So what you are saying is that in order to get up to the 10 kilometer boundary these lower flows don't ever go as high in elevation, as shallow in elevation as the Cohasset flow?

MR. BACA: That is what our calculations indicate, yes, that the upper bound would be like in this region here just above the Cohasset.

MR. FOSTER: In other words, the Cohasset is providing the ---

MR. BACA: That is right. It has a high degree of containment compared to the other two.

MR. FOSTER: Okay.

MR. PHILLERICK: But we don't have any scheme for using the Cohasset as a respository horizon.

MR. BACA: We are just finishing up a study. We conducted a report where we have done a study called the Horizon Selection Report which was a joint effort between Rockwell and Woodward and Clyde, and we will be making a recommendation to DOE on a particular emplacement horizon.

MR. PHILLERICK: But you are considering the Cohasset then in some way?

MR. BACA: Yes, as candidate horizons for a repository. What I am saying is that a recommendation is going forth on a particular horizon.

MR. MOELLER: Other questions for Dr. Baca?

Yes, Dick Foster.

MR. FOSTER: I have another one. At least the material that you have in the SCR assumes that the difference in hydraulic head in a vertical direction is relatively limited unless you have a relatively small driving force for moving water in a vertical direction in contrast with the horizontal direction.

MR. BACA: That is correct.

MR. FOSTER: I don't see anywhere in here where you have assumed any kind of a scenario that the overall ground water level off which site the Hanford Reservation would undergo a major change from pumping for irrigation purposes.

I know that, for example, in the northeastern section of Oregon in the Pendleton area that there have been drawdowns of the watertable there amounting to several hundreds of feet, and I am wondering whether this kind of scenario is worth looking at and if you just change the overall groundwater levels by, let's say, 100 meters what that would do to some of your calculations.

MR. BACA: Most of our emphasis to date has been

to try to develop an understanding and to try to start quantifying these performance measures for the existing system as opposed to getting into a spectrum of hypothetical situations which really falls more into the domain of risk assessment.

What we know now about the impact of water usage is that in the area of Pasco Basin that water usage would impact aquifers in the upper Wanapum and in the Saddle Mountains, but we have not looked at any hypothetical situations of pump-down effects.

MR. MOELLER: But as I hear Dr. Foster, it is not hypothetical. It is quite likely to occur.

MR. BACA: I don't believe I heard him say that.

MR. MOELLER: He pointed out there were already drawndowns or that the groundwater level in northeastern Oregon was down by 200 feet in some places, and he said have you looked at the potential impact of a 100 meter reduction in groundwater level. To me that is not hypothetical at all. That is almost a sure thing.

MR. BACA: Well, from the hydrologic information that we have there are no bore holes that tap down the aquifers in the Grande Ronde. The points that Dr. Foster is making have to do with systems outside the Pasco Basin.

MR. MOELLER: They will have no impact whatsoever on your basin?

MR. BACA: No, sir, not that particular question he raised.

MR. FOSTER: Well, two further questions in that area.

One of them is that you don't really know where the Grande Ronde discharges at this point? You think this may be in the Columbia River area not far from the area I am talking about?

MR. BACA: That is right.

MR. FOSTER: So it seems to me that there could be an impact, perhaps not at the upper areas, where you are now assuming that the discharge of the nuclides will take place, but still impacting the Imatella horizons themselves.

The second one is that my scenario would in fact assume that a number of years from now perhaps irrigation does take place on the Hanford Reservation per se, which I don't think is too farfetched, and if there is a drawdown of the head, the groundwater level on the Hanford Reservation.

Now if you have -- what I am visualizing is providing this hydraulic head above all of these horizons of interest. Consequently you now have an artesian effect that you don't have now.

MR. BACA: You mean a larger gradient so

therefore ---

MR. FOSTER: Instead of a gradient of a few feet, you may have a gradient of several hundred feet.

MR. FITCH: Can I interject something for just a second. We have not done calculations for that kind of drawdown. We, too -- and you will hear Dr. Baker talk about the hydrologic monitoring program that we are now implementing, which will indeed allow us to get that kind of time varying behavior and indeed where are the heads going so we can analyze those things.

I think, to divide your question into two parts, one, there is a concern over what what the surface water system effect or the unconfined to systems will be on groundwater transport. I think that was the porport of your question. The answer is we haven't done those yet, but we will be doing them.

The second part is the probability of the deep groundwaters, like in the Grand Ronde being used for agricultural purposes, the water has such high chlorides and such high TDS that all you would do is kill your crops if you used it, but we will be monitoring those and Steve is going to talk in some detail about our time varying monitoring program that we are now getting underway. So we will be able to deal with that question.

MR. PHILLERICK: Do you have the heads in the

Cohasset, the Middle Sentinel Bluff and the Umtanum flows?

MR. BACA: We have head measurements or head profiles of various bore holes in the RL area.

MR. PHILLERICK: Are they the same?

MR. BACA: No, they are not the same. They indicate a very weak vertical gradient, and as far as a horizontal gradient, they suggest gradients of less than 10 to the minus 4 meters per meter.

Now we need more information to get better estimates of that.

MR. PHILLERICK: So what you have then is a situation in which you have got three groundwater systems.

MR. BACA: Yes, I would agree with that statement.

MR. PHILLERICK: Then how do you get them to flow together? Do you put the repository in one of those places? In the Cohasset it is not going to get the lower ground waters.

MR. BACA: I would agree with that statement.

MR. PHILLERICK: I mean, aren't you leaving out a very positive element? If they don't flow together now and they are not connected now, why should they be connected in the future?

MR. BACA: Well, let's go back to some of my earlier remarks, and that was ---

MR. PHILLERICK: Can I apologize for not having been here. We had a hell of a snow storm in Upper State New York yesterday.

MR. BACA: In this layered system here because of the permeability contrast you have predominantly a horizontal movement of water. That does not mean that there is no water movement through the emplacement horizons.

We believe on the basis of the low permeability measurements that the amount of water that goes vertically through these interiors is small, and what we find from our hydrochemistry data is that the chemistry of the Grande Ronde formation is quite similar but distinct from the other two formations. So in that sense we have three groundwater systems, one for the Grande Ronde, one for the Wanapum and one for the Saddle Mountain.

MR. PHILLERICK: You are saying that the ground water systems in the Cohasset, the Middle Sentinel Bluff and the Umtanum is similar chemically?

MR. BACA: Yes.

MR. PHILLERICK: Why shouldn't they be similar? They are coming out of the same rocks. How does that indicate that you have got flow between them?

MR. BACA: I think I would like to defer that question for a little later time.

MR. PHILLERICK: Aren't you making the assumption that they are interconnected because they are of the same character that you are working with the same kind of rocks?

MR. BACA: I guess I really can't put my hands around your question.

MR. MOELLER: Will someone else be addressing this later?

MR. PHILLERICK: It can be done later.

MR. FITCH: Yes, we can do that.

MR. MOELLER: All right, let's pick it up later because we are into the time for our break.

Let's take a 15 minute break.

(Recess.)

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MR. MOELLER: The meeting will resume.

The next item on our agenda is a presentation by Dr. Sue Price on the geology aspects of the SCR.

Dr. Price.

(Slide)

MS. PRICE: I need some assistance with this microphone here.

MR. MOELLER: Okay, we will get you some in a minute. Hang on.

MS. PRICE: My name is Sue Price, Manager of the Geosciences Group.

(Slide)

Geologic studies in support of the Basalt Waste Isolation Project have been under way since the project's inception in 1977. These studies have included regional reconnaisance work in a broad area in the Columbia Plateau, and more detailed studies in the vicinity of the Pasco Basin where the Hanford site is located.

The focus of the geologic work has been toward providing stratigrahic, lithologic, structural and tectonic data, particularly as it pertains to being used to identify a preferred site or the reference repository location, and also to provide data which could serve as a basis for the more detailed characterization of that particular site.

The studies that have been conducted in support of

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BWIP have been complemented, particularly in the tectonics area, by work that has been under way as far as siting and licensing nuclear power plants in the Hanford site area.

I will be concentrating in my discussion on giving you a brief synopsis on the status of geologic work, primarily as it is contained in Chapter 3 of the Site Characterization Report, trying to emphasize in some more detail the kind of work that we have done in the interim since the SCR has been published, and then try to give you an overview of the plans that are contained in Chapter 13 and to expand in a little more detail on some of the substance of those plans.

The plan for the geology portion or component of the system is contained in Chapter 13, as I said, and geology being considered as a component of site, hydrology being the other area that Steve Baker will cover in the talk that follows.

Before I proceed, then, into a discussion of those areas, I would like to expand a little bit on some of the information that Bob Baca alluded to earlier to try to give you a little bit broader geologic background information that will serve as a framework for some of the discussions, particularly in the plans area that are to follow.

(Slide)

This is an artist's concept of the eruption of the Columbia River basalt flow. We are speaking in terms of using a medium that is compiled of a thick basalt sequence

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that comprises what we call the Columbia Plateau, which was extruded about 6.5 and 16 million years ago. This is an example of what one of those flows might have looked like. It was extruded as molten material from long linear fissures spread out over large areas, inundating pre-existing topography, this being the sequence of flows or older flows and the layering aspect of the sequence that Bob spoke to earlier.

Right now we are referring to the Columbia Plateau for purposes of this discussion as an 80,000 square mile area primarily underlain by what we call the Columbia River Basalt Group, the Myocene sequence. By looking at the topography of the Columbia Plateau, we see that it is generally reflective of the underlying structure. In fact, we can subdivide the plateau into three informal structural subprovinces, which generally comprise about one-third of each portion of the plateau. We call it the Blue Subprovince in this area to the northeast, which is generally a gradually dipping Paleo slope toward the southwest. We have the Blue Mountain structural subprovince, which lies to the south and is an Anticline, generally a large Anticline which trends to the northeast. And then we have what we call the Yakima Province, which comprises the western central portion of the plateau in this area here.

It is particularly important in the sense that the folds of this particular subprovince are comprised of long

linear Anticlines and form a series of basins in this area, one of them being the Pasco Basin where the Hanford site is located.

(Slide)

MR. MOELLER: At the time that these basalt lava flows occurred, that was on the surface, what was then the surface of the earth?

MS. PRICE: That's correct. In fact, I might point out that the source fissures for these particular flows are located in the northeastern portion of the plateau in the area of Snake River Canyon and the Grande Ronde. There are over 200 fissures exposed in that area. We can match those chemically with many of the flows that we find throughout the basin.

MR. MOELLER: Thank you.

MS. PRICE: Moving now into the Pasco Basin area, I would like to show you just a rather simplified cross-section to give you some stratigraphic instructional background. This is the north-south cross-section through the Pasco Basin, the Saddle Mountain structure being an anticline. It defines the northern boundary of the basin, with the Rattlesnake Mountain structure the second anticline that forms the southern boundary of the basin. We do find anticlines of the Yakima Fold Belt that trend into the basin from the west, but generally there it is really plunged beneath the sediment cover and it dies out toward the eastern portion of the Hanford site.

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For purposes of illustration, this does have a vertical exaggeration of a little over 12 times to accentuate the folds, particularly in the interior of the Pasco Basin.

I would like to point out some areas I will be discussing in a little more detail, particularly the Umtanum Ridge Cable Mountain structure and what we call the Cold Creek syncline. The reference repository is located in the west central portion of the Cold Creek syncline, just to give you a perspective as far as the structural setting of that particular site.

Stratigraphically we do have a series of sediments that belong to two formations, The Hanford Pasco gravels is a catastrophic sequence of gravels that were deposited as a result of catastrophic Pleistocene floods about 13,000 years ago. Beneath that is effleuvial sequence called the Ringold formation, which is deposited about 3.5 and 8 million years ago. This generally is situated on the top of this basalt sequence that Bob spoke to earlier, the three major formations being the Saddle Mountain basalt, the Wanapum basalt and the Grande Ronde basalt, the Grande Ronde sequence containing the candidate repository horizons.

The basalt sequence in the basin is estimated to be over 10,000 feet thick on the basis of a well that was drilled on the Rattlesnake Ridge structure shown here, which went to a depth of over 10,000 feet. We have chemically analyzed that

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basalt and it still appears to be chemically similar to the Grande Ronde basalt, so we estimate that they are still indeed part of the same formation.

Just a brief overview of the kind of data that has been considered in putting together the geologic picture that we now have. We used a combination of looking at exposures at the surface, particularly in the anticline areas, combining that with borehole information that we have within the basin and also geophysical surveys to make an interpretation of the subsurface stratigraphy.

MR. IVES: Question.

MR. MOELLER: Come to a microphone and give us your name, please.

MR. IVES: I am William Ives, with Roy Westin. Obviously, there has been something to compress those basalts to form those anticlines, synclines and faults. Can you date that activity?

MS. PRICE: I would like to defer that to a little later in the discussion, but I will cover that, and I think it would be more appropriate if I wait until I get into the structural deformation portion presentation.

(Slide)

I would like to just in the overview portion, by zeroing in on the Grande Ronde basalt formation, I would like

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to add just a little bit more detail to what Bob Baca alluded to earlier, and in the area of the horizon selection work that we have done, you will note that in the SCR there are only two candidate repository horizons mentioned. At that point in time we had what was called the Middle Sentinel Bluffs flow. I would like to clarify that we are formalizing that name. The Middle Sentinel Bluffs flow will become the Cohassett flow, so they are indeed one and the same flow, but we cannot use Middle Sentinel Bluffs because it is informal stratigraphic nomenclature and we will be redefining it as the Cohassett flow.

Also mentioned was the Umtanum flow. A third flow that was not mentioned was the McCoy Canyon flow. Just to give you a little background information, just before we went into writing the SCR, the engineers came to us with a question of were there flows higher up in the Grande Ronde basalt sequence that could be considered, primarily because of temperature considerations and the advantage it might have from a construction standpoint and ventilation standpoint of moving up in the section.

We did a preliminary survey, a screening survey based on some very fundamental properties, primarily flow thicknesses being greater than 80 feet, and came up with two flows, the Cohassett and the Untanum flow, and decided this should be subjected to more rigorous selection process as had

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the selection of the reference repository location, and it did go into a subcontract with Woodward-Clyde and they also went through the screening process and came up with this third flow.

As far as being candidate repository horizons, we have gone through a more rigorous identification process using decision analysis theory that will be coming out in May or that general timeframe. As far as the results of that analysis and the flow that we are recommending to DOE, as far as considering for exploratory shaft breakout and development of the repository, these three flows are now being evaluated and some of the new data I am going to be talking about was generated primarily in support of that particular documentation.

Volume 1 will be a data volume, and Volume 2 will be discussing the selection process using the data contained in Volume 1.

MR. PHILBRICK: Will you compare the two on the basis of cost over the life of the repository?

MS. PRICE: That is one of the factors being considered, yes.

(Slide)

Okay, I would like to move, then, into a discussion of basically the geology issues now and where we stand on some of the areas that relate to some of the concerns that have mentioned in the SCA. I might start out, then, with the

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regulatory criteria. As Larry mentioned in his talk, this was the foundation for establishing the kinds of work that we thought we needed to proceed with in order to characterize the site. These are the general regulatory criteria that we used. Because this is a geologic repository, we find that a little bit of geology is throughout 10 CFR 60. We didn't try to address all of that but primarily took out those areas that pertain specifically to characterization and also geologic stability.

We find in particular one of the criteria mentions that particular attention has to be paid to the host rock and surrounding strata, particularly as it pertains to determining what kind of factors need to be considered as far as pre-emplacement groundwater travel times, that they not exceed 1000 years, mentioning some of the things in the siting requirement as far as favorable and potentially unfavorable conditions that need to be considered, and also looking at the overall system performance that Bob Baca spoke of in the last presentation concerning host waste emplacement performance.

We have seen already the close association between the geologic setting and thy hydrologic regime as far as the flow tops and the influence it can have on hydrologic parameters. I don't think I need to go into too much more detail than this.

On the basis of looking at these criteria, we have

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defined two basic geology issues. The first one is an issue we call the host rock characteristics issue, and that looks basically at what is the setting of those candidate horizons and surrounding strata, what are their characteristics, what kind of mineralogy do they have, what kind of structures might be found in those horizons as we now see it.

The second issue is really one more of geologic stability, of also looking at the nature and rates of past, present and projected structural and tectonic processes and trying to determine how this might change and what factors need to be considered from a risk aspect as far as predicting groundwater travel times in the future.

Other areas that relate not only to that host waste emplacement issue that Larry listed earlier was those areas that we are providing information on in situ stress that need to be taken into account as far as repository construction, also borehole sealing, shaft sealing and certainly from a seismicity standpoint need to be taken into account. This is providing fundamental information that leads directly into those three key issues that were spoken of earlier.

MR. PHILBRICK: You don't mention erosion in this.

MS. PRICE: Considering that as part of the tectonic process, in a sense. You are right, it is a combination of processes, but we are particularly looking at upgrades as they might accelerate erosion. We have done a study about that

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and it is mentioned in the SCR. As far as the likelihood of eroding two repository levels, it is very remote. In fact, you would probably expect to have aggretion more than degradation over a 10,000-year or 20,000-year period, and even if you had catastrophic floods, they do have an erosion effect but they also have an aggregational effect as well. I will talk a little bit more about uplift rates, but it has been taken into account some of our initial work.

(Slide)

MR. FOSTER: Question.

MR. MOELLER: Dick Foster.

MR. FOSTER: Relative to your geologic issues, have you made any estimates of the possibility of having to take into account every establishment of a dam in the Wallulla Gap area?

MS. PRICE: That is mainly considered to be a hydrologic issue. This is sort of a stairstep approach in that we provide basic information, would feed that information into scenario analyses and try to predict the changes as far as risk assessment. There is one area -- I don't have it in my list -- but there is a work element in the hydrologic performance and the performance assessment portion in the site analysis chapter that specifically addresses that as far as what would happen to the hydrologic regime if you had a man-made or a natural impalement down the Columbia River.

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MR. FOSTER: My question there was related not to a man-made structure but reestablishing the old original dam that existed in that zone.

MS. PRICE: You are talking about catastrophic floods?

MR. FOSTER: Yes. And since, you know, there was a barrier in that region to begin with of geologic nature, what is the chances it would ever be reestablished?

MR. PRICE: There is a work element for that. We are right now looking at a 10,000-year period in time. As far as the regulatory requirements, we don't know if that would still hold with some of the revisions, but we anticipate that over a 10,000-year time period there probably would not be a change that would precipitate glaciation in that period of time. However, we will try to factor that in as part of the scenario analysis to see what kind of effect it might have. At least we do have a work element for that right now.

MR. FOSTER: Thank you.

MS. PRICE: What he is referring to is further south in the Walulla Gap area there is an underfed area, and when these catastrophic floods came down --

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-- we had glacialized dams up in this area that were breached sometime during the Pleistocene, and we had amounts of water that poured out over this Paleo slope that

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I referred to earlier. It came down the ancestral Columbia River and temporarily dammed within the Pasco Basin because of the underfit construction of the Walulla Gap here, so you had an underfit for a matter of weeks or months before it drained on out into the Columbia River, so we need to look at that again in the sense that if that reoccurred, what effect would that have on the groundwater in the future?

(Slide)

I don't want to dwell too much on the work elements, but I will just show these very briefly as far as the type of information that we are gathering, as far as being associated with these issues.

With the host rock characteristic issue, we have determined stratigraphic characteristics, structural characteristics, mineralogy and petrology, not only to provide to the chemist but also, as we will see, to provide information on intraflow structures as far as the cooling that was mentioned, the cooling joints that are formed just by virtue of the genesis of these particular flows, and we will talk a little bit later about that, about how these parameters factor in fracture and fracture infillings, and then the presence of what we call other possible anomalies.

I won't dwell on that now, but we can get into a discussion of the type of things that need to be taken into account in that area.

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For the structural and tectonic issue, looking at evaluating the regional, structural and tectonic setting, we find particularly in the tectonics area we need to have a knowledge of the surrounding area and the geology in order to give us a perspective on what to expect as far as the tectonic regime, determining the location of folds and faults as they now stand, evaluating fault characteristics such as the age, the slip rate, evaluating the relationship of folding and faulting, evaluate geologic long-term and continuing rates of deformation in the stress field, evaluate seismicity, volcanism, and then to develop a conceptual tectonic model which tries to combine all these particular aspects of data provided by the previous work elements and to giving us some kind of overall concept of what might be happening in the future over a 10,000-year period.

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I would like to emphasize that the concerns addressed by these work elements cover for the most part those that have been expressed by our own DOE overview committee; also, in a techtonics workshop that we held in February, at which we had over 30 professionals in attendance that had expertise in the techtonics of the Northwest to discuss primarily the status of techtonic models, and then just in the meeting that we had last week with the NRC that specifically addressed geologic stability and gave us an opportunity to discuss some of the things that were in the SCA and to get sort of a basis for further evaluation of the type of work that we need to be continuing in to provide information in some of the geologic stability areas.

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The work elements, as I said, for the most part cover these. I want to just detail a little bit more, because of the emphasis of this meeting, the NRC concerns. And again, they fall into the same general areas that we have as far as the two issues that I have shown here, where the present stratigraphic discontinuities particularly concerned about intraflow structure variations, particularly because of the influence it might have on the groundwater flow paths.

Structural discontinuities, the significance of

aeromagnetic anomalies that we found in our work and the probability and nature of undetected faulting. All these relate in a sense to host waste emplacement or pre-emplacement groundwater traveltimes. So they pertain directly to the hydrology area.

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MR. PHILBRICK: Now, all of this has to do with the recommendation as to selection for a site. This does not have to do with the engineering characteristics of the site?

MS. PRICE: I think I understand what you are asking. In other words, we have provided information, as far as site identification goes, in the geology area. The location of geophysical linears, flow thickness, this type of thing. That was factored into the site identification process that was discussed in Chapter 2 of the SCR.

Now, at the same time, enough information is certainly applicable to the other areas. But as far as the engineering goes, I think some of the questions perhaps that you have in that area we input to the repository group, and Dave Turner will be talking specifically about how in situ stress applied to construction of a repository and the rock mechanics of the work. I won't be discussing that; I will defer questions in that area to him.

The other area of concern is geologic stability. I have techtonics and seismicity with an asterisk here because we mentioned earlier about Appendix B that some of the issues are considered to be more relevant and perhaps more difficult to address than some of the other issues.

We would like to concentrate in this presentation on the techtonic and seismicity area knowing that we have already assessed or have a study out that has looked at the probability of renewed volcanism and have called upon some work by PNL to look at the probability of renewed glaciation. And we will not be discussing those in detail today, although they are addressed in the SCR and will be looked at in more detail as we enlarge the study.

Here is another area as far as micro earthquakes we will be discussing and the possible effects that might have on hydrologics.

(Slide)

We have taken these concerns and put them in a matrix, as shown here. And as I spoke to earlier and Larry mentioned as far as plans or resolution, we have given you an outline basically of our plans in the SCR. The details of those plans will really be contained in test plans.

I have shown here the test plans that have been completed, and the test plans that are in progress or under consideration.

We do have, for all practical purposes, a seismic surveillance test plan that we put together recently. We have given or will give a copy of that to the NRC as a result of the visit that they had last week with them, and hope to get some feedback on whether we're heading in the right direction.

But that does talk particularly in the area of addressing seismicity in the reference repository location.

I want to go through then each of these particular concerns very briefly, just giving you a little bit of background information on where we stand as of now with looking at those concerns, primarily drawing upon information contained in the SCR and also in two reports that have been subseqently completed in the geology area. That is the geologic portion of the horizon identification report, and also what we call the techtonic stability report, ST-19. That is not out yet, but should be in the very near future, and was not out in time to put in the SCR.

MR. MOELLER: Excuse me. On this, I understand the asterisk, whether the plant is completed or it's in progress. But a dot means you are working on that particular --

MS. PRICE: I will go through that. What I would like to do is these particular plans apply in one fashion

or another to these particular concerns. We are gathering data from these test plans. In other words, for instance, let's take the drilling and testing plan. That applies not only to geologic work but also to hydrologic work and contains all the testing that is going to be done for the entire program in bore holes. Therefore, it's necessary for us to look in a sense and form a matrix of what particular aspects those test plans apply to the host rock studies program and to the techtonic program or to broader programs.

You might have an example on a seismic surveillance test plan that really applies only to a geology area but because of the nature of many of our test plans, such as the barrier materials test plan that Mike Smith will talk to you later on, we need to form a sort of umbrella approach of having the broader programs which draw upon these components of different test plans. So that's why it is noted that way.

So what I will do is go through each one of these. I will start out with the intraflow structures and talk to you about the kinds of plans that we have in each of these areas very briefly.

MR. MOELLER: Okay. In looking at that then, the seismic surveillance plan will not address intraflow structures, is that --

PRICE: No, it will not, primarily. In other words, it would be more applicable to giving us some ideas about microseismicity. There are some areas in there that you could hedge a little bit and say there are certain aspects. I tried to just list the dominant areas of influence.

Starting in with intraflow structures, I mentioned that the genesis of the Columbia River basalt was one of a volcanic aspect. As part of that when you have the cooling of this molten material, you have the formation of cooling joints. You will see a common pattern to these joints within the plateau and three basic subdivisions as shown on here, partially eroded flow top and entabulature, and then the colonnade, which I think is fairly indicative of why it's named that.

That's not to say there aren't different patterns of these three basic --

MR. THOMPSON: May I ask a question? What would you expect the hydraulic transmissivity to be in that sort of a situation?

MS. PRICE: Steve, do you want to speak to that?

MR. BAKER: I am Steve Baker, manager of site analysis for Rockwell. If you look at the fissures in the entabulature or the colonnade, or what we generically refer to as a dense interior, we would expect the hydraulic

conductivity in those zones to be very small. We measured the conductivity from bore holes. That's the number Bob gave you previously of 10 to the -13.

MR. THOMPSON: In the Columbia joints you --

MS. PRICE: I will speak to that in a few minutes about the in-filling of the joints. That's one of the areas that we're looking at.

MR. BAKER: That's correct. We think most of these fractures are evidence to indicate that they are partially filled with clay, which is also higher hydrostatic loads than one would expect the conductivity to be lower or deeper. However, where the fissure shows a partly eroded flow top, those are the zones that have much higher conductivity.

The number that Bob gave was the mean of 10 to the -7.

MR. THOMPSON: Those are not sealed with the same material?

MS. PRICE: This flow has been subject to erosion.

MR. THOMPSON: I realize that, but I sort of extrpolate that to a --

MS. PRICE: I will get to the fact that we have looked and we are looking at that very thing.

MR. THOMPSON: What about looks like the

sedimentary areas between the entabulature and the flow top?

MS. PRICE: This is just a little bit of colluvium as far as depositing. This is the cliff exposure.

MR. PHILBRICK: If the material we're concerned about is liquid coming out of the repository and the respository is situated in the colonnade zone or the zone above it and you have permeabilities there of 10 to the -13, what difference does it make what the permeability is in the upper rock in the intraflow if you can't get the water to it?

MR. BAKER: I will be addressing that later on. I think the question -- the concern is that other people have expressed concerns about the representativeness of data and the validity of the assumptions of homogeneous low permeability sites. I think if the rock is truly a homogeneous medium with a 10 to the -13 conductivity in those structures which would allow water flow, then there is no issue.

MR. PHILBRICK: We are talking about the whole mass. And if the mass is 10 to the -13, you cannot move the water up to get it to the point where it can flow.

MR. BAKER: Two points, and I will cover that later. The measurements we have are very small volumes of rock from bore holes, and they tested not particularly in

that direction. So there could be conductivities which could change the picture.

MR. PHILBRICK: But they wouldn't have the conductivities of the upper zone.

MR. BAKER: We don't think so, but a lot of people have expressed concerns, and we feel it is important for us to address this.

MR. PHILBRICK: What was the basis of their concern?

MS. PRICE: Maybe I just need to talk about variation. I think we definitely want to move into that.

MR. PHILBRICK: Let me ask the next question. You show no geophysical surveys with respect to the intraflow structures. One of the critical things is how much solid roof do you have over the repository? Can you locate the top of the colonnade zone geophysically?

MS.PRICE: We are going to try. We are looking at methods right now. The Bureau of Mines has tried studies as far as in-mine monitoring for anomalies --

MR. PHILBRICK: I am talking about --

MS. PRICE: -- at repository depths. We just would not have the penetration to detect these features.

MR. PHILBRICK: Okay.

MS. PRICE: Possibly in the mine itself we could come up with something that might be able to do that.

MR. THOMPSON: What about detection of steep fracture zones that may breach the low permeabilities that you mentioned in a zone like that? That would be one of my principal concerns. We are talking about in homogenieties, but the fractures that cross over vertically through that not even easily detected by drill holes, you will address this at some point?

MS. PRICE: In this techtonic fracture analysis in that area. I wanted to just put that up. This is, as I said, looking at an outcrop. It's easy to see the subdivisions here. Also, looking at an outcrop, we find different renditions of that in the sense of perhaps you will have different combinations.

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Maybe an intervening entabulature colonnade with a tiered flow. For instance, the Cohasset exhibited some of these characteristics. And so we just wanted to give you an idea, but that is sort of an idealized flow in purposes of a stepping-off place for our discussion.

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Of particular importance is looking at the flow top and variations from that flow top because of differences of hydrologic problem.

What is discussed in the SCR and SCA is primarily a combination of information that was gathered by

looking at outcrops at the northwest and the Sentinel Gap area. There are exposures in the grand ronde in this area. There are not exposures in the grand ronde when you get into the reference repository location.

So we are trying to do a combination of looking at what is in bore holes and looking at what is on the surface.

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One of the things we have done for the horizon selection report is try to look at variability, particularly flow top thickness as compared to total flow thickness, as shown by this graph. These are the three flows of Cohasset, McCoy Canyon, and Umtanan.

Although we have enough dense interior for construction of a repository, we certainly see that we have a higher degree of variabiltiy of that flow top in the Umtanum flow top as compared to the flow tops that we find in the other two candidate repository horizons that we are considering.

One of the concerns partiuclarly from looking --

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-- one of the sections there, there is a section of the Umtanum's flows. Looking at the flow top in that area we find depths in the flow top in the colonnade entabulature portions, and you find the flow top does get down into the dense interior.

One of the concerns expressed is that the degree of variability, what kind of influence would that have on predicting what kind of influence that would have on hydrology.

One of the ways we are trying to address that is to continue to look at outcrops in combination with bore holes, although we only have one more bore hole that is

planned right now, as far DC-18. We also have done studies on the origin of the flows. We find, for instance, that the Umtanum flow was probably deposited within a lake, and you had a thick flow top formed. The other two flows were probably formed subaerially and you have the more common cooling type of history and do not get this thick flow top that you have in the Umtanum.

We want to provide the data to demonstrate that, so we are looking at outcrops, bore hole studies, particularly using laboratory analysis. And we find petragraphic differences in the colonnade and entabulature as well as using geophysical surfaces of bore holes.

One of the areas is exploratory shaft, and we will make predictions about what we might find down there and be confirming some of those through the exploratory shaft.

We will be trying to come up with a conceptual model in a little more detail to provide some field evidence to the performance assessment group so they can factor this into their performance and assessment work that they are conducting.

MR. PHILBRICK: May I ask you about the statement that DC-18 is the only other hole you are going to drill?

MS. PRICE: Right now. That is the way it is outlined. However --

MR. PHILBRICK: Why is it outside the proposed repository?

MS. PRICE: This is located in the structural area, and one of the concerns was to establish what kind of hydrologic parameters you might have in a structural area, since most of the drilling is in a synclinal area and how would these parameters influence groundwater exchange? What are the bounding conditions, in other words, of this area?

MR. PHILBRICK: Now let me ask you about the shaft. Who logs it and when?

MS. PRICE: From a geologic standpoint or --

MR. PHILBRICK: Who logs it and when do they log it?

MR. FITCH: It will not be logged.

MR. PHILBRICK: Why are we drilling the thing?

MR. FITCH: The technique for sinking the shaft at Hanford through all of these interbeds that have potentially high pressure water systems in them, that shaft will be blind-hole-bored from the surface, encased, and grouted into place before anyone goes below. So there will not be an opportunity to do that geologic mapping.

And the reason that technique was picked was, one, it's the fastest way, and two, even more importantly, it's the safest way to put the shaft down.

MR. PHILBRICK: You don't get the information

that way and that's why you're putting the shafts down or you're putting it in for access and for information so that you can see firsthand in the repository what the materials are and what their structure and continuity is.

Now, if that's the case and this is the fundamental business, then you must modify the variety of drilling that you are doing. There is no reason why you cannot case off that stuff that's producing water.

MS. PRICE: We will be breaking out in the potential horizon.

MR. PHILBRICK: In little holes?

MS. PRICE: No; on Phase II we will be emplacing a thousand-foot tunnel and putting a test facility in.

MR. PHILBRICK: That doesn't give you the route through which the water escapes from the repository. I think you have got a fundamental weakness in your exploration scheme unless you design it so that you can investigate the overhead, the roof materials in the Cohasset and the roof materials in the Umtanum.

MS. PRICE: That would be an option to consider breaking out both of those horizons.

MR. PHILBRICK: Set your casing, grout it in place above the Cohasset, several hundred feet or 200 feet or 2,500 feet or whatever seems to be reasonable; reduce the size of the hole and go on down and see what you've got

in the way of materials. This is what you are trying to do. All this money is being spent to prove conditions above the repository horizons and in the repository horizons.

MS. PRICE: Dave, do you want to add anything to that? Dave will talk a little bit more.

MR. FITCH: The project is currently producing a document called "Exploratory Shaft Test Plan." A draft has been prepared, and it is being reviewed by the NWTS program and currently being reworked right now and will be finalized in the next several months.

We would be more than willing to supply that to the committee when it's finalized and have a detailed discussion on it if you would care to.

We have discussed the approach for sinking that shaft with probably 40 or 50 experts around the world. Your point has been brought up by others. And right now, in the name of safety, we have decided that that is not the pertinent thing to do.

We would be more than happy to discuss it with you at your pleasure.

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MR. PHILBRICK: Do you want me to comment again?

MR. MOELLER: If you want to as a summary statement, sure.

MR. PHILBRICK: I think that this is a fundamental point of exploration, and I don't believe the safety factor is what you say because you can set the casing, grout it and then proceed to investigate with the deeper part of the hole. Now, if you are in such a situation that you have got so much water that you cannot open the hole through the critical repository zone, you are wasting a lot of time talking about a site that should not be further investigated.

MR. MOELLER: Go ahead.

(Slide)

MS. PRICE: I would like to move in just to the next area in the matrix, and that is talking about fracture analysis, particular cooling fractures, because they appear to form the most predominant aspect of the basalt flows. We are particularly interested in the nature of these cooling fractures at depths where the repository will be located.

We have utilized core and performed a fracture analysis on this core. The results are discussed in the SCR. I will just briefly review them here. The aperture of these fractures are less than 0.5 millimeter in width. As far as volume percent, there is less than .5 percent that are unfilled, and as far as the type of material filling these fractures, we

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find that it is like clays or silica for the most part. I think Mike Smith will discuss in a little more detail about the properties of these clays, particularly as it pertains to what might happen in a repository where you might have waste that would elevate the temperature. So I just wanted to alert you to the fact that we have done fracture analysis at depth and we find the bulk of the fractures to be filled. Hydrostatic load probably helps out in this area as well, as was mentioned earlier.

(Slide)

We still want to continue, however, plans to look at these fractures in more detail, and we will analyze as we continue to gather borehole data the fractures and provide laboratory analysis as far as the secondary minerals that are contained, and also the same type of thing in the exploratory shaft as far as looking at the fracture and whether it meets the predicted conditions based on a combination of bore hole and surface data.

MR. STEINDLER: What do you expect to use the laboratory data for?

MR. PRICE: This would be to provide the geochemical setting as far as the nature of the secondary minerals. The actual composition, types of clay.

MR. STEINDLER: The implication is that you are going to transmit water from the repository through those

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clays; is that right?

MS. PRICE: That's correct. That's one of the concerns.

MR. STEINDLER: Is that a reasonable expectation?

MS. PRICE: I think so. Mike, do you just want to say a few words?

MR. STEINDLER: If you are going to cover that later, I can quit.

MR. SMITH: Well, I can just add a little bit, in that one of the reasons for doing this analysis is to try to understand which clays are there,and the reason you want to do that is the only source of materials that you have on the solubility experiments in those materials is from another source. So you certainly want to compare the composition and the characteristics of the materials you see in fractures at depth to what you might doing the experimental work with and then accounting for the differences between those materials.

MR. STEINDLER: I have one other question. Is there any information available on how those clays were formed specifically, temperature and some indication and the source of -- I assume it is hydrothermal groundwater?

MS. PRICE: Those clays were formed as a result of groundwater interactions with basalts, and we see the exact same materials forming in the hydrothermal experiments we carry out in the laboratory.

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MR. MOELLER: George?

MR. THOMPSON: Some of the same materials in the spaces in the flow tops, too. Geologically I get the picture that the fractures in the basalt are filled but the flow tops are not so filled.

MS. PRICE: You would find some materials in the flow tops, but you still have a greater permeability in the flow top.

MR. THOMPSON: It simply didn't get filled up. I see.

MS. PRICE: I would like to move on, then, to the next area of just fracture analysis as far as tectonic fractures.

(Slide)

We will just briefly review the structural setting of the reference repository location. As I said earlier, we are in a synclinal area. The flows are flat line in this area. Most of the faults that we see appear to be associated in areas of the anticlinal areas where the folding has been most intense. In order to give us an idea of what kind of deformation we might expect in a synclinal area, we did have a study done in the Umtanum Ridge, a mechanical analysis done trying to predict on the basis of looking at deformation associated with one of these ridges, moving down toward the synclinal area, what kind of features you might expect in the

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syncline.

We have difficulty in this area because for the most part in the western portion of the plateau the synclines are covered by sediment, so it is difficult to get exposures in some areas.

(Slide)

This was discussed in the SCR as far as the work that Ed Price did as far as looking at the type of deformation associated with the anticlines. He did find the most extensive faulting to be in the areas of greater structural depth; however, that is not to say that he wouldn't have localized small faults or areas of minor displacement within the Cold Creek synclinal trough.

We plan to look at these features. We are picking up boreholes that were drilled less than 4 inches in width, but we need to know the properties of these, particularly from the hydrologic standpoint, and what their tectonic implications might be; and indeed, if we are looking at them in the correct perspective as far as what they might mean with regard to the tectonic setting of the syncline, and that is that area being an area of much lesser deformation.

(Slide)

MR. STEINDLER: Do they tend to be mineralized too?

MS. PRICE: Yes, for the most part. We have not done as much work on the breccias as we would like to. We

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are going to go back through the breccias and do an outcrop analysis or what we call an analog study, in that we are going to be going up again into this area here, particularly in another anticlinal area. In the Frenchman Hills where you do have a very gradual dipping, that is exposed and we have found some tectonic breccias in that location. We want to characterize those possibly with the plans of knowing where those breccias actually are to see how they are related to the folds, and also it is possible that we could do some actual hydrological testing of those particular features.

The same type of thing, DC-18 is being drilled near the Gable Mountain Anticline and expect to encounter tectonic breccias. We will try to hydrologically test them to see what their properties are at depth. Steve will talk about a cluster well in here, and I think I want to conclude this section just by saying that, for instance, cluster testing would allow us to stress a larger area and we can perhaps take into account some of those anomalies to see what kind of values we get taking into account perhaps some of these perturbations that are not easily picked up on the basis of trying to predict from available borehole and outcrop information.

Seismic surveillance also will apply in this area, that we will be putting in a microseismic network in the RL area, and when we begin to record, we will try to see as far as are there any patterns of microseismicity that might be

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associated with any linear areas that perhaps could account for adjustments that would cause tectonic brecciation.

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Another concern is the geophysical anomalies that have been picked up in synclinal areas as part of the site identification process. We did conduct an aeromagnetic survey in the Cold Creek syncline area and used the locations of these linaments to give us some indication of where we should site, trying to stay away from as many of these anomalies as we could.

I want to qualify this particular method is called an interpretive bedrock structures map, but I do want to note that these are for the most part anomalies that have been interpreted on the basis of looking at the five levels going through the analytical process. As far as whether they do actually indicate fault at depth, right now it is unknown in the sense that many of these anomalies could possibly represent something in the sediments or you could have buried channels from the catastrophic floods that would cause these anomalies or actually folds or monoclines that are actually just folds.

So one of the aspects that we are looking at right now is starting to try to detail the properties of one of these anomalies called an ANCI linear, which is located here, trying to correlate that or look at that in relation to an interpretive hydrologic barrier which is located in this area. We would

like to look at that from the standpoint of possibly drilling in that area, getting some information both from a hydrologic standpoint and a geologic standpoint as far as looking particularly in the sediments to see if there is any offset at the Ringold sediments that might be related and conducting other geophysical surveys as well in that area.

But that is one of the ways we are trying to address this particular anomaly. We find that in some of these areas the anomalies are rather elusive. This was the main juncture linear, which was looked at in some detail by PNL as far as looking at nuclear power plant siting in this area by Energy Services Company and could not find any geologic evidence that this was an offset or was a fault.

So as I said, these can be rather elusive, but because we have some indication there might be a structural feature here, we will be looking at our plans right now at that in more detail.

(Slide)

I want to move into this last area as far as tectonic stability. As I said earlier, we had published or are getting ready to publish a document that is called a preliminary assessment of the tectonic stability of the reference repository location, and I do stress the word "preliminary" in that we have taken several approaches combining both geologic and contemporary data to give us some indication right now of

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what the tectonic setting of the reference repository is. Geologic deformation rates in particular look at uplift/subsidence/folding rates, have used the basalt flows as an instance in time in which these flows have come out. We have dated these flows. They predate existing topography, and you can tell by looking at flow thickness variations what the topography looked like at that time, and by taking that through a series of sequence of flows and actually come up with an average rate of deformation.

Right now we find it to be less than 0.1 millimeters per year.

I have also looked at the information regarding the fault age and the slip rate, particularly for the central Gable Mountain Fault. I think most of you are probably aware of that as far as WPPS and some of the work they have done on that fault and find that is a fault which cuts and appears to go into overlying glacial material being younger than 13,000 years old. There is a slip rate that has been determined on that fault, averaging also less than .01 millimeters per year. Again, that is an average rate, but that does give us some indication of how the geologic information might compare with the contemporary deformation rates in the stress fields.

We do have a geodetic survey rate in the Hanford area done by USGS that had five surveys of that network in the last ten years and also indicates a very slow deformation rate

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from a contemporary standpoint near the limited detection of that instrument system.

Seismic monitoring. There has been a seismic monitoring network run for the Department of Energy by the University of Washington that has been in operation also for the last ten years, and we find that from a seismic standpoint, at least in the synclinal areas, the most characteristic seismic character is one of micro-earthquakes or a grouping of earthquakes spatially in time in small areas. Most earthquakes have a magnitude of less than 3.

We have taken this information and compared it to the tectonic models that we now find that have been published in the literature and made some conclusions regarding what the present tectonic situation is.

(Slide)

One of the reasons for holding the workshop was to provide an opportunity for people to take a look at that document before it was finalized and give some feedback on whether some of the general conclusions we have come to regarding the tectonic setting in the area were also considered to be in general agreement by peer reviewers.

These are just general points. The age of the Yakima fold belt deformation. By looking at the geologic information, we know that the Yakima fold belt deformation began at least 15 million years ago. Looking at the long-term deformation

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rates, and these are average rates, the fact that we have a low long-term average rate of deformation of less than .1 millimeter per year. Stress orientation appears to be north-south, which certainly accounts for the trend in the folds that we have in the area.

The style of deformation is that strain appears to be concentrated in the anticlinal areas. Synclinal areas appear to be much less relatively deformed than the anticlinal area.

Earthquake patterns are far as microseismicity does not appear to be associated, and the strike-slip fault displacement, although prominent in the western portion of the plateau, southwest portion, appears to be decreasing in influence as you go toward the Pasco Basin.

There might be some strike-slip fault displacement within the Pasco Basin, but the consensus was at this point in time it would perhaps be minor and be more associated with tear faults than with the folding process. That is not to say that the workshop was without concerns,and many of these parallel the same concerns in the SCA.

(Slide)

Potential for episodic deformation. We are looking at average rates for deformation. What would be the seismicity that might be associated particularly with faulting? The relationship of in situ stress to structures, particularly some

of the in situ stress measurements. The core disking that we find in the central synclinal areas. What does that tell us about in situ stress and how can that tectonically be explained? Is there a higher in situ stress in synclinal areas than what we would expect?

Occurrence of fault breccia: the same thing. What are they telling us from that standpoint? Detection and potential thrust of strike-slip faults. Although from looking at the models it was surmised that it is not likely, it was also felt it would be very difficult to detect strike-slip faults for geophysical or other means in a synclinal area, which has to be factored in in some fashion into the influence it might have from a hydrologic standpoint.

Earthquake swarms in basalt: what effect would these have hydrologically? A discrete microseismic event wouldn't have much effect, but what happens over a 10,000-year period when you get repetition of these events and then determination of design basis earthquake, particularly for a subsurface facility when you are going into a new area? What kind of studies do you need to carry out to carry this into the subsurface?

(Slide)

I want to briefly address this first area as far as seismicity. One of the concerns that was expressed, particularly in the SCA, was the lack of information or plans

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that related to giving some parameters on microseismicity, particularly in the reference repository location. We previously started to address this concern and have developed a seismic monitoring test plan. At the present time we have networks in existence, the regional network that I spoke to. We also have a portable network that is a three-component network that we can move into swarm areas to give us some parameters on the rupture size, but we like to get information on the reference repository location, particularly for events that are 0.0 magnitude.

This was a value that was recommended to us by TERA. We did get a consulting firm that looked at the parameters that needed to be measured, and this was one of the recommendations. We also want to know from a hypocenter standpoint whether these earthquakes could be localized in your candidate repository horizons. They do occur at potential repository depths, and one of the plans is to use this eight-station network to try to get to a hypocenter situation of 5200 meters, also frequences at depth and ground motion. Right now we can only detect up to about 50 hertz. There is some indication from some of the studies that have been done that subsurface-wise you may need to look at the frequencies up to 100 hertz to make some kind of assessment as far as what kind of data you might have at depth.

MR. MOELLER: Don Orth.

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MR. ORTH: I don't really understand the sense in which you are using limited. If something is limited to 2 to 4, that means you can only measure between 2 and 4, For example, or it is limited to 0 magnitude or greater. I mean what negative magnitude were we trying to get to?

MS. PRICE: Trying to get to 0.0 magnitude. As far as detecting throughout the network area, we can detect to 0.0 magnitude. That is the limit.

MR. THOMPSON: There are negative magnitudes.

MS. PRICE: That's right, but it is 0.0 right now.

MR. ORTH: Okay. Now, how about where it is limited to a range, limited to such and such?

MS. PRICE: The reason it is expressed as this is because this is a 40-station network. It is a surface network throughout eastern Washington. The locations of the stations, in some areas you have a closer station spacing and are able to get to a hypocenter of 2 kilometers. In other areas you have a larger station space and don't have the same degree of precision, and that is why it is give as 2 to 4.

MR. MOELLER: Martin Steindler.

MR. STEINDLER: Can you relate briefly the output of those kind of experiments? For example, performance assessment models. In other words, what are you going to do with the information once you have it? How does it impinge on an analysis of some safety-related issue?

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MS. PRICE: There are two areas we would be looking at. One would be from a pre-closure aspect as far as what would microseismicity do as far as if you needed to retrieve your canisters, for instance, what kind of effect would it have on mine openings. The other thing from a hydrologic standpoint is hopefully with this system we would be able to detect the size of the ruptures. In other words, you are having breaking of rocks somewhere. When you get these events, we want to know whether the size of these events, the interconnectedness of these events to give you some idea of whether that would be the size of fracture that might short-circuit some of your hydrologic flow paths.

(Slide)

Moving into this last area, then, tectonic model development and tectonic stability, this is just, again, a picture of the structural elements of the Pasco Basin. Right now as far as the surface facilities, the design basis earthquake has been established by looking at what we call the Rattlesnake-Walulla alignment. It is possible right now that a 6.5 earthquake -- at least that is being considered as far as the design basis -- could be generated anywhere along this structure. Because of the closer proximity of this structure to the syncline, we certainly feel this is a structure that needs to be looked at.

The size of that earthquake, and indeed the source

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area of that earthquake, needs to be examined as far as taking into account what kind of influence it might have on the facility.

Another area is the Central Gable Mountain fault, and as far as the capability right now, that structure is considered to be a 5.5. These are two structures that need to be looked at from the seismic design standpoint,and also looking at tectonic models right now we are in the process -- there are several models that have been proposed for the area.

(Slide)

Basically we have a question of whether you have a situation of thick or thin skin tectonics. In other words, could these folds be called by deep-seated structures in the area and the folding would just be a propagation of a deep-seated structure, or could you indeed have some kind of structure where you are actually getting some kind of thrust faulting?

From a repository standpoint, we need to look at both those models, particularly from the standpoint of what type of geologic information we might try to gather to distinguish between those two; and indeed, if we cannot gather sufficient information to distinguish between the two, what kind of consequences would it have as far as seismic design and for evaluation of performance?

So we are getting into that area. As I said,the

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report we put out is a first step in that area, but we certainly feel this is an area that we need to provide more detail on.

MR. PHILBRICK: Are you going to make any seismic surveys to determine thin skin versus thick skin?

MS. PRICE: Right now we do have a magnetic survey in the area. It is sort of a black box technique. There are various opinions on the validity of that kind of work, but it does show that there is some degree of structural relief on the layer below the basalt, which is interpreted right now from the properties to be some kind of sediment. If that interpretation is indeed correct, it would be difficult to see a large detachment such as has been proposed in some models at the basin of the basalt. One of the ways we are trying to determine whether we can indeed confirm or give some kind of additional information on the survey is to get a refraction survey in the area. The USGS is going to do a refraction of the cascades, and we are trying to tie in with them to see if we can get some kind of confirmation for the magneto data. We would like to do that this summer as possible.

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MR. PHILBRICK: Is this the kind of thing that microseismicity would --

MS. PRICE: I don't think it would penetrate deep enough. And the reason I say that is because we also have about 120 line-miles of reflection in the area. We haven't gone over all the seismic information that we have, and when we first decided to use that technique, we did run an experiment as far as whether we could penetrate down to the depth of the Umtanum and give us some kind of identification of what would be underneath. We found that generally not to be very effective. We could not get the degree of penetration required to give us a resolution at that depth.

MR. MOELLER: Dr. Axtmann and then Dr. Thompson.

MR. AXTMANN: One of the tectonic workshop concerns was determination of the design-basis earthquake. Could you give us a feel for what that might be compared to a design-basis accident for a nuclear power plant?

MS. PRICE: I am going to address that with my second-to-the-last slide. So can we wait just a few minutes? In fact, I don't really know if we touched upon the plans here as far as outcrop analysis. We will continue, for instance, in the tectonic breaches studies to relate that to the tectonic regime. We will try to do some more kinematic modeling if that can tell us about anything

that might be happening at depth.

We will continue our geodetic survey and seismic surveillance as well to provide data input to the central model.

Now, as far as addressing --

(Slide)

-- seismic design, we are really just getting into that area right now. We have put together a seismic design task force which one of their first charges is to really look at the criteria guideline evaluation and indeed the appropriateness of nuclear reactor guidelines.

One of the particular aspects we are looking at right now is are there really any Category 1 structures in a repository in that you do not have the same situation that you have with a nuclear power plant as far as containment vessels and the same type of consequences that you mgiht have with rupture of thta vessel.

We right now think that the surface faclities particularly would be more akin to some of your reprocessing type of facilities that you have in the area where you are handling the nuclear materials and cannisters and fuel rods and would not have the same type of risk to contend with as far as releases.

This is an area that is one that is going to be difficult in the sense that there is no precedent set for

the approach as far as designing for a subsurface facility. There have been several workshops that have been held dealing with this particular aspect. We think some of the information that the Nevada test sites, some of the types of blasting that you have in that area and what effect it has on an underground facility.

There will be another workshop in Philadelphia in May on the same subject.

So right now I think we are just trying to develop an approach, what we think would be an approach, and then send that approach out to consultants and NRC and try to get some feedback on whether we are headed in the right direction.

MR. MOELLER: George.

MR. THOMPSON: Earlier you alluded to the monocline, discussing some of the structural linears and how they have been investigated geophysically. And I seem to recall that there was one rather highly relevant type of study that was made on that. Many of the studies were trying to detect whether large faults -- they did this in seismic refraction work in which they found a large contrast of velocity along the structure and across the trend of the structure. And that's a technique that might be useful along the structural lineaments for detecting fracture.

The explanation for that, and I think probably the only good explanation too, was that there was a swarm of fractures along the May juncture monocline. The velocities were higher along the monocline than across it. So it might be worth considering. But that would be a fairly high resolution method for detecting fracture where you have some reason to concentrate your effort along the zone that is indicated by aeromagnetic anomalies or gravity or otherwise.

MS. PRICE: We have conducted in the RL area refraction from the standpoint of trying to give us more detail about the sediments, just because we have found that the properties of some of the sediments can give you anomalie at thepth. And I think the point is well taken. We will look at that and see if there is anything that can be done in that area.

The other thing that we are doing that I didn't mention is that we do have some bore holes in the Ringold in the RL area and also have done some stratigraphic work to see if we can find marker beds to also expand on the deformation type of work. There looked to be some things that are promising in that area, but the work is fairly preliminary right now. But I did want to make mention of the fact that we are doing that.

(Slide)

I would like to conclude then by just two very general statements that right now from a geologic basis we don't find anything that would preclude development of a repository. But this is certainly not to say that we don't need to do additional work, particularly in the areas that I just mentioned previously.

And so right now we are proceeding to conduct and plan the work to address some of the geologic uncertainty that has been mentioned in the SCA and the workshop participants, and particularly to try to develop detailed test plans that can be looked at by the NRC as far as getting feedback on the particular way that we are going to try to resolve some of these things.

MR. MOELLER: Any additional questions for Dr. Price?

MR. WRIGHT: May I rise to point of clarification? My name is Wright. I am with the NRC.

As Dr. Price mentioned, there has been within 1983 two meetings on tectonic and related problems, one in February with the overview group of DOE/Rockwell; the second one concluded only last week was with the NRC.

I simply want to note for the purpose of the record that the viewgraph which is headed "Tectonics Workshop General Agreement" refers to February, and which NRC did not participate.

MS. PRICE: That's a good point.

MR. MOELLER: Thank you for that clarification.

Any other questions or comments?

Well, thank you, Dr. Price. I gather you will be here through the day so we can ask questions if they come up.

I have received further word on the Commission's review of 10 CFR 60. That word is that it may be scheduled a week from today and it may be scheduled 2 weeks from today.

We will now recess 60 minutes for lunch.

(Whereupon, at 12:30 p.m., the Subcommittee was recessed, to reconvene at 1:30 p.m. this same day.)

END T. 10

AFTERNOON SESSION

(1:30 p.m.)

MR. MOELLER: The meeting will resume.

We are going to move now into the area of hydrology, and for that presentation we have with us Dr. Stephen Baker. Dr. Baker.

MR. BAKER: Thank you.

The reviewing organizations were mentioned. We have mentioned frequently this morning that other organizations have provided peer review to us.

(Slide)

Let me just briefly acquaint you with different organizations that we have had some peer review from in some way or another. Of course, the NRC, as you saw this morning, has visited us several times to review the project, along with their consultants.

Sue mentioned the tectonic workshop in which we gathered together about 35 experts in the Pacific Northwest tectonic activity. And that workshop lasted what, a week?

MS. PRICE: No. 2 days.

MR. BAKER: We have had an overview committee for some years now. The overview committee has recently been restructured to provide a focus as licensing preparation. However, they have quite a few consultants that support them. We have gotten an awful lot of review from them. It

has been internal, principally.

MR. MOELLER: Do they meet as a body totally together and individually too?

MR. BAKER: Yes. They meet as a body generally when they come, and they will review us. They will be there for several days and review some topic. They will caucus independently.

Let me make it clear they don't work for Rockwell. They work for DOE.

MR. MOELLER: That's good. And how frequently have they been meeting?

MR. BAKER: Quarterly. It's been about quarterly in the past.

MR. MOELLER: Well, that's good to hear. And I think the project reflects the benefits of such a process.

MR. BAKER: I hope you can see that.

(Laughter)

MR. MOELLER: Mr. Philbrick has a question.

MR. PHILBRICK: Who is on the committee?

MR. BAKER: John Bartlett is the chairman. Chase Smith is the member of the committee that oversees the site activities. Dick Vianowski is the member that oversees the rock mechanics. He is from Penn State.

MR. MOELLER: Could we have maybe for the record simply a list of them?

MR. FITCH: I will write it down and give it to you.

MR. BAKER: We can give you the consultants too.

And the one other thing which I will mention in the absence of this kind of preparation that maybe would be confusing is that we have had what we refer to as a Model Task Force. It's a multiorganizational task force that is composed of Rockwell, Hanford, the U.S.G.S., Pacific Northwest Labs, the Battelle facility in Hanford, and with support from Lawrence Berkeley labs, basically addressing a variety of questions that the U.S.G.S. has brought up. And we will talk about that later.

This is the hydrology section of our presentation. I would like to divide it into two parts.

(Slide)

First I would like to briefly summarize what we put in the site characterization report and basically explain a little more what conclusions we drew and try to put them in perspective. And to put it really in perspective, I would like to spend most of my time talking about the issues that we have identified and what we are doing to address those issues. There are quite a few issues that have been arised in the hydrology area.

Yes? Oh, I thought I had a question.

(Slide)

I would first like to reinforce something that Larry said when he started. We don't view the site characterization report as a final licensing document which is a final Rockwell picture of what the Hanford site looks like. Rather, we view it as a best estimate based upon limited data, certainly limited compared to what will be required for a final license submittal.

We did not address uncertainties except to mention that we recognize that they exist and we would have to in the future deal with them in a systematic way. We have started doing preliminary uncertainty analysis that Bob Baca gave you the results of this morning.

Based upon some of the questions, I would like to talk a little bit more about what went into those uncertainty analyses today. We feel the major source of uncertainty is the data base and our future program is directed at first understanding what the uncertainty is and, second, doing what it takes to reduce that, primarily which involves collection of more data.

I guess I should mention also that we view the collection of data as an iterative process where we collect data, try to understand the uncertainty of that information, assess the performance of the site, propagate the uncertainty due to the data through the performance analysis and use that as the basis for determining the

adequacy of the data base. That is almost all in the future. We have not done that; we intend to.

(Slide)

There are activities to provide the level of site characterization which we reported in the report and were based on hydrologic and geologic fact considerations. Basically, what that challenge is is to provide the setting in which the groundwater system exists.

We looked at stratigraphy and structure, and Sue talked about that this morning. We also looked at the hydrologic properties of the site. We drilled a lot of bore holes and collected hydrologic properties, hydraulic heads for looking at hydrochemistry. And we are trying to determine recharge and discharge areas and interactions between flow systems.

(Slide)

As was mentioned earlier, we see the water bearing zones in the Hanford basalts as being basically two types. One is an underbed in which the intervals between subsequent basalt flows was fairly long, long enough for sedimentary material to accumulate. Those are relatively permeable, we find, in field testing compared to the dense material flows.

And by far, the more common flow type and the type that is predominant in the deeper basalts are flow

contacts, a region between subsequent flows where there is little sedimentary interbed material -- obviously, in flow contacts of this type the top of the lower flow has been subjected to two thermal transients: one, the cooling cycle is basalt below from initial deposition; and secondly, subsequent reheating and recooling caused by the overlying flow.

It appears that this in fact does what you would expect it to: it breaks up the rock at that zone and makes it more permeable to water flow.

Now, there were questions this morning about where the major water-bearing zones are.

(Slide)

And since we did not have a graphic which described that very well, let me go over this hand-drawn graphic and see if that answers some of the questions that were raised.

We see the relatively thick sedimentary material on the top of the basalt column and unconfirmed flow system. The system is perhaps 200 to 400 feet below the surface of the ground. The sediments there are perhaps 200 to 600 feet thick.

(Slide)

And below that we have the Saddle Mountain formation, which is this sequance of flows with interbeds

in between. These are periods of relatively long interval between subsequent flows. The one up on the basalts have fewer interbeds to the relatively thin interbed on the side of what I will call the Vantage in the grande ronde is below that. The grande ronde is on the flow and flow contact site.

Now, as you read our material, you probably read a lot about the Mapton, and the reason we have overemphasized that is it's very difficult as a practical matter to drill through. It can cave in.

It's not the predominant water-bearing zone. In fact, for most of the Hanford site the flow contacts are --

MR. PHILBRICK: When that was caving in, what did you do? Did you drive a casing down below through it?

MR. BAKER: The current practice is to avoid that. We drilled with bentonite drilling fluid in either rotary or core and go through as rapidly as we can and case it.

MR. PHILBRICK: Do you lose much fluid?

MR. BAKER: Yes, we do lose fluid. I can't give you numbers right now. In general, though, I believe we used more fluid here. Lost fluid is something that has become a very high-level topic in the project and NRC has expressed a lot of concern about that.

MR. PHILBRICK: Thank you.

MR. BAKER: So that is schematically shown here, that the Mapton is the interbed that causes the difficulties, the rapid contacts in some of the Frenchman Springs. However, the water qualities, I think Larry mentioned, deteriorates as you go deeper in Frenchman's Springs. And generally, we have excess fluorides in the water as you go deeper.

The Vantage interbed is of interest because in some places they don't find this at all.

MR. PHILBRICK: Somebody built a dam with up at Priest Rapids, didn't they? Did you ever relate the grouting characteristics of the basalt at Priest Rapids to your permeability here?

MR. BAKER: I am not sure I understand the question.

MR. PHILBRICK: I am assuming that they grouted the foundation at Priest Rapids.

MR. BAKER: You are asking did they grout it into the Priest Rapids flow? I am not sure.

Do you know, Sue?

MR. PHILBRICK: They were in basalt, and they grouted it. Now, did you ever relate the quantity of grout to the permeability that you're talking about?

MR. BAKER: I don't believe we have done any study like that. I am still not quite sure what exactly --

MR. PHILBRICK: The value is what they took with a permeable rock. If it was permeable, they grouted it. The only place they could put the grout was in the fracture system unless they were up in the bubbly stuff at the top. So you've got a relationship there between what the mass permeability of the basalt situation is and what you're talking about.

(Slide)

MR. BAKER: I am not familiar with that particular structure at Priest Rapids Dam. I would assume, though, that the bond between the dam and the --

MR. PHILBRICK: This is a penetration into the foundation rock with holes and injection into those holes of a cement grout.

MR. BAKER: I guess I am just not familiar with what was done there, but perhaps we could talk about that later.

MR. MOELLER: And you are saying that would give them one handle on the permeability?

MR. PHILBRICK: Not a solid handle, but it gives you an idea, if you get a series of grout holes that you are grouting under a reasonable amount of pressure and you can't get any cement into them, this means then that the hole is tight.

Now, if this is basaltic material with the same

fracture pattern that we're talking about here and it's in the bottom of the valley, you've got a handle. It isn't a real tight handle, but it gives you an indication of what's going on.

MR. BAKER: I think maybe what I was going to say next might bear on that a little bit more. I was going to go back to this photograph showing colonnade entabulature and a little bit of the flow top. When we test basalts, we generally drill a bore hole and isolate either the flow top or some zone in what we call the dense interior region. We don't generally hydologically distinguish between the colonnade and entabulature, and by doing standard hydrologic tests, standard field practices, we can obtain hydraulic conductivity numbers, or more precisely, hydraulic transmissivity numbers which are an indication of the types of rock.

And what we find there generally is that when you test this region of the rock we get conductivities which are in general less transmissive than concrete, 10 to the -10 right up to the limit of our ability to detect it, 10 to the -13, 10 to the -14.

When we test the flow tops, we get conductivities which are substantially higher. Sometimes they are very low. Sometimes it might be as low as 10 to the -9 meters per second, sometimes as high as 10 to the

-4.

I don't know if those numbers mean anything, but at least they give a relative value of flow. So we feel we are looking at this layered flow system with a high degree of resolution and we are distinguishing between the interior of the basalt flow and the flow top in which substantial water flow is possible in some cases.

MR. MOELLER: It doesn't have a lot to do, I am sure, with the subject. But why does the colonnade solidify in the vertical structures?

MR. BAKER: They are hexagonal columns.

MS. PRICE: It's perpendicular to the cooling base at right angles.

MR. MOELLER: Well, why didn't the layer above that do the same thing?

MS. PRICE: There are various discussions on what the cooling history of the flows were. These various ideas as far as what the cooling history of the flows were. As far as doing theoretical studies with isotherms, you cannot without some kind of differential in the cooling history get that kind of pattern.

The idea is that possibly these flows were inundated by water. In other words, we do know there was drainage at certain times so that you would get drainage which would come over, come down, and lower that cooling

base down below, and finally you are having cooling from the bottom up and the top down. You are getting faster cooling from the top than you are at the bottom, and you finally meet at that interface.

That's one idea. The other idea I mentioned this morning is without actually having the Umtanum flow extruded into a lake that would completely inundate the flow. So those two options are discussed in a little more detail in this horizon identification report.

One of our people is looking into ideas for cooling history of the flow and what would cause these fractures.

MR. MOELLER: And in a structure such as the colonnade, there would, I gather, be a distinct difference in the movement of water vertically versus horizontally if water were --

MR. BAKER: That's something we don't know yet.

MS. PRICE: You certainly have much more irregular patterns, but don't know if it really affects the movement of water with the infilling of the fractures.

MR. MOELLER: Okay. Thank you.

MR. BAKER: And as Bob mentioned -- I think he mentioned at least -- in some of these studies we have assumed that some of these are nonisotropic and they would be 10 times more transmissive vertically than horizontally.

That's really not substantiated even by theoretical calculations. One can go through a calculation assuming the fractures are all the same way; then you get more like 3 or 2 to 1 as the ratio. If the fractures are really held as they appear to be, one would suspect really that the conductivity here would be isotropic.

We do have plans, though, to do that. And we will obtain that kind of information. We just don't have it now.

(Slide)

Now let's go back to give a little more qualified picture. I think Bob showed this earlier this morning. This is the spread of data plotted on a probability paper. In case it's not obvious to everybody, the scales are arranged to make a straight line on an S-shaped curve. And we simply plotted the number of the conductivity in sequence. And as you can see, it falls in a fairly straight line, which suggests that the conductivity measurements that were taken -- the conductivity varies spatially in with flows as a log-normal distribution, of course.

You can see the mean there is about 10 to the -12. Oh, he's got it up here. 1.5 x 10 to the -13. The standard deviation is about an order of magnitude.

(Slide)

This is the same sort of plot for flow top conductivities, and as you can see, they are much more transmissive. He has some numbers for flow tops which are quite transmissive, some that are approaching the conductivity of the flow interior with a mean of about 10 to the -7, and a much larger standard deviation.

These deviations are probably artifacts of the way the data were recorded. We round them off to the nearest order of magnitude.

Does that give a little better picture of the flow system as we visualize it?

Now I would like you to bear in mind -- we will come to it later -- we have done two types of modeling: one in which we model these flows as a distinct flow for flow top, and the other in which we have not modeled the actual basalt flows but rather modeled some hypothetical porous medium which should have the same types of properties as the basalt flows. That porous medium would be nonisotropic to a large degree.

There were a couple of other questions that came up this morning. Let me just make sure we answered those. There were questions about the effect of groundwater withdrawal on possible future hydrologic regimes. The Pasco Basin is, of course, in a transient state with respect to groundwater use. There are places where the groundwater

level is decreasing and places where it is increasing.

It turns out at the Hanford site itself in either of those cases it appears to be fairly stable. However, the wells directly to the west of the repository location -- let me show a map to orient you -- the McGee well is an old farm well to the west of the Nancy linear, one of the geophysical anomalies that has been identified. The heads of the McGee well are about 900 feet above sea level. The heads on the other side of that geophysical anomaly are very constant at about 400 feet. This is an artesian flowing well. These are nonflowing wells.

MR. MOELLER: Excuse me. When you say the head is 900 feet above sea level, what is the elevation of the land?

MR. BAKER: The land here is about 600-750.

MR. MOELLER: So one does flow there, and the second one is too low to flow even though it's 400 feet or something, it's still below land level.

MR. BAKER: That's correct.

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Now, the McGee well and wells in this region are demonstrably experiencing the effect of irrigation for vineyards that are further up Cold Creek syncline. I don't know the numbers exactly, but I think it has been seen to decline ten feet in three years. It is still over 900 feet, though. It is a very strongly-flowing artesian well.

MR. MOELLER: While you are on that, Dick, you didn't comment, I don't believe, but Larry or someone made the comment that the water has lots of chlorides and therefore it will never be used. Can you really conclude that?

MR. BAKER: The deeper waters.

(Slide)

The deepest irrigation wells we see are at Priest Rapids. I think O'Brien well is in here. That seems to be the deepest irrigation wells we could find.

MR. MOELLER: It is not that much chloride?

VOICE: It is fluoride.

MR. MOELLER: Oh, I'm sorry, I misheard.

MR. BAKER: The fluorides are not that high either. The 250 parts per million is about the highest we see.

VOICE: We see average fluoride concentrations of about 37 milligrams per liter. That's pretty high for water.

MR. MOELLER: 37 parts per million?

VOICE: Certainly something not suitable for drinking.

MR. MOELLER: Well, 1 part per million is all you

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want to drink.

MR. THOMPSON: Is there any problem of disposal of water that is pumped out of a repository like Salem -- I shouldn't say Salem, but as those dissolved solids -- I'm asking a question here.

MR. BAKER: Oh, I'm sorry. I don't think so.

MR. MOELLER: Well, of course ocean water is several parts per million of sodium chloride, so you are saying -- I never did hear the chloride content.

MR. BAKER: I think the chloride content is --

VOICE: Chloride average, I think, is about 137. It is somewhere in the SCR.

MR. BAKER: As a matter of fact, I do have some transparencies if you would like to look at that to get that data.

MR. MOELLER: Well, we may have enough. Let Dr. Foster speak.

MR. FOSTER: You mentioned this nearby well with the head of 900 feet. How do you explain that high head in relationship to the basalt flows? Have you got any kind of fix on where that is originating?

MR. BAKER: Of course, that's an area under active investigation now. I hadn't intended to talk about it too much, but we can. I hate to use the word "barrier," but it appears as though there is some sort of a barrier to

groundwater flow. There probably are other explanations. Roughly in the vicinity of the geophysical anomaly that we see stretching through here, it looks as though with the small information that we have now the water is backed up at that point. We are deepening the McGee well. The intent is to see --

MR. FOSTER: You say it's backed up. Backed up from where?

MR. BAKER: This is not a recent uplift, so there certainly is recharge of groundwaters in this region, so the groundwater flow, one would assume, would be coming down the syncline, experiencing a region of high resistance to hydraulic flow, given a relatively high head to the west and relatively low head to the east.

MR. FOSTER: To get up to 900 feet, that's up Grand Coulee area.

MR. BAKER: Oh, no, no. You could get above this -- this comes up fairly steep in here. Sue, maybe you could help.

MR. FOSTER: The water level at Priest Rapids is not that high.

MR. BAKER: It's about 900 feet, I think it is, at Priest Rapids, that's true. But the top of Seven Hills must be about 2000 feet above sea level, and there is a water table up there.

MR. FOSTER: Relative to the wells in that area, as

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I recall there is a warm springs in that area where the temperature is high, up in the Bernita area.

MR. BAKER: I don't know of that. Do you know, Sue?

MS. PRICE: I'm trying to think.

MR. BAKER: The McGee well flows for -- it's used for showers for the National Guard. That might be what you are thinking of.

MR. FOSTER: It's hot. It might be 80 degrees. Is there an explanation for that temperature?

MR. BAKER: That would be explained by the geothermal gradient. Let's see, it was about 1000 feet when it was flowing. I guess that might be a little high for the geothermal gradient in that region, but we do experience temperatures in the repository depth of about 130 degrees Fahrenheit.

MR. FOSTER: I'm not sure this is the right time for it, but I would like to ask a hypothetical question for answer sometime, and that is: If you increase the overall head and the unconfined aquifers in the region of the repository in toward the river from irrigation water or something of that sort, what would be your guess as to the effect of that on the movement of the groundwater from the confined aquifers in the lower horizons?

In other words, would this create a dampening effect to minimize the upward flow?

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MR. BAKER: I think in theory, of course, the higher head in the higher zone would be an impediment to discharge at the location of higher heads. I don't think it would make much difference, though, all together. We could discuss that in further depth if you would like, either now or at some later time. I don't think that would be a major factor.

MR. FOSTER: Thank you.

MR. BAKER: I think the questioning, as I heard it this morning, was how could changes in hydrologic conditions affect the performance of the repository, either adversely or favorably? That is something we need to look at. We have a program which we refer to as scenario development, in which currently we are looking for a contractor -- and I don't know if we found it yet -- Bob, do you? -- to do an adelphi process to determine the proper scenarios for us to look at. Certainly groundwater changes is one area which we will ask experts to assess, and then they will come up with a set of scenarios for us to analyze in each element of repository performance. Of course, one could possibly withdraw water in Priest Rapids and Rosa to decrease the head by several hundred feet. That would be of obvious interest to the repository.

One other thing I wanted to mention. Somebody was surprised that we didn't know more about the groundwater flow system at Hanford. In fact, the unconfined aquifer system, of course, has been studied quite extensively, and they are now

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starting some studies to understand the connection between the unconfined and the upper-confined systems. That is not done by the basalt project. It is done by both Rockwell and Battelle and it is very interesting work. I don't have any of the results yet.

There are, because of the waste management activities at Hanford, materials in the groundwater that can be tracked. I hope I have covered the concerns that you had.

This shows some of the wells which we have collected information from. Not all of those wells are deep and not all of them are specific to the basalt project.

(Slide)

These, however, are some of the deep wells and these are some of the hydraulic conductivity numbers for the flow tops which went into that probability plot that I just showed you. This shows the three candidate horizons we are considering: Umtanum, Cohassett and McCoy Canyon. As you can see, there are places where we now don't have information.

This is reference repository location, and that label goes with this hole -- this is RL-2. It is the pilot bore hole for the exploratory shaft, and that could be in the center of a column, the pillar area.

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The summary of hydrologic information we have in the site characterization report included these conclusions.

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That is, we felt that we could see trends in the hydrochemical properties on the groundwater flow system. We felt we could see hydrochemical breaks for the hydrochemical signature of the water. We felt that the deeper waters were older for a variety of reasons, including isotopic information. We felt that there were small head gradients with depth, and we felt that as we got deeper, we got less groundwater, that the zones were less productive and less transmissive and we could pump less water out. On a typical hydraulic test, one might pump a few hundred gallons a minute out of a flow top high on this section. Some of the flow tops in the Grande Ronde, we can hardly pump 10 gallons a minute.

One picture I don't have which I could mention. We did one well, DC-3. We drilled into the Untanum, cased it into the Untanum.

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I don't have it on this map, but DC-3 is right about here. We cased it in the Untanum, swabbed it dry and let it sit for about a year and a half, and the water level did not increase appreciably in that period of time.

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We also felt we saw areal differences in groundwater and could see differences in the hydrochemistry between wells, and we felt that the hydraulic gradient was to the southeast.

(Slide)

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Now, that conceptual model led to the numerical models that Bob discussed earlier this morning.

MR. MOELLER: When you say the gradient is to the southeast, that would be perpendicular to the river where it would intersect? I mean is it directly toward the river, is what I'm asking?

(Slide)

MR. BAKER: Again, the data are not really dense enough to draw strong conclusions.

MR. MOELLER: It could almost be northeast if it were toward the river.

MR. BAKER: Yes. What I would like to do is report what we said in the Site Characterization Report. We will talk about come of the concerns that have been raised since then, and that, to me, is probably the central concern that has been raised, is the validity of the head information.

MR. ORTH: Do you have any aged data on any of the water when you are talking about with distance along there?

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MR. BAKER: We have tried various age dating techniques and we have reported some dates in some of the shallow waters. Again, there have been concerns raised as to the validity of those dates. Carbon-14 is the only technique that we have used for which we feel we can even assign a number, and of course that can only go back about 40,000 years.

So age dating is something we are trying very hard to do. It is very complex in a hydrologic setting.

MR. ORTH: I understand that, but even within a factor of 2, if you took stuff at the upper end of the recharge area and then in the direction that you think you are going, if there really is 10 or 20 or 40,000 years difference in travel between those two zones, there ought to be something showing up.

MR. BAKER: The trouble with Carbon-14 is we think the waters are much older than 40,000 years in the deep flows where we are interested, and Carbon-14 is just simply gone by that period of time. We are trying Chlorine-36, a similar type of age-dating technique.

The current uncertainty on that technique seems to bear principally upon the neutron flux in the deep horizons, and we have not really quantified that but we are trying other age-dating techniques for older waters. We are also looking at techniques of looking for secular equilibria in transuranic-type decay products, but there are large uncertainties involved in these analytical techniques and I think most of them are at least at or beyond the state of the art.

MR. MOELLER: You were saying secular equilibria in transuranic --

MR. BAKER: The decay products from U-238. The decay products, the heavy metals, the alpha-decaying -- I'm

ar12joy101 right -- for uranium.

MR. MOELLER: Thank you.

(Slide)

Okay, I would like to go back to some of the numerical results because they give the final conclusions.

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The model results that Bob showed earlier for the Cohassett under the influence of a thermal heat load come from these assumptions.

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Let me go over them quickly to make sure that we have made it clear what it is we did. For this particular model, this is a coupled heat transfer of a numeric code. We sent constant head boundaries beyond the sphere of thermal influence about a mile away from the repository so we could assume constant heads. We used stratigraphy from borehole data which we feel is pretty good. We have been very good at predicting stratigraphy.

We used flow top conductivities from well tests, and we showed you some of that data. On vertical conductivity, as Bob mentioned, we arbitrarily assumed -- not arbitrarily -- we assumed it to be ten times higher in the flow interiors than the horizontal conductivivity because of the preferential fracture pattern. We used the storage coefficient from well testing. We used thermal properties from laboratory tests.

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There were several other properties required. The radionuclide transport, porosity, transmissivity. We don't have enough data that we could use real data, so we used reference values for those parameters based upon a combination of literature tests and some analytical testing. We used the basalt reference porosity,which Dave Turner will tell you about next, and we used thermal loading properties and parameters from the Standard National Waste Terminal Storage Program. There is a standardized repository load which is assumed in these constants.

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Now, as I have mentioned, we have also performed modeling on a larger scale. This is called far-field modeling and this is a result that is presented in the Site Characterization Report. For this particular model we modeled the the three formations, the Grande Ronde, Wanapum, and Saddle Mountains, as homogeneous, non-isotropic porous medium. We called it composite flow systems. We smeared out the difference between the flow interior and the flow top. We used horizontal conductivity for that equivalent medium from the well test for the flow tops. We felt that the lateral motion would be controlled by the flow top conductivity, and similarly we felt that the vertical motion would be controlled by the conductivity in the flow interiors.

So in this case the medium is non-isotropic, but there are three orders of magnitude difference between

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horizontal and vertical conductivity and it is more conductive horizontally than vertically. There has been quite a bit of confusion. There are just two different sets of modeling assumptions that were made. We assumed boundary conditions, some of them constant heads and some of them low flow. We assumed the hydraulic gradient at 10^{-3} meters, and we did not model any structures. Under those assumptions, this is the flow path that one calculates if you look at a vertical section of that. There is very little vertical motion under these assumptions.

MR. MOELLER: And where does that terminate?

MR. BAKER: At the edge of the model. We don't think this is real at all because there is a slope to the formations here. If water got that far in the Grande Ronde, it certainly would discharge to the river at that point. That is perhaps -- it discharges out Wallula Gap. This is the analysis from which one might conclude that.

MR. ORTH: What does it take to verify such a model?

MR. BAKER: Of course, that's a monumental question, and we expect that to take years. We are, in fact, actively, as Bob mentioned, undergoing quite a bit of verification and validation techniques.

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I should mention I think that perhaps one of the more important steps in that process perhaps is the modeling task force activity that we have with the USGS. They are of course a very critical reviewer and they in fact modeling the entire Columbia Basin in the regional aquifer system analysis. I am not sure of the exact name.

They are interested in our information because they would like to have a good model for groundwater use reasons. They are doing this in support of the Washington State Department of Ecology. Of course, we are intereted in their information because when they get their model running, their model will be a way to determine boundary conditions for this model.

So far the major concerns about modeling have not been the exact modeling techniques, rather they have been are the data good and are you using the data properly and have you assigned the right number and conditions.

MR. MOELLER: Don Orth and Martin Steindler.

MR. ORTH: With respect to my other questions on the age being I think a crucial aspect of this because you can get very good data on horizontal conductivity which tells you how fast water can flow based upon some assumed gradient which we don't know for sure. So the gradient then becomes a very crucial part there. Lacking any good data on the gradient, then the flow is going to be controlled

regardless of conductivity by what kind of supply of water you have and the fact that water can flow at a certain rate means nothing.

So the only way you will find out how fast it is flowing is to make some kind of a measurement between a couple of points either in this strata, the assorted strata that you want to explore the test between wells or by dating techniques.

I can't keep having water come out of my strata and filling up my interbeds without some relieving of the interbeds and getting back into the other starta. So again I have a problem with something coming up into there and then going like a bat out of hell all the way down the gradient when I don't have any data to support that that model is even reasonably physically possible.

MR. BAKER: First, let me point out that we do feel that we need more head data, but we intend to get it. We intend to establish the gradients in a highly defensible way.

Secondly, I guess I will just say we don't feel that age dating is an absolute prerequisite. We think one can plan an extensive program of other activities and determine the flow in a convincing way. It might not be posible to get definitive age dating for the older waters.

MR. ORTH: That is perfectly true, but how long

it takes a sample to get from here to there at various places is a very little proven technique.

MR. BAKER: We did have a program I wanted to talk about of the future collection activities we have. We do have a coordinated program of collecting conductivity data at different scales, collecting head data with time dependence and conducting a variety of tests like tracer tests.

MR. MOELLER: Martin is next, but let me comment we realize, Dr. Baker, that you started late and that you have been picking up answers or giving us answers to many leftover questions. So don't look at the clock.

(Laughter.)

Martin.

MR. STEINDLER: Have you tried to apply the far-field model to any natural underground water movement for which data are available?

MR. BAKER: I guess I don't know.

Do you know the answer to that, Bob?

MR. BACA: No, we haven't. We have done comparisons with other models and the basic approach that we are using in this far-field model is the same approach thae has been used in the models that have been applied extensively to the unconfined system there on the Hanford site and there are several reports that cover the

comparison to those model calculations and the measurements.

MR. BAKER: The major activity we do have going on now is with the USGS and this Model Task Force activity. Pacific Northwest Laboratories are using the USGS model with the consensus input, consensus of the Lawrence-Berkley Laboratories, PNL, USGS and Rockwell, which is a larger scale than this, but which encompasses the scale.

We are modeling structures and using boundary conditions which are agreed upon by the USGS and we are using a model which has been used extensively in the past, but we have got a long way to go. This is not an overnight activity to validate this.

(Slide.)

Okay, now I would like to go onto our future plans, where are we going, how are we going to conduct site characterization in the context of the Nuclear Waste Storage Act.

I would like to emphasize that since we are talking about the characterization of the groundwater flow system that it is needed for two simple reasons.

First, one needs to understand the flow system well enough to make predictions about what radionuclide transport and well enough that we can have confidence in the answers that we obtain, which implies fairly extensive

and in-depth understanding of the flow system.

(Slide.)

Of course, groundwater would be the principle means by which radionuclides could get to the accessible environment in this particular repository site.

The site characterization report referenced the criteria basically in 10 CFR 60 and 40 CFR 191, and from those criteria we established a set of issues, three key issues and other issues. Those issues were further broken down into what we call work elements in the site characterization report.

(Slide.)

And for hydrology those work elements can be encapsulized. We determined that we needed to understand the hydraulic properties, that is the conductivity, the effective porosity on transient coefficients. On transmissivity we need to understand heads and interactions between flow systems and vertical groundwater motion. The possibility for groundwater motion has been more extensive than we envisioned in the SCR and has been a major concern, I think it is safe to say, for all of our reviewers.

We feel we need to understand the hydraulic hydrologic significance of the structures. They are fairly new to the repository and we need to be able to model those both conceptually and numerically. We need to understand

the changes, the potential changes in hydraulic stability which may impact to change the performance of this site. We need to understand travel time for emplacement and we certainly need to understand the uncertainties.

(Slide.)

Now I apologize. Your pages in your handout are somewhat out of order at this point in what is missing. The programs that we are either implementing or attempting to implement to do this work are these.

We collect information from bore holes. We intend to initiate a program of groundwater monitoring. We have developed special tests where there is no state of the art tests or a standard test that can be used to obtain particular information.

We feel we need to understand how to apply information obtained upon one scale of a physical size -- bore hole information, for example, on a much larger scale to be modeled.

We have a program for determining the hydrochemistry and all those things fit into a conceptual modeling effort which in turn feeds the numerical models in performance assessment.

(Slide.)

MR. STEINDLER: What is hyrochemistry?

MR. BAKER: We draw groundwater samples from the

wells and determine what the chemical constituency of the water is. We, in fact, have a program to relate that to the constituents, the chemical constituency of the rock. We observe chlorides and fluorides in the water. We have trace elements. We collect a variety of isotopic information.

MR. PHILBRICK: How much is the water that you are drawing from the wells affected in its composition by the drilling?

MR. BAKER: That is one of the major issues that has been raised and we are going to speak to as an example. Could we wait? That will be later. That will be the last item.

As a matter of fact, the two issues, and one can hardly avoid them, the two issues I would like to speak to as examples are in fact the two that we have mentioned, the validity of the head information we have collected and the influence of the drilling operation upon the information we get from the bore holes.

Now the site characterization report contains these three boxes, regulatory criteria issues and work elements. I won't repeat this other than to mention there are two issues, a key issue under the hydrology area and that is can we make the EPA relief criteria, and the second is can we determine adequately the groundwater travel time. I think it was a question this morning.

(Slide.)

Now as we perform the work that it takes to determine whether the site meets this criteria, one would expect that concerns will be raised as to the adequacy of what we are doing, or the validity of it, and certainly our expectations have been realized.

There are many concerns about the program. We feel in parallel to doing this work we need to have a program to acknowledge and address those concerns. We see both generalized concerns, and we don't have enough data, and every specific concerns.

The drilling fluid can change the conductivity we get on this particular test. So we are in the process of trying to categorize these concerns and compare these concerns against the programs. We have to make sure we are doing what it takes to address them.

I would like to make it clear also that this is not a finished product. This is where we are going. This is a planning activity which is starting.

The general concerns we have identified are lack of data that comes up in a variety of forms. We haven't seen the data, so we don't know whether it is any good. I don't think you can ever get enough data to characterize the ground water system at this particular site.

There have been questions about our evaluation

of the data. People say okay, I agree your data is good, but I don't agree with the conclusions you have drawn from the data. In particular, hydrochemistry is one example of that. The representativeness of the data has been questioned.

In particular when we collect conductivity data from the bore holes, we are really only testing a relatively small amount of rock. Depending on the test, we might get a few meters or we might get a few hundred meters we hope, but not much more than that.

How do we know there is not some vertical structure in the rock that is just outside of the reach of the test that has been conducted and would cause a problem with either performance of the repository, and we feel we need to address those concerns.

In general we feel we need to establish a program of high credibility. We are very concerned about that and intend to do it.

(Slide.)

Now the concerns have come from three different areas. We have our Overview Committee which I mentioned and these are some of the concerns that they have raised. In particular, we don't have any particle conductivity measurements, although we have a test in progress now and we have a limited effect of porosity data which is

important for groundwater velocity.

Rather than go through all of these, let me take a couple of examples and talk about them in depth.

(Slide.)

The NRC has expressed a lot of concerns. Let me also mention that this was prepared before the site characterization analysis. I have not had the opportunity to read that in enough depth to address it directly here, although I have read the first few chapters.

MR. MOELLER: Probably you will tell us this, but are there similarities to the concerns?

MR. BAKER: There is a tremendous amount we found out that can be fed into those four general categories, and for most of the concerns, they are concerns that we share and feel we need programs and are establishing programs to address this.

MR. STEINDLER: Did you ever get a serious critic to tell you that you cannot ever get enough data?

MR. BAKER: Not exactly in those terms, no, although people have come close to it.

Okay, the NRC, going back over previous interactions we have had with them, we have determined these were some of the concerns that had been raised.

The one I would like to talk about is the effect of mud or drilling fluid on not only the measurement

of transmissivity but also the hydrochemistry.

(Slide.)

One other organization is the Modeling Task Force.

MR. MOELLER: Now this is a different group. This is a USGS group that is reviewing things?

MR. BAKER: Yes. Maybe I had better fall back a little bit. The Department of Energy has asked USGS out at Reston to review the site characteristics. They in fact are doing that. The Reston organization in turn has asked the hydrologists in Tacoma to review the hydrology part of the site characterization report.

The Tacoma people have had a double dose because they are reviewing our site characterization report for Reston and they are independently of that sharing data and knowledge of the Columbia River basalt system.

MR. MOELLER: Now these concerns were also prepared before the SCR was published or issued?

MR. BAKER: The SCA.

MR. MOELLER: Oh, before the SCA, but are these concerns of USGS based upon the SCR?

MR. BAKER: No, they are based upon ---

MR. MOELLER: The review as it was being prepared?

MR. BAKER: Yes, and they are based upon their

knowledge of the Columbia River basalt. They have done a lot of work. In fact, they have done some work for us.

MR. SQUIRES: May I make a statement, please, a point of clarification. The Modeling Task Force that Dr. Baker is talking about is made up of the USGS, Battelle Northwest Laboratories at Richland and the Lawrence-Berkley Laboratory also sits in on it.

MR. MOELLER: So it is more than USGS, and at the point of being redundant what you are telling us is that the concerns shown on the slide are concerns that developed as the SCR was being prepared. They have not formally reviewed the SCR and said these are their concerns.

MR. SQUIRES: Let me clarify one more point. In addition to the task force, the Department of Energy has asked the USGS to review the SCR and provide formal comments back to us at Reston.

The Reston office in turn, as Steve said, has asked the Tacoma office to review the SCR. So they doing a double dose.

MR. MOELLER: But that will be a pure USGS review?

MR. SQUIRES: Of the SCR, yes, sir.

MR. BAKER: And based upon our interactions with them, we would expect them to tell us of these concerns.

MR. MOELLER: And will their report be made

available to us in the NRC?

MR. SQUIRES: Yes, it will.

MR. PHILBRICK: Now all of this is based on having unlimited funds.

(Laughter.)

MR. BAKER: No.

MR. PHILBRICK: Well, where is the cut off point?

MR. BAKER: How do we decide, when we have enough information?

MR. PHILBRICK: Yes. Somebody says we have got enough dope. Let's go on this. Where do you think you are now?

MR. BAKER: I think we have a large percentage of the information that we need to do the work. I think we have a lot of analysis yet to do, and I think we have a lot of interaction we need between our organization and the regulatory bodies to establish a consensus as to our understanding.

MR. PHILBRICK: Do you think you have spent 50 percent of the money that you are going to have to spend?

MR. BAKER: I just have to give you a personal guess, unless DOE would like to ---

MR. FITCH: That is a ball park number. That is close. We have been at it about seven years. In the beginning the program was a very small effort and we had

until 1986. We have until 1987 to submit a license application. We have until 1990 before we expect to get a construction permit from NRC. So we have got farther calendar-wise to go than we have come.

MR. BAKER: There is another observation we ought to make, and that is I think we are on quite a steep learning curve. I don't think we can see ourselves getting much more efficient in identifying the work that needs to be done, and I think the last part of the work will come cheaper than the early part of the work because we will have the benefit of years of experience.

MR. ORTH: How much does it cost to dig one bore hole?

MR. BAKER: Well, if you just want to put a rotory hole down, you can do it for about $100,000. A piezometer of the type I will talk about in a minute might be any place from $700,000 to a million and a half.

A bore hole which we core and take a full amount of information out of is kind of hard to quantify the costs of it because we keep a ring sitting on it for two years. It is in the millions of dollars. It is expensive information.

MR. MOELLER: Does that first bulletin say what it says, that there is a lack of data about the lack of data?

(Laughter.)

MR. BAKER: Perhaps it is an artifact about trying to force the concerns into categories. The USGS has been most adamant about the fact that they feel we need more data. Of course, they would like a lot more data than we think is probably necessary, but they really haven't gotten much more specific than that. I think they want a lot of data.

MR. MOELLER: To comment, too, somewhat on Don Orth's comment, I think we do need to recognize that the basalt group is the pioneer for the whole process of doing an SCR and hopefully if they do a good job and set up a good plan for doing these, then future groups who look at other sites can save themselves a lot of time.

MR. BAKER: We can certainly tell people a lot of mistakes to make.

(Laughter.)

(Slide.)

The USGS issue I would like to talk about a little bit. Our concern is the validity of our head data collection techniques. As I have mentioned, we in general collect head data by drilling part way in a hold and stopping in the dense interior of the flow below the top in which we want to test putting a packer above the flow top and doing a variety of tests in which you take samples and

watch the recovery for a long time in order to get the data.

One of the concerns raised by USGS is that it might take a long time for that to recover from the transient that you caused by constructing the well. How do you know that it is equilbrating? Well, we can answer that by saying the heads versus time. All god parameters do this, but that still does not satisfy the concern. They point to wells which have taken much longer to equilibrate. They have pointed to wells which appear to equilibrate and then go to some other kind of phase where it takes longer to equilibrate. So we do need some more work to address that issue.

They have suggested that the testing that we have done previously -- and I am not real clear on what their concern here is -- perhaps injection of mud and changing the lithostatic head. In any event, it might change how we measure and we need to show that doesn't happen.

Thirdly, and I am paraphrasing of course, I think the concern is even if the heads we have collected are exactly accurate, this process causes you to test one zone. How do you know there hasn't been some variation of heads which could cause the gradient, cause by subtracting two numbers.

In the model that Bob showed you, it is not the pressure that counts. It is the force, the difference between the two zones. One could be fairly accurate in measuring a head, but you know the differential head accurately, that would be adequate.

So these are the concerns that they have expressed.

(Slide.)

If you remember, one of the programs that I talked about is the groundwater monitoring program.

(Slide.)

It is multifaceted program that has six elements in it. One of these elements is to understand the state, the transient state of the reference repository location.

(Slide.)

And quantify the head transients that may or may not be taking place there. I won't talk about the other five programs, but just the first one.

In general what we are proposing to do is construct a triangulation of three piezometric locations at which places we would get time dependent head data in several horizons.

Three locations which we have proposed in the past would be a new well, DC-19, which would be somewhat to the south of the reference repository location. We have

considered refiguring the three-hold cluster to conduct large-scale hydraulic tests.

When we are done with the stress testing, we have considered configuring that with piezometric tubes so we can get data at that point, and we had considered instrumenting the exploratory shaft to get the same kind of information. That would be obtained in a slightly different way in which we have some advantages and some disadvantages currently for a variety of reasons, and we would also do another configuration that would look more that here.

Those are quite preliminary planning activities that I would share with you.

MR. PHILBRICK: When you drilled DC-16 had you drilled RRL-2?

MR. BAKER: That is a more complicated question it sounds like.

MR. PHILBRICK: All I am trying to find out is did you pump 16?

MR. BAKER: We are testing it, that is correct.

MR. PHILBRICK: Have you done any drawdown?

MR. BAKER: We have not done a test in which we were able to look and in turn watch a pump drawdown test.

MR. PHILBRICK: You said you had three holes in 16.

MR. BAKER: That is correct.

MR. PHILBRICK: How far apart were they?

MR. BAKER: This is a more complete picture of the wells we have in that zone. That is still not the picture I wanted. There are three holes, 16 A, B and C. A is being cored, a core hole so we get stratographic information. It currently is in McCoy Canyon I believe.

What we have been doing is we have done conventional testing. We have monitored 16-C. That is 500 feet and that is 50 feet.

MR. PHILBRICK: What was the result? Was there any effect from pumping any one of those on any of the other wells?

MR. BAKER: Yes, the only one we have pumped is A and we have seen it at C. We have not done large-scale testing where we would look, say, at DC-19 where there is a well here.

MR. PHILBRICK: What sort of a drawdown did you get from A and C?

MR. BAKER: With distance you mean?

MR. PHILBRICK: Yes.

MR. BAKER: I don't have that data here. I can show you though ---

MR. PHILBRICK: Was there an appreciable effect on C?

MR. BAKER: Yes, if there is a ---

MR. PHILBRICK: In which horizons?

MR. BAKER: We have been able to monitor in C from the vantage on down. We saw a fix there in Cohasset and flow bottom in the flow top above the Cohasset.

MR. PHILBRICK: Did you have it rigged so that you could pump A and get a drawdown in the Umtanum cutoff in C?

MR. BAKER: A is not all the way to the Umtanum, but it is past the Cohasset. We have tested the bottom of the Cohasset and in fact saw the drawdown in C from testing of A. We will do the same thing in Umtanum also.

Now B is simply cased through the mapton, and the reason we did that is so we could conduct this large-scale stress test. The plain is to perforate the casing in the mapton. Either that or it is -- I don't know. At any rate, we would use B as the pumping well and then by perforating the casing in a variety of other wells, including RL-6 and RL-2, we will pump if B and we expect to see the drawdown.

MR PHILBRICK: In the confined horizons?

MR. BAKER: Yes.

#14-dhl

Based upon the transmissivities which we have measured there. We are going to show the calculated draw down for -- this is the picture I wanted.

(Slide.)

This shows the configuration of the wells 16A, B and C. The monitoring wells would be RL-6, DB-14, and RL-2 as well of course, as the other 16 holes.

MR. PHILBRICK: Will all those wells be cut off so that you are only in a confined horizons?

MR. BAKER: That's correct; only one confined horizon.

(Slide.)

Here is a calculated draw-down curve. It's not like, oh, I'm sorry, I think this is the mapton. So we expect to see from here several feet.

MR. MOELLER: You say calculated. What do you mean?

MR. BAKER: We have measured transmissivity, and so you can calculate the draw-down you would expect. Of course, if we get a different draw-down than that, than that means either --

MR. PHILBRICK: But you don't have a draw-down in 6 and in 2.

MR. BAKER: Yes, I do. I have not measured that yet. We will be conducting a test this summer to do this, precisely this. This is the pretest protection for that

dh2

particular test.

MR. PHILBRICK: Well, you didn't get the recovery curve, too?

MR. BAKER: Yes.

MR. MOELLER: Larry Fitch?

MR. FITCH: I think maybe there's a point of confusion here. That draw-down is only expected to be saying in the permeable region, and not in the flow interior.

MR. BAKER: Oh, yes.

MR. PHILBRICK: Where would it go, then?

MR. FITCH: In the interior.

And it is -- our calculations show that it is so tight you could not expect to see a pertubation in the flow interior of one hole very far away if you have permeabilities in the range of 10 to the minus 11 or 12 or 13.

MR. PHILBRICK: Then why the hell are you doing it, if you know you are not going to get any draw-down and the stuff is tight. Aren't you finished?

MR. FITCH: No.

MR. PHILBRICK: Why not?

MR. FITCH: Because the staff said very early on there is concern about the inhomogeneities of the rock, and indeed we may have meshed 11 places in a small bore hole, where indeed it's very tight and you don't know what the bounding area around it is. We're going to attempt at least between the

two holes that are 50 feet apart, to see if indeed you can stress it such that you could invoke a cone like that you could measure.

MR. PHILBRICK: Then you're not satisfied whether your -13 is a good number or not?

MR. FITCH: We're satisfied on the scale we've been measuring it it is, but on a macroscopic scale, no, we are not.

MR. BAKER: I think there is another -- this is a difficult area; there's sort of a Catch-22 in this testing; and that is if we are to test the sense where we put a repository you can't see anything; it's just like concrete or stale.

MR. PHILBRICK: Well, all right, that's what you want; let's quit right now.

MR. BAKER: Regulatory requirements require that we do calculations about the radionuclide transport to 10 kilometers, so we have to have properties that are representative.

MR. PHILBRICK: Maybe the criteria are wrong.

(Laughter.)

MR. BAKER: Well, that's not our --

MR. PHILBRICK: Well, if you don't say so, who's going to? I mean, what you are trying to do is get the waste underground. This is the fundamental thing.

MR. MOELLER: Mr. Miller wants to comment, and he's the proper person.

MR. MILLER: Dr. Philbrick, I think Larry Fitch said

dh4

it right; it's a matter of scale, and tomorrow -- I wanted him here to give you the uncertainties that the NRC feels exist, and I think Rockwell is talking about them here today; they give rise to questioning that 10 to the minus 13 is a value that applies to this dense, intact -- over the scale that you will be developing your repository.

So I guess what I'm saying is, our talks tomorrow will be addressing your question specifically.

MR. PHILBRICK: If it's a scale, our repository, then it's part of the wells; it's something like a mile apart maximum. And you think your investigation is within that mile square? Then if it's tight, well, you've got it made.

MR. MILLER: We're very sensitive to asking curself, when do we have enough; and not going beyond that. And I think that tomorrow we will be discussing at least the concerns that we have and how we are I guess recommending the matter be approached.

MR. BAKER: I think, too, it's -- this test does attempt to reach into the location where the repository would be to see if we can see any inhomogeneties. This is as close to the repository as you can get without violating the integrity of the zone.

MR. PHILBRICK: How do you know you've violated the integrity?

MR. BAKER: The regulatory prohibitions against it.

dh5

MR. PHILBRICK: One of the things not being taken into account is that you can grout a hole absolutely tight.

MR. BAKER: Sealing is one of the things they will talk about next.

MR. PHILBRICK: You will have a chance tomorrow to discuss it with the NRC.

MR. BAKER: But I guess I don't think we disagree that we don't want to put a lot of holes in a repository; we do feel that putting it at the edge and in the metal, we have a chance of conducting good tests that will give us information that will be representative and that would have benefit, if we found some major break in a draw-down curve that would indicate some kind of homogeneity, we would want to know it.

MR. MOELLER: What Mr. Philbrick is saying is you can seal a hole once you put it in.

MR. BAKER: We're sure we can, but there's no need to put a hole any closer than that; that's the right place to put it.

MR. MOELLER: Martin Steindler and George Thompson.

MR. STEINDLER: If your value is not 10 to the minus 13 but was in fact 10 to the minus 10th or 9th, would the shape of the curve be different enough so that you could determine that effect?

MR. BAKER: I'm sorry, again I didn't make this clear. This is a test in the permeable zone where the conducti-

dh6

vity in meters per second is 10-7.

MR. STEINDLER: I understand that, but if the values for the impermeable sub were different by three orders of magnitude, would they interfere or be reflected in the shape of that curve sufficiently so you could determine that?

MR. BAKER: Sure, if the aquifers were in fact not confined or confined part of the way and there was some vertical connection, it should be detectable. In general, that looks like a break in a draw-down curve. You pump, and when you get your more permeable zone, the draw-down would decrease less rapidly than it had previously.

MR. STEINDLER: I don't think --

MR. MOELLER: Try again.

MR. STEINDLER: The question apparently is whether or not in the impermeable zone, the value is 10 to the minus 13th homogeneously or do you have in fact an undiscovered fault or undiscovered flaw someplace that gives you a drastically different value.

You're pumping in the permeable zone and you're doing your draw-down test. The question is, would that draw-down test -- would the draw-down test data look significantly different if your permeable zone criteria and data were sent with the impermeable data were off by three orders of magnitude being significantly lower than the permeable.

MR. BAKER: Yes, they would be. I'm not sure exactly

dh7

how this was calculated. I think that this was calculated assuming there was no leakage at all. This was a totally confined aquifer.

MR. STEINDLER: You would expect some differences due to leakage.

MR. BAKER: We would expect some differences, and I think if conductivity was 10 to the minus 13, the draw-down should look something like this. It was where the draw-down should be less.

MR. MOELLER: George Thompson. You've answered my question. Thank you.

MR. BAKER: Okay. We covered two concerns. One was the quality of the head data. The other was searching for inhomogeneities over the scale of the repository.

(Slide.)

The second example I said I would talk about was the impact of drilling fluid on test results -- and the measurements that we take from a bore hole. The transmissivity measurement could be affected by simply having pores clogged. The head value could be affected inasmuch as it would take it longer to recover, and it would be more difficult to get an appropriate value.

MR. MOELLER: What sort of volumes of fluid are you talking about?

MR. BAKER: Drilling fluid.

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MR. MOELLER: Yes.

MR. BAKER: Hundreds of thousands of gallons, in some cases.

MR. MOELLER: Oh, okay.

MR. BAKER: In general, we try to pump when we develop a well ten times the water out of the well as we lost fluid in. In general, we don't know exactly where we've lost all of the fluid as we drill.

VOICE: What kind of drilling fluid are you using?

MR. BAKER: It's a mixture of bentonite clays and water.

VOICE: No gels or anything like that?

MR. BAKER: In some of our wells, we've used a variety of things and we've tried to avoid that; that's certainly one of the lessons that we encourage other people to learn; to be careful what you put down a hole.

MR. PHILBRICK: If you don't know where you lost the drilling fluid, this means you didn't lose the hold on it one time, did you?

MR. BAKER: Yes. We drilled in the grande rond, in the test sequence we try not to case off the zones that we've previously tested so we have the capability of coming back and retesting. And that means that as we are drilling, some fluid can be lost in the permeable zones above the zone that you're currently drilling in.

dh9

MR. PHILBRICK: But you record when the stuff starts to drop?

MR. BAKER: Yes, we collect that information.

Now, in some of our earlier wells, we have not collected as well we are now. That is a lesson we learned. The hydrochemistry could be affected; we do now put tracer material in the drilling fluid so that we can monitor recovery as we clean the well up.

We use a fluorisine dye because it has -- we think it doesn't hang up in the formation, and it is easy to measure in the field. These are the measurements that might be affected. We need to understand whether in fact those measurements are affected and to quantify that.

So the program that we are initiating now to help address these questions is two phase.

(Slide.)

It's been done as a special task because we don't know of any standardized procedure for doing this kind of thing.

One test which is being conducted right now at our borehole DC-14, which is near the river, is a long term hydrology test for cleanup of the well. This particular well is artesian flowing. It had been flowing freely for about a year after we had drilled it, before we started this test.

So in order to conduct the test, we established a baseline. We monitored a variety of parameters: the water

dh10

that we used to drill the wells is contaminated, of course, by atmospheric tritium. And so that is a good indication of long term cleanup as well. So we established an extensive baseline in that well. We then injected mud as though we were drilling. In this particular case, we did not in fact drill; we just injected mud, and now we're in the process of monitoring.

So we will be able to compare the baseline we had over a year with the recovery over a few weeks and months, and that will give us a baseline to go back, and with the previous data we've collected where we might have only -- where we might have only developed a few thousand gallons -- a few hundred thousand gallons before we did the test, that test is in progress now; we have several other wells, two other wells in particular which had been drilled without drilling fluid; they had been drilled with a method called air rotary.

In those wells, we in one case have and in one case will conduct an initial series of hydroelectric tests to determine their properties under conditions without mud. We will then inject mud in those wells and do some drilling, in the dense flow interior.

We then would clean the well, using the same practice that we do routinely in the test process, and test it again. We already have done that once at DC-12, and we intend to do it at DC-16-C, which was air rotaried for that purpose. And there is another well on the river that we intend to do

dh11

another test like that.

These are the kinds of activities that we envision. If there are any other questions -- that's all I had prepared.

MR. MOELLER: Dick Foster.

MR. FOSTER: I'd like to come back to the anomalous heads that you got in the special well with that McGee.

MR. BAKER: Yes.

(Slide.)

MR. FOSTER: Can you show us where that is? And does that exist only in one well at this point?

MR. BAKER: Yes, sir.

MR. FOSTER: Since that head is something like twice as much as you get in other places.

MR. BAKER: Well, twice as much is perhaps not a good way to state it, since we are measuring to an arbitrary reference; sea level. It's 900 versus 400 feet.

MR. FOSTER: That's good enough for me.

(Laughter.)

MR. BAKER: The McGee well we are deepening, and it was initially a firm well; it was artesian at the time, and it has head-- 900 feet.

MR. FOSTER: Do you know whether that head is being produced in the same strata that you're looking at, or whether it's coming from something quite deep, deper than the Umtanum?

MR. BAKER: We're visualizing needs of combined

dh12

systems so the depth of the well would be the zones that we consider for the head. The well is being deepened now. Right now it's just going through the Vantage interbed. The heads stay high up through there.

We measure each -- each zone is packed off individually and measured, so we're trying to get a head which is representative of that particular flow top, and there may be some extended communication between that flow top and others. That of course is one of the concerns.

(Slide.)

But for example the well right now is in Vantage. But as we went through Frenchman Springs, we would stop the drilling process, back off a flow top, and test it. One of the tests that we do is to determine hydraulic head. It has been fairly constant at about 920 feet above sea level.

MR. FOSTER: There are no other wells that you have had which are to the west of that hydrologic barrier that you've got there, is that right?

MR. BAKER: None that are deeper than the mapton and none that have the high heads.

MR. FOSTER: That gives some indication that the postulated barrier there is doing a whale of a job on holding back a lot of water, isn't it?

MR. BAKER: It certainly is.

MR. FOSTER: If one postulates a breach in that for

dh13

whatever reason, why, then your whole hydrologic regime in this test area changes drastically and suddenly, doesn't it?

MR. BAKER: I think that might be one of the scenarios that would be determined; we would want to look at. We do have a process where we would by an Adelphi process plant to do that; we would get experts in and determine exactly, as much as we can about this anomalie; determine what would be a reasonable scenario to analyze.

MR. PHILBRICK: What's the drop across that?

MR. BAKER: It's about 400 feet -- 500 feet.

What do you mean by drop? The drop in head?

MR. PHILBRICK: Yes.

MR. BAKER: There's some topographic relief; perhaps 100 feet or so between these two wells. But the head relief is much more traumatic; it's about 900 feet here or about 400 feet here. And again, we have seen some decrease in that head which could be associated with irrigation.

MR. FOSTER: That barrier really sort of has to go around to prevent communication with the Columbia River in that region.

MR. BAKER: There is an anticlinal axis on each side. One of the things we're doing in conjunction with the modeling task force, if you remember we were modeling structures; we have agreed-upon parameters where this barrier, the USGS has seen the same type of barrier that's quite a bit longer; about

dh14

right there.

(Indicating.)

They have investigated enough that they feel fairly confident about it; it is the same sort of behavior that this one does. So we do intend to put this in models and see what kind of flow system we would get with the same assumptions that the GS -- the same parameters that the GS used for modeling theirs.

Of course, if we would model it so the barrier exactly matched the geophysical anomalie, then there would be a path for water to flow around it, and perhaps we would not see the traumatic head differential; of course, these are fairly tight zones.

MR. THOMPSON: Geologically, what is it?

MR. BAKER: I wouldn't want to state what it is. I will tell you what the GS thinks there is; they think it's a fault on which there is some significant lateral displacement; an old fault that's held and not significant vertical displacement.

It's not on this map, but there is a well here, RL-16, which as we drove the well, we discovered it has about 12 feet of tectonic breccia. We stopped and hydrologically tested the breccia, thinking it would be hydrologically significant; it turned out not to be. I can't remember the exact number, but I think it had a conductivity of something like

dh15

10-9. So it's possible the breccia from a fault somehow is tighter than the flow top.

MR. FOSTER: What are your plans for further characterizing that barrier?

MR. BAKER: Well, the first plan is to see if the head stays high all the way down. If that's the case, then I think the major activity after that is simply modeling it. We would model that barrier, try to match the heads as hydrologic properties were observed, and at that point if we can match the heads we might feel fairly confident that we at least understand the hydrologic significance of it, even if we don't understand the geologic significance.

Sue also is considering a program of some sort of geologic investigation. Do you have anything to add to that?

MS. PRICE: What I mentioned this morning in terms of, if it does look like it is a structure, some kind of program that we can parlay and see if there is any indication of movement among the structures.

And this is in conjunction with the USGS and the older structure in basalt that did not show evidence more recently. That's the reason we were talking about, in terms of scenario.

MR. PHILBRICK: What gave you the limits on that barrier?

MR. BAKER: You mean from this picture? This should

dh16

be interpreted as a schematic -- we don't know exactly where it is; all we know is that there are high heads here, low heads here, and the geophysical anomalie which is probably not even -- Sue showed it earlier in one of her Vugraphs.

MS. PRICE: We do have some ground surveys that indicate there is something there, whether it is a monocline or a fault; we don't have enough information to distinguish between the two.

But there have been some ground surveys where there is some seismic reflection lines that indicate there might be something there.

MR. PHILBRICK: Do you think you have the limits?

MS. PRICE: Not precisely, no.

MR. PHILBRICK: Do you think you are close to the limit?

MS. PRICE: I think we --

MR. PHILBRICK: How long then do you have to have to wash out before entry phase?

MR. BAKER: I think that's a question that has to be answered by modeling, and we aren't doing it with USGS.

MR. PHILBRICK: If you model it, the permeability -- we want to know the limits of the structure, because from that you get an indication of the permeability is. A long structure needs -- a short structure will wash out with --

MS. PRICE: I think you have to look at both. I

dh17

think you would want to do a combination of geologic and also testing.

You didn't mention as far as the DB-11 result. There is the well just to the west of that that indicates from an hydrologic standpoint that --

MR. BAKER: It is a high head well; that's correct; thank you, Sue. So we do have that indication twice. Unfortunately, DB-11 is in Priest Rapids in Rozo.

MR. MOELLER: Dick, why don't you finish up?

MR. FOSTER: Does that high head exist in the unconfined aquifer?

MR. BAKER: No, it couldn't, really; otherwise it would be a swamp.

MR. FOSTER: So you are also saying here that you have a 400-foot excess head underneath the unconfined aquifer. In other words, you've got tremendous pressure upward, which seemingly is holding. That's got to tell you something about your vertical permeability, too, doesn't it?

MR. BAKER: Yes, it does. Although certainly that suggests a program of investigation which we in fact are embarking on but have not done. Again, it's a model, and one would want to model that potential vertical motion given the data that we have and try to draw some inference about the conductivity.

Certainly it suggests segregation of the systems.

end14

MR. FOSTER: My top-of-the-head feeling here is that you have put an awful lot of work into characterizing what the hydrogeology is, let's say, to the east of that particular barrier, and you have something there that could be relatively flimsy and change the whole thing that you don't know very much about.

MR. PHILBRICK: What would change it?

MR. FOSTER: The high head, what would change it?

MR. BAKER: The concern is if it's really a dam and it broke, that would change the hydrologic regime. Well, let me put this in the proper perspective of our current status.

Under the terms of the legislation, we are not even starting site characterization yet. There were reasons to avoid potential repository sites, investigation of those sites, prior to selecting them. It has not been that long ago that we selected the site. And so what we are looking at is the characterization activities that it takes, given that we have now selected a site. This is the beginning of the process.

MR. MOELLER: Don Orth has a question.

MR. ORTH: Going the other direction, toward the southeast from the site, are the heads essentially the same all the way across over to the river and all the way around 400?

MR. BAKER: Yes, that's what our data indicate. However, as long as there is doubt as to the validity of them, it's difficult to draw definitive conclusions. We do intend to put piezometers in to remove that doubt. One can inger, though, as the NRC has, that any gradient that exists across the syncline is lost in technique. So it requires a higher resolution of head data in order to infer an actual gradient.

MR. MOELLER: Bob Axtmann.

MR. AXTMANN: I have a brief question about the Adelphi study you mentioned a couple of times. How do you pick the clientele, and how much do you tell them?

MR. BAKER: We haven't done it yet. What we have is a request for proposals out -- and I don't know the exact status of it -- where we have asked people to make proposals to do this kind of activity for us.

In general, when we ask somebody like we did Woodward Clyde in the horizon selection activity and the process that we went through, we try to avoid prejudicing them as much as we can.

So I would imagine, although I haven't seen the request for proposal, I would imagine that we are trying to avoid injecting anything into that process, just provide the data, tell them what the problem is, and tell them we need a set of scenarios to analyze that are realistic and

believable by the technical community at large.

I didn't answer your question, though. I guess the real answer is I don't know exactly what we would tell them because I am not directly involved in that.

MR. AXTMANN: I would think the question you are asking them is going to require data.

MR. BAKER: Oh, yes, they would have access to everything.

MR. AXTMANN: But there are uncertainties in the data, and they will all get the same data, and I guess all you're doing is finding out whether ten men agree with you.

MR. BAKER: No. We are asking the ten men to come to a consensus independently of us.

MR. AXTMANN: Yes. Right.

MR. BAKER: We can provide the data and whatever assessment we can get then.

MR. MOELLER: Well, Dr. Baker, you have been on for a long time.

(Laughter)

MR. BAKER: It has been enjoyable.

MR. MOELLER: Well, it has been good for us too. You have certainly helped our understanding of what you have been doing.

Why don't we take a 15-minute break.

(Brief recess.)

MR. MOELLER: The meeting will resume.

The next topic is a discussion of the repository, and that will be presented by David Turner.

(Slide)

MR. TURNER: I am Dave Turner, manager of the Engineering Development Department for the basalt waste isolation project. And I will cover the repository portion of the site characterization report.

(Slide)

As a way of introduction, I thought I would describe briefly our recently completed conceptual design report for the nuclear waste repository in basalt.

This was performed for DOE by Raymond Kaiser Engineers, Parsons, Brinkerhoff, our architect-engineer. And it will be provided to DOE in the clearance process started at the end of the month. So we will have a conceptual design in the public domain very shortly.

This is an artist's perspective of the repository itself. It shows the surface facilities, occupying approximately 200 acres. The subsurface facilities, located for the repository conceptual design purposes, in the Umtanum formation at approximately 3,700 feet, occupying an area of about 2,000 acres.

It shows five access shafts terminating in a shaft pillar at the bottom. The area for waste storage on

either side of the shaft pillar.

One reason for dividing the waste storage into two parts was to leave a portion of the repository around the base of the shaft in an area that would experience only a moderate temperature increase from the emplaced waste to ensure that when seals were subsequently placed in the manmade accesses, that the excess temperature would not make this job more difficult.

MR. PHILBRICK: Which way are the placement rooms? Are we looking at the waste itself or at the placement room?

MR. TURNER: Each one of the lines that you see here represents a repository tunnel. I have a plane view that's a little better that I will put on next. But each line in here represents a repository tunnel.

Let's go to the plane viewgraph that will help somewhat more.

(Slide)

MR. MOELLER: And I think just for our education it would help to know how far the people actually move down and across or how much is done remotely and so forth.

MR. TURNER: All right. This is a plane view of the repository as it would appear at the end of the construction period. Initially, we would construct the surface facilities, the five access shafts, the shaft

pillar, and then approximately five waste storage panels. The waste storage panel is sized to accommodate one year's waste storage and consists of four tunnels. And we will look at the physical description of the waste panel --

MR. PHILBRICK: Which way do the cannisters run?

MR. TURNER: The cannisters themselves are stored in horizontal holes 200 feet along, approximately 30 inches in diameter that are bored from one tunnel to another and are not depicted on this plane view.

MR. PHILBRICK: So they are crossways?

MR. TURNER: Yes, sir. They would be placed between this tunnel and that and on over here.

The overall dimensions of the repository are about 2 miles in length, about a mile and a half in width for the repository. The total length of the tunnel and repository, at least the last time I calculated, was roughly 120 miles.

MR. PHILBRICK: Which is the first room occupied by waste?

MR. TURNER: I believe this is the panel we had set aside during a normal construction sequence. We always have a spare panel between the one that is being constructed and one in which waste is being emplaced. So we are always one panel ahead.

MR. PHILBRICK: Then you haul past the waste?

MR. TURNER: Yes, in some cases. We do have two separate ventilation systems for the repository as it is presently designed. One of the systems serves that portion of the repository where construction operations are under way, and then there is a separate air system for the waste handling area with an appropriate differential pressure so that we always have leakage from the construction toward the confinement side.

Now, I think the next design phase, it's quite possible we will change this for all the shafts. They're not centralized in one area. It may very well be that the first waste would be emplaced would be emplaced toward the end of the repository, and then we would work back.

There are a number of schemes of doing this. Each have their own advantages and disadvantages.

MR. PHILBRICK: Which would you rather do?

MR. TURNER: I personally would prefer placing the shafts out on the periphery. A simplified ventilation system and emplaced waste out here and mine away from it. There are some advantages to that that I think outweigh the present scheme, but then we don't have conceptual design for that. So that simply is my engineering assessment right now.

MR. AXTMANN: I got in here after the first viewgraph.

(Slide)

These things are stacked up, and we are looking -- these go -- these are stacked up to --

MR. MOELLER: How many floors are there?

MR. TURNER: This is all on a single level, with one exception. In a shaft pillar area, due to the complexity of the mines there, on an artist's perspective of that you will have about three levels there. But the main storage area is a single flat plane, each of these lines on there being a room approximately 20 feet wide and 10 feet tall. So you are looking at a planar storage area.

MR. AXTMANN: And how many capsules are there in the entire repository?

MR. TURNER: On the order of 25,000 or 30,000.

MR. PHILBRICK: What are the dimensions of 25 x 10?

MR. TURNER: That was discussed by handling requirements, which I will discuss in a little more detail. That was determined by the length of the waste package. Does that answer the question?

MR. AXTMANN: So we are seeing a tiny segment of the thing?

MR. TURNER: No, you are seeing the entire repository.

MR. AXTMANN: I don't see any 30,000 --

MR. TURNER: Okay. Again, the waste cannisters themselves are stored in long horizontal holes 200 foot in length, about 30 inches in diameter, that are bored between adjacent tunnels on here. And that is not shown.

Let me step back here.

(Slide)

MR. MOELLER: If you are going to cover it, why don't you move along?

MR. TURNER: There does seem to be a bit of confusion. I think this will help to resolve it.

Here is the tunnel represented by one of the single lines. It's roughly 20 feet in width, about 10 foot long, a semi-horsehoe-shaped tunnel. The waste is stored in large holes 200 foot in length, 30 inches in diameter.

This does not show the necessary hardware. But waste cannisters are placed end to end with small space between each on either side of the rooms. So that is how our -- it's a planar emplacement configuration. It minimizes the amount of host rock that you require in the vertical direction.

MR. MOELLER: Now, does the next channel interleaf with this one, or do you follow the storage holes? Do they intersperse with these?

MR. TURNER: The next tunnel would sit right over here 200 feet away connected with a storage holes with this

tunnel here.

MR. MOELLER: The storage hole connects the tunnels all the way through?

MR. TURNER: Yes. The method of construction is we would drill a pilot hole from this tunnel to this tunnel over here, attach a head, and then bring the 30-inch diameter by pulling back this way. So they are interconnected.

Further, each tunnel is connected to the other by intermediate cross-cuts --

(Slide)

-- as depicted here. This shows adjacent tunnels. These are cross-cuts. Those are in the waste storage holes. Although the bore holes are parallel, they are just not shown on there.

(Slide)

MR. MOELLER: And how far apart horizontally are the holes?

MR. TURNER: The cannister bore holes themselves, in case of spent fuel, approximately 80 feet. For higher commercial waste we had to go to a spacing of about 170 feet.

(Slide)

This viewgraph shows the perspective of the near-surface test facility which was constructed in Gable

Mountain about 3 years ago. The reason I show it is that a major portion of the geomechanics information here at the time we started this phase of the repository design was based on near-surface information.

Very briefly, this facility, for those of you who haven't seen it, consists of three tunnels constructed into the mountain with a test area on the back side. it is constructed in the Pomona flow, which is in some respects similar to the Umtanum in terms of density, hardness, and so on.

We felt the information we got from near-surface testing would to an extent be applicable and support repository design at depth, although there is certainly not a one-to-one transfer.

There are three major tests in the near-surface test facility: The full-scale heater test number 1, located here, consists of a central heater with eight guard heaters. Two in effect makes it an infinite array. We are analyzing the results now.

MR. MOELLER: How long did that go on?

MR. TURNER: Those heaters ran approximately 2 years.

MR. MOELLER: Okay.

MR. TURNER: The second test consisted of a single heater. We had planned, and subsequently did, load

it to higher thermal densities to try to in effect make the bore hole wall fail.

Now, while this heater was designed for something like 1 to 2 kilowatts, we ran this heater on up to 9 kilowatts and never did get any significant decrepitation of the bore hole walls. That doesn't mean it wouldn't happen at depths with higher stresses, but nonetheless this was the first information that we ever had how basalt would behave under relatively high heat loads.

That test has been completed, and we are analyzing the results.

One case that is in progress at this time is the block test. Our representative equivalent volume of rock there consists of basically a cube, a rock, 2 meters on a side. We are using flat jacks to apply the known stress field. There are heaters there. We have just completed the ambient temperature phase, and we will now activate the heaters and complete the elevated temperature effects.

And the major purpose of the block test is to provide our initial knowledge on deformation properties. It has been a highly successful test so far. The remainder of the facility is available for other work. At one time we considered the possibility of actual high-level waste emplacement in this area. However, it is not being used for that purpose at this time.

MR. PHILBRICK: What is the diameter of the heater test in the heater test room? Is it comparable to 30-inch holes?

MR. TURNER: I believe it was a 24-inch hole for heater test 1 and 2, so it is comparable.

MR. PHILBRICK: All right.

(Slide)

MR. TURNER: I would like to briefly summarize in very brief fashion the major concerns that have been expressed regarding the site characterization report. This includes certainly the analysis of the NRC staff, the BWIP overview committee, and for that matter, the Rockwell staff.

I was quite surprised at the concerns by the number of reviewing parties were as close together as they were. In fact, I thought the analysis by the NRC staff was -- I certainly agree with the concerns they expressed, so we certainly have no misgivings with what we have gotten with the review.

It covered four major areas: opening stability basically will be excavated openings, and the repository remains stable in both the heated and unheated condition over the design life of approximately 100 years.

MR. PHILBRICK: Are you going to 20 x 10?

MR. TURNER: That's in the conceptual design. We

have got to learn some more before we can really commit to a 20 x 10 opening. We have some misgivings with that.

MR. PHILBRICK: Do you mean it's flat?

MR. TURNER: Well, it is flat, yes, a 2-to-1 aspect ratio. We will look at that in some more detail momentarily. That's all right.

The second major area is ceiling enclosure of the manmade areas. Can we be assured that we can adequately seal these areas at the time of decommissioning?

Third was maintenance of the retrievability option for the required time period, and we agree that is still in the area of concern.

And lastly, the fourth major concern is the rationale support and the amount of detail that was previously available regarding the in situ test program. We think we have made significant strides recently in upgrading our knowledge in this area, and I will try to discuss that briefly as well.

MR. MOELLER: Go over the first one once again, the opening stability. I am blank on that.

MR. TURNER: The major concern was how we would demonstrate that excavated openings would remain stable for the design life of the repository.

MR. MOELLER: At depth?

MR. TURNER: At depth under both the heated and

subsequently heated conditions.

MR. PHILBRICK: You have not stated that you are going to make any 10 x 20 or whatever the agreed-upon opening is.

MR. TURNER: Well, that concern really regards opening whether they are 20 x 10 or 10 x 10 and so on.

MR. PHILBRICK: It's a hell of a difference. You cut that span down in half.

MR. TURNER: That's possible. We have some ideas that would permit us to do that if it is necessary. It also hinges on what waste emplacement configuration we end up with.

MR. PHILBRICK: Are you going to do any roof treatment?

MR. TURNER: Yes, the design was based on rock bolts and shot creek.

MR. PHILBRICK: I mean in testing.

MR. TURNER: Yes, we feel that's necessary.

MR. THOMPSON: When you say "in situ testing," do you mean at depth?

MR. TURNER: Yes. The concern was the adequacy of the rationale and the detail that supported our at-depth test program.

MR. PHILBRICK: Are you going to consider variation in the rock bolt material at the time you want

this open?

MR. TURNER: Yes, I think we have to. In fact at that depth, as I described, we do plan to construct a repository-size room and solve the appropriate rock support and then monitor the performance of that support; for example, load cell and rock bolts. We feel we need to do that to get adequate answers.

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MR. PHILBRICK: Now, when you're sealing and closing, against what head are you assuming that you have to close?

MR. TURNER: Initially, when you close, you will be emplacing seals at atmospheric pressure in the repository. That is --

MR. PHILBRICK: 500 years later, what is that closure head supposed to be working against? What is the closure supposed to be sealing?

MR. TURNER: Basically, we plan to seal initially at 1,600 pounds pressure. As it resaturates, that will decrease where your pressure difference essentially drops to zero as resaturation pressure essentially reaches 1,600 pounds.

MR. PHILBRICK: What is the maximum sealing pressure you are going to have to protect against?

MR. TURNER: 1,600 pounds at a 37-foot depth.

Now, as the repository resaturates over a period which Dr. Baca indicated, from tens to hundreds of years, that pressure differential will decrease.

MR. PHILBRICK: You are filling the whole cavity?

MR. TURNER: Yes. Our plans are to backfill the rooms with crushed basalt and bentonite, emplace, if you will, some bulkhead seals, which I will describe momentarily, in both the shaft and the tunnels.

MR. MOELLER: When you say "backfill," you will backfill the room. Now, do you fill the holes tight also around the cannisters?

MR. TURNER: Yes.

MR. MOELLER: You fill that tight also?

MR. TURNER: Yes. Dr. Smith will describe that in some detail, since we think that is key to maintaining isolation capability.

Is it all right to go on?

MR. MOELLER: Yes.

MR. TURNER: The concerns are shown on one of the screens. And a very brief description of our engineering logic is shown over here. The dotted line shows approximately where we are at this time in the program.

As previously indicated, we have completed our initial phase in the repository conceptual design. The geomechanics, technical support for that work was really

based primarily on information we got from the near-surface test facility, and it was at this stage of our design process that we did make our input to the site characterization report.

And we are in the process of initiating a series of engineering studies. This is really two-fold. Number one, support the next phase of repository design. We call this the upgraded conceptual design. We will initiate that work in fiscal year 1985, a little over a year from now.

Secondly, we feel these engineering studies will indicate some areas where some engineering development either of equipment, instrumentation, or techniques is required. So we do have a relatively comprehensive engineering development program plan which we will implement if indeed these studies confirm the need for that.

We have also just started the first phase of the exploratory shaft program. I believe everyone is familiar with the current status there. That will then continue through construction of the shaft and break-out station.

And then in the second phase we will construct approximately 1,000 foot of tunnel for a more comprehensive geomechanical testing at depth.

The end product of all this effort shown here is being the repository preliminary design which will be

initiated in fiscal year 1986 and preliminary design reports and submittal of a license application. So this is really the end point of the program at which our efforts are primarily directed.

Following submittal of the license application, however, it may be necessary to conduct a limited amount of testing at depth, either continuation of tests in progress or initiation of tests which require a longer time frame to complete. So we do show some confirmatory testing in situ after submittal of the license application.

(Slide)

All right. Combining the engineering logic diagrams we have here -- namely, the engineering studies design phases, engineering development, in situ testing and confirmatory testing -- with the major concerns that we have here, our overall plan for addressing the concerns in the engineering area are shown here.

(Slide)

All right. The first concern, as previously mentioned, is opening stability. And the concerns that we listed under this generic concern was the fact that there will be certain variability in rock properties within the repository horizon. The concern was how do we adequately account for these in our geomechanics modeling work?

The second concern was the modeling that we used

in the first phase of the design. We used a linear elastic method of analysis in the first phase of the repository design. It seemed to be compatible with the level of information we had at that time. However, we recognize now that linear elastic modeling is really not adequate to describe the behavior. So our efforts will be bent toward upgrading our capabilities in that particular area.

The third concern was the fact that the geomechanics analyses that we conducted in support of the design really had not been properly referenced. And we agree with that. And during our subsequent design phases we do plan to document and clear for public distribution as appropriate the analytical work that supports stability analyses.

And then lastly, there were some work elements listed in the SCR where it was felt we should reassess our priority, and we are in the process of doing that.

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The conceptual design was based on subsurface facilities layout, the major concern being the in situ state of stress, and depicted on here is the maximum horizontal stress in line with the canister boreholes, and the minimum horizontal stress in line with the crown of the placement, and then the vertical stress.

MR. PHILBRICK: What has the greatest horizontal stress on it?

MR. TURNER: The canister borehole right here.

MR. PHILBRICK: The walls of the placement rooms have the greatest horizontal stress on them.

MR. TURNER: Right in this location?

MR. PHILBRICK: Where is the rock burst going to occur?

MR. TURNER: My best guess would be probably somewhere in this vicinity here.

MR. PHILBRICK: On the walls of the placement rooms.

MR. TURNER: I would think so.

MR. PHILBRICK: Then why don't you reverse it.

MR. TURNER: Well, we have argued about that and that is one reason we just haven't reversed that, is we need to reassess our waste emplacement configuration. If we are left with this one and we have an analytical technique that permits us to demonstrate that the contrary is better, we will certainly do that.

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MR. PHILBRICK: Once you get the waste in the hole, it is going to sit there and the stresses are going to span that hole, so that you are going to have no trouble with the waste hole once it is drilled, but you can have trouble forever in the placement hole.

MR. TURNER: All right. So if you are saying high stress here, what we should do is reorient that 90 degrees.

MR. PHILBRICK: That's right, and then be careful how you are handling it when you are advancing the room.

MR. TURNER: I think that's a good point.

MR. MOELLER: Could you show on the blackboard or something what you are talking about? I don't follow. You are just going to turn the whole system 90 degrees?

MR. PHILBRICK: That's all.

MR. MOELLER: Oh, okay.

MR. TURNER: So that the storage room is parallel to the direction of maximum principal stress.

MR. MOELLER: Okay, thank you.

(Slide)

MR. TURNER: In fact, to quantify that a little bit, our consumptions during the conceptual design are shown here, in which we show as a function of time calculated rock stress. The in situ stresses are shown here. So these are the in situ stress levels. The reason they differ, obviously, is on a horizontal you have a greater stress in one direction than the

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other.

Following excavation, this describes what we felt the post-excavation stresses would be for that particular configuration, and then following waste emplacement as the thermal pulse comes through these stresses increase over a period of time to where we calculate a maximum stress in the storage hole occurring somewhere around 50 years, and in the crown of the placement room, sometime around 25 and 50 years.

That is indeed dependent on the configuration that we have assumed.

(Slide)

Very briefly, there is some of the geomechanical information that was employed in the conceptual design. This will certainly be updated on the information we have gotten from the reference repository location before we start the next design phase.

(Slide)

One of the major unknowns at the time we started conceptual design was our in situ state of stress. We had very little information on it beyond the fact that, as Dr. Price indicated this morning, there appears to be a north-south compression tectonically in that general area; consequently, we figured we would have a principal horizontal stress that was generally northerly in direction.

We attempted to determine in situ stress information

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by using a hydrofracturing technique. Our first effort was in DB-15 in the Rosa formation, and the results we got there were encouraging. We felt the technique was giving us valid information.

We subsequently then conducted a series of tests in the Uptanum formation in DB-12 and came up with the results shown here, that we had a maximum horizontal to vertical stress of 2.33, and then a maximun horizontal to minimum horizontal of 1.28. Interestingly enough, the direction of the maximum horizontal stress was shown to be about north 23 degrees east, and if you recall Dr. Price's Vu-graph, I think if you recall the direction of the axis of the Cold Creek syncline, it is generally east-southeast, which puts this almost exactly perpendicular to that. That was one of the things that led us to believe that the facts we are getting --

MR. MOELLER: Picking up on a point you made earlier but it slipped past me -- why is the waste hotter, meaning thermally, than spent fuel? How can the waste be more concentrated than the fission products in the spent fuel?

MR. TURNER: That's our reference waste forms.

MR. MOELLER: Oh, they are not diluted with Uranium. Okay. You have extracted them, so they are actually more concentrated.

MR. TURNER: The spent fuel consists of bundles of spent fuel pins.

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MR. MOELLER: Okay. I see the point.

MR. TURNER: Subsequent to our work in DC-12, we did do work in borehole RRL-2 for the repository reference site and got in situ stress values in the Umtanum that are quite comparable to those shown here in DC-12, so that provided somewhat more substantiating information for our approximation of in situ stress.

(Slide)

Okay. Our plan for really addressing the concerns regarding opening stability are shown here. First of all, we had a series of engineering studies planned in which we will prepare design basis data from the data base that we have acquired in the rock mechanics are so we are assured that we and the architect engineer are using conservative data in the next design phase. We plan to look at the various geomechanics parameters and conduct a brief sensitivity analysis to assure that we concentrate our efforts on those parameters whose variability have the greatest impact on stress analysis.

We are also looking at a non-linear continuum model since the linear elastic analysis is not a very good way to analyze a jointed rock. So our effort here is to define specifically what rock failure criteria we have. When a rock fails, I think you really need criteria to describe just what that failure is, and then employ the appropriate non-linear model for subsequent analysis.

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The in situ data support that we will have for this effort will include construction of a borehole at depth in Phase 2 of the exploratory shaft. We will gain information on opening stability when we construct a breakout station in Phase 1, and then also approximately 1000 feet of tunnels in Phase 2, including a repository-size tunnel during tests.

During the present time our design is based on linear elastic analysis; however, as we upgrade our capability in this area, we will document and clear all analyses, so that is no longer a concern.

MR. PHILBRICK: What establishes Phase 1 versus Phase 2?

MR. TURNER: Phase 1 includes construction of the shaft, the sinking the shaft lining. Phase 2 then includes construction of approximately 1000 feet of tunnel. So it is really a programmatic differentiation at this point.

MR. PHILBRICK: Have you got any idea which way you are going to take that tunnel with respect to the stresses?

MR. TURNER: I have a layout and we are going both in the direction of and perpendicular to principal stresses.

MR. STEINDLER: Has anyone else ever dug a fairly deep line kind of arrangement in basalt anywhere in the world? Is there any other experience available to you in this general area?

MR. TURNER: Not at that depth. There have been a

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number of openings constructed in basalt that have remained stable, but they have been near surface. So I know of no adequate example in basalt. There certainly are deep mines, as you very well know, in South Africa, but that is not basalt.

(Slide)

A second major area of concern was sealing and closure of the repository openings, and the concerns that really make up this generic concern are shown here. One concern expressed was the effect of the liner, whether it be exploratory or repository shafts, on the ability to reseal the repository. Apparently we didn't make our intent clear in the Site Characterization Report. Our intent is to remove the shaft liners and competent basalt zones as part of the Salem program. We will talk about that a little bit more later.

There was some concern expressed regarding the fact that we were setting performance requirements for seals based almost strictly on performance allocator or performance assessment. We are reconsidering our position there. There is also a concern regarding our plans for accelerated testing in the laboratory seal components to ensure that they did indeed have the design life they needed. And then lastly, the priority that we are assigning to certain portions of the lab and field test work.

MR. STEINDLER: Do you know how to design an accelerated longevity test fcr closure?

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MR. TURNER: No, we don't have a final recommendation on that yet. I think we know how to conduct longevity tests, but whether we will be able to convince ourselves and other people that it is a valid accelerated test remains to be seen. We are really working with that right now.

MR. STEINDLER: There is a plan to get at that information?

MR. TURNER: Yes, yes. We need to finalize our plan in that regard.

MR. MOELLER: Well, you almost ultimately have to come up with an acceptable test. I mean what if you can't?

MR. TURNER: That would cause a real problem, yes indeed it would, because design life of the seal approximates something on the order of 10,000 years, so you would certainly have to have good basis for extrapolating data obtained in a limited time.

MR. AXTMANN: I'm bemused by the makeup of the Overview Committees which identify no structural engineer and the alacrity with which you took Professor Philbrick's suggestion on the orientation on the axis. There is a structural problem there.

MR. TURNER: I agree there is, but we have argued the same point before today and w e have come to the conclusion that that probably was not the optimum orientation, so we have been over that problem previously.

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MR. AXTMANN: But your Overview Committees still don't have any structural engineers on them.

MR. TURNER: Dick Vianowski is certainly a very capable rock mechanic engineer.

MR. AXTMANN: Which is somewhat different than concrete structures.

MR. TURNER: Somewhat different.

Any comments on that, Larry?

(Slide)

MR. PHILBRICK: So the initial sealing has the maximum load, and then as you go on and the water fills up in the overhead, then it is all saturated both ways, so you have got uniform pressure?

MR. TURNER: 1600 pound uniform pressure. The absolute pressure increases; the pressure differential decreases. In the conceptual design we conceived of putting seals in the shafts, both above and below flow tops, and these seals could be repeated in competent basalt flows more than one time.

MR. PHILBRICK: Are you going to grout those things horizontally?

MR. TURNER: One scheme that we have come up with does show grouting around those bulkheads.

MR. PHILBRICK: You aren't going to take the funnel shape out to the limit of disturbed rock, are you?

MR. TURNER: We had talked about trying to

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excavate very carefully to minimize the amount of disturbed rock that remained around that seal, and that is what this shows, this very careful excavation out into the rock to minimize the disturbed rock zone.

Now, whether that will be necessary, we are attempting to answer.

MR. PHILBRICK: This is something you find out after you get the hole drilled. You are not going to seal that thing for 50 years.

MR. TURNER: Well, that's true, and just the nature of that disturbed rock zone, I feel we are going to be adequately assessed analytically once we get the exploratory shaft down. Part of that program does address the nature and extent of the disturbed rock zone.

MR. PHILBRICK: Did you ever run across any of those drawings showing mine seals for bituminous coal made with brick?

MR. TURNER: No, I don't believe I have.

MR. PHILBRICK: They are very simple.

MR. TURNER: At least the performance assessment on the seal program has tended to get simpler as opposed to more complicated.

MR. PHILBRICK: I think the idea of using basalt blocks -- unless you have got masons like the Incas were, I would just build it out of concrete.

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MR. TURNER: If concrete will survive in that environment for the required period of time, I'm inclined to agree, and that is certainly one of the candidate materials we are looking at.

MR. PHILBRICK: Why wouldn't it survive?

MR. TURNER: Basalt would. Concrete, I'm just not certain.

MR. PHILBRICK: If you put the basalt in there, you would have to put mortar in the joints, so you might as well go to concrete and quit fooling with the mortar.

MR. TURNER: If the concrete will survive.

MR. PHILBRICK: Will the mortar survive?

MR. TURNER: I'm not certain.

MR. PHILBRICK: So you don't have either one. If you knock out the concrete, you knock out the mortar, too.

MR. TURNER: That's true.

MR. PHILBRICK: So let's make it simple, build it out of concrete and be through with it. Make it four times as big as you want to make it.

MR. TURNER: I think we may end up there.

(Slide)

MR. MOELLER: Don, did you have a question?

MR. ORTH: No, no.

MR. TURNER: This shows another perspective of the sealing system in which we show bulkhead seals both in the

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tunnels and at the end of the storage room, with a tailored backfill placed between seals. Similarly in the shaft we show shaft seals excavated out to minimize the disturbed rock zone with backfill material between seals.

MR. PHILBRICK: That's a different design than you had in the report.

MR. TURNER: Yes, marginally different.

MR. PHILBRICK: Because you had sloping like this in the report.

MR. TURNER: Yes.

MR. PHILBRICK: Why did you change it?

MR. TURNER: Based on what work we have done since we prepared the Site Characterization Report, we feel that the performance requirements for the seal system are going to be less technically difficult to meet than we had originally thought, so we are trying to simplify our design, and when the process of translating those performance requirements into design criteria, when we have finished doing that, we will be in position, I hope, to simplify that even more.

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In fact, the work we are doing right now to translate performance requirements into design criteria is shown schematically here where we show the various components that must be considered in the hydraulic analysis of the seal system, including a bulkhead seal that goes out into the

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disturbed rock zone.

Now, by doing this analysis and seeing if commonly available engineered materials such as concrete have low enough permeability -- and it does appear that they do have adequate properties -- hopefully we can simplify that where we don't have to excavate out to the disturbed rock zone after we have removed the liner; but we have got to go through that kind of analysis before we can come to that kind of conclusion, and that is where our effort is really directed now.

(Slide)

We have got a plan for addressing our concerns in the sealing area, as shown here. We will be initiating engineering studies to complete allocation of performance requirements and complete our seal design criteria. In the development area, our thought is to see if current technology would not indeed meet the seal criteria that we come up with. In other words, use concrete instead of something more exotic. We need to develop the capability to conduct accelerated longevity tests on candidate seal materials in the laboratory and in the exploratory shaft. We will try to characterize the disturbed rock zone since that is the one parameter we don't have a very good hold on at the present time, and then conduct an engineered scale field test following completion of exploratory shaft Phase 2 after submittal of a license application.

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But addressing one concern that apparently we didn't do a very good job of before is our current concept is indeed based on removal of the shaft liner so it doesn't deteriorate and create a preferential pathway.

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The third concern regards maintenance of the retrievability option. The reason that was a concern was it does have many impacts on the repository design. There was concern regarding our ability to actually construct a 200-foot long, 30-inch diameter borehole, and we share that concern.

MR. PHILBRICK: Why are you concerned about that?

MR. TURNER: Well, it's right at the edge of existing capability, we are given to understand. There is a problem of maintaining at least a minimum of directional control when we construct that borehole from one tunnel to another. We would like to do it without too much deviation because at least our present design requires us to put some metallic components into that hole, emplaced waste canisters and subsequently backfill it, and we are concerned if you get a wave shape when you are trying to construct that hole, that you could have some problems.

I think the easiest way to resolve it is, as we plan to do, go out to the nearest surface test facility with appropriate equipment and really try it. Another concern is whether that borehole will remain stable in both the unheated

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and heated condition; the availability of equipment and procedures actually in place to retrieve waste canisters; and then the fact lastly that we did not list retrievability as a key issue.

However, regarding some of the unknowns, regarding stability more than anything else, we are inclined to agree that it certainly is a significant concern.

At risk of repetition, here is what we are looking at regarding the bore holes. It shows the main repository tunnels 20 feet in width and 10 feet tall. Here is the back rooms, which are 10 by 10, horseshoe-shaped. The boreholes would be constructed by drilling a pilot hole toward the reaming room, attaching a reaming head and then opening the full diameter as it is drawn back this way.

MR. PHILBRICK: Going in there with a small diameter hole, you can put pressure on the drill head by blocking across the room, but coming back, how do you get to pressure?

MR. TURNER: You are pulling on that reaming head hydraulically against the face of the main tunnel. You are hydraulically bringing it back. So it should minimize the problems.

Now, one concept that we had that we thought would be worth investigating during our engineering development program is if we could blind-hole bore those holes, it might very well eliminate the need for constructing these reaming

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rooms because the only purpose of those rooms is to enable you to attach that reaming head. The waste is all emplaced from this room to this room. In fact, it is sized in terms of width to accommodate a waste package and handling device that approximates about 18 feet in length.

MR. PHILBRICK: So your biggest problem really is the design of the bit, isn't it?

MR. TURNER: Design of the bit, probably getting the cuttings out of the hole, maintaining directional control. But if we could blind-hole bore these, and we are proposing that we try this, we might be able to get rid of that room and that room and significantly reduce the amount of the basalt we have to excavate down there. So we are proposing to try that at the near-surface test facility, and then also demonstrate the preferred method at depth.

MR. MOELLER: And why do you bore a smaller hole and then a larger one?

MR. TURNER: Well, that is the technique that is commonly used now, but you can maintain directional control of a relatively small hole, and that provides you a guide coming back.

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MR. MOELLER: Who cares if they aren't precisely straight?

MR. TURNER: There are limits, and we are just unable to define those limits now. If you have to put metallic components in that storage hole as shown here --

MR. MOELLER: It has to be straight enough for them to go in, but if instead of going precisely perpendicular it revolved a few degrees, would anyone worry?

MR. TURNER: I don't believe we would. There is just some point where you don't want to exceed the limits.

MR. MOELLER: You can't have a snakey hole or you couldn't get the waste in. Okay.

MR. TURNER: After the hole is constructed and waste canisters are in place, that is how we envision it would look in our present design, and what it consists of is within the hole there is a semicircular metal assembly that would be placed in the hole one after the other. That consists basically of a metal frame, supports for the waste canister, and then a support bracket to be used for a backfill pipe whose function I will explain in a moment.

The metallic components would be placed in the hole, and then to emplace a waste package, we propose using a small dolly that would ride on these rails. The waste package would be brought up to the face of the tunnel, the shielded transfer cask mated up at this point, and then the waste canister would

be transported down the bore hole in the elevated position shown by the dotted line. When it reached the storage position, the dolly would lower it on the support post. The dolly would then be withdrawn for the next operation.

Now, we propose to leave these holes, at least in the existing conceptual design, as shown here, without back-fill during the retrievability period, and our rationale for that was that if we defer placing the backfill in those holes, it will ensure that the waste would be readily retrievable throughout the retrievability period.

A second reason for doing that is that given a 50-year retrievability period, the thermal output of both spent fuel and high level commercial waste increases significantly, and the backfill that we propose using around these canisters is one of our major engineered barriers and at one time was the temperature-limiting component. So by deferring replacement of that backfill for 50 years, we were able to place one bore hole closer to another, thereby reducing the amount of basalt we had to excavate.

Following the end of the retrievability period, however, a mixture of crushed basalt and bentonite would be emplaced in the full 200-foot length of the hole by blowing it pneumatically down the tube, withdrawing that tube out into the central portion of the room section by section.

Dr. Smith will describe work that he has under way

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now to verify the feasibility of that particular concept.

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Our plan for addressing some of the retrievability concerns shown here, Dr. Smith has at this time studies under way to help us define an optimum waste emplacement configuration. The present design is based on storage and long horizontal holds. There are certainly options that we need to readdress to make sure that what we have is indeed an optimum emplacement method.

The development work that we plan to undertake at the near-surface test facility includes bore-hole constructability by at least two construction methods. We also plan to emplace and retrieve waste packages using -- on a cold basis using mocked-up equipment. The in situ data that will eventually support our retrievability concept includes construction of a bore hole in situ as part of the exploratory shaft Phase 2 program, emplacing a heater in that hole to assess the stability.

The present design, as indicated, is based on deferred backfill, and that is a concept we will need to examine in the next design phase.

MR. MOELLER: Perhaps you have said it, but will you want to have the potential for retrievability after you have backfilled or only up to the time of backfill?

MR. TURNER: Our concept was up to the time. We

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would go through the required retrievability period, backfill the canister holes and then not too long thereafter backfill the tunnels. Now, there are variations on that theme. You could conceivably backfill the canister bore holes immediately, in fact as soon as they are in place, and certainly not backfill the tunnels until the end of the retrievability period.

MR. PHILBRICK: So if you did backfill initially, how would you get the backfill out?

MR. TURNER: That could pose a significant problem, as that backfill that is blown in pneumatically -- we feel we are going to get relatively high density. One way you get that density is through impact velocity. You just about have to, I believe, over-core those canisters out of there. I don't think you can go in and grab them and pull hard enough.

MR. PHILBRICK: Then you come up from a 30-inch hole to a 36-inch hole or something like that with a casing boring machine.

MR. TURNER: That's a possibility. You do have some metallic components in that hole. You would have to allow for that.

MR. PHILBRICK: You have got to go around it.

MR. TURNER: Uh-huh. That is a far more complicated operation than going in there with the same equipment you used to emplace them and bring them back up. So that is really the decision you wrestle with, and unless you can see some

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decided advantages for initial backfilling, our conclusion was we should defer it.

MR. PHILBRICK: It looks like from what you have said and what I have seen in your drawing, that if you do backfill, you have lost the -- you have lost retrievability.

MR. TURNER: It certainly may not be readily retrievable.

MR. MOELLER: Even if you did bore it out, your shipping cask would not be able to carry the canister, would it?

MR. TURNER: No, you would have to have a redesigned transfer cask.

MR. MOELLER: And a redesigned mating to mate it to the end of the bore hole.

MR. TURNER: Oh, indeed. That could really get ugly.

The last concern I intended to address today regard in situ testing, and some of the concerns expressed there regarded our rationale for structuring the in situ test program and the fact that we really didn't do an adequate job on sensitivity studies to pin down the key parameters. We really didn't detail our first test plan very adequately. I think we are doing a better job now.

There were some key tests that we had not included before, and those include, for example, a mine test. Those

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certainly need to be included and they are included in our present test plan, and there was some concern regarding the priority that we assigned to some activities.

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The objectives of Phase 1 of the exploratory shaft test program are shown here. The first one addresses the principal bore hole which was constructed approximately 100 meters from the proposed exploratory shaft site. I will show a diagram of that in just a moment.

The second and third objectives regarded constructability of the shaft. The fourth objective addressed how we determine suitability of the candidate horizon prior to breakout, and then the fifth and sixth regarded the ability to actually construct the shaft station at the bottom of the exploratory shaft.

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This shows conceptually what Phase 1 of the exploratory shaft would consist of, a modest surface facility and a six-foot finished diameter shaft to approximately 3900 foot depth, with the required utility lines on the exterior of the shaft to minimize what we had inside since it was a relatively small shaft.

One thing I would like to point out is the fact that prior to breakout, we plan to construct or we plan to place test holes not only in the candidate horizon but above

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and below as necessary. So while we may not be able to log from a geophysical standpoint during shaft construction, having a principal bore hole within 100 meters of the shaft and having done a complete test during and following construction of that bore hole, and the fact that we will have core holes for geologic and hydrologic testing, not only in the shaft horizon but above and below -- we felt that we would have a pretty good basis for geologic and hydrologic characterization using this scheme. This addresses a question we had earlier. Probably no substitute for being able to view the entire wall of the hole all the way down, but we felt that was about the best compromise that we could reach as a balance between safety and acquisition of information.

MR. PHILBRICK: If you were taking that hole down on a drill and blast basis, how would you shore it?

MR. TURNER: If you were going to construct that conventionally, you would be either freezing or chemically grouting to control the aquifers.

MR. PHILBRICK: That's the only thing you are concerned about?

MR. TURNER: You could probably use cast-iron tubbing if you were constructing conventionally to provide ground support.

MR. PHILBRICK: Get down into the bedrock basalt.

MR. TURNER: I think once you are down into the

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basalt, I wouldn't be concerned about ground stability. I think we probably have a very stable situation. I would be concerned about water in-flow from, for example, the top of the flow.

MR. PHILBRICK: Top of all the flows?

MR. TURNER: Certainly some of those flows because certainly some of the aquifers, as has been indicated, are relatively prolific producers.

MR. PHILBRICK: Is that the way it is in the Cohassett and the Umtanum?

MR. TURNER: I am going to defer to Steve Baker.

MR. BAKER: In general the Cohassett is transmissive and the reference repository and the flow top is pretty tight. Both of those would be too prolific, though, to conventionally mine through without freezing.

MR. PHILBRICK: But I got beat last year this time in June on this business of how good was a small hole, and all the people sitting around the table wanted a big hole because they could see the rock and they could log in detail. You may not have been in this game last year, but now you come back with the idea that it is not necessary to log the big hole, and I reduce the area in which the logging should occur to be the zones which would be candidate repository zones. I don't understand how we get turned around inside of a year.

MR. TURNER: Well, on the next phase of this when

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we do breakout and construct tunnels, we will be able to map quite well at that point. But your point is in the horizon above there.

MR. PHILBRICK: That's too late. You want to know the stratigraphic character of the repository horizon. You want to know the structural character of the repository horizons before you pick them, before you commit yourself; and the only way to do that is to see just as much rock as you can see, and the only way to do that is to base your casing at the top of one of these aquifer situations, the bottom on the aquifer situations, pore a plug, set the casing in there, grout the outside of the casing until you are solid and then come on down, drilling open with a smaller diameter hole and logging as you get down to the point where you can log. I think you are cutting yourself out of fundamental information which is basic to the design of the repository, the location of it to the horizon and the understanding of what the problem will be with respect to roof conditions in the repository.

MR. TURNER: Would you be able to assess that from an open hole?

MR. PHILBRICK: I think so. You will get a lot more information than you will if you don't have an open hole because if you have a four-inch core or a three-inch core, you will get a very small sample. You do not get any

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inclined vertical joints determined by that hole unless you are extraordinarily lucky, whereas if you have a 12-foot diameter shaft and you have a spacing of joints on the order of 3 feet, you have got a chance for four joints.

MR. TURNER: I think we will have a little better chance of catching joints. Now, we cannot incline these holes. In fact, that will be done. Some of these holes are inclined. This is not a very adequate diagram, I must admit.

MR. PHILBRICK: No, but you are saying you will put in inclined or angled holes to catch the vertical fractures or whatever they are.

MR. TURNER: Yes, because we have a fracture frequency, that is -- what would you guess, on average, right now, Sue? Two or three a foot?

MS. PRICE: I would have to look at those figures.

MR. TURNER: I had the perception that our joint frequency we expected down there was enough that we would catch those adequately with core holes if we did a proper job of angling.

MR. PHILBRICK: But that would still be a few core holes versus the circumference of the 12-foot hole.

MR. TURNER: That's a hard point to argue. It's an interesting concept. It has been discussed and argued and discussed again before.

MR. PHILBRICK: Now, you spoke of safety. You would

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not be unsafe if you cement your casing in, pour a plug and then go through the plug. If you find troubles as you go down, you lose your water, you lose the fluid, you grout that off and then go on down some more and work your way through. This is not a piece of stuff that can be done on a quick basis. This is just as much exploration in the process of drilling it as there is going out laterally, and I think you ought to be prepared to pay for it.

MR. TURNER: I think it's a good suggestion. I don't know how to respond other than to say we will certainly take note and consider that proposal because it's a good one. I can't argue with it.

MR. MOELLER: Don Orth.

MR. ORTH: When you are down there in the bottom in the final repository drilling your holes and starting to put in waste, do you expect to see any free water at that time?

MR. TURNER: I'm certain we will have some in-flow of water. We made an attempt to calculate that in the current conceptual design, and we provided pumping capacity and draining capabilities to handle water in-flow. But certainly since it is saturated medium, no matter how tight, you are going to get a greater or lesser amount of water in-flow.

MR. ORTH: Does that mean, then, when I have a bore hole or two full of spent fuel in a casement that hasn't been backfilled or anything else, it is sitting there in water?

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MR. TURNER: It could be if it were not for the fact the temperature -- let me back up. When you emplace waste in that bore hole, you build up a temperature of 100 degrees Centigrade in a relatively short period of time. We feel the water that will come into that hole probably will vent itself out.

MR. ORTH: Then also shortly thereafter I have good, heavy plugs on both ends for shielding for the people who are trying to work in those tunnels.

MR. TURNER: That is true,but we did not make a provision for a vent to vent any vapor that we did not vaporize.

MR. ORTH: That still classifies as a fairly wet environment.

MR. TURNER: Yes, but our feeling was what water we would see down there in the bore holes would be vaporized by decay heat, so we are trying to make provision for that.

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MR. ORTH: Whoever is looking at the canisters and packs I hope is considering this.

MR. TURNER: Dr. Smith will be glad to address that, I know.

(Laughter)

No, he will address that. We do show a vent hole here. It is a good point, no question about it. Good point.

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I thought what I would do is, based on the Phase 1 objectives, very briefly go through what we have based on a very recent meeting to restructure our exploratory shaft test plan agreed on regarding data, names and the appropriate test to meet each of these objectives.

Our first objective regards the principal bore hole, and I have shown here that that activity is complete since we have drilled the hole, we have completed the testing, and the date of report has just recently been released internally. So that objective has been met.

The second objective regards the shaft sinking constructability, and there is the information or the data we feel that we need to extrapolate our experience in this hole to a larger repository shaft, and there is the appropriate test that we plan to conduct.

I won't go through those one by one unless there is interest in a particular test.

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The third objective regards installation and successful grouting of the liner in place.

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The fourth objective regards the suitability of the candidate horizon for breakout, and we will conduct tests there to ensure through the portholes that the horizon is not

ar17joy141 only suitable but safe for the breakout operation.

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The fifth objective regards stability of the shaft station. There are the tests that we plan to conduct, and you will note that we do have over-coring test planned for stress measurement, and those will be augmented as need be by hydraulic fracturing tests, but this is our first in situ measurement of stress.

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The last objective in Phase 1 regards shaft station constructability. Here is our proposed test program, including extensive geological mapping by the breakout horizon.

Following completion of Phase 1, we will proceed with Phase 2 of the exploratory shaft. The objectives are shown on one screen, and a preconceptual design of the Phase 2 facility is shown over here. Here is the Phase 1 shaft. The facility itself consists of approximately 1000 feet of tunnel. We will conduct hydrology tests in this area. This is going to be reserved for a large-scale hydrology test. We will have three lateral bore holes extending roughly 500 feet in three directions.

We will conduct rock mechanics tests in this area, installing the required instrumentation to conduct a test of approximately 200 feet in this area here of a full-scale repository room.

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MR. PHILBRICK: What are you going to do about checking the roof?

MR. TURNER: Okay. One thing that we had planned to do throughout our construction here was emplace rock bolts, use load cells to monitor the performance of those rock bolts.

MR. PHILBRICK: Have you considered any core holes going vertically up to well above what the zone of disturbance would be?

MR. TURNER: I have seen proposals for core holes. They are not shown on here, but we will construct some core holes, if for nothing else, to install instruments. So we will have some vertical core holes.

MR. PHILBRICK: You don't know what your roof is like if you follow your scheme. If you break out, you break out at the roof line, so you never see the roof above the tunnel.

MR. TURNER: No, no. The breakout sequence is a little more complicated than that, where there is a minimum breakout, installation of instruments, and then that is enlarged.

MR. PHILBRICK: What will be the height of your rooms?

MR. TURNER: These are about 10 by 10 rooms.

MR. PHILBRICK: What is going to be the breakout height?

MR. TURNEP: About 20 feet before we are finished with the shaft station there.

MR. PHILBRICK: So then you will have 10 feet of visibility above the roof.

MR. TURNER: Approximately in that initial area. If that initial configuration proves to be stable based on further analysis.

MR. PHILBRICK: If you weren't going in like this, like so, and then go out --

MR. TURNER: No, no.

MR. PHILBRICK: You are coming out like this and going down at 10 feet, aren't you?

MR. TURNER: We haven't picked a final configuration. I really can't say because we have to conduct some more analyses on which openings we think will be stable.

MR. PHILBRICK: Are you going to assume, then, that your configuration of the breakout will be no wider than the rooms?

MR. TURNER: No, we had planned to have a shaft station there somewhat larger than the rooms. The initial breakout, and then the room is constructed off of that. So you could be up above the room, but we have just not settled on a final configuration for the excavation.

MR. PHILBRICK: What I'm concerned about is you find yourself in what looks like a good face, and you go

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through and the structures and the basalt have a tendency to pitch down somewhere, and you suddenly find that instead of having a solid basalt column overlying the roof, you have got a basalt column with some vertical and horizontal fractures in it, which is going to change the whole thing. That is why I think you ought to go along those rooms, the tunnels, at a reasonable distance every 50 or 100 feet and go up every 15 feet and see what you are dealing with, what you thought you saw when you made the breakout.

MR. TURNER: Could you do that from the working face by drilling upward at an angle?

MR. PHILBRICK: Oh, sure, sure. You can drill it up from the stuff that comes off the face.

MR. TURNER: So that way you would be able to look ahead before you went there as opposed to drilling through the ceiling.

MR. PHILBRICK: You can do that anyway as long as you go up there and see that the stuff is constant.

MR. TURNER: All right, good suggestion.

(Slide)

Okay. To very briefly cover data needs and tests for Phase 2, for geologic characterization there are planned data needs and tests; for the second objective on geomechanics characterization, there is a rock mechanics testing program; for the third objective on hydrologic characterization and

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then lastly, on tunnel constructibility, planned tests and data needs.

MR. PHILBRICK: When you take the samples of core, do you maintain the water content before they are tested?

MR. TURNER: We try to. Isn't that done now routinely?

MS. PRICE: (Nods affirmatively)

MR. TURNER: I think we will have a better opportunity down there but we will attempt to retain that.

Any other questions?

MR. MOELLER: Yes. George?

MR. THOMPSON: You measured the tectonic stresses. How far below the rock failure are they?

MR. TURNER: Right now computed stresses are approximately 25, 27 ksi. We have a uniaxial compressive strength, at least for purposes of the conceptual design, of 30 ksi. So they are not very far below uniaxial compressive strength.

MR. THOMPSON: Your compressive strength is without confinement?

MR. TURNER: That is unconfined compressive strength. We feel the linear elastic analysis tends to overstate the stresses. We really at this time do not have an adequate rock failure criteria, As indicated, this is one of our development efforts.

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MR. THOMPSON: That would be an effective stress too with water pressure.

MR. TURNER: Indeed.

MR. MOELLER: Any other questions? Well, thank you very much for another stimulating presentation.

We have one more presentation, by Dr. Smith, which is the last one scheduled for the day.

Would you like a ten-minute break before we start? Let's take ten minutes.

END 17

(Recess)

MR. MOELLER: The meeting will resume.

Let me offer just a couple of comments. The agenda shows this is the last presentation, the one by Dr. Michael Smith, and then it shows discussion by the subcommittee. I think we will probably forgo the discussion this evening because it is a little bit out of cycle for us to discuss today's presentation without having heard tomorrow's.

So tomorrow we will break up the meeting -- we will break up the meeting after the next presentation, which we hope to have finished about 6:00 p.m., and then tomorrow we will hear from NRC. And I am hoping tomorrow we can run things along so that when they have finished, we will then call upon DOE for at least half an hour or so -- rebuttal is not the right word -- but to have an opportunity to comment on anything you feel that you want to comment on that NRC has said. And certainly, the subcommittee would want that type of an interchange anyway.

So, Dr. Smith, the floor is yours. The topic is the waste package and geochemistry.

(Slide)

MR. SMITH: I am manager of the Waste Package Department for Rockwell and the BWIP project. This function is a little unusual in that not only is it destined to produce the designs and specifications for designs for

waste packages, it also has the responsibility for materials testing associated with those objects used in the package design and also is responsible for assessing and evaluating the very near-field geochemistry, the environment that the package would expect to usually see.

(Slide)

The presentation I am going to make to you will begin with the program objectives I just explained to you and then move into a generalized list of concerns that have been expressed about this particular area of the program.

This list of concerns I am going to show you is a generalized list. It is a composite of the kinds of concerns that have been expressed by DOE overview committees at the DOE-RL level, the NWTS overview committee who reviewed in particular the materials testing aspects and those comments of the NRC.

I will then move along to discussion of the program and the concerns expressed and I will cover the topics that are listed here, some more than others, but at least we will touch on those topics.

(Slide)

First, the list of concerns that have been expressed in this area of the program. And I follow the same general format as the previous speakers.

First of all, there has always been a general

concern expressed that we develop a program in this particular area that encompasses both laboratory and field tests and that those tests be quite comprehensive, since a good deal of the objective of the containment life and the release rate criterion for the waste package is dependent upon the evaluation of data from both the laboratory and the field.

There is concern that we fully evaluate the stability and transport characteristics of backfill materials that we're using. People have questions about stability of bentonite in the presence of the heat conditions that we expect to subject this package design to.

They are also concerned that we look at in particular the long-term corrosion behavior of the cannister, the container material that is supplied by the manufacturer, and in the case of spent fuel cladding that surrounds the material itself.

And they are concerned that we make this evaluation in the radiation field and that we evaluate the possibility of not only uniform pitting attack but stress corrosion cracking as well.

In the evaluation of data they believe we should evaluate the data we are getting from the laboratory and the field and combine it with whatever information we can

get about components that we expect to use in the waste package to include an overall comprehensive evaluation of how well we expect that design to work.

There has been concern expressed -- and you have echoed some of that concern already -- surrounding the use of long-holed storage, and there is concern that we evaluate alternative designs for these packages prior to making a commitment to the final storage that would be used in the repository.

Finally, there has been expression of concern that we evaluate and establish quite early in the program at least objectives for reliability of the waste package itself.

(Slide)

Continuing with this list, the representativeness of the data. There is concern that we not base our estimates of the transport characteristics of the site on simple KD values or sorption characteristics but rather than we use sorption isotherms and test them for reversibility of the sorption processes and that we use these kinds of information to define the transport characteristics.

They are concerned that since we are relying so much on solubility testing that we include the effects of radiation potential speciation of components in groundwater

and the evaluation of colloid formation.

In the area that you could characterize as credibility of the program there has been expressed the concern that we confirm our solubility estimates by experimental data. And certainly we intend to do this. But all of our estimates of releases from the waste package itself, estimates of solubility limits in the site, have either been referred from some existing experimental evidence or from thermodynamic data compilations that exist in the literature and they are evaluated in the literature.

One of the features of this system that lies ahead of us is a good deal of experiments in this area. The last area then -- and everyone I think has expressed this concern -- that we be sure to determine the effect of barrier components that we put into the waste package on the release rate that that package has as the materials that are released from the waste form transgress barriers. Each of those barrier components in some cases has a drastic effect on the release rate from the waste package itself.

(Slide)

In the interest of time, I will just put this up to show you that we have within the program a method of evaluating each of the issues that are outlined for you on the previous viewgraphs.

Using one as an example, the concern over backfill stability and transport, we are addressing that in terms of the sorption properties, what the backfill material might bring to the materials released, and then evaluating the backfill component testing area, the physical properties of the backfill. And, of course, the stability of the material itself would be evaluated in the waste barrier rock interactions.

We simply then cannot rely on laboratory data but would use field tests of both proof tests of the performance of the backfill for as long as we can observe it and combine that with engineering data. That engineering data, along with what we observe in the laboratory to make final selections of dimensions and other physical properties of the backfill component.

(Slide)

Now, where we are with respect to the concerns that have been addressed is we have at this point in the program completed conceptual designs for the waste program, packages for spent fuel commercial high-level waste and defense high-level waste.

We have just completed a barrier materials test plan that describes the testing necessary to evaluate the components we are going to put in the waste packages and other barriers in the repository.

This particular test plan is now in the review-and-approval cycle. We have made preliminary estimates of the expected performance we intend to see from this waste package. And I will touch on that later.

And work that we have in progress now is we do have a full-scale engineering test, as Dave Turner mentioned to you earlier, of the ability to backfill these. We are doing that.

We are in the process of starting up the testing program and looking at material interactions with fully radioactive waste forms. That testing effort is jointly carried out as kind of a team effort by three Hanford contractors: ourselves, Pacific Northwest Laboratories, and Westinghouse Hanford Corporation. So we have kind of a three-cornered program.

We have just begun the measurement of backfill physical properties under the expected conditions. We have some data I will show you for hydraulic materials, and we are in the process of collecting some detailed characteristics.

We have initiated radiation corrosion testing and slow strain and crack growth testing on cannister materials. We have just begun the determination of solubility for key radionuclides. We are scheduled by June of this year to complete waste acceptance criteria for

defense, commercial spent fuel, and perhaps TRU waste for this particular repository.

And by the end of this fiscal year we are aiming to collect a sufficient quantity of materials data and additional information from the engineering program to allow us to proceed with the conceptual design upgrade beginning in October of this fiscal year. That would precede the conceptual design upgrading of the repository by approximately one year.

MR. MOELLER: On the solubility determinations, is this on a simulated waste, meaning the waste form under pressures and temperatures?

MR. SMITH: There are two ways that data is being collected. One is from a hydrothermal test in which we interact the waste form groundwater in either -- the components -- either together or in sequence. Those tests get you the steady-state concentration limits -- and I will touch on this later -- or solubility in some cases for the materials under the conditions we expect to see in the repository at that temperature and that pressure that we expect to see.

They are done in inner vessels and under conditions where you can sample the flow periodically as the test proceeds.

MR. MOELLER: And this is to simulate it where

the cannister has failed and it is reaching the waste form?

MR. SMITH: Yes. One of the things to be careful of when you do that kind of testing is not putting too many components in the system at the beginning because the reactions are so complicated you can never unravel the puzzle. So we have chosen to do that sequentially.

MR. MOELLER: Thank you. It is that with actually radioactive material?

MR. SMITH: We have done that with simulated materials containing only uranium as the radioactive component because of the expensiveness of that kind of testing.

We have just started a series of tests where fully radioactive testing will begin in October.

MR. MOELLER: Thank you.

(Slide)

MR. SMITH: What can we conclude from what we have seen is concerns expressed by others and what I have told you so far? First of all, we conclude that we agree with the concerns in the requirements that the NRC has expressed in the site characterization analysis with respect to both the waste package and geochemistry program.

We feel that we have a program in progress to address NRC's concerns and the concerns expressed by others. We are at this time evaluating alternatives to this

long-hole storage concept waste package that is in progress and the conceptual update of the studies in progress.

As I mentioned earlier, we have a full-scale backfill replacement development test in progress. And I will touch on that in a few minutes.

(Slide)

The first topic I would like to cover will be the materials testing that we are doing in this particular time. The sorption data that is being collected for the site is collected in this particular area. We will touch on first what we have and more recent information on the corrosion characteristics of the cannister, what we know about the backfill at this point in time.

We are evaluating the stability of this material and this material through the barriers program and the effects in the waste barrier. And we are also carrying out sorption measurements for several years.

MR. PHILBRICK: When you talk about backfill, you are talking about backfill around the cannisters or about room backfill?

MR. SMITH: The waste package backfill, the material that builds that 6-inch annulus which Dave Turner showed you.

MR. PHILBRICK: Are you going to modify and check the various grain sizes?

MR. FOSTER: Yes, sir. At this point in time we are trying to avoid the selection of specific particle size, but rather trying to take materials that you get out of conventional crushing operation to see if that works first before we look at whether or not we have to segregate it.

MR. PHILBRICK: What size pipe did you figure to place it through?

MR. SMITH: I don't remember that. The final test is just being finalized now. if I remember correctly, that pipe is 2 inches ID, I believe.

Now, there is a number of pipe sizes and a number of nozzle configurations at the end of that pipe. They are being evaluated in a pretest prior to the evaluation.

MR. PHILBRICK: So it gets you anyway below 3 inches, which means you are going to have to prepare the material.

MR. SMITH: We don't believe that's the case.

MR. PHILBRICK: You think you are going to get material of the right size?

MR. SMITH: We have a consultant assisting Westinghouse who is carrying out this test who has extensive experience in backfilling, mining operations, pneumatically using bentonite. There are some pieces of

equipment that can be used to do this that can maintain a mixture that you would want. I suspect your concern is segregation of particle sizes.

MR. PHILBRICK: You are going to get this material out of the excavation for the placement run. Now, that material isn't going to be any maximum size 3 inches.

MR. SMITH: That's right. But the maximum size that we're looking at is a quarter-inch.

MR. PHILBRICK: So then you are going to have to process it, aren't you?

MR. SMITH: That material goes to the surface anyway.

(Slide)

MR. TURNER: The cannister materials testing. Let's see. We have just completed the conceptual design for the waste package and are on our way to developing the conceptual design upgrade. We have initiated, as I mentioned earlier, some slow strain testing of these materials under repository conditions with autoclaves. We have both short-term static and autoclave test of the corrosion properties of the material. And we have, as I mentioned earlier, initiated studies on the solid environment.

Eventually we will turn these tests into a little more sophisticated test and include the effect of

the backfill in the longer-term test, and we will evaluate that shorter-term test here. We expect to be doing radiation corrosion tests under repository-specific conditions with the backfill we intend to use.

Someone else expressed the concern earlier that we look at air/steam corrosion because we would have a period of time in the repository in which we will have a steam-saturated atmosphere at high temperature. And we are in the process of doing that now.

The first tests have just begun, and I have no results to report to you now, but they will be reported by the end of this year.

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The ranges of test parameters that are covered in this program are quite large. We are looking at temperatures that range from 50 to 300 degrees centigrade. Test durations that range from a few weeks up to 10 years. Eh over a range of values as low as -.45 that we expect to see in the repository. The range of pH that we have seen in autoclave tests that is exhibited by the host rock. Upon heating that range is actually a little less than 7 to a little less than 10, but we put the range 6 to 10 to be sure we covered it.

The effects of radiation, the variations of groundwater chemistry since these components are all

present in the groundwater system, looking at the effect of groundwater velocity, we feel that because of the slow velocities we will see around these packages in static tests, it should come close to mimicking what we see in the repository.

We are planning tests with flow velocities as high as 4 x 10 to the -4 meters per year to find out where that assumption breaks down and where we have a break point in the design process.

We are evaluating it also in material condition the effect of weldments, the heat-affected zone, surface condition of the model, whether or not heat treatment is required in heat-to-heat variation.

I mentioned earlier this will be done both in the presence or the absence of backfill, and we will look at this fiscal year, at least take a peek at what effects we might see from anaerobic bacterial corrosion, since that concern has been expressed by several people.

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On mechanical properties testing, we have slow strain rates to determine the effects of stress corrosion cracking, and we have static and cyclic crack growth. That program will not begin until next fiscal year. We do have some data out on the corrosion rates of ferrous alloys. This is some data taken in autoclave systems for ductile iron and low chrome steels combined with some carbon steel data that we have taken from short-term tests in our own laboratories.

A couple of striking things about these curves. One is that the early short-term tests tend to fall in line with what we have seen in the longer-term autoclave corrosion tests. And secondly, after a brief period of exposure in the presence of basalt, we see a fairly uniform corrosion surface and a uniform corrosion rate. So that our initial estimate was a requirement of about a quarter of an inch for a thousand years of penetration if generalized corrosion were the only mechanism for corrosion in the canister. The corrosion rate is not much different at 250 degrees once you get past this first few months of the canister life, not much different than it is at 150 degrees Centigrade.

MR. THOMPSON: What pressure were you involved in here?

MR. SMITH: These tests were run in a flow-through mode, the autoclave tests. There is a backpressure regulator on there. If my memory is correct, the backpressure was about

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a thousand pounds per square inch. The way these corrosion tests were done was in an autoclave system with a bed of basalt beneath the corrosion specimen. The specimen is hung in a tree and the fluid comes up through the basalt and goes over the corrosion specimen. There were U-bend specimens.

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The other comforting thing is that if we take the 250 degree corrosion data that I showed you in the previous Vu-graph and combine it with what other people have observed for the corrosion of ferrous alloys at this temperature in chloride-containing media, you can see that the data we are collecting does correlate fairly well with what other people have observed. So this gives us some feeling that at least the data we are collecting is in the right ballpark.

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I will move on, then, to backfill materials. We are in the process of doing some thermal conductivity testing of dried backfill material. We have experiments in process right now and we have done quite a bit on assessing the hydrothermal stability testing of backfill mixtures. Certainly before we got to the license application we went to look at the effects of flow-through and the effects of alteration of the backfill material on the intended functions.

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We have some hydraulic conductivity data for the

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mix that we expect to see as a function of density. These densities range and this data is set from 1.5 to 1.8. We expect in the pneumatic emplacement test to be able to achieve densities about 1.7.

I put as an example the hydraulic conductivity -- you take the bentonite out of this backfill and do the test over with basalt. You get a hydraulic conductivity of about 7.6×10^{-5}. So you have got almost three to four orders of magnitude difference between the hydraulic conductivity in this component just by adding 25 percent clay to the mix.

The last box is an estimate of what hydraulic conductivity we would have to have to maintain diffusion control of release of radioactive materials from the package. The calculated value says we have numbers less than 3×10^{-4}, and we certainly should be in the ballpark of being able to achieve control. Certainly we are at least four orders of magnitude below that.

MR. PHILBRICK: How did you achieve the density that you show?

MR. SMITH: These materials are pre-exposure -- that is pre-exposure densities -- and they are compacted to that density prior to the test.

MR. PHILBRICK: You know what you have got there, don't you? You have got a good earth dam. Those are the conductivities.

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MR. SMITH: When these tests are run, then, the specimens are placed in a triaxial cell and loaded so that you maintain the kind of density. We also have done this in periameters at 1500 pounds per square inch of pressure. The interesting thing is, if you have ever seen this, you can take about an inch of this material at 1.5 density, put 1500 pounds per square inch of pressure on one side of the membrane and atmospheric pressure on the other,and hardly anything comes out.

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There were a number of concerns expressed about the stability of bentonite but just simply if you heat it long enough, if you heat it high enough, you will get structural collapse of the clay itself and you will no longer have the swelling property which seems to be the magic ingredient which causes this component to exhibit those kinds of conductive activities.

We have got some preliminary data taken on one-year age samples. This is dry heated bentonite, heated for approximately one year and then tested for the swelling capability after that one year. The as-received material is shown in the middle, and you can see how it swells above the surface of the cup that it is put into. The 250-degree material after even 340 days and the 370-degree material is the same, but once you get above about 370 degrees Centigrade, you do get

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the structural collapse of the clay, and it certainly loses its swelling properties and the material behaves more like sand than it does clay.

We have done extensive electromicroscopy on this exposure. We have done X-ray defraction work on that material and we have done optical microscopy on it as well. Those results will be published soon, but they are basically below about 370 degrees there is just little or no alteration of the material whatever The literature concerning this component will tell you that you should see alteration at about 300 degrees Centigrade. It looks like we will be raising the temperature for that backfill component to 370 degrees Centigrade from the current 300.

(Slide)

In the hydrothermal testing area, our goal is to evaluate the impact of other barriers and the release rates from the waste package.

MR. MOELLER: Excuse me a second. Have you tested the bentonite with the crushed basalt?

MR. SMITH: In water?

MR. MOELLER: No, the combination in temperatures and so forth.

MR. SMITH: We have not tested the bentonite in the dry condition in the presence of basalt, but we have evaluated the stability of basalt in the presence of basalt

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and the bentonite with the basalt and bentonite together at 300 degrees Centigrade. We just don't see much alteration in the material at all.

MR. MOELLER: But at 400 you would?

MR. SMITH: We have not run temperatures above 300 because we don't expect to see anything near 300 degrees in the package.

MR. MOELLER: Oh, okay. Thank you.

MR. SMITH: As I mentioned, in this particular area we are putting together a hot cell facility and preparing fully radioactive waste form for testing under repository conditions. These initial conditions will be static release rate tests with fully radioactive waste, and we have in our possession now a flow-through autoclave system that will allow us to compare static release rates to release rates obtained in the package under flow-through condition.

The reason you want to do this is if you have a static test, you make it one set of minerals, and if you increase the flow rate, you may get another set of minerals and you may want to change that for purposes of design. And certainly the result of this laboratory evaluation is to do some confirmatory testing on an engineering scale.

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Now, before I get into this area, I want to talk a little bit about what we might think about our flow rates.

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This is a simulation of fluid movement. These are stream lines around a single waste package horizontally placed in basalt. The arrows represent thousand-year time markers, so these are stream lines with thousand-year time markers.

This is the backfill of the waste package, and inside of that is the canister and the disturbed rock zone around it. I think even a little distance away from the waste package, a few meters,that the time it takes for fluid to move even a meter is approximately a thousand or a few thousand years. This is only a snapshot in time, again, an evaluation made with one data set, and the uncertainty of that data set not taken into account but it is indicative of the kind of flow rates we would expect to see.

Another thing we would point out here is the condition of the time markers around the canister where the backfill is. I think you can see what the porosity of that backfill mix does for slowing the fluid. That black line represents a large number of these thousand-year time markers.

The point to make here, then, is not to be concerned about the exact value that that Vu-graph shows you, but to be remembering that we have very long periods of time for reactions between the waste form, the host rock and the waste package components to occur in this repository system.

As a result of that, we concentrate on t he solubility limits for the waste package and in the waste package itself.

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We feel at least if we don't establish a solubility limit, there will at least be some steady state limit here that will define the maximum concentration of materials that we should see in the waste packages.

The only question is, in doing your testing, how long does it take for this to occur? So far in what we have done it looks like you reach this plateau in a matter of months, and I will show you some data in a few months, even at temperatures as low as 90 degrees Centigrade. So the collection of leach rate data concentrating on this early buildup of the component in solution is really of not much importance to the particular design we have or to the repository situation. We are more interested in what happens after the system comes to steady state and after the components reach their maximum concentration in solution.

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Now, do they really look like that? Does it really work like that? This is some data we just collected for technetium doped borosilicate glass run at 200 degrees Centigrade in an autoclave system. The vessel these materials were in is a little bag of about 250 milliliters. The system is designed so that the sampling is accomplished through a titanium valve system in the top of the autoclave, so these sample concentrations that you see are periodically removed. The test was done just with the glass alone and in the presence

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of a mix of half basalt and half glass.

The thing I would like you to see first of all is the dramatic difference that basalt makes.

MR. MOELLER: When you say 50 percent glass and 50 percent basalt, you haven't crushed the glass?

MR. SMITH: Yes, these are crushed materials.

MR. MOELLER: Oh, okay.

MR. SMITH: Crushed glass and crushed basalt. We are trying to enhance the reaction as much as possible to get to that steady state concentration as quickly as possible so we can do more experiments rather than waiting a year for those reactions to occur.

The other thing is that I want you to remember the number of about 3×10^{-5} mols per liter because it will become important later. The data that we have now got, we have got some thousand-hour data that shows that this curve is still continuing and that this curve simply has leveled off at the plateau I talked to you about earlier.

I think that is about all that needs to be said.

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None of those data points your glass was fully dissolved.

MR. SMITH: Let's say this point right here after exposure of about a thousand hours represents 60 percent of the technitium. Basically, some of the materials are released slower than the rate of dissolution of the glass, and some are released a little bit faster. But basically, the dissolution of the materials mimics the appearance of silicate. So it's basically a matrix dissolution.

(Slide)

The next thing I would like to touch on is what we have made in the way of a preliminary, very simple comparison of how our waste packages might perform, again with the NRC requirement or the fractional release rate requirement. We are going to do this analysis in the presence and the absence of backfill.

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The assumptions that were made in doing this assessment is that we have 100-year-old spent fuel or commercial high-level waste that transport through the backfill, diffusion was controlled and all we were looking at was radial transport through a porous cylinder, and that we had neglected the effects of radionuclide decay because when you finally learned that the radionuclides that are of concern, they have one half-life and the decay process is

relatively important.

In the case of no backfill, we assume that the annulus around the waste package is filled with water. And again, this analysis was done assuming no waste form performance, trying to see what radionuclides we might need waste form performance for.

MR. MOELLER: When you say "no waste form performance," you mean no retention?

MR. SMITH: I mean the inventory of material inside the waste package at the age of 100 years out of the reactor that is released to the solution instantaneously to the solubility level as we predicted.

MR. MOELLER: No retention then in the waste form?

MR. SMITH: No. And again, we are trying to look at what the waste form needs to do.

(Slide)

Here is a result using the expected solubilities and the expected Kd values. If our estimates are correct, this backfill barrier by itself should be able to achieve a 10 to the -5 release rate with the exception of iodine-129. Again, we would expect to see some performance of the surrounding matrix. This is simply an indication of what contributionthis particular barrier might make to the system.

(Slide)

If our solubility estimates are not so good -- that is, if our estimates that we are using as reference values are not conservative enough -- and we employ some conservative numbers in the analysis -- I think you can see that it could change the picture quite dramatically. We could still in that case, if our estimates are wrong, meet requirements of the waste form for iodine and carbon-14 and perhaps tin.

I mentioned to you the concentration of technitium we saw inside the waste package in the particular test was 3 x 10 to the -5 mol and 300 degrees centigrade. This gives you an idea of how the data is coming in compared with the estimates that we made both conservatively and with expected values.

(Slide)

Now I will talk a little bit about the conceptual design and the functions of the waste package and what they are supposed to perform.

(Slide)

The functional requirements of the cannister component are similar to provide radionuclide containment during shipping, handling, and possibly retrieval and to provide containment for up to 1,000 years after emplacement of the waste package.

MR. MOELLER: Excuse me. Back on the two charts, the bar graphs, the thing that I don't follow is one is expected solubilities in Kds and one is conservative. And yet take I-129, if you look at the conservative versus teh expected, there is not all that much --

MR. SMITH: That's because the solubility is very high.

MR. MOELLER: Oh, okay.

MR. SMITH: Essentially, you release all the material.

MR. MOELLER: I see. That's why we just don't see -- okay.

MR. SMITH: And its absorptive properties, its ability to absorb in the back of the component itself, is minimal as it is on any geologic material.

MR. MOELLER: And here we have to realize -- there is a lot of difference. There is a factor of 10 for each unit.

MR. SMITH: I think it also shows you the value of the backfill components.

MR. STEINDLER: One other point there. The difference between the expected and conservative, the differences in Kds and solubilities are directly proportional to what is released, so you have a difference between those two and log release of 10 to the 3. That

means that built into that is a 10 to the 3 difference in Kds.

MR. SMITH: Yes, the expected values of Kd were the lowest observed experimental value that we had divided by 2, and the conservative number was the highest value observed experimentally divided by 5 with solubilities were either an observed experimental value or estimated value of thermodynamic data. The best of our ability to estimate the conservative values were a conservative estimate of the thermodynamic data are the highest observed experimental solubility.

Some of those were indirect observations multiplied by 10. So in some cases, when you look at that result, some of the differences are due to the solubility differences, some due to absorption, and some due to both.

So, yes, you are right, it's about 10 to 3 range.

(Slide)

The functional requirements in the backfill component are a little more difficult to picture and one which I suppose we haven't explained very well because there seemed to be a lot of question about this function.

First of all, the first function that we are trying to achieve with this backfill is to minimize cannister corrosion during the containment period. And the

way we intend to backfill the component and to assist in that is still a water contact with the cannister for as long as possible and then to minimize the rate of flow of groundwater past the cannister.

And I think you can see the dramatic effect it has on the flow rate and next to buffer oxygen content near the cannister, since we have some experimental data that shows tha the salt can very rapidly consume oxygen. And of course, if we had significant quantities of oxygen approaching the cannister at these temperatures, we certainly wouldn't be using carbon steel.

Also, we want to localize the corrosion products of the backfill cannister interface to minimize the effects. If you look at the corrosion chart I showed you earlier, which begins at a fairly high clip and goes off to a low value, that's due to the buildup of a corrosion product at the surface of the metal. And if you were to lose that periodically, you would have a heck of a time extrapolating the behavior of that cannister for a thousand years.

Again this doesn't guarantee that there won't be differences in stresses between the materials that are corrosion products and the cannister surface itself that cause some separating of the surface, but that's something we have to evaluate.

At least this is a way of minimizing that kind of problem and increasing your reliability. Once the cannister is breached, one of the things to do is for the cannister component to reduce radionuclide release rate.

Another function that we are still looking at that looks to be quite an interesting one is preventing radionuclide transport to the host rock in the event this containment fails prematurely.

So while we may never be able to establish an undeniable 100 percent reliability for this container and we can't prove that the transport waste characteristics of the backfill are 100 percent sure, perhaps together these two components in series will give us enough reliability that that containment requirement is met.

(Slide)

Now, the things that we considered in developing this design is we felt that retrievability from this repository should be fairly simple because we would not expect the repository to resaturate for a fairly long period of time, perhaps as long as 300 years.

So there is some probability that this system won't resaturate until after the operation of the repository. We do have to design the cannister for hydrostatic pressure that we expect to be exerted on it at about 1,645 psi. It's rounded off to 1,700 pounds per

square inch for a thousand years.

The corrosion data I showed you earlier showed tha reducing conditions permit use of carbon steel and that a half-inch corrosion allowance would be more than generous for the cannister corrosion.

We have some corrosion data for carbon steel that I showed you on the earlier viewgraph that would about double in the presence of radiation if the preliminary data we have is correct. And in the design that we finally developed, the designer chose to incorporate a 1-inch corrosion allowance for a little more safety factor.

We included crushed basalt because of the ability to control Eh and to consume oxygen, especially under these high-temperature conditions and since it could control Eh its ability to limit the solubility of radionuclides, especially those that exist in the oxidation state.

And we set a backfill temperature limit of 300 degrees on the basis of literature data, although the experiments we had done, as I mentioned earlier, in the presence of basalt groundwater showed little alteration. We were unable to determine whether the -- we could not determine whether there was any more there at the end of this test than what was in the original material that we started with.

We knew that because we had this 2-to-1 horizontal-to-vertical stress ratio, that horizontal emplacement of packages must be possible, and we knew it was advantageous to keep the borehole diameter less than about 3 feet because information indicated that above that diameter we might have to do a little development work in the drilling process.

And we knew that as long as we were using backfilling from our preliminary studies that rock stress was really going to be the thing that determined spacing of these cannisters. And actually, even though we established these temperaure limits, we never came anywhere near exceeding them.

(Slide)

The final design or the final version of the conceptual design that we came up with was what Dave showed you. Waste packages are placed in the site walls of the placement tunnels and long boreholes opposing each other. A number of packages in each borehole.

(Slide)

The design then -- I am just showing you a cartoon here -- was to use the 75 percent, 25 percent bentonite backfill mix, 6 inches of the material in the annulus between the carbon steel cannister and the borehole wall.

I think in the interest of time, Dave covered this pretty well.

EVENING SESSION

(6:00 P.M.)

MR. MOELLER: We talked about the fact that moisure would be there and that you would generate steam, and you just showed us, though, that you thought it would be 300 years before --

MR. SMITH: Before we would establish a liquid phase.

MR. MOELLER: Oh, okay. And you talked about backfill, and we talked about retrievability. What I am driving at is in terms of the integrity and the long life of the cannister. Do we want to backfill immediately? Forgetting retrievability, are you smarter to backfill as soon as possible?

MR. SMITH: I don't believe so, and I will tell you why. Certainly, this borehole is closed in a sense, and you would expect that borehole to fill with steam and displace any air that is in there.

MR. MOELLER: Correct.

MR. SMITH: So the corrosion of that container in a steam environment should be very small. So we really don't expect that to be difficult. People postulate one of the things you should worry about is drips. The water can drip down on the cannister and accumulate carbonate and see stress corrosion cracking because of that.

I think it would be pretty hard to establish a liquid phase at one atmospheric pressure.

MR. MOELLER: That's another question. You were going to have a seal at the end of the borehole, and you were going to have a steam vent, but you are still going -- you are not going to try to pressurize the borehole?

MR. SMITH: No, I am not. I think it's important to realize how much water will come into this borehole. If you couple the thermal driving forces here, we're talking about maximum amounts of material on the order of a few liters per year per waste package of water. So we're not talking about gushers; a very small amount.

MR. MOELLER: Okay. Thank you.

MR. STEINDLER: In the SCR I think you showed the saturation times as 3,000 years. Is your 300-year number now a new value?

MR. SMITH: I think that's a revision to that estimate. That number that says up to 300 years could be a short as 50 years, 3 years, and as long as 3,000. I think 300 is probably a safer estimate and probably more nearly a reality.

MR. STEINDLER: Have you looked at the reaction of bentonite with steam at 200 or 250 or 300?

MR. SMITH: Not yet, but we will do that.

We have some corrosion test which is the

backfill component in essentially titanium. Those are done at steam pressures, of course, and we don't see any difference in the behavior of the material there and what we saw in the one that maintained a fluid base.

Now, what temperatures do we expect to see? I just picked one as an example. This is the highest heat package.

(Slide)

Assuming backfilling in 50 years. Concentrate on the solid lines. We're talking about a centerline temperature that appears very early in the repository's life of 307 degrees centigrade, maximum temperature about 250 degrees centigrade, and the storage wall surface would be at peak temperature of 235 degrees.

Thinking about what design life you might want for the container, you can see that you maintain temperatures above 100 degrees for about 450 years. So if you found some advantage to keeping the waste form protected, this might indicate to you how you would achieve a design life.

If we were to go in and immediately backfill these waste packages, you would see a peak temperature for a very brief period of time of about 317 degrees at the backfill interior surface. If we wanted to lower that number, we would put the packages farther apart. But even

at 317 degrees, we don't see any real problems with doing this.

(Slide)

MR. MOELLER: Pardon me. To help me on the temperatures, are you saying that the temperature would be lower if you don't backfill?

MR. SMITH: If you delay the backfilling -- you've got a lot of heat to radiate.

MR. MOELLER: Okay. Fine. Thank you.

(Slide)

MR. SMITH: Now, several people have expressed concern over the use of this long-hole storage concept. Certainly, if you found that you had to backfill that long-hole tunnel immediately or you learned something in the materials development process that caused you to do that, you would want to go back and reassess the utility of that design.

And that's one of the reasons for our looking for alternatives to that design. We arrived at that design by minimizing rock extraction from the repository. The total cost savings for doing that -- that is, going from long-hole storage packages to single off-tunnel placements -- is about $21 million for all the packages in place.

After we saw that number and thought about what we were doing, we thought we'd pay a pretty dear price. And

$21 million isn't much savings to give away some of the feasibility we're giving away, because now we're looking down a long borehole that you can't get your hands on the package anymore, and that certainly complicates and brings about questions about how certain it is you can achieve it.

(Slide)

So we are looking really at six different basic types of alternates to that concept. I will just mention one to you here. This one is in-tunnel placement of the packages. It eliminates the need for a large number of these large tunnels in the repository. You only need a large tunnel because you are bringing a long waste package down a corridor.

What we would look at is perhaps tunnels 7 or 8 feet in diameter off this main access tunnel in this particular concept. We would backfill these packages as we go.

That is a containment pipe right there. We would use a carbon-steel pipe system to emplace the packages, simply slide them into this one at a time. We sought to work out how many packages you could put in before you run into trouble, but this does use the storage tunnel backfill as part of the engineered system and is something that can assist you in achieving your release rate criterion.

Secondly, it does have the advantage that by

using a pipe you now have removed the responbility for developing a container cannister upstairs. You can simply bring this pipe downstairs, weld it, inspect it, and then begin placing packages.

And the preliminary work that was done on this shows we shouldn't run into any temperature extremes in the packages. What we are doing now is evaluating waht effect these packages have on rock stresses. This is just one of a number of concepts we are considering before we go to the conceptual upgrade.

(Slide)

The last topic -- and I will try to be brief on this -- this filled an engineering testing program that we have.

(Slide)

We have outlined five failed engineering or combination tests that we feel are necessary for us to test to confirm, as I mentioned, that the backfill mixture can be emplaced in boreholes or tunnels.

Here we are looking for what packing density can be achieved, what rates of withdrawal. And secondly, we are looking at confirming the performance of the backfill to verify the resaturation rates of the backfill. In temperature profiles that we have predicted from models and from what we have seen in the laboratory, what kinds of

water concentrations we see as a function of time.

Certainly, we are looking at here again on an engineering scale the effect of discussing what might be applied to the container. There is a waste pacakge emplacement retrieval test which is actually being carried out by the repository. Again, this is a method and technique developed in the process.

(Slide)

We also have a long-term material degradation test plan, and we are in the process of doing that planning right now.

Here we were looking for confirmation of our laboratory data on the degradation rate of the cannister and the backfill on an internally heated vessel. At the end of this test we wanted to look at the properties of the backfill after being subjected to the conditions that would be carried out in this test.

There is also a radionuclide migration test carried out by the Siting Department to validate the predictions we make for the sorption and solubility behavior in basalt.

I want to verify that the data we are collecting in the laboratory mimics what we have seen in the field. There is a question about measuring Eh in situ. We certainly recognize that in situ measuring techniques

people commonly use just doesn't work in the system, and there is a lot of data in the literature that indicates that. We refer you to papers by Stern and Morgan that say that.

So we do have a program that goes along with this engineering development phase to look at alternate techniques of measuring Eh in situ.

We also have developed probes that can be used in autoclaves at temperatures and pressures that measure both pH and Eh directly. So we will not be extrapolating that data, but rather will be collecting data under conditions that we can measure.

MR. ORTH: Question.

MR. MOELLER: Don Orth.

MR. ORTH: With respect to the groundwater compositions -- and I am going back to some questions earlier today -- have you decided on any sources for things like carbonates specifically?

MR. SMITH: Sources? What kind of concentrations we see?

MR. ORTH: I know what it is, but why is it there in those concentrations? You are aware, of course, that NRC has raised carbonate as being a major thing that could interfere with the calculations you provided on transport times. So where did it come from?

MR. SMITH: It's basically from me -- we are near carbonate saturation from our calculations in the system.

MR. ORTH: Well, then are there carbonates scattered through the basalt in the various sediments and minerals in fractures?

MR. SMITH: Yes, there are. I have not seen any experimental evidence to date, and that evidence extends to plutonium, neptunium, and uranium. We really don't see any strange behavior. We have not seen the solubilities orders of magnitude bigger than what we predicted.

The carbon concentrations that we see at even 300 degrees centigrade are not much different than what we see at the ambient temperature. So we are very near saturation.

MR. ORTH: In your test program for radionuclides, will you have things like carbon-14?

MR. SMITH: Yes. We are doing a test right now looking at how carbon-14 partitions in the absorption and solubility testing. We will have against that field tests that incorporate carbon-14, and we will be very interested in the behavior of that material.

Somebody asked the question before, why didn't Bob include the isotopic exchange of carbon? We simply did not have any data for that and we didn't include it in the analysis.

MR. ORTH: It's just that the common phenomenon of chemical exchange -- if I have got carbonate solution and I have an insoluble carbonate on the ground, it is always going to be because of the solubility relation, some exchange.

So there is retardation without the phenomenon of absorption in the classic sense.

MR. SMITH: Dissolution and reprecipitation.

MR. ORTH: This is used to get retardation of things that are otherwise unabsorbable.

MR. STEINDLER: Have you been able to run any analyses for the content of your groundwater?

MR. SMITH: Generally, the organic content is generally less than 1 part per million.

MR. STEINDLER: That's as far down as you can see?

MR. SMITH: No, we can go to parts per billion.

MR. STEINDLER: The solubility limits of some of the hydroxides that you folks postulate, 1 part per million organic carbon could give you a significant difference in transport.

MR. SMITH: If you had that, if you even calculated that as EDTA, you wouldn't form much of a complex at the concentration we're talking about. The formation process simply can't be large enough to cause a

significant problem. If you do that calculation, you will find it's off by about 6 to 10 orders of magnitude.

MR. AXTMANN: I have discovered either a heroic experiment you are proposing or a misprint in the handouts. The test parameters for the cannister include variation of groundwater velocities from static to 4 x 10 to the -4 meters per year maximum, which I come out, if my arithmetic is right, to a tenth of an angstrom per second, which something like vector flow would greatly exceed that.

I am just wondering first how you do that?

MR. SMITH: The flow velocities you can achieve experimentally are basically, as you point out, the biggest experimental hurdle to overcome. Pumps that are available pump on the order of, if I remember the numbers correctly, about a tenth of a mil per hour. The way you achieve that is periodically turn the pump on so that you slow the flow rate down significantly. There is a backpressure regulator on the system for vent flow.

So you can get down to very low experimentally observed flow rates, and once you get down to the point where you can't make the flow rate slow down anymore, then you are simply going to have to extrapolate between what you can achieve experimentally and down to static conditions.

MR. AXTMANN: What I am suggesting is if you

could get down to that, you would long since have been swamped out by molecular motions.

MR. SMITH: That's correct, and the diffusion as well.

(Slide)

Just a word about this process development test. It's going to be carried out. This is a simulated borehole that the material will be blown into. Having observation windows that we can observe the packing densities that are being achieved. There are three cannisters in this borehole.

(Slide)

The simulated borehole then is connected to a 200-foot long pipe. The backfill feedpipe to simulate the 200-foot long borehole that we would have to do the replacement in. We withdraw the pipe as we do the backfilling. There are a couple of transformers on the system to make sure that we don't have a problem to boost the material up the corners.

It would be very interesting to see the results of these tests. The preliminary estimates that we have from the designer is that there is a very high probability that we should achieve this.

That is about all I have to say. Are there any questions?

MR. MOELLER: Yes. Don Orth and then Dick Foster.

MR. ORTH: I guess I am asking the question a little bit outside of what you have covered here, but again there was that question on the solubilities in theoretical and thermodynamic solubilities versus the real world and that sort of thing.

Are you going to rely for rebuttal on high solubilities in rapid transport for the field tests or the flow tests, or are you going to go back and try to redo thermodynamics and theoretical calculations?

MR. SMITH: Part of the sorption testing method involves the use of flowthrough testing apparatus. In fact, the apparatus we have is designed as a modification of the one that Marty and other people used at Argon.

We would be looking to confirm the behavior under those flow conditions. So what we would do would be comparing the experimental evidence that we had to what we have observed in the field. That is, you do see Ehs that we expect to see that rock is capable of controlling

solubility that we observed in the laboratory. Certainly we want to supplement that with thermodynamic calculations, Eh/pH diagrams and solubility calculations.

They are simply additional evidence to affirm the correlation between experimental evidence and what we see in the field.

MR. ORTH: The reason I asked the question the way I did was, having been involved in solubility work and sometimes in literature reviews and things like that, I don't trust much of the historical literature, simply because the calculation, for example, of a solubility product depends upon what you postulated you were dissolving and if you did not define the reactions right, you don't come out with the right answers.

So that comes down to the question of what are you going to believe? The flow test? And to what extent do you really go all out to spend your calculations? At some point in time somebody will always challenge your test that it isn't consistent with the model. So you are going to have to make some decisions as to what you are going to lean on. It helps early on if you already at least decided which way you are going to go.

MR. SMITH: First you have to make a decision on the availability of money to accomplish this, and I think if you look at a brute-force technique, which is simply,

let's learn what all the phases are, let's learn what effect all the groundwater parameters have on all the phases, then let's see if we can synthesize that and observe that.

I don't think there is enough money in my budget or NRC's budget to accomplish that. It's simply not feasible within the time frame we have available, nor is it feasible to do with the monetary situation that exists.

What you can do, however, is what we have been trained to do. I think maybe it's a reasonable compromise. We are looking at deviations from sorption isotherms where the sorption isotherm turns up and you see precipitation processes occurring, using that to estimate the solubilities.

We then are attempting to identify the solid phases that can cause that solubility to exist to the best of our ability. In some cases, I am sure we will be able to identify the phases. In other cases, they are very complex materials that we may never identify. And I think we will just have to ride the storm here to determine which piece of information come out on the other side.

MR. MOELLER: Dick Foster.

MR. FOSTER: After you turn the ventilation off and get this thing loaded up, is radiolytic decomposition of water molecules going to cause any problems?

MR. SMITH: That is a potential problem. We have not done any evaluation of the radiation effects on basalt groundwater. I think in particular we would be more concerned about the production of oxidants -- peroxide, chlorine oxides, chlorine -- from the components in the groundwater.

All I could tell you now from the information we have available is that in the autoclave corrosion tests and in the radiation pit you really don't see a terrific enhancement of the corrosion process.

If I could hazard a guess -- it would be something close to idle speculation -- maybe I would say that once we surround that corrosion specimen with basalt, that we will see much less of an effect than we have already seen. When we ran that experiment the basalt was separated from the corrosion specimen.

So there could be some serious groundwater irradiation effects that we have not evaluated, but it doesn't look like it's too serious a problem, at least from the indirect evidence that we do have.

The potential exists. I wouldn't want to stand here and tell you it doesn't, because I have no data other than that one indication to support that.

MR. MOELLER: Marty.

MR. STEINDLER: Is the amount of basalt in the

backfill sufficient in chemical reducing power to reduce all of the actinites to their loweest states in the event that they are born?

MR. SMITH: By remaining orders of magnitude, yes.

MR. MOELLER: Okay, I have a question which maybe I should ask of Larry, and if there is a short answer for it. In the report it said that you used dominant analysis or dominance analysis to decide on your site? Could you in a sentence or two tell me what that is?

MR. FITCH: I can't, but Sue Price is the one who can, the young lady who wrote Chapter 2.

MS. PRICE: That was a study that was done by Woodward Clyde. And it's a decision analysis technique. I can't go into detail.

MR. MOELLER: I just want to know roughly.

MS. PRICE: What it basically boils out to, it's a weighted documented decision process, and Woodward Clyde in a sense is the facilitator for this process. The selection process for the candidate repository. There was a committee made up of geologists and other people from the staff as well as some people from out in the area, 200 east and 200 west, that were familiar with the facilities.

We had the criteria that we evaluated, the ranking criteria. We went through the process of weighting

this criteria one against the other. As part of this, Woodward Clyde went through and assessed the opinions around the table one against another, a continual sort of a trade-off criteria against the other, and through this process came up with a dominance analysis as part of a mathematical expression.

Basically, it's a way just to sort of track the decision process and put some kind of quantitative evaluation of that process.

MR. MOELLER: Okay. Thanks.

And thank you, Dr. Smith.

Do the DOE people have any final comments for the day?

All right, I think even in view of the fact it's only 3:25 in Richland, we are still going to recess for the evening. Let the record show that we recessed at 3:26 Hanford time.

(Whereupon, at 6:26, the Subcommittee was recessed, to reconvene at 8:30 a.m., Friday, April 22, 1983.)

CERTIFICATE OF PROCEEDINGS

This is to certify that the attached proceedings before the NRC COMMISSION

In the matter of: ACRS SUBCOMMITTEE ON WASTE MANAGEMENT

Date of Proceeding: Thursday, April 21, 1983

Place of Proceeding: Washington, D.C.

were held as herein appears, and that this is the original transcript for the file of the Commission.

ANN RILEY
Official Reporter - Typed

Ann Riley
Official Reporter - Signature

AGENDA

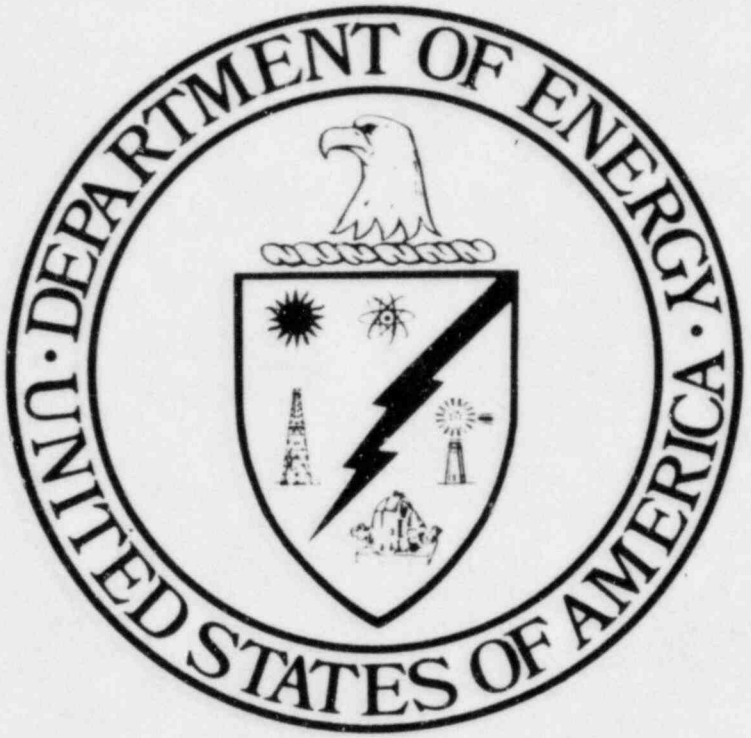
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS (ACRS)
SUBCOMMITTEE ON WASTE MANAGEMENT PROGRAM

H STREET, WASHINGTON, DC
THURSDAY, APRIL 21, 1983

BASALT WASTE ISOLATION PROJECT (BWIP)
SITE CHARACTERIZATION REPORT (SCR)

THURSDAY, APRIL 21, 1983

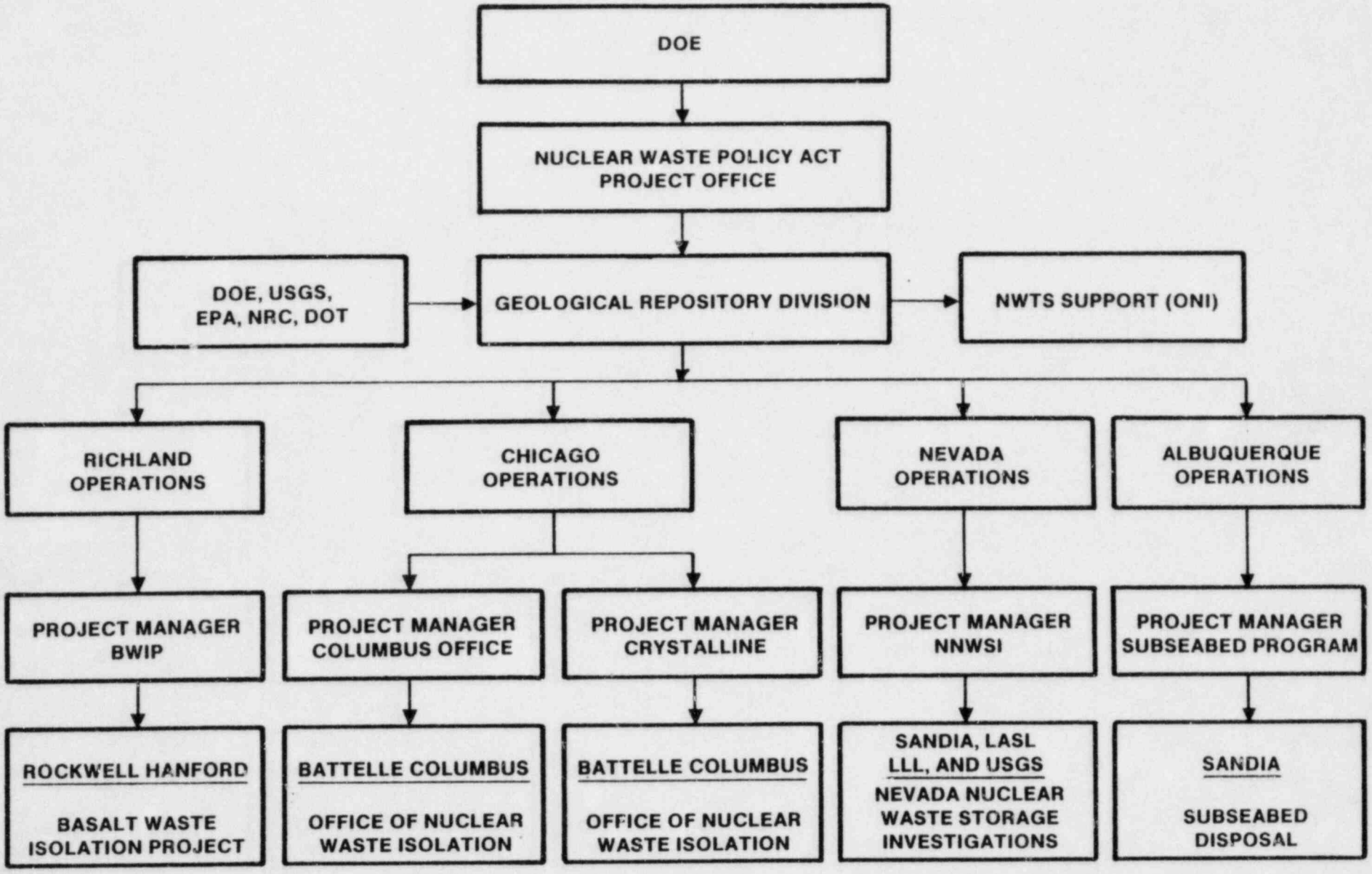
8:30 a.m.	OPENING	D. W. MOELLER
8:45	INTRODUCTIONS AND OPENING REMARKS	O. L. OLSON
9:00	PROGRAM OVERVIEW	D. J. SQUIRES
9:15	APPROACH TO SCR PLANNING EFFORTS	L. R. FITCH
9:45	PERFORMANCE ASSESSMENT	R. G. BACA
10.45	BREAK	
11:00	GEOLOGY	S. M. PRICE
12:15 p.m.	LUNCH	
1:15	HYDROLOGY	S. M. BAKER
2:30	BREAK	
2:45	REPOSITORY	D. A. TURNER
4:00	WASTE PACKAGE	M. J. SMITH
5:00	QUESTIONS AND ANSWERS	O. L. OLSON
5:30	ADJOURN	



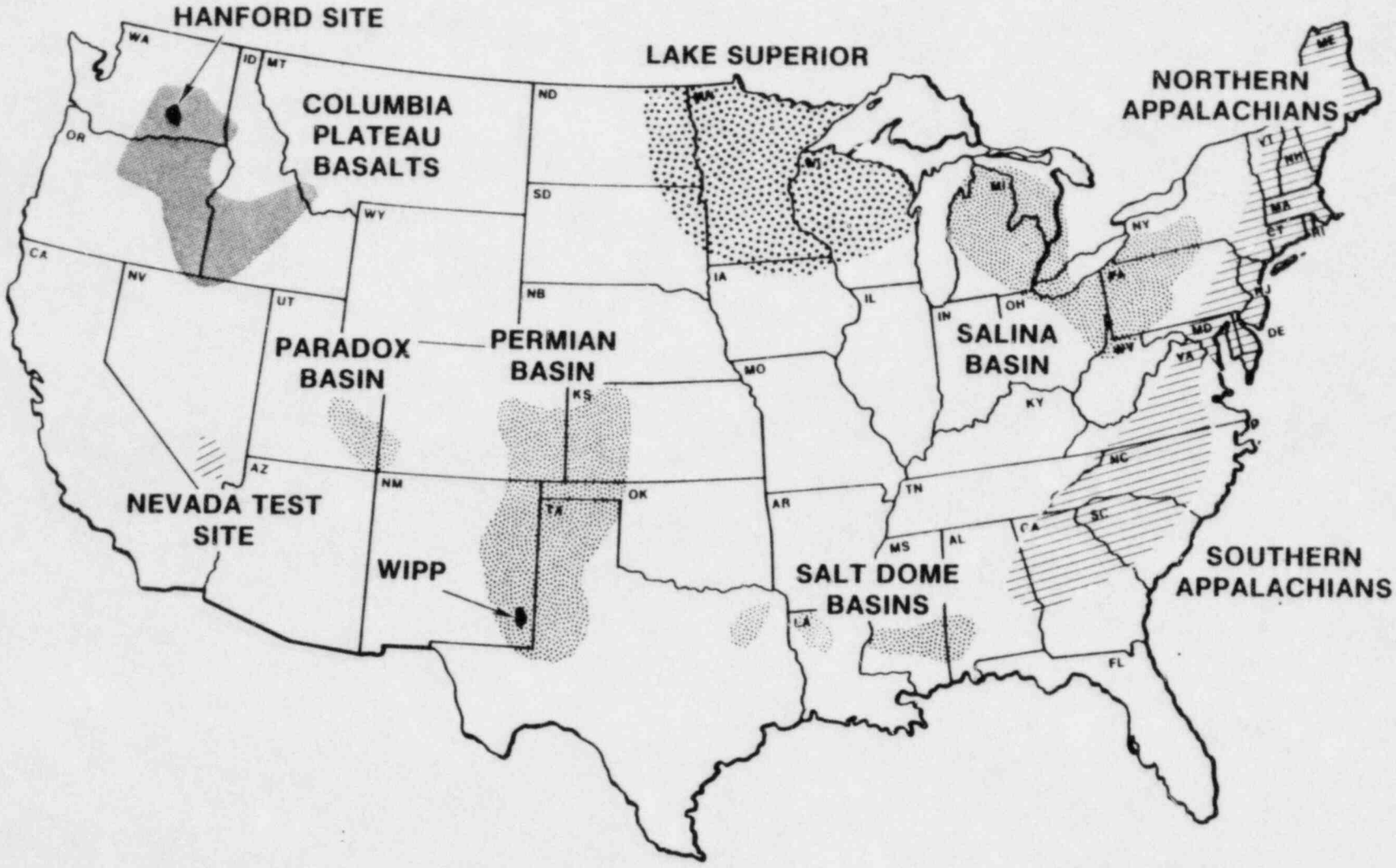
BASALT WASTE ISOLATION PROJECT

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
SUBCOMMITTEE ON WASTE MANAGEMENT PROGRAM
WASHINGTON D.C.
APRIL 21, 1983

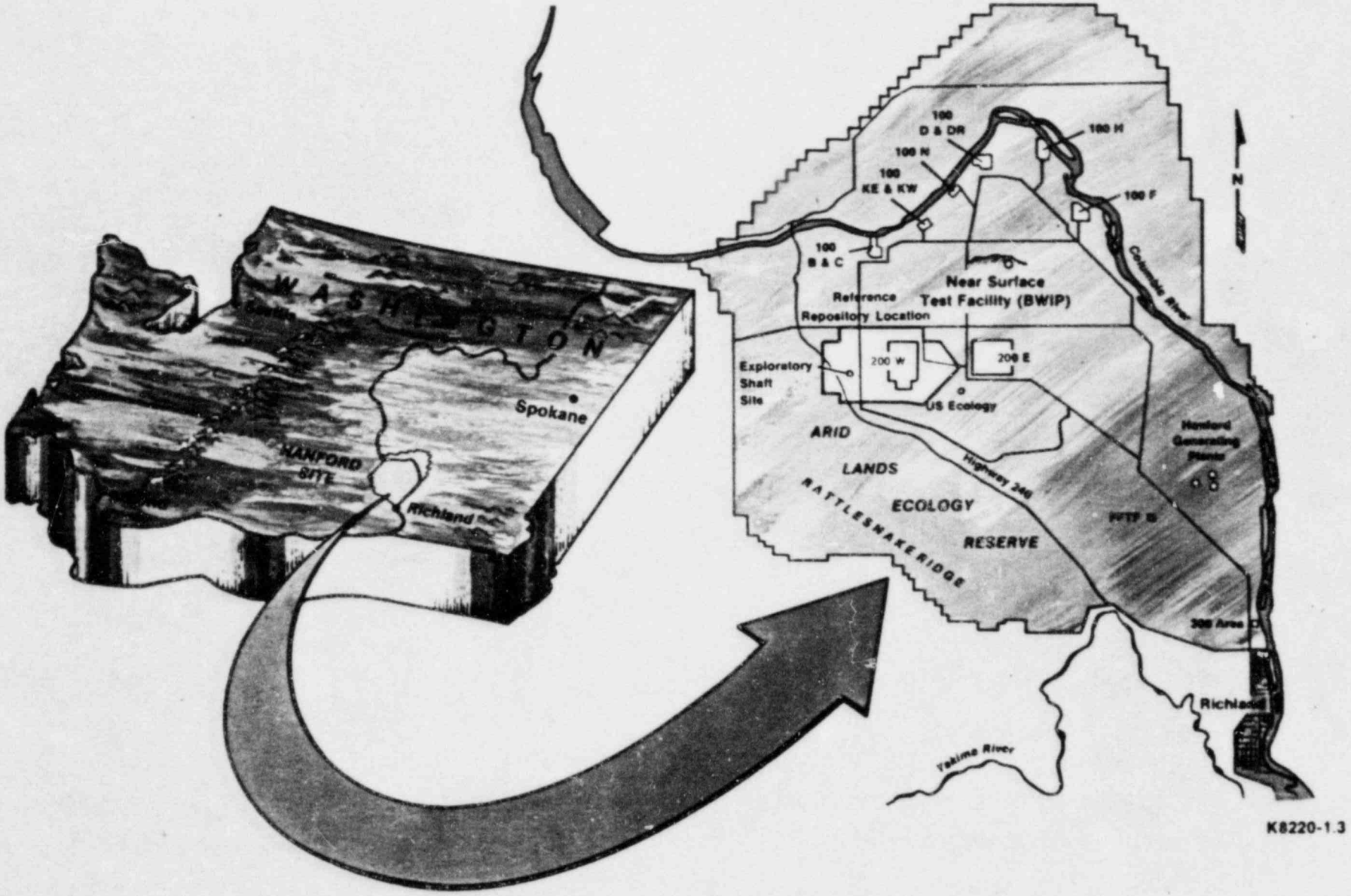
NWTS PROGRAM ORGANIZATION



REGIONS OF POTENTIAL INTEREST FOR TERMINAL STORAGE OF RADIOACTIVE WASTE



THE HANFORD SITE

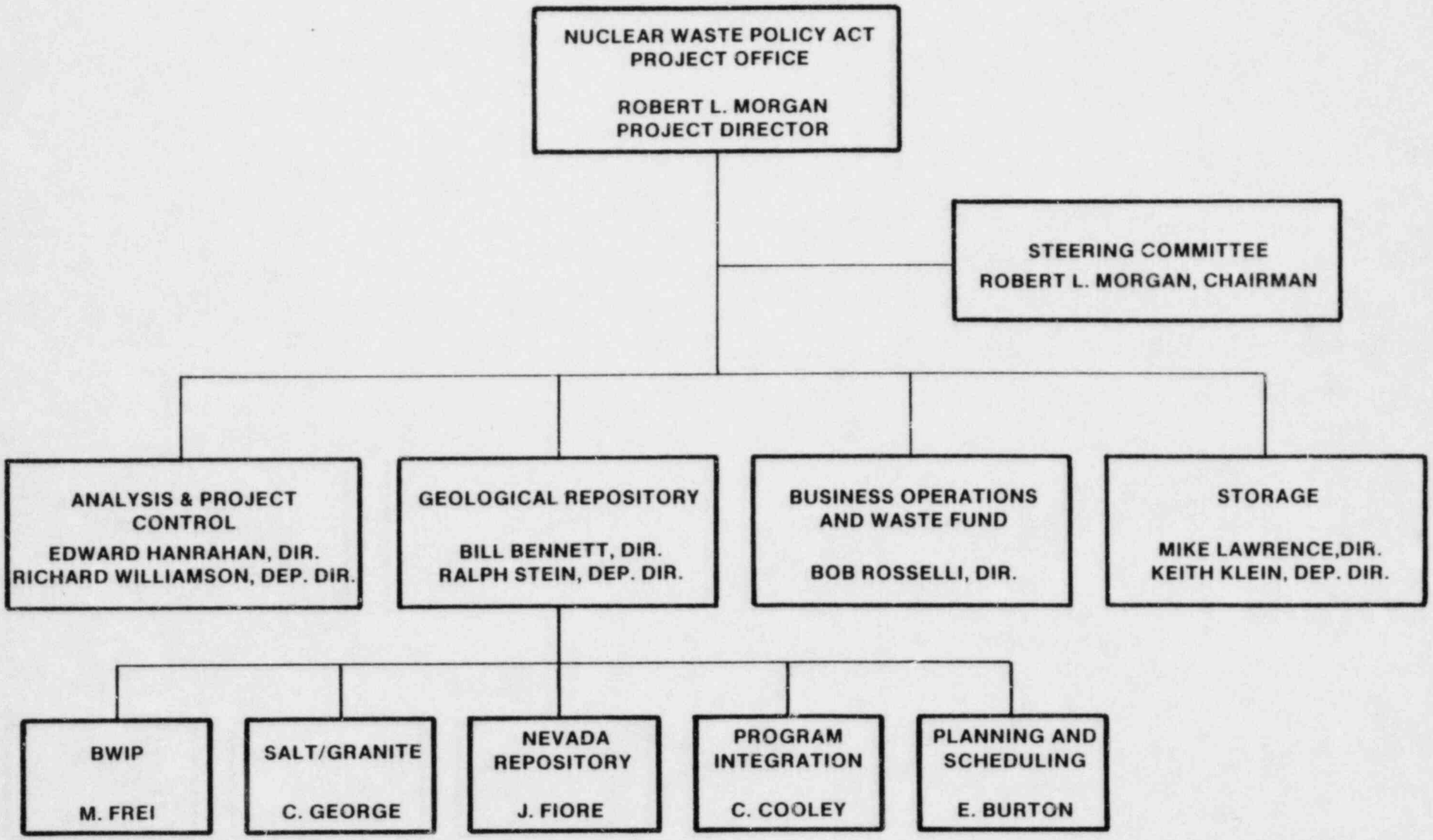


BASALT WASTE ISOLATION PROJECT

KEY FACTORS IN SITING OF REPOSITORY

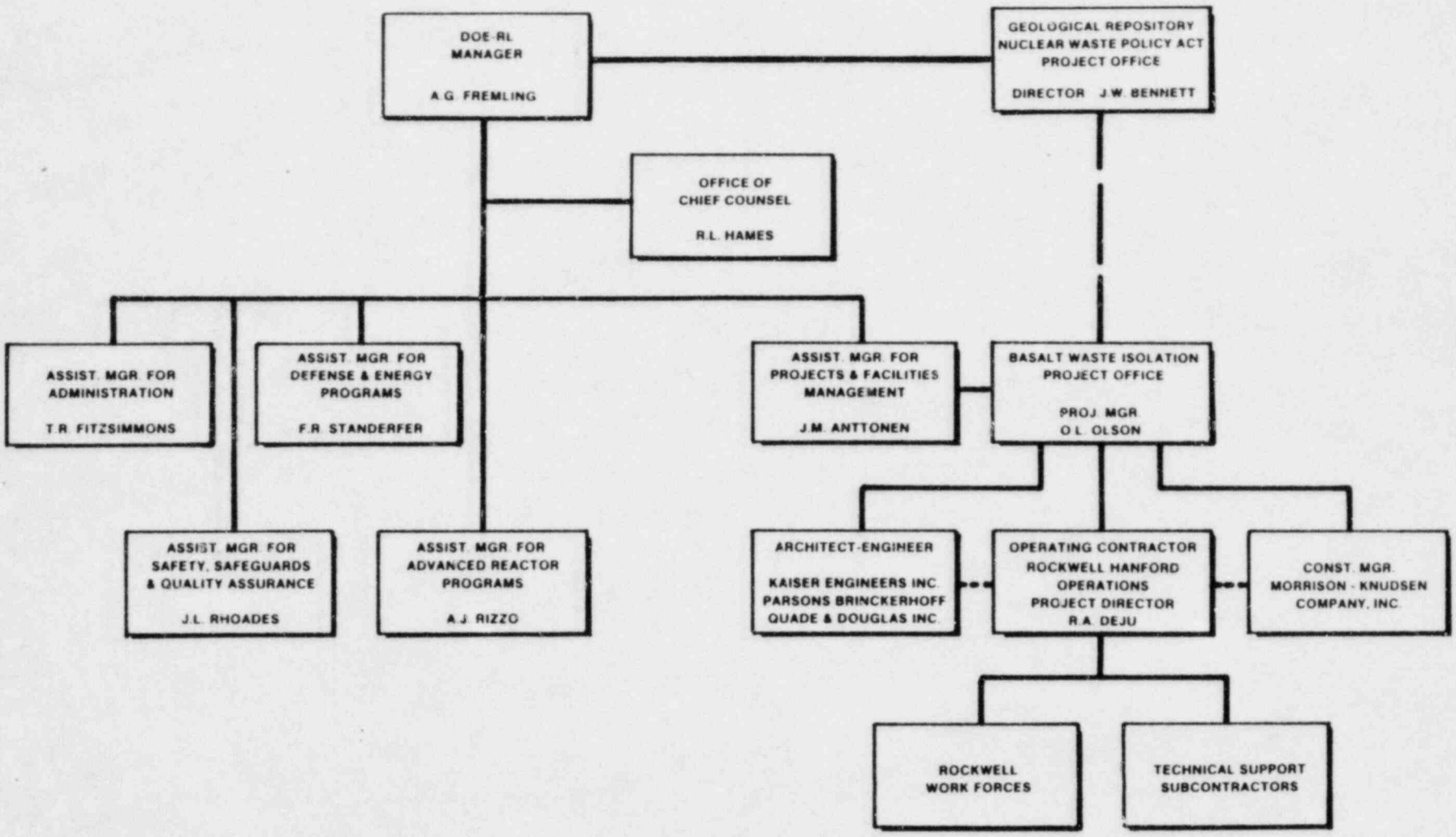
- HYDROLOGY
  - RELATIONSHIP TO COLUMBIA RIVER
  - TRANSPORT OF NUCLIDES
- GEOLOGY
  - STABILITY
  - THICKNESS AND LATERAL EXTENT
- ROCK MECHANICS
  - ROCK STRESSES
- ENGINEERED BARRIERS
  - ENHANCEMENT OF CONTAINMENT
- TRANSPORTATION LOGISTICS
- LONG TERM COMMITMENT
- SOCIOECONOMIC FACTORS
  - POLITICAL ACCEPTANCE
  - PUBLIC ACCEPTANCE

U.S. DEPARTMENT OF ENERGY
ORGANIZATION

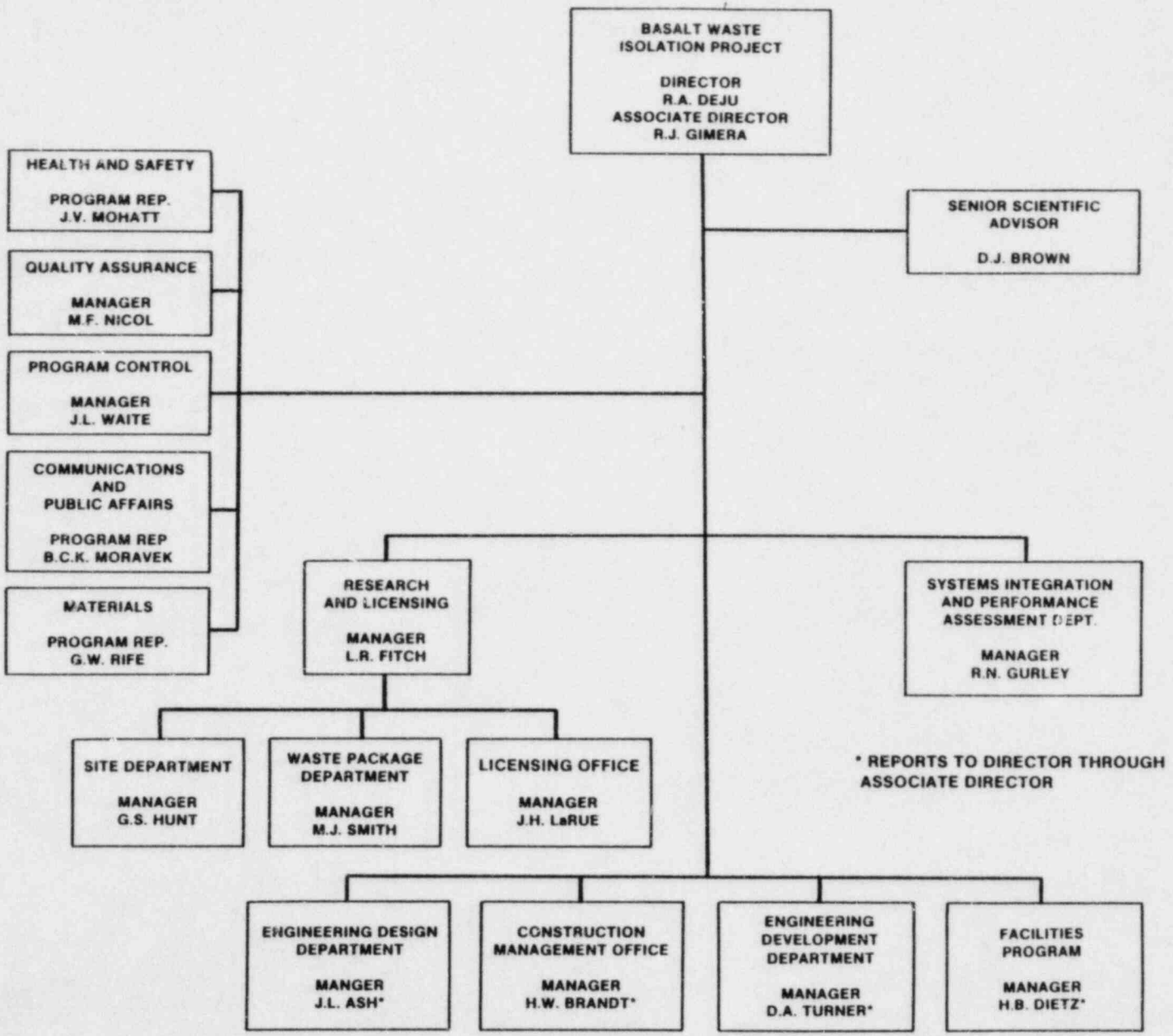


BASALT WASTE ISOLATION PROJECT

PROJECT MANAGEMENT ORGANIZATION

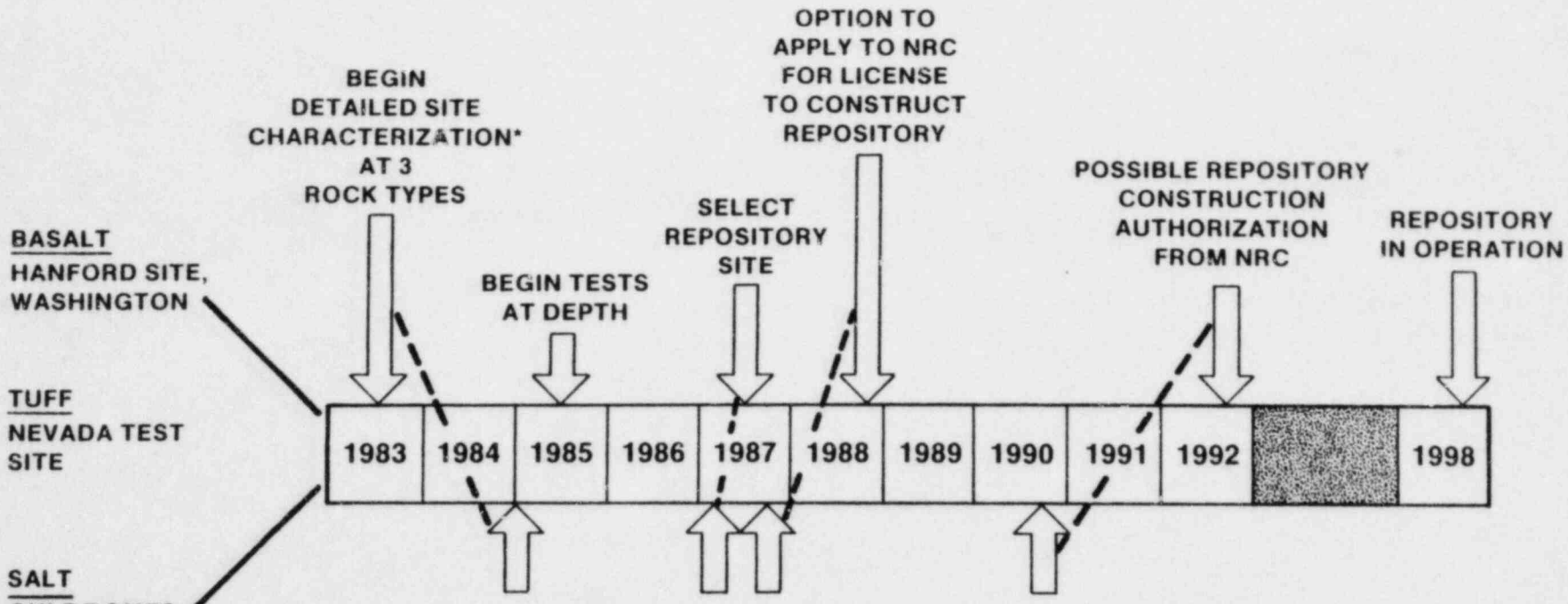


BASALT WASTE ISOLATION PROJECT
ROCKWELL ORGANIZATION



NWTS PROGRAM SCHEDULE
NUCLEAR WASTE POLICY ACT IMPACTS

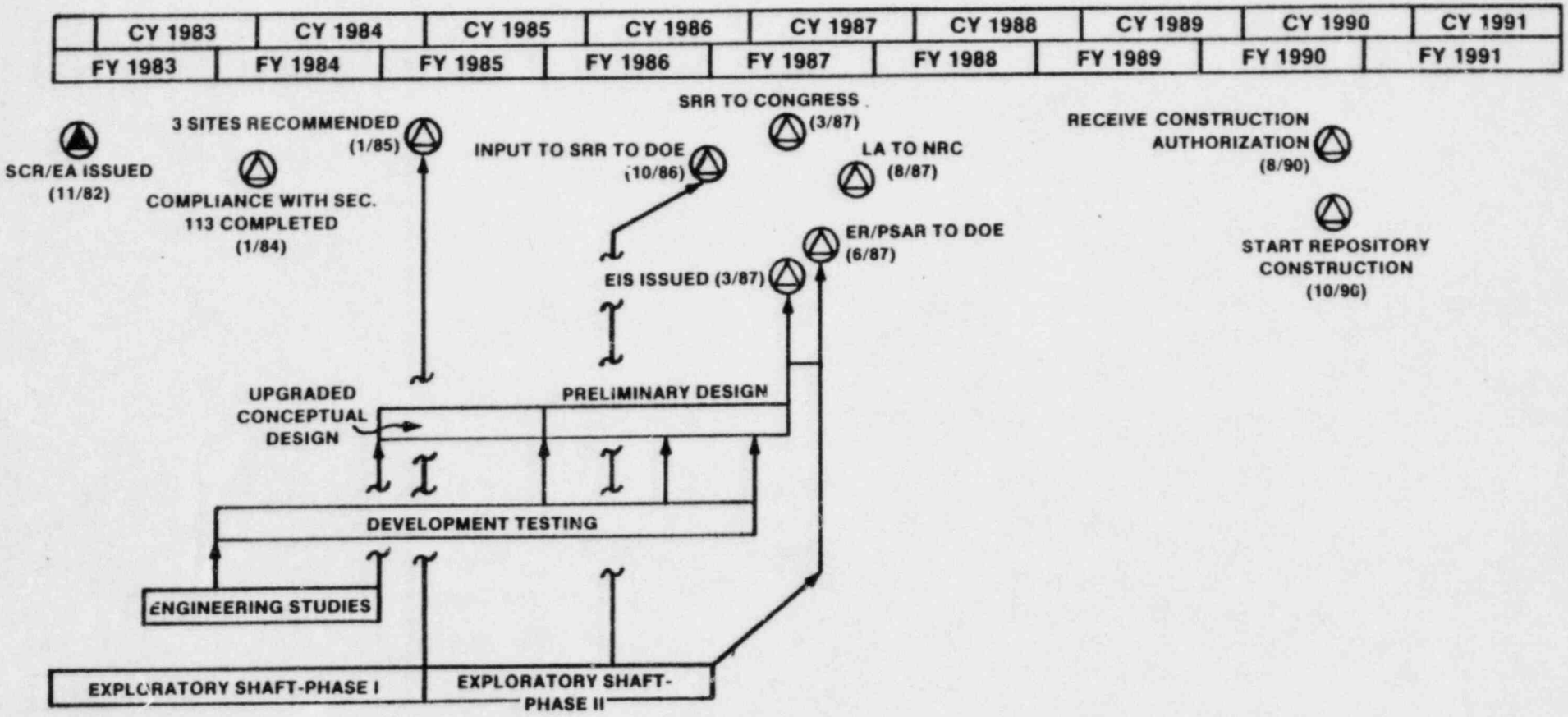
PRE-LEGISLATED SCHEDULE



LEGISLATED SCHEDULE

*INCLUDES EXPLORATORY SHAFT

NUCLEAR WASTE POLICY ACT OF 1982
COMPLIANCE SCHEDULE



BASALT WASTE ISOLATION PROJECT
FUNDING SUMMARY

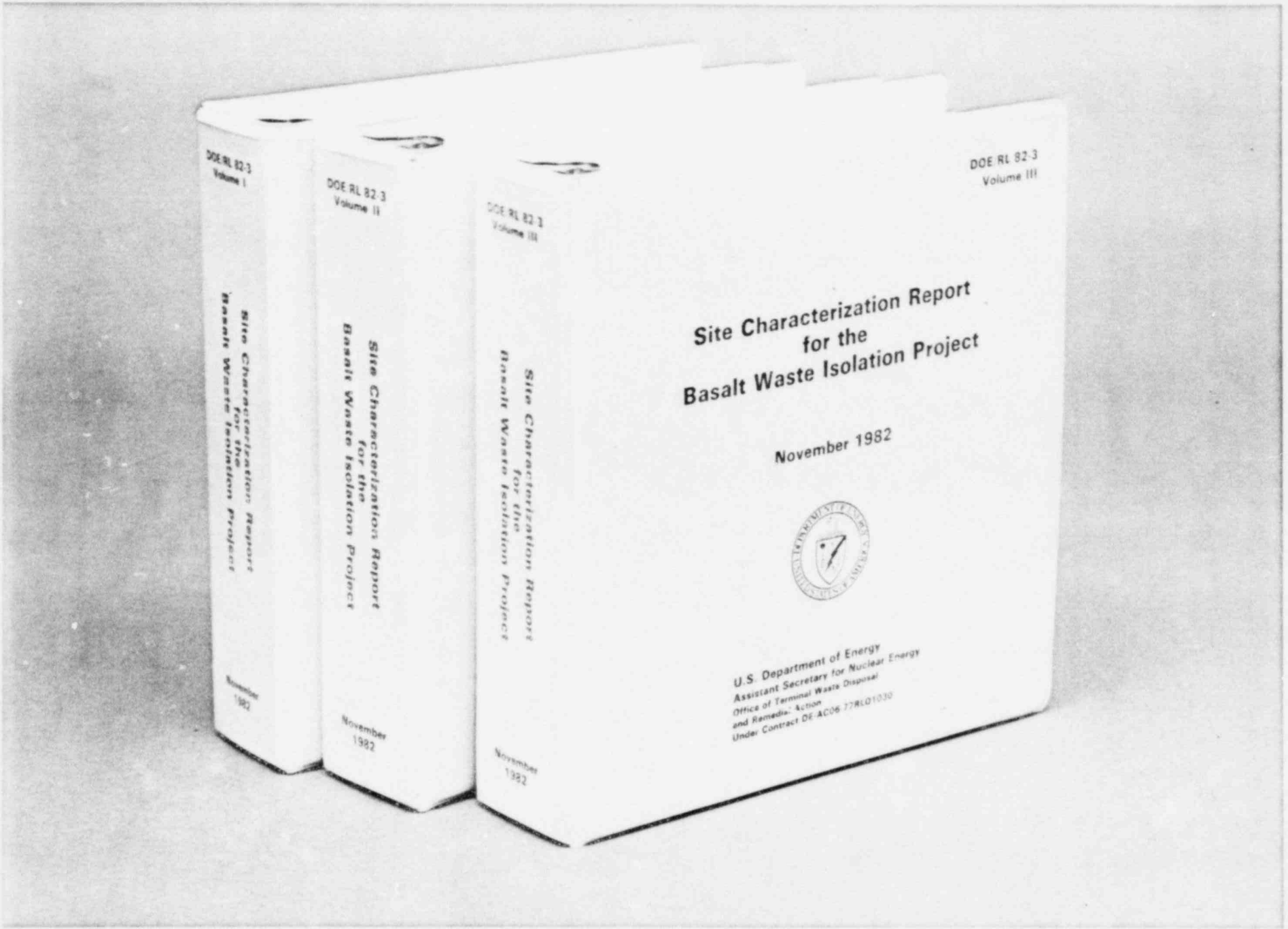
($ IN MILLIONS)

		ACTUAL THRU FY 1982	FY 1983 PLAN	FY 1984 CONGRESSIONAL REQUEST
OPERATING	B/A	156.0	57.7	60.3
	B/O	149.2[1]	60.3	56.6
CAPITAL EQUIPMENT	B/A	12.2	6.1	2.8
CONSTRUCTION	B/A	13.4	.0	0

[1] UNCOSTED OBLIGATIONS AT 9/30/82 $6.8M

APPROACH TO SITE CHARACTERIZATION REPORT PLANNING EFFORT

L. R. FITCH


DOE/RL 82-3
Volume I
Site Characterization Report
for the
Basalt Waste Isolation Project
November
1982
DOE/RL 82-3
Volume II
Site Characterization Report
for the
Basalt Waste Isolation Project
November
1982
DOE/RL 82-3
Volume III
Site Characterization Report
for the
Basalt Waste Isolation Project
November
1982
DOE/RL 82-3
Volume III
Site Characterization Report
for the
Basalt Waste Isolation Project
November 1982
U.S. Department of Energy
Assistant Secretary for Nuclear Energy
Office of Terminal Waste Disposal
and Remedial Action
Under Contract DE-AC06-77RL01030

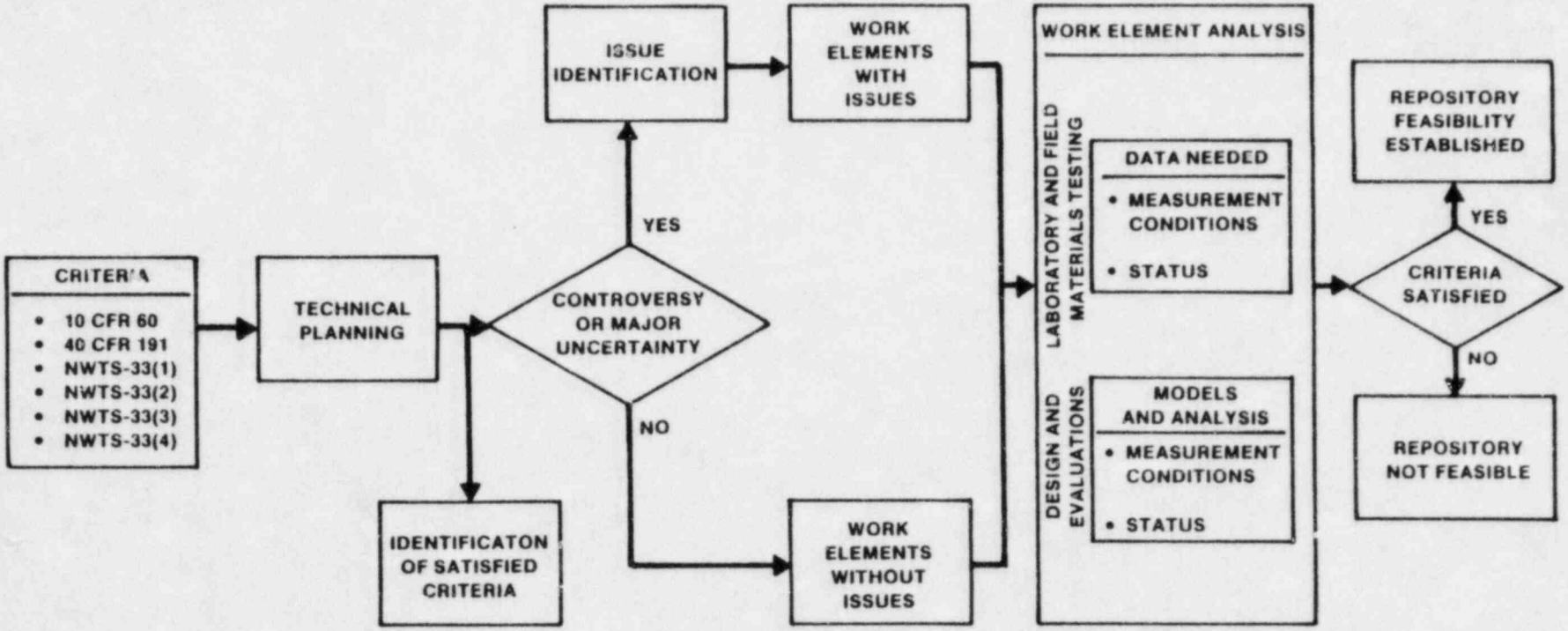
STATUS CHAPTERS

CHAPTER	TITLE
2	DECISION PROCESS FOR CHOOSING A REFERENCE REPOSITORY LOCATION AND AN ALTERNATE REPOSITORY LOCATION
3	GEOLOGIC DESCRIPTION OF THE REFERENCE REPOSITORY LOCATION AND THE SURROUNDING AREA
4	GEOENGINEERING
5	HYDROGEOLOGY
6	GEOCHEMISTRY
7	SURFACE HYDROLOGY
8	CLIMATOLOGY, METEOROLOGY, AND AIR QUALITY
9	ENVIRONMENTAL, LAND–USE, AND SOCIOECONOMIC CHARACTERISTICS
10	REPOSITORY DESIGN
11	WASTE PACKAGE
12	PERFORMANCE ASSESSMENT

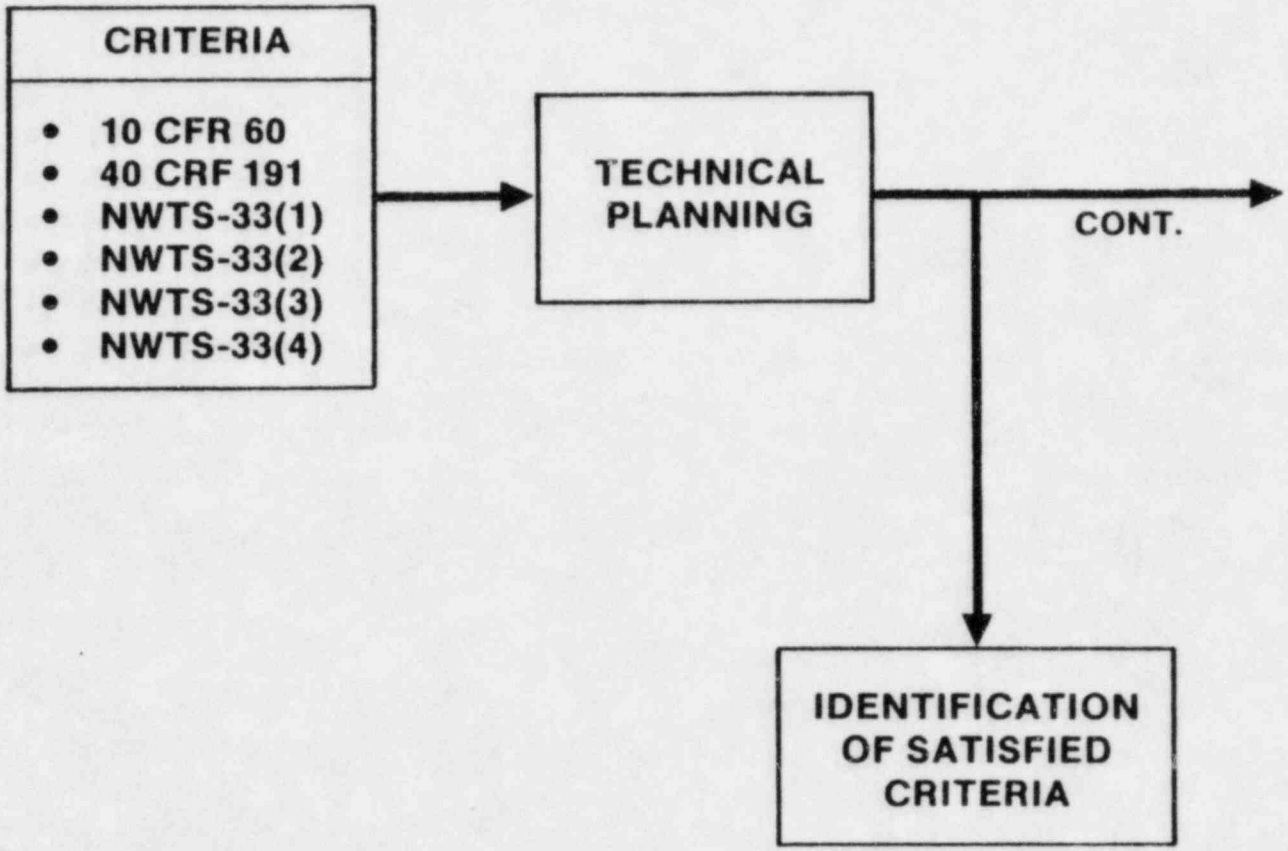
SITE CHARACTERIZATION REPORT ISSUES AND PLANS CHAPTERS

CHAPTER	TITLE
13	SITE ISSUES AND PLANS
14	GEOENGINEERING AND REPOSITORY–DESIGN ISSUES AND PLANS
15	WASTE–PACKAGE AND SITE GEOCHEMISTRY ISSUES AND PLANS
16	PERFORMANCE ASSESSMENT ISSUES AND PLANS

LOGIC FOR DEFINITION OF BWIP ISSUES/WORK ELEMENTS/ DATA NEEDS



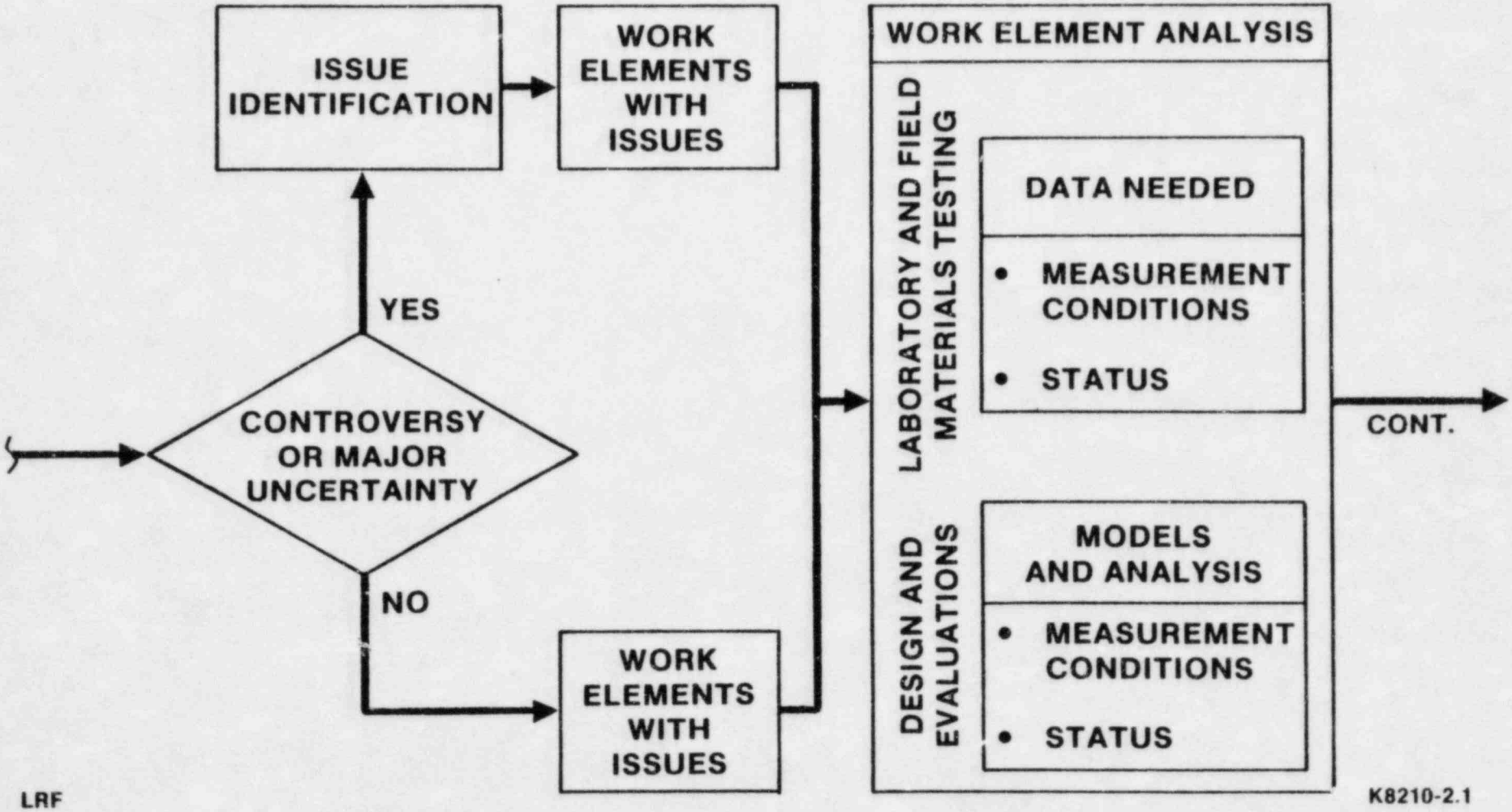
LOGIC
WORK ELEMENT IDENTIFICATION



LRF

K8210-2.2

LOGIC
WORK ELEMENT IDENTIFICATION (CONTINUED)



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LOGIC
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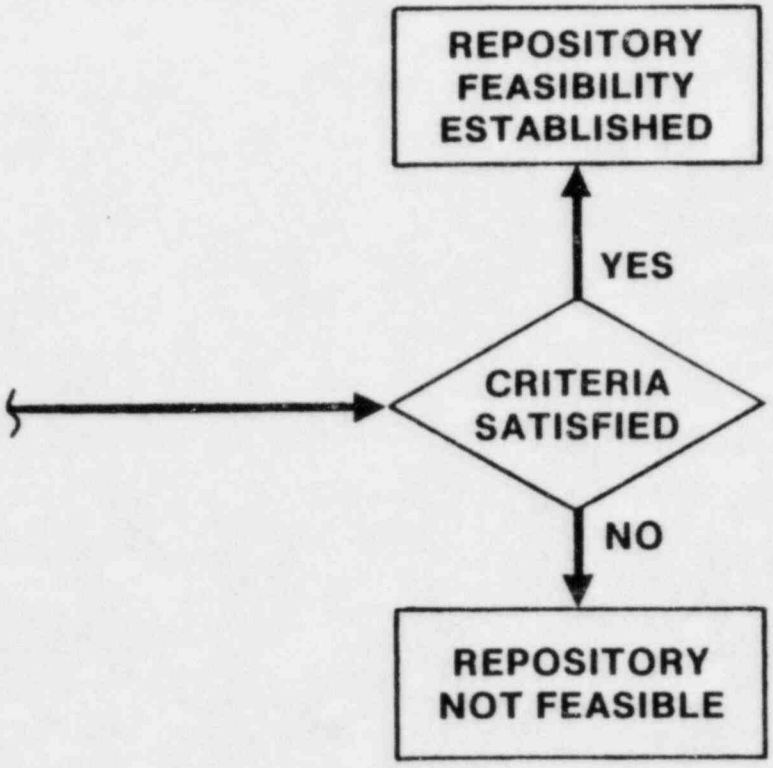

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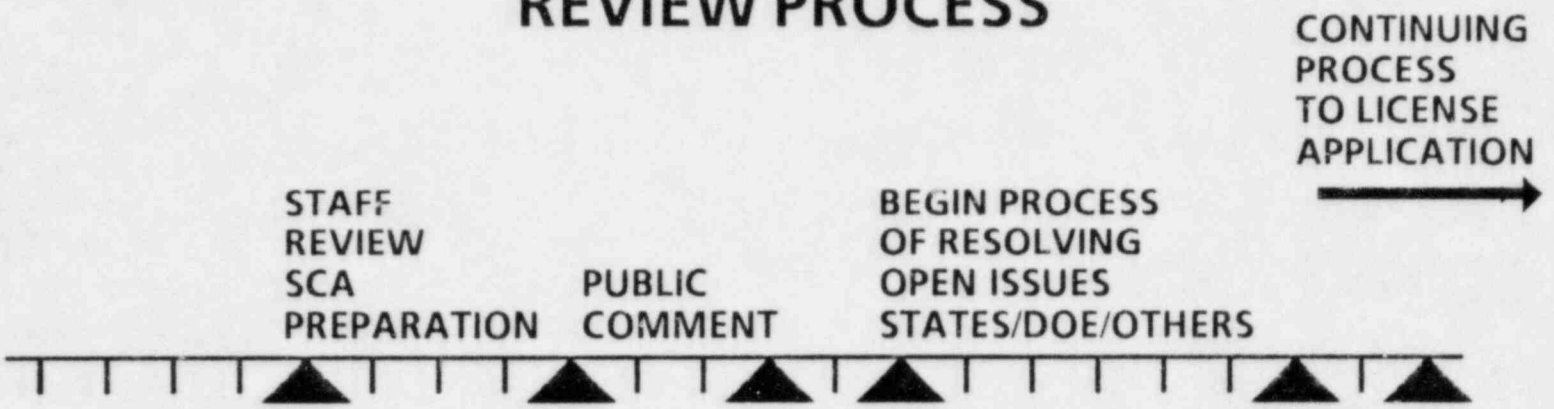
KEY BWIP TECHNICAL ISSUES

- WHAT IS THE TOTAL AMOUNT (ACTIVITY) OF RADIONUCLIDES POTENTIALLY RELEASED TO THE ACCESSIBLE ENVIRONMENT IN A 10,000–YEAR PERIOD, AND IS THIS AMOUNT IN COMPLIANCE WITH ENVIRONMENTAL PROTECTION AGENCY (1981) REGULATIONS?

- CAN STABILITY AND ISOLATION CAPABILITY OF THE REPOSITORY BE MAINTAINED IN THE PRESENCE OF COUPLED IN SITU, EXCAVATION–INDUCED, AND THERMAL STRESSES?

- CAN REPOSITORY SHAFTS, TUNNELS, AND EXPLORATORY BOREHOLES BE CONSTRUCTED AND SEALED WITHOUT CAUSING PREFERENTIAL PATHWAYS FOR GROUNDWATER OR INCREASING THE POTNETIAL FOR RADIONUCLIDE MIGRATION FROM A NUCLEAR WASTE REPOSITORY?

SITE CHARACTERIZATION REVIEW PROCESS



- CONDUCT PRE-SCR TECHNICAL WORKSHOPS DOE/NRC/OTHERS

- CONSULTATION WITH STATES/TRIBES/ GOVT AGENCIES

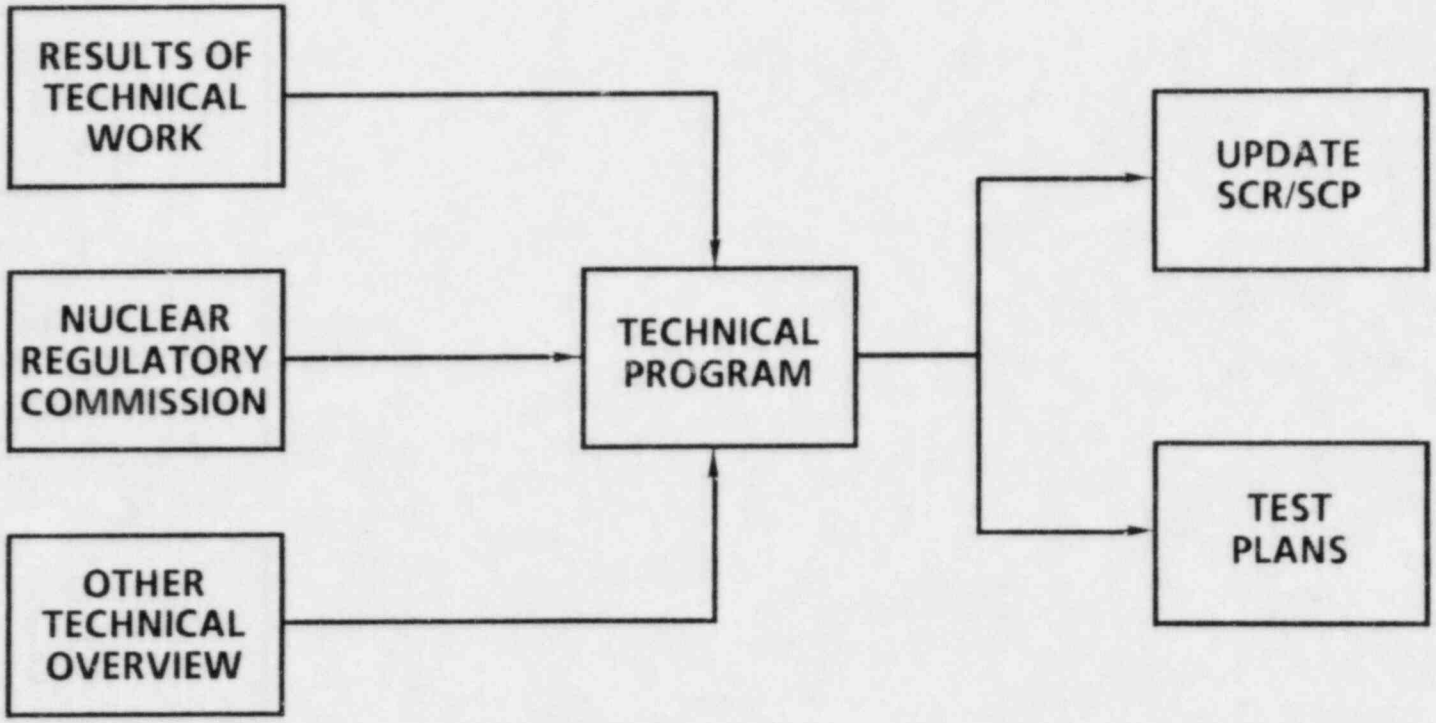
UPDATE OF PLANS

11/82 3/83 6/83 8/83 2/84

TECHNICAL INFORMATION WORKSHOPS WITH NUCLEAR REGULATORY COMMISSION

DATE	SUBJECT
7/21–27/82	HYDROLOGY OF PASCO BASIN AND HANFORD SITE
8/9–12/82	WASTE PACKAGE AND GEOCHEMISTRY
10/6–7/82	REPOSITORY DESIGN AND EXPLORATORY SHAFT
4/11–15/83	GEOLOGY WORKSHOP

INTEGRATION AND REVISION TO PROGRAM



PERFORMANCE ASSESSMENT STATUS

R. G. BACA

PRESENTATION SUMMARY

- INTRODUCTION
- REVIEW OF SITE CHARACTERIZATION REPORT PERFORMANCE ASSESSMENT RESULTS
- RESULTS FROM RECENT STUDIES OF REPOSITORY PERFORMANCE

INTRODUCTION

SIGNIFICANT POINTS

- ALTHOUGH THE SITE MIGHT PROVIDE SIGNIFICANT ISOLATION BY ITSELF, THERE WILL ALWAYS BE SOME UNCERTAINTY

- ENGINEERED SYSTEMS CAN PROVIDE REDUNDANT BARRIER TO ACCOMMODATE SITE UNCERTAINTY

- PERFORMANCE ASSESSMENT ISSUES NEED TO BE ADDRESSED BY FY 1986 TO SUPPORT SITE RECOMMENDATION REPORT AND PRELIMINARY SAFETY ANALYSIS REPORT

PROPOSED REGULATORY CRITERIA

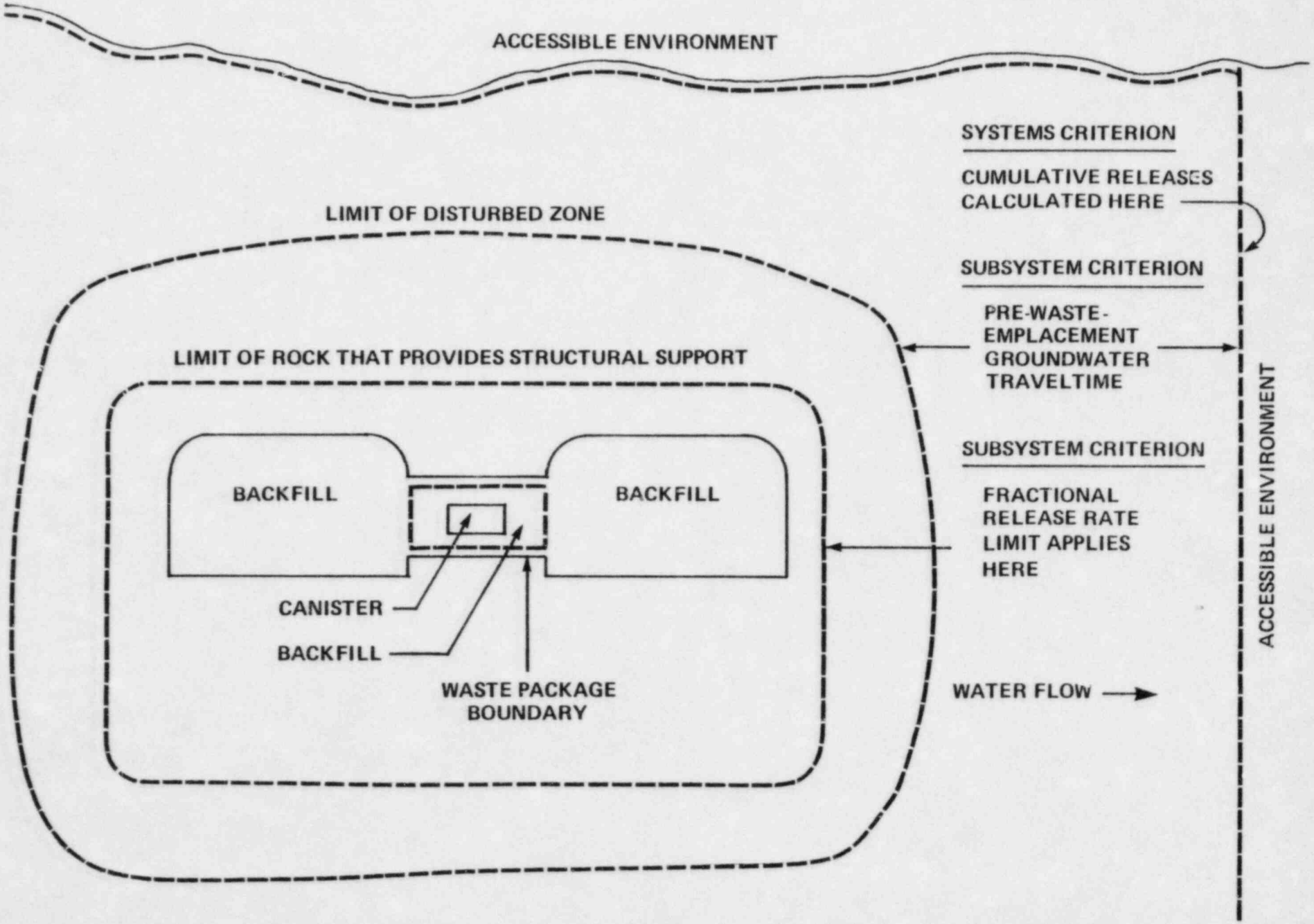
SYSTEM CRITERION (40 CFR 191)

- LIMIT THE TOTAL ACTIVITY OF RADIONUCLIDES POTENTIALLY RELEASED TO THE ACCESSIBLE ENVIRONMENT IN 10,000 YEARS TO LESS THAN THE SUGGESTED EPA LIMITS

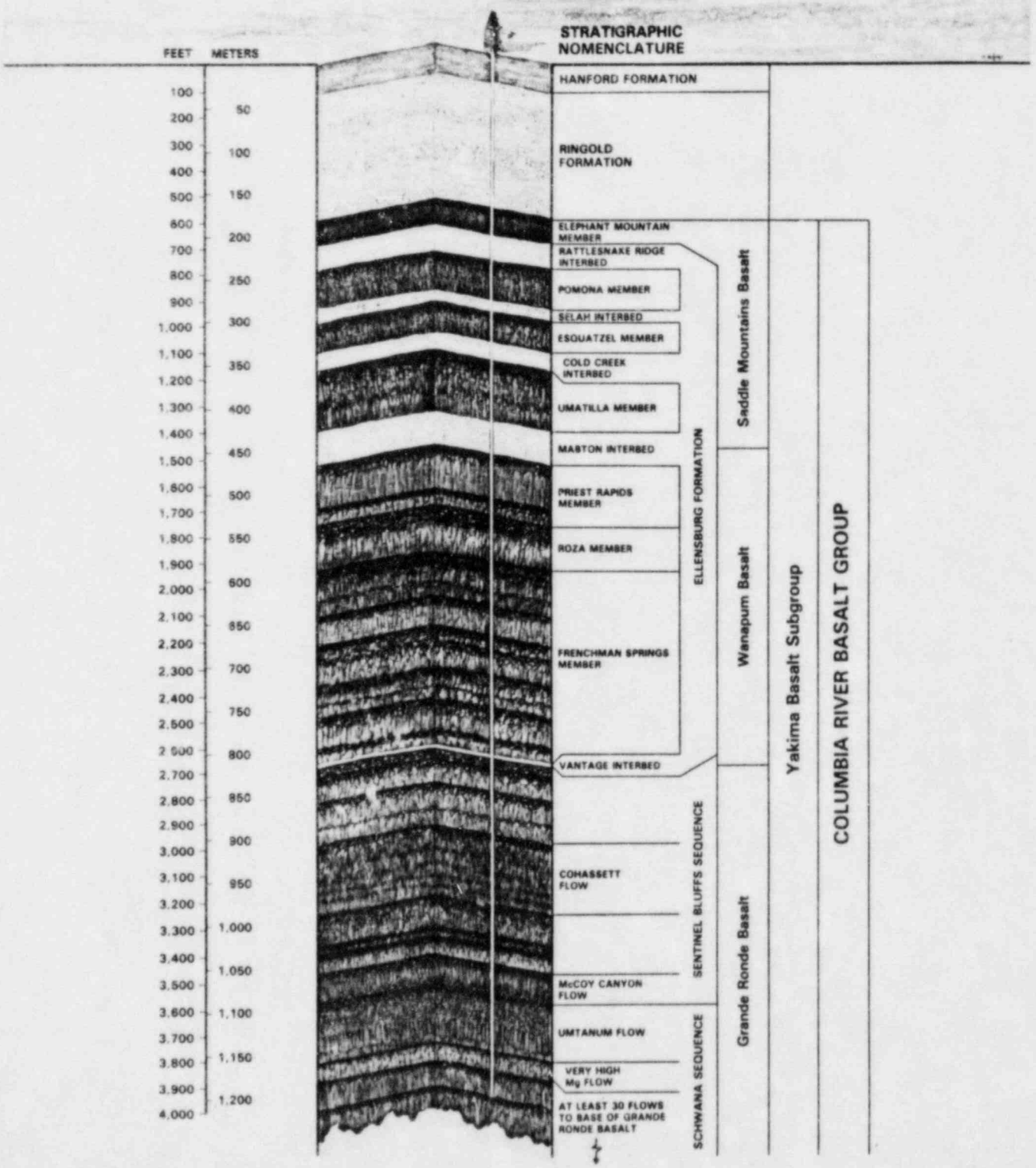
SUBSYSTEM CRITERIA (10 CFR 60)

- PRE-WASTE-EMPLACEMENT GROUNDWATER TRAVELTIME FROM THE EDGE OF THE REPOSITORY TO THE ACCESSIBLE ENVIRONMENT GREATER THAN 1,000 YEARS
- FRACTIONAL RADIONUCLIDE RELEASE RATES FOR THE ENGINEERED SYSTEM LESS THAN 1 PART IN 100,000 PER YEAR
- MAINTAIN CONTAINMENT WITHIN THE ENGINEERED SYSTEM FOR 1,000 YEARS
- ALTERNATE NUMERICAL VALUES TO SUBSYSTEM CRITERIA MAY BE APPROVED OR SPECIFIED BY NRC

DEFINITION OF SYSTEM AND SUBSYSTEM BOUNDARIES



REFERENCE REPOSITORY LOCATION STRATIGRAPHY



REVIEW OF SITE CHARACTERIZATION REPORT PERFORMANCE ASSESSMENT RESULTS

CHAPTER 12
PERFORMANCE ASSESSMENT

SCOPE AND OBJECTIVES

- IDENTIFY THE MAJOR PERFORMANCE ISSUES
- DESCRIBE THE METHODOLOGY FOR ASSESSING LONG–TERM PERFORMANCE
- PRESENT A REVIEW OF PREVIOUS PERFORMANCE ANALYSES FOR BASALT
- PRESENT PERFORMANCE ASSESSMENT CONDUCTED FOR THE SITE CHARACTERIZATION REPORT

SUMMARY OF PRE-WASTE-EMPLACEMENT TRAVELTIME ESTIMATES

STUDY	YEAR	PATH LENGTH* (km)	TRAVELTIME (yr)
ROCKWELL	1979	15	20,000-100,000
LATA/INTERA	1979	10	34,000
PNL (AEGIS)	1979	8	13,000-17,000
ROCKWELL/RMA	1981	65	100,000
TASC	1982	60	60,000-7,000,000

AEGIS ASSESSMENT OF EFFECTIVENESS OF GEOLOGIC ISOLATION SYSTEM PROGRAM

INTERA INTERA ENVIRONMENTAL CONSULTANTS

LATA LOS ALAMOS TECHNICAL ASSOCIATES

PNL PACIFIC NORTHWEST LABORATORY

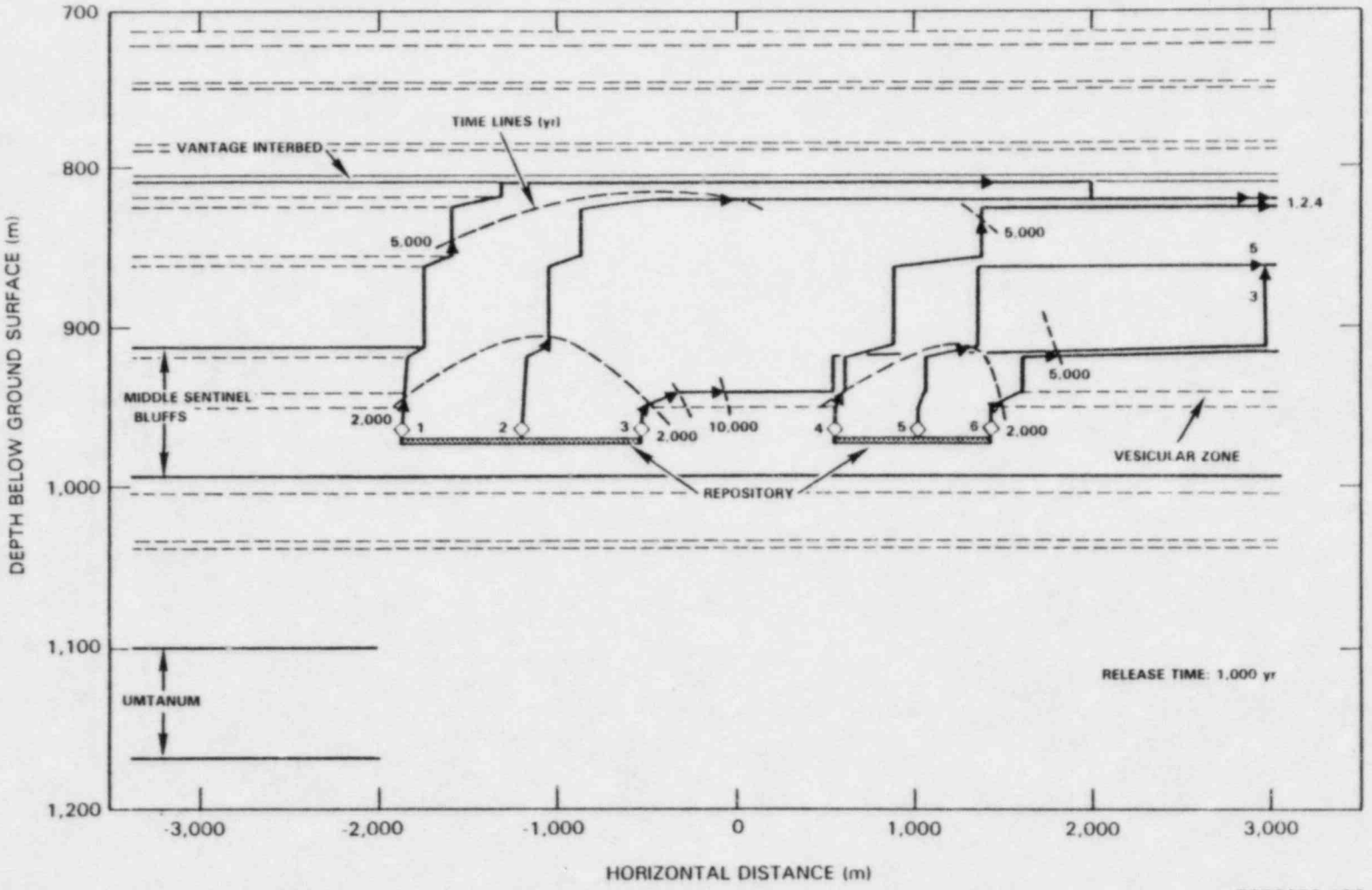
RMA RESOURCE MANAGEMENT ASSOCIATES

ROCKWELL ROCKWELL HANFORD OPERATIONS

TASC THE ANALYTIC SCIENCES CORPORATION

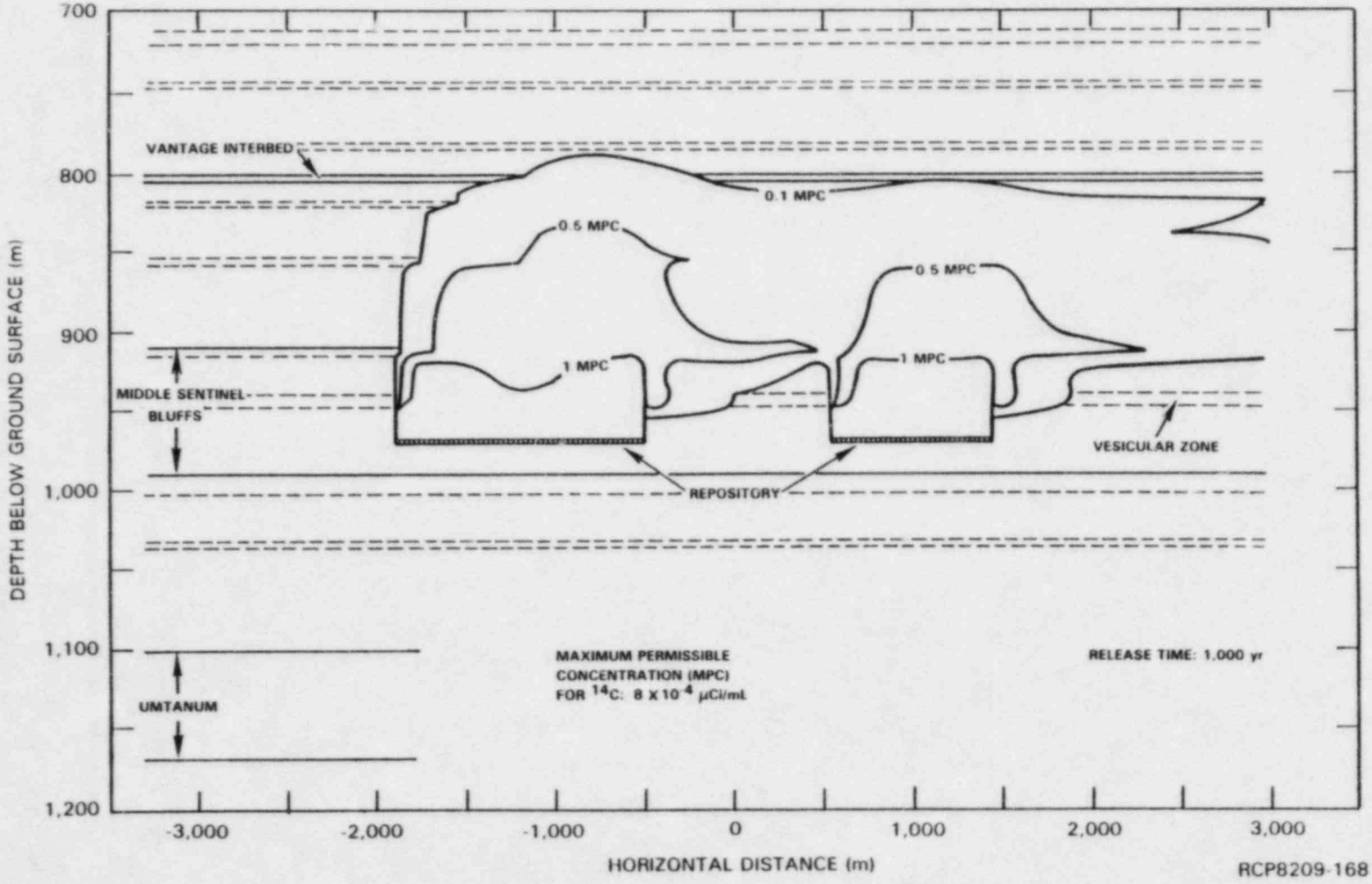
*DISTANCE FROM REFERENCE REPOSITORY LOCATION TO COLUMBIA RIVER.

GROUNDWATER PATHLINES AND TRAVELTIMES FOR MIDDLE SENTINEL BLUFFS FLOW



RCP8209-166

CARBON-14 CONCENTRATION CONTOURS AT 10,000 YEARS FOR MIDDLE SENTINEL BLUFFS FLOW



RCP8209-168

SITE CHARACTERIZATION REPORT CONCLUSIONS

- TRANSPORT OF MOBILE LONG-LIVED RADIONUCLIDES, ^{14}C, IS LIMITED TO ABOUT 200 VERTICAL METERS AND LESS THAN A FEW KILOMETERS HORIZONTALLY AFTER 10,000 YEARS

- RADIONUCLIDE RELEASE ACROSS REFERENCE BOUNDARY APPEARS TO REMAIN WELL BELOW THE EPA DRAFT REGULATIONS FOR NO-DISRUPTION AND POSTULATED FAULT ZONE CONDITIONS

- POST-WASTE-EMPLACEMENT GROUNDWATER TRAVELTIMES FROM THE REPOSITORY TO THE REFERENCE BOUNDARY ARE ESTIMATED TO BE GREATER THAN 10,000 YEARS

- GROUNDWATER FLOW PATHS FROM CANDIDATE REPOSITORY HORIZONS ARE PREDOMINANTLY HORIZONTAL AND ARE RESTRICTED TO THE GRANDE RONDE BASALT

- SOLUBILITY OF RADIONUCLIDES LIMITS THE REPOSITORY RELEASE RATES TO LEVELS WELL BELOW THE NRC-PROPOSED CRITERIA, PARTICULARLY FOR SUCH RADIONUCLIDES AS TECHNETIUM, AMERICIUM, NEPTUNIUM, AND PLUTONIUM

UNCERTAINTIES AND LIMITATIONS

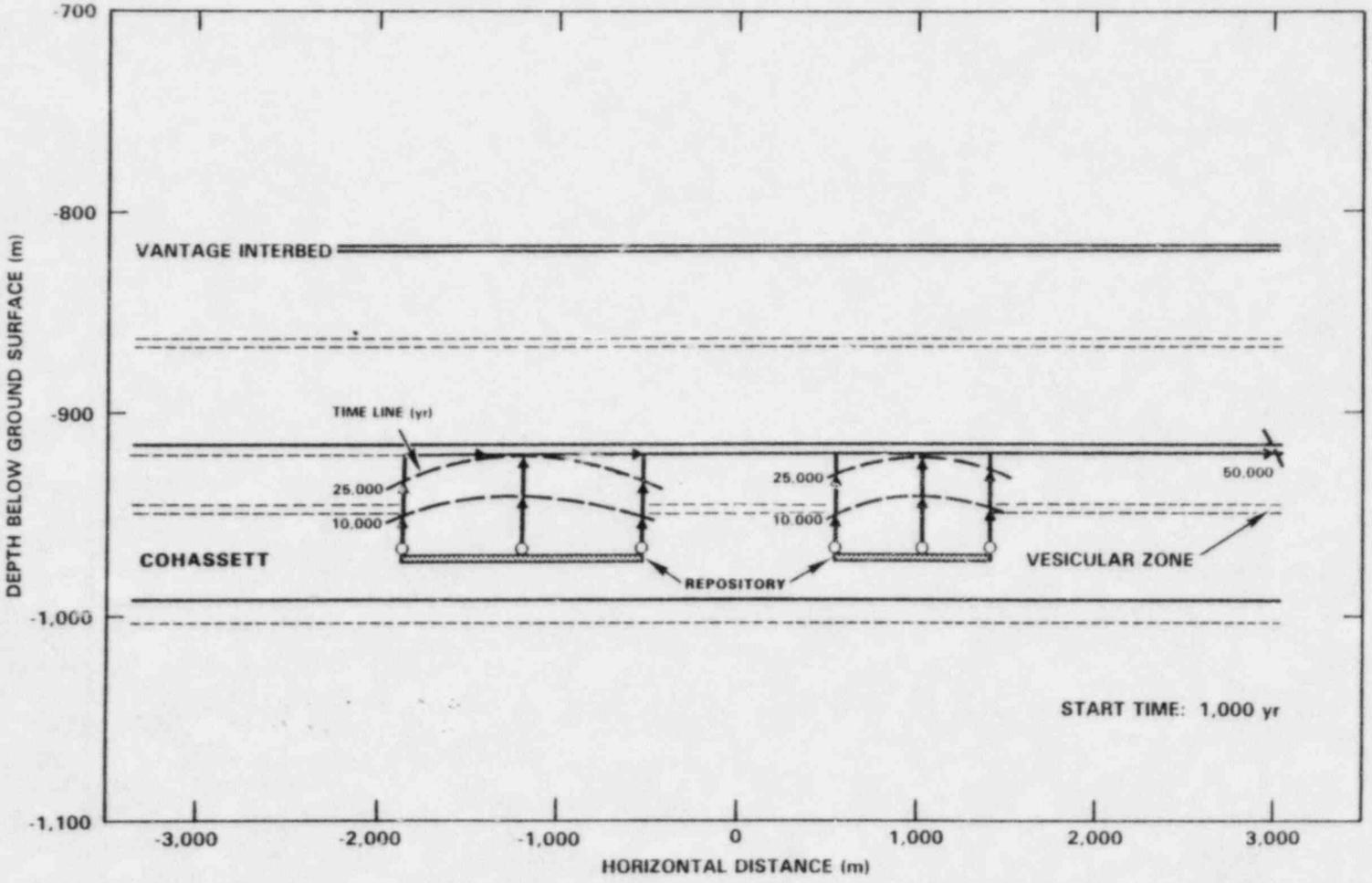
- LIMITED AMOUNT OF HYDRAULIC HEAD PROFILES ALONG THE BOUNDARIES OF THE PASCO BASIN (i.e., BOUNDARY CONDITIONS)
- LACK OF AREAL DISTRIBUTION MAPS OF HYDRAULIC CONDUCTIVITY, PARTICULARLY IN THE GRANDE RONDE BASALT
- LACK OF EFFECTIVE POROSITY DATA FOR THE DEEP BASALT FLOWS AND FLOW CONTACTS
- LACK OF FIRM ESTIMATES OF VERTICAL HYDRAULIC CONDUCTIVITY
- LIMITED UNDERSTANDING OF THE ROLE OF CERTAIN GEOLOGIC STRUCTURES IN DETERMINING GROUNDWATER FLOW PATTERNS AND IN ESTABLISHING ACTUAL BOUNDARIES AROUND THE REFERENCE REPOSITORY LOCATION

RESULTS FROM RECENT STUDIES OF REPOSITORY PERFORMANCE

ADDITIONAL DATA AND NEW ANALYSES

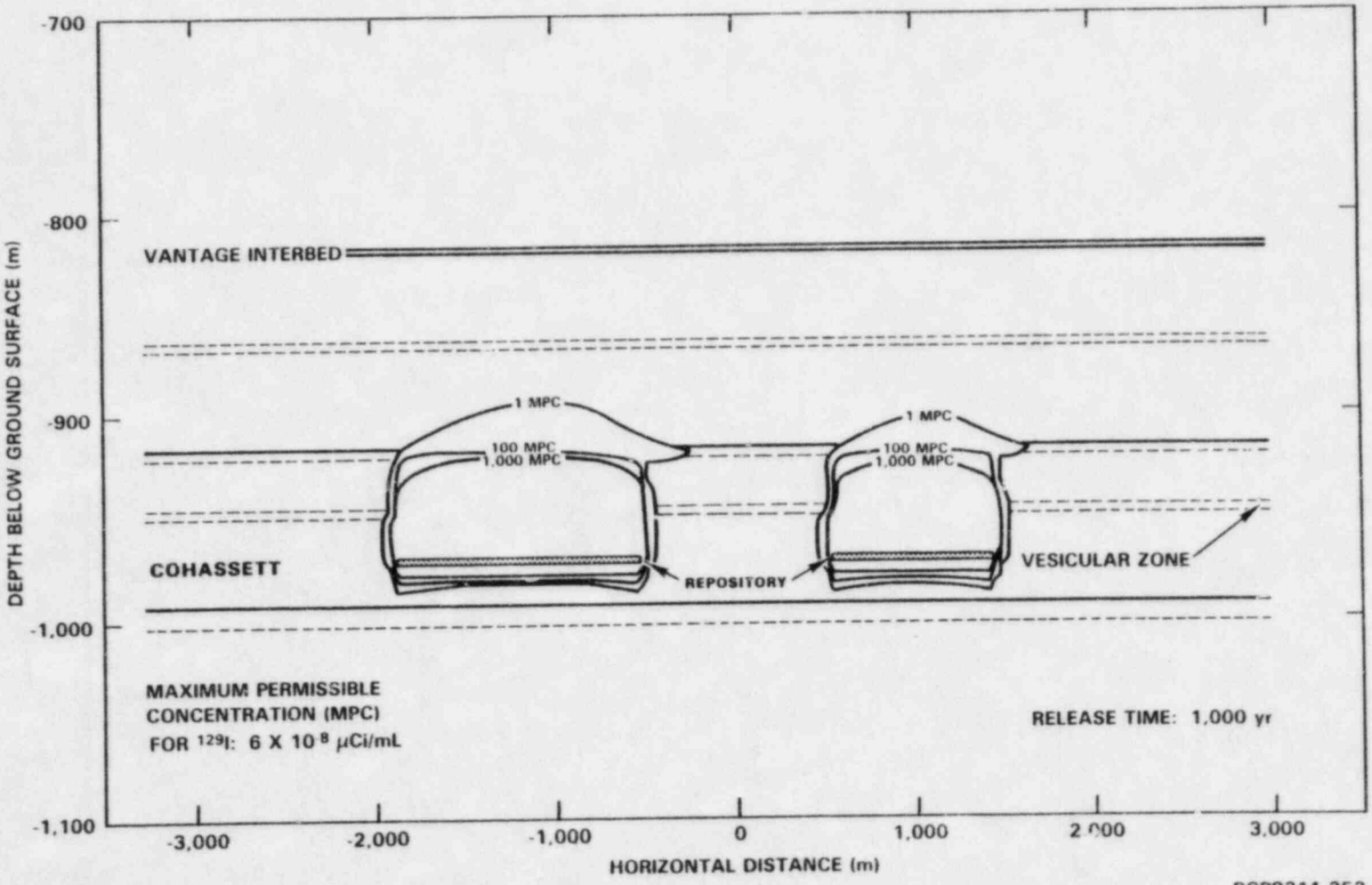
- ADDITIONAL BOREHOLES IN THE REFERENCE REPOSITORY LOCATION
- ADDITIONAL DETERMINATIONS OF HYDRAULIC CONDUCTIVITY
- DEVELOPMENT AND APPLICATION OF PROBABILISTIC MODELING APPROACHES
- HYDROLOGIC ANALYSIS FOCUSING ON COLD CREEK SYNCLINE

GROUNDWATER PATHLINES AND TRAVELTIMES FOR COHASSETT FLOW



RCP8211-252

IODINE-129 CONCENTRATION CONTOURS AT 10,000 YEARS FOR COHASSETT FLOW



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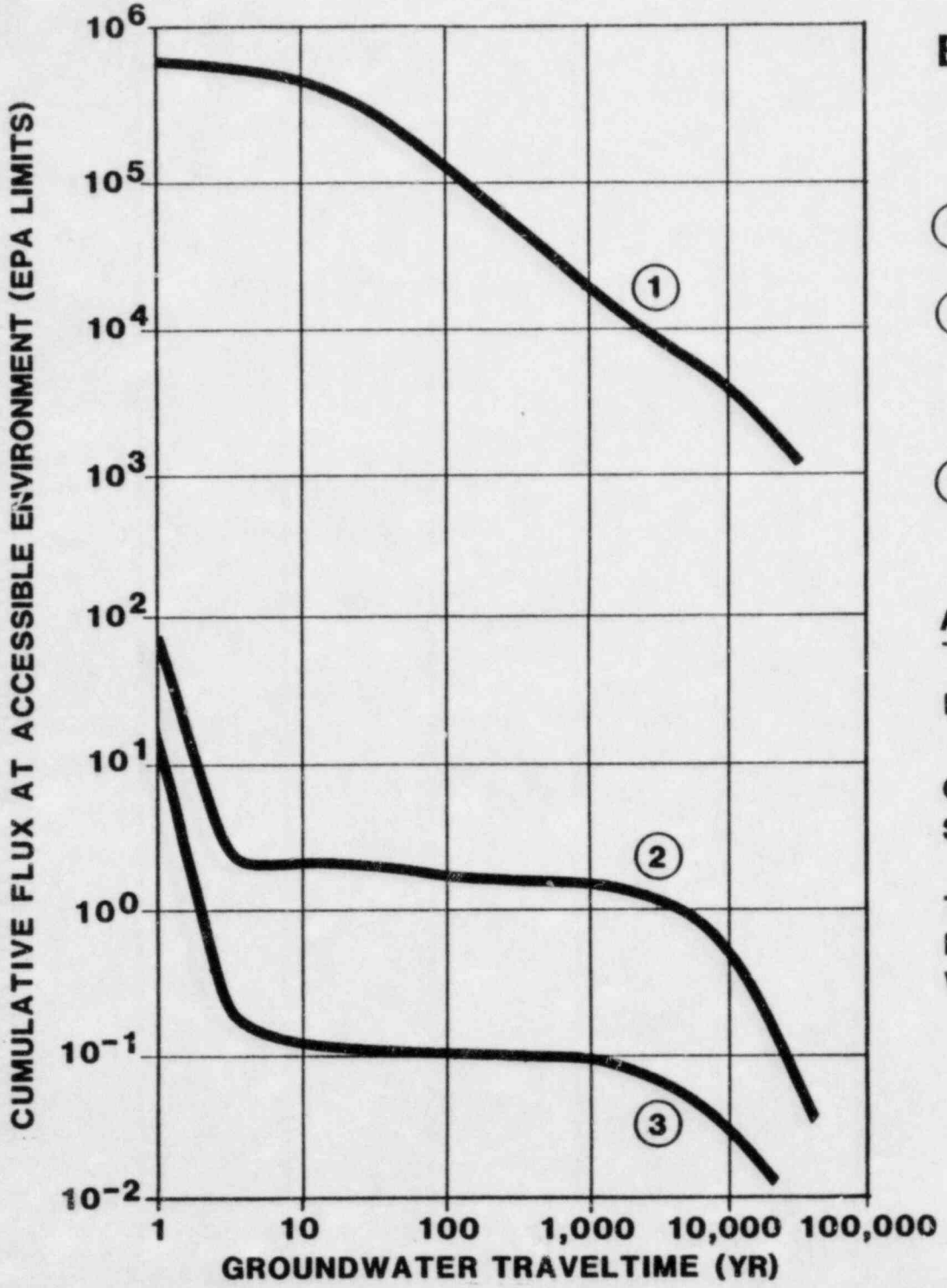


BARRIER EFFECTS

(1) INSTANT RELEASE, NO SORPTION

(2) RADIONUCLIDE SOLUBILITY LIMITED RELEASE AND SORPTION

(3) RELEASE RATE OF 1 PART IN 100,000 PER YEAR

ASSUMPTIONS

INSTANTANEOUS RELEASE

CONSERVATIVE Kd's AND SOLUBILITIES

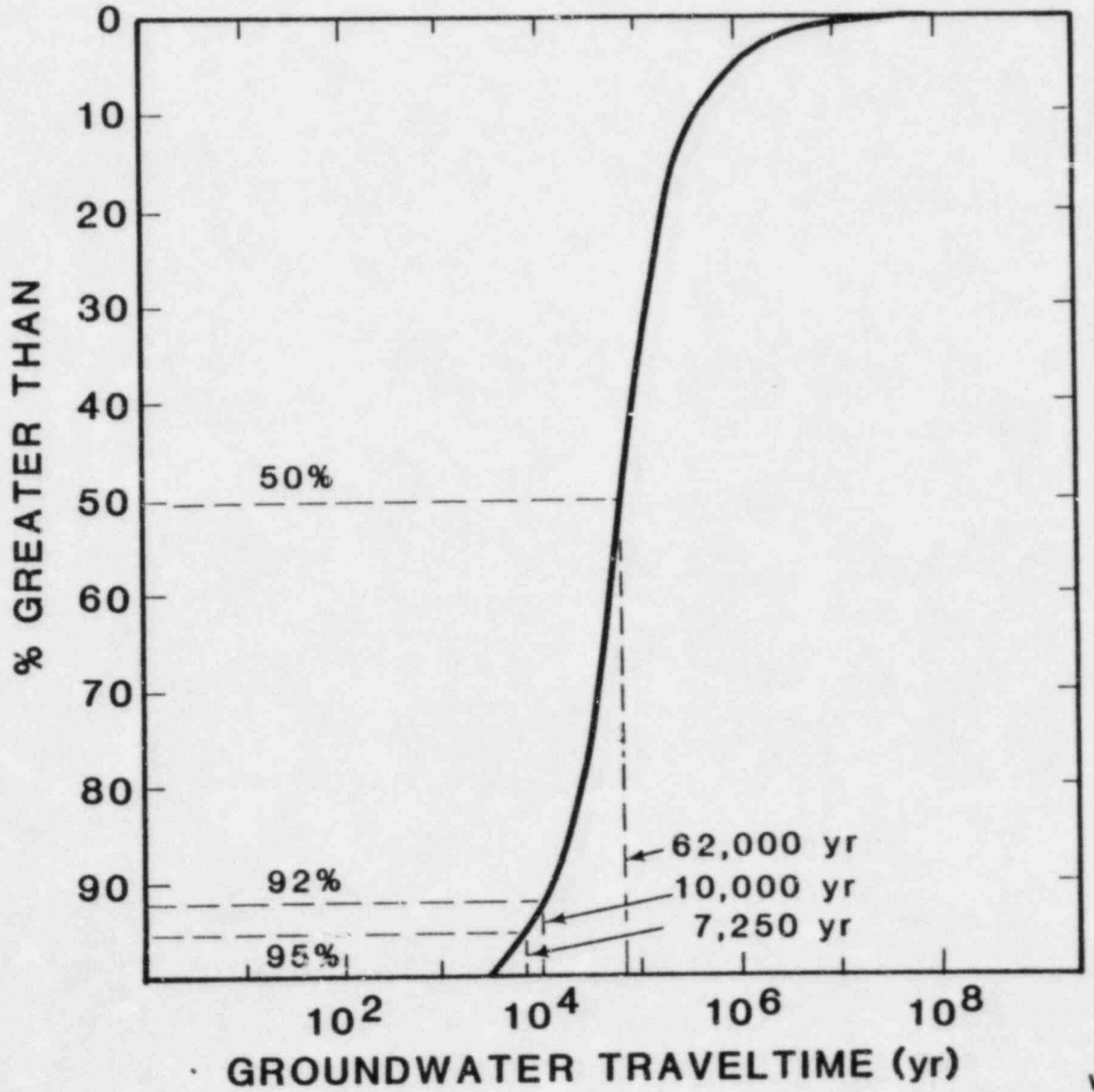
TOTAL ACTIVITY CALCULATED FOR 10,000-YEAR INTERVAL WITH MAXIMUM RELEASE

PROBABILISTIC ANALYSIS OF GROUNDWATER TRAVELTIMES

- CONSIDER MOST UNCERTAIN HYDROLOGIC PARAMETERS (PERMEABILITY OF BASALT FLOWS AND FLOW TOP)
- SET DETERMINISTIC VALUES OF POROSITY AND BOUNDARY CONDITIONS
- MODEL GROUNDWATER FLOW USING MONTE CARLO APPROACH
- FOR EACH HEAD FIELD, CALCULATE TRAVELTIMES FROM REPOSITORY BOUNDARY TO THE 10–KILOMETER BOUNDARY
- DETERMINE THE PROBABILITY DISTRIBUTION OF THE SET OF GROUNDWATER TRAVELTIME REALIZATIONS

DISTRIBUTION OF GROUNDWATER TRAVELTIMES

FROM REPOSITORY IN COHASSETT FLOW
TO 10-KILOMETER BOUNDARY



WP8304-43A

GROUNDWATER TRAVELTIME TO 10–KILOMETER BOUNDARY ALONG FASTEST PATHLINE

	MEDIAN TRAVELTIME ALONG FASTEST PATHLINE (yr)	TRAVELTIME WHICH HAS A 0.95 PROBABILITY OF BEING EXCEEDED (yr)	PROBABILITY THAT TRAVELTIME IS GREATER THAN 10,000 yrs
COHASSETT	62,000	7,250	0.92
McCOY CANYON	35,000	5,100	0.85
UMTANUM	37,000	5,200	0.85

SUMMARY OF DATA NEEDS

- DEVELOP AREAL DISTRIBUTIONS FOR HYDRAULIC HEADS AND HYDRAULIC CONDUCTIVITIES FOR THE FLOW TOPS ABOVE THE SELECTED HORIZON

- DEVELOP A BETTER UNDERSTANDING OF THE RELATIONSHIP BETWEEN HYDRAULIC CONDUCTIVITIES AND POROSITIES IN FLOW TOPS

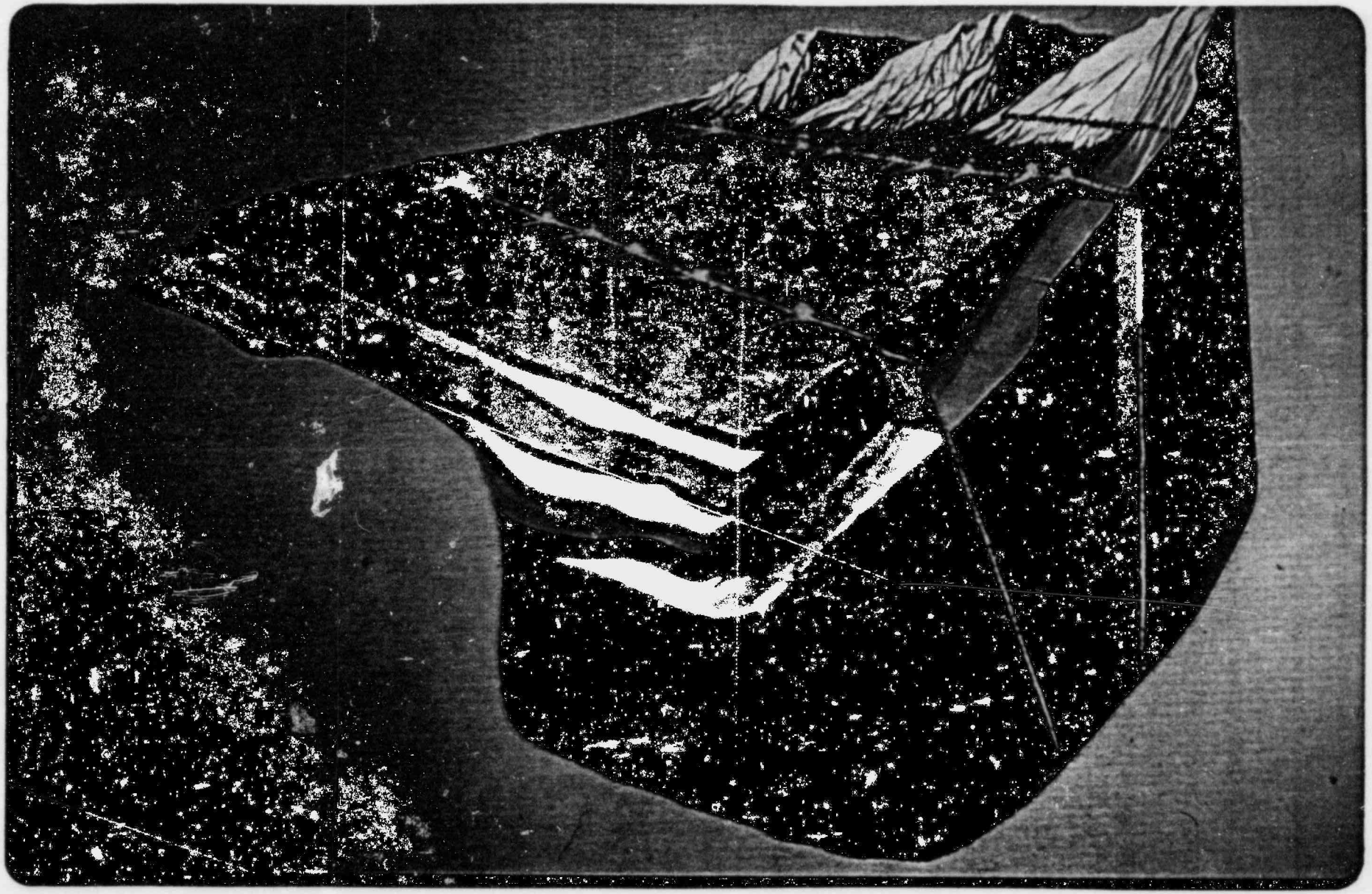
- CONFIRM THE HYDRAULIC CONDUCTIVITY ESTIMATES FOR THE DENSE INTERIORS, WITH EMPHASIS ON VERTICAL HYDRAULIC CONDUCTIVITIES

- CONFIRM THE ESTIMATES OF SORPTION AND/OR SOLUBILITY PROPERTIES FOR KEY RADIONUCLDES

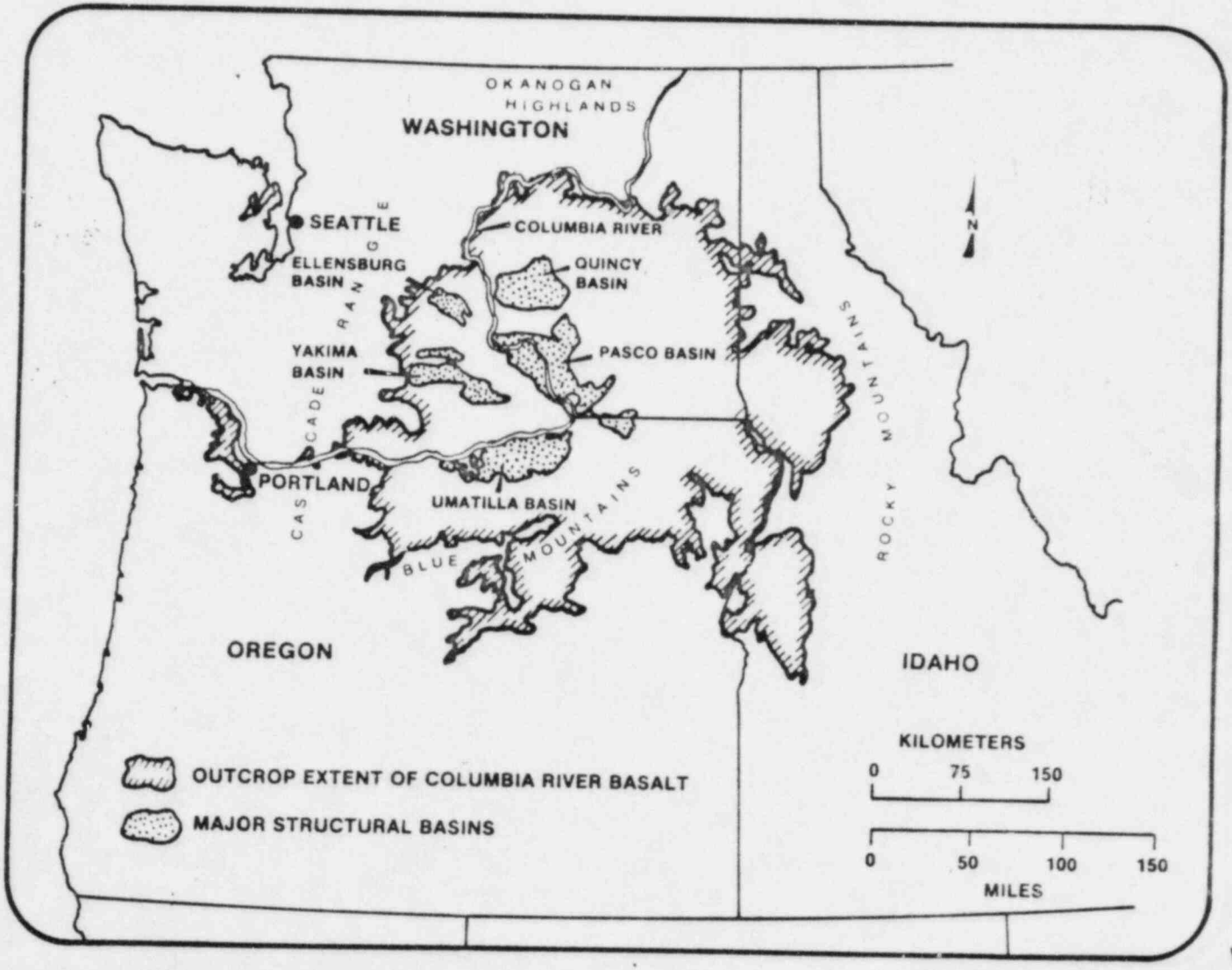
CURRENT PLANS CALL FOR COLLECTION OF THESE DATA AS PART OF THE SITE CHARACTERIZATION EFFORT AND THE EXPLORATORY SHAFT TESTING PROGRAM

GEOLOGIC CHARACTERIZATION STATUS AND PLANS

S. M. PRICE



The Columbia Plateau



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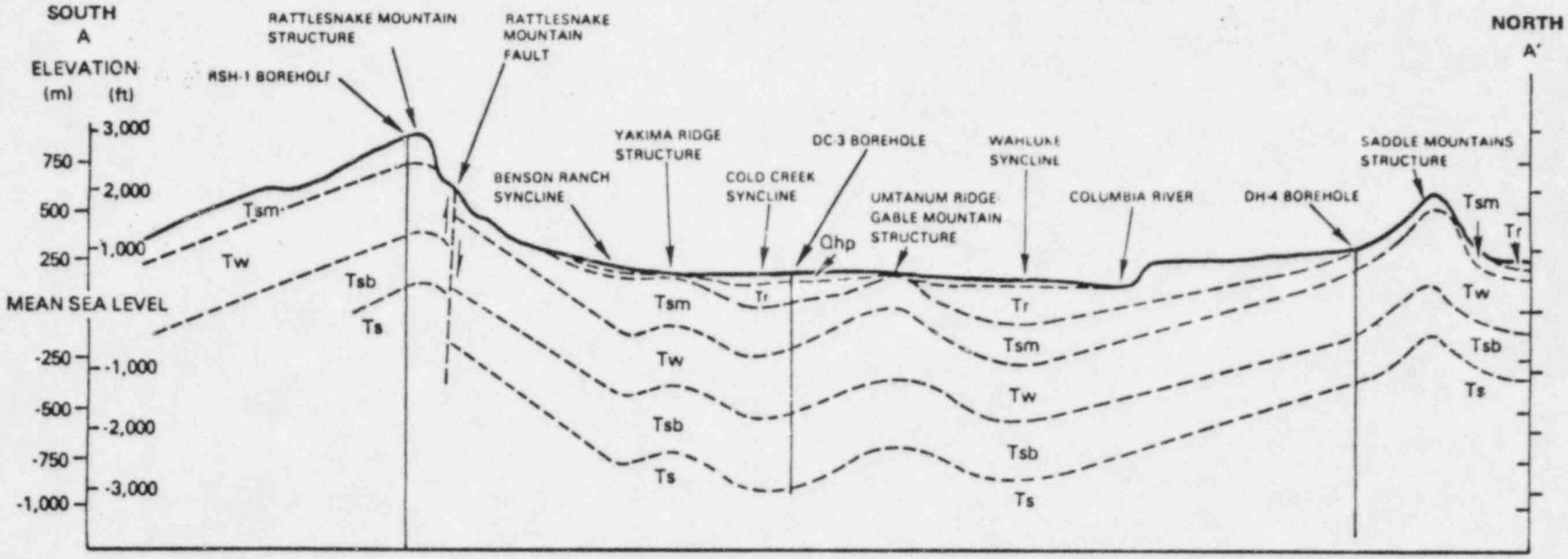
GENERALIZED STRUCTURE CROSS SECTION: PASCO BASIN



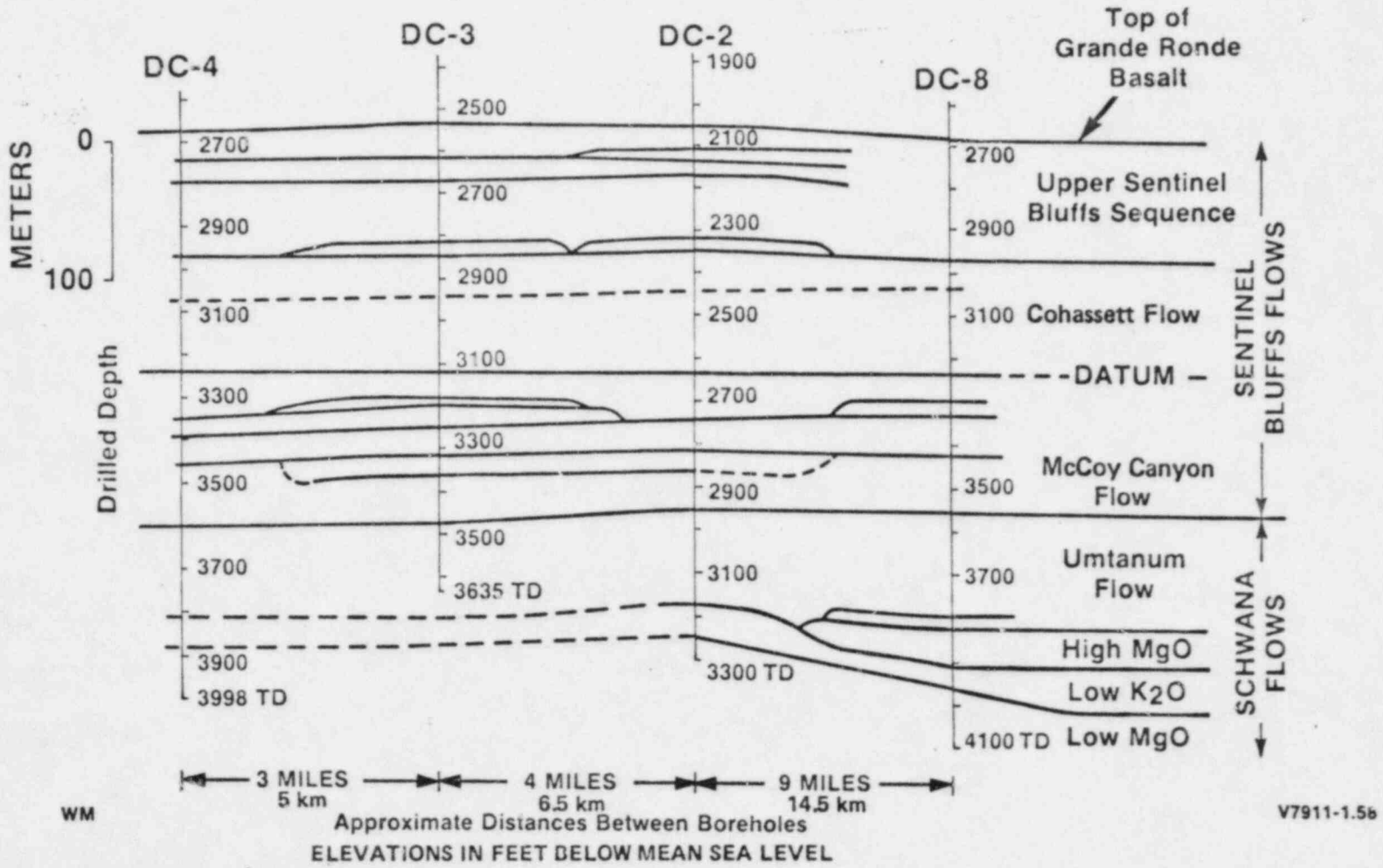
Qhp-HANFORD FORMATION-PASCO GRAVELS
Tr- RINGOLD FORMATION
Tsm-SADDLE MOUNTAINS BASALT
Tw-WANAPUM BASALT
Tsb-SENTINEL BLUFFS SEQUENCE } GRANDE RONDE
Ts-SCHWANA SEQUENCE } BASALT

0 5 10 KILOMETERS
0 5 MILES

VERTICAL EXAGGERATION = 12.5x

RCP8202-52

INTERPRETATION OF ROCK - STRATIGRAPHIC UNITS



REGULATORY CRITERIA
RELEVANT SECTIONS OF PROPOSED 10 CFR 60

60.102, GEOLOGIC SETTING—REQUIRING PARTICULAR ATTENTION TO THE CHARACTERIZATION OF THE HOST ROCK, AS WELL AS ANY ROCK UNITS SURROUNDING THE HOST ROCK

60.113, GEOLOGIC SETTING—REQUIRING THAT PRE-EMPLACEMENT GROUND-WATER TRAVELTIMES FROM THE DISTURBED ZONE TO THE ACCESSIBLE ENVIRONMENT EXCEED 1,000 YEARS

60.122, SITING REQUIREMENTS—LISTING VARIOUS FAVORABLE AND POTENTIALLY ADVERSE CONDITIONS THAT REQUIRE GEOLOGIC EVALUATIONS

60.112, OVERALL SYSTEM PERFORMANCE OBJECTIVES—STATING THE REQUIREMENTS OF THE GEOLOGIC SETTING AFTER PERMANENT CLOSURE (RELEASES TO BE WITHIN EPA LIMITS)

GEOLOGY ISSUES

- WHAT ARE THE GEOLOGIC, MINERALOGIC, AND PETROGRAPHIC CHARACTERISTICS OF THE CANDIDATE REPOSITORY HORIZONS AND SURROUNDING STRATA WITHIN THE REFERENCE REPOSITORY LOCATION?

- WHAT ARE THE NATURE AND RATES OF PAST, PRESENT, AND PROJECTED STRUCTURAL AND TECTONIC PROCESSES WITHIN THE GEOLOGIC SETTING AND REFERENCE REPOSITORY LOCATION?

HOST ROCK CHARACTERISTICS

WORK ELEMENT SUMMARY

- DETERMINE STRATIGRAPHIC CHARACTERISTICS
- DETERMINE STRUCTURAL CHARACTERISTICS
- DETERMINE MINERALOGIC AND PETROGRAPHIC CHARACTERISTICS
- DETERMINE PRIMARY INTRAFLOW STRUCTURES
- DETERMINE CHARACTERISTICS OF PRIMARY AND SECONDARY FRACTURES AND FRACTURE INFILLINGS
- DETERMINE PRESENCE AND CHARACTERISTICS OF OTHER POSSIBLE ANOMALIES

STRUCTURAL AND TECTONIC CHARACTERISTICS

WORK ELEMENT SUMMARY

- EVALUATE REGIONAL STRUCTURAL AND TECTONIC SETTING
- DETERMINE LOCATION OF FOLDS AND FAULTS
- EVALUATE FAULT CHARACTERISTICS
- EVALUATE RELATIONSHIP OF FOLDING AND FAULTING
- EVALUATE GEOLOGIC (LONG–TERM) AND CONTEMPORARY RATE OF DEFOR–MATION AND STRESS FIELD
- EVALUATE SEISMICITY
- EVALUATE VOLCANISM
- DEVELOP A CONCEPTUAL TECTONIC MODEL

CONCERNS ADDRESSED BY WORK ELEMENTS

- DOE OVERVIEW COMMITTEE
- TECTONICS WORKSHOP (FEBRUARY 1983)
- NRC/BWIP MEETING (APRIL 1983)

NRC CONCERNS

STRATIGRAPHIC AND STRUCTURAL DISCONTINUITIES

- PRESENT STRATIGRAPHIC DISCONTINUITIES
  - LATERAL CONTINUITY OF INTRAFLOW STRUCTURES
  - VARIATION IN THICKNESS OF INTRAFLOW STRUCTURES
- PRESENT STRUCTURAL DISCONTINUITIES IN PASCO BASIN
  - SIGNIFICANCE OF AEROMAGNETIC ANOMALIES
  - PROBABILITY AND NATURE OF UNDETECTED FAULTING

NRC CONCERNS

GEOLOGIC STABILITY
(Tectonics and Seismicity)*

- PROBABILITIES AND NATURE OF NATURAL CHANGES THAT WOULD AFFECT REPOSITORY PERFORMANCE
  - PROBABILITY OF EARTHQUAKE ACTIVITY*
  - NATURE AND PROBABILITY OF STRUCTURAL DEFORMATION*
  - NATURE AND PROBABILITY OF RENEWED VOLCANISM
  - PROBABILITY OF GLACIATION
- PROBABILITY AND NATURE OF GROUNDWATER WITHDRAWAL OR RECHARGE TRIGGERING MICROEARTHQUAKE OR EARTHQUAKE SWARMS*

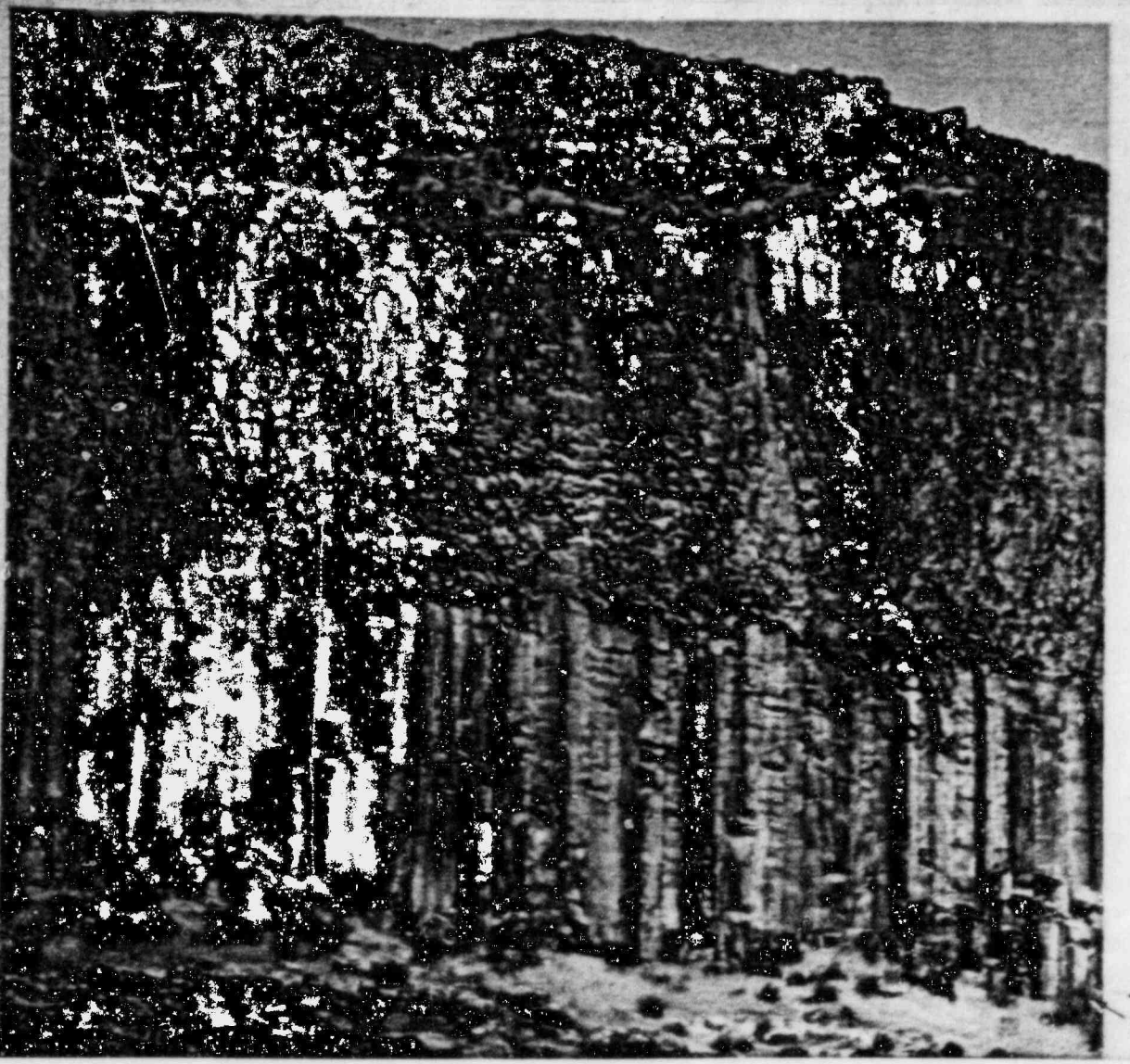
GEOLOGIC PROGRAMS

CONCERNS / PLANS FOR RESOLUTION	HOST ROCK STUDIES: STRATIGRAPHIC AND STRUCTURAL DISCONTINUITIES				TECTONIC STUDIES: TECTONICS AND SEISMICITY		
		FRACTURE ANALYSIS			TECTONIC STABILITY		
	INTRAFLOW STRUCTURES	COOLING	TECTONIC	GEOPHYSICAL ANOMALIES	SEISMICITY	TECTONIC MODEL(s)	SEISMIC DESIGN/ CONSTRUCTIBILITY
OUTCROP ANALYSIS	●	●	●	●		●	
BOREHOLE STUDIES/TESTING*	●	●	○	●	●	●	
LABORATORY ANALYSIS**	●	●	●				
EXPLORATORY SHAFT**	●	●	●		●	●	●
GEOPHYSICAL SURVEYS**				●		●	
SEISMIC SURVEILLANCE**			●	●	●	●	●
GEODETIC LEVELING/SURVEYS**						●	
CONCEPTUAL MODELING	●	●	●	●	●	●	●

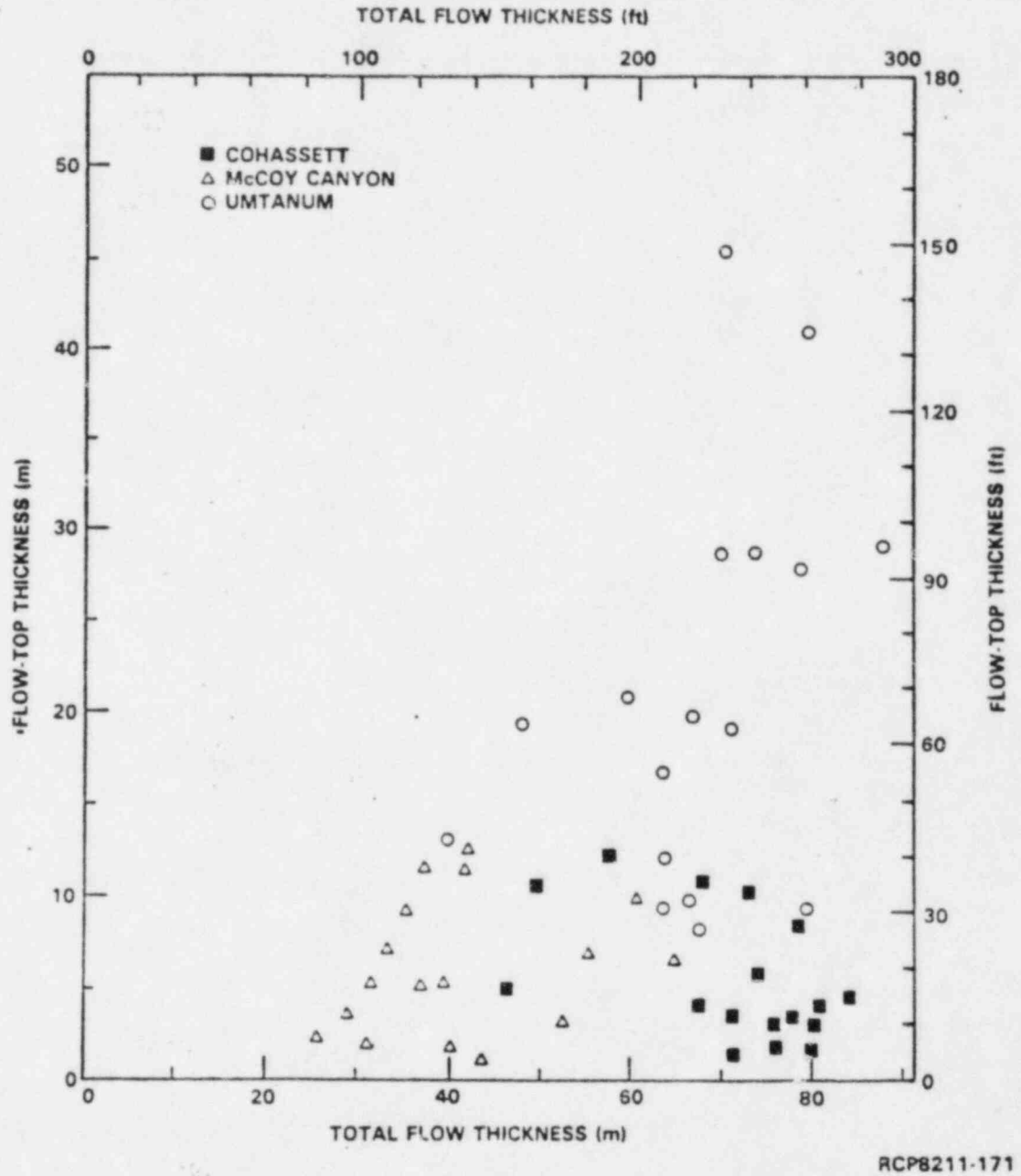
* TEST PLAN COMPLETED

** TEST PLAN IN PROGRESS OR UNDER CONSIDERATION

OUTCROP EXPOSURE OF A TYPICAL COLUMBIA RIVER BASALT FLOW



PLOT OF FLOW THICKNESS VERSUS TOTAL FLOW THICKNESS: CANDIDATE REPOSITORY HORIZONS



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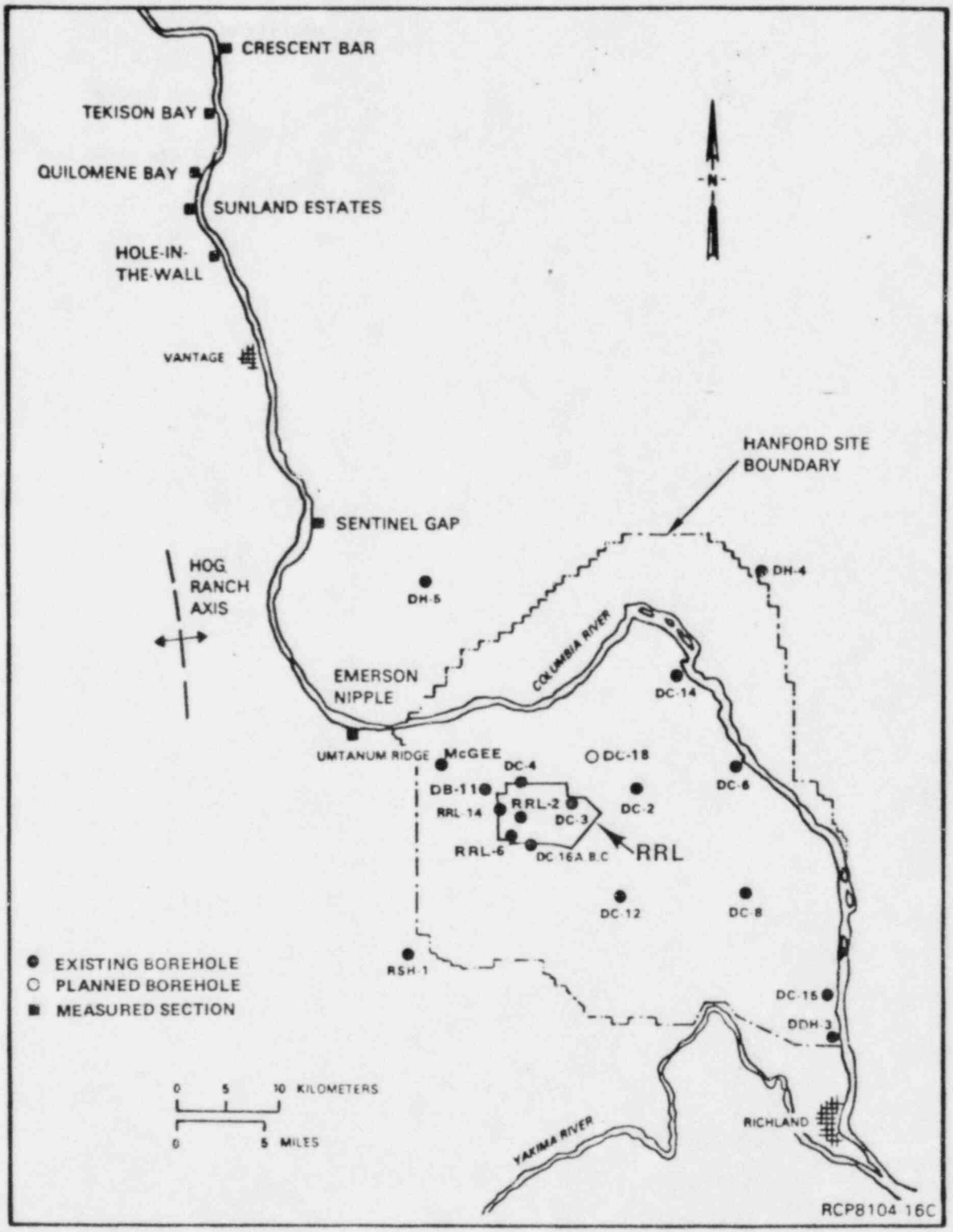
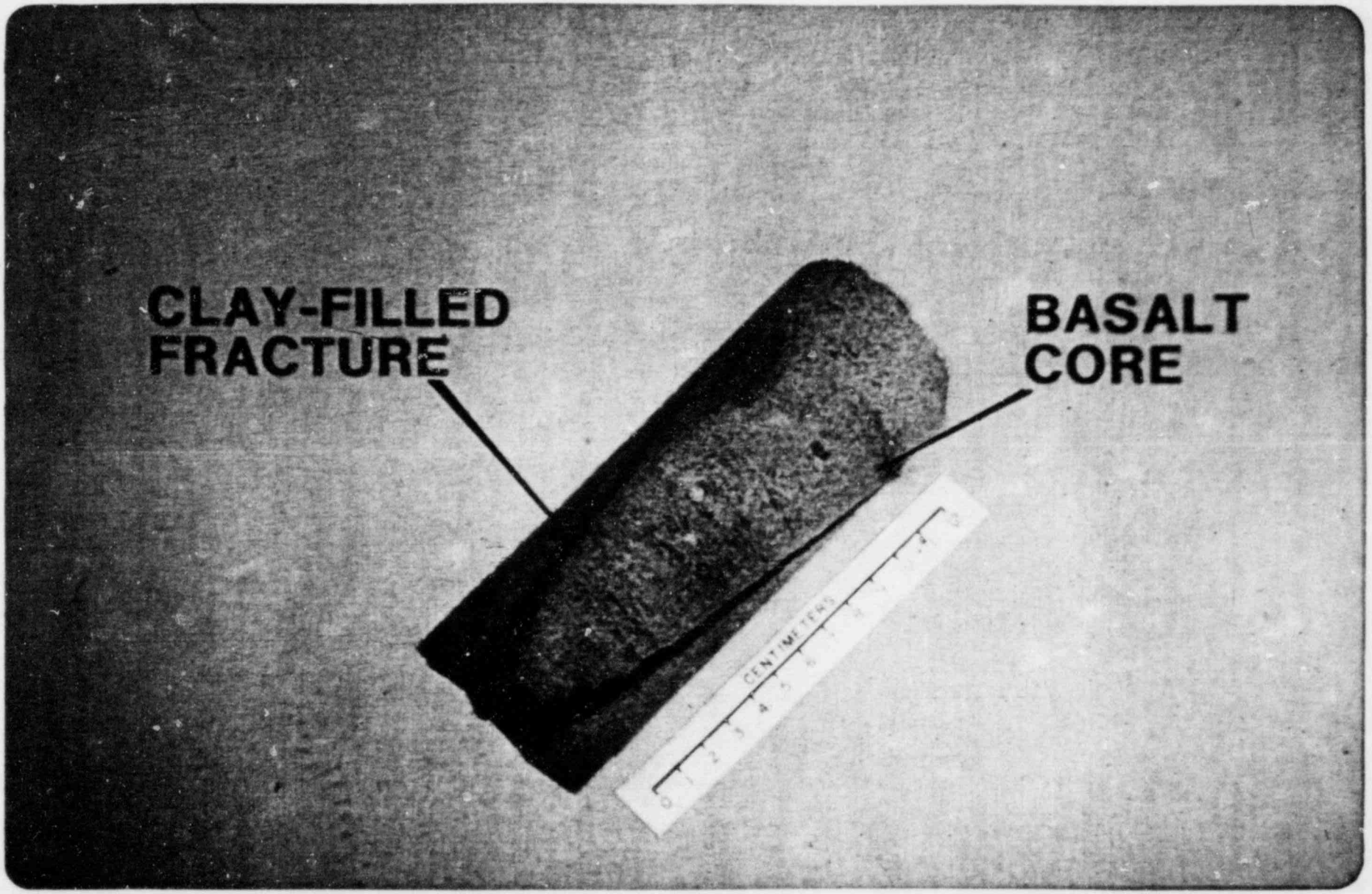
INTRAFLOW STRUCTURES

PLANS

- OUTCROP ANALYSIS
- BOREHOLE STUDIES/TESTING
- LABORATORY ANALYSIS
- EXPLORATORY SHAFT
- CONCEPTUAL MODELING

LOCATION MAP, PASCO BASIN AND SURROUNDING AREAS

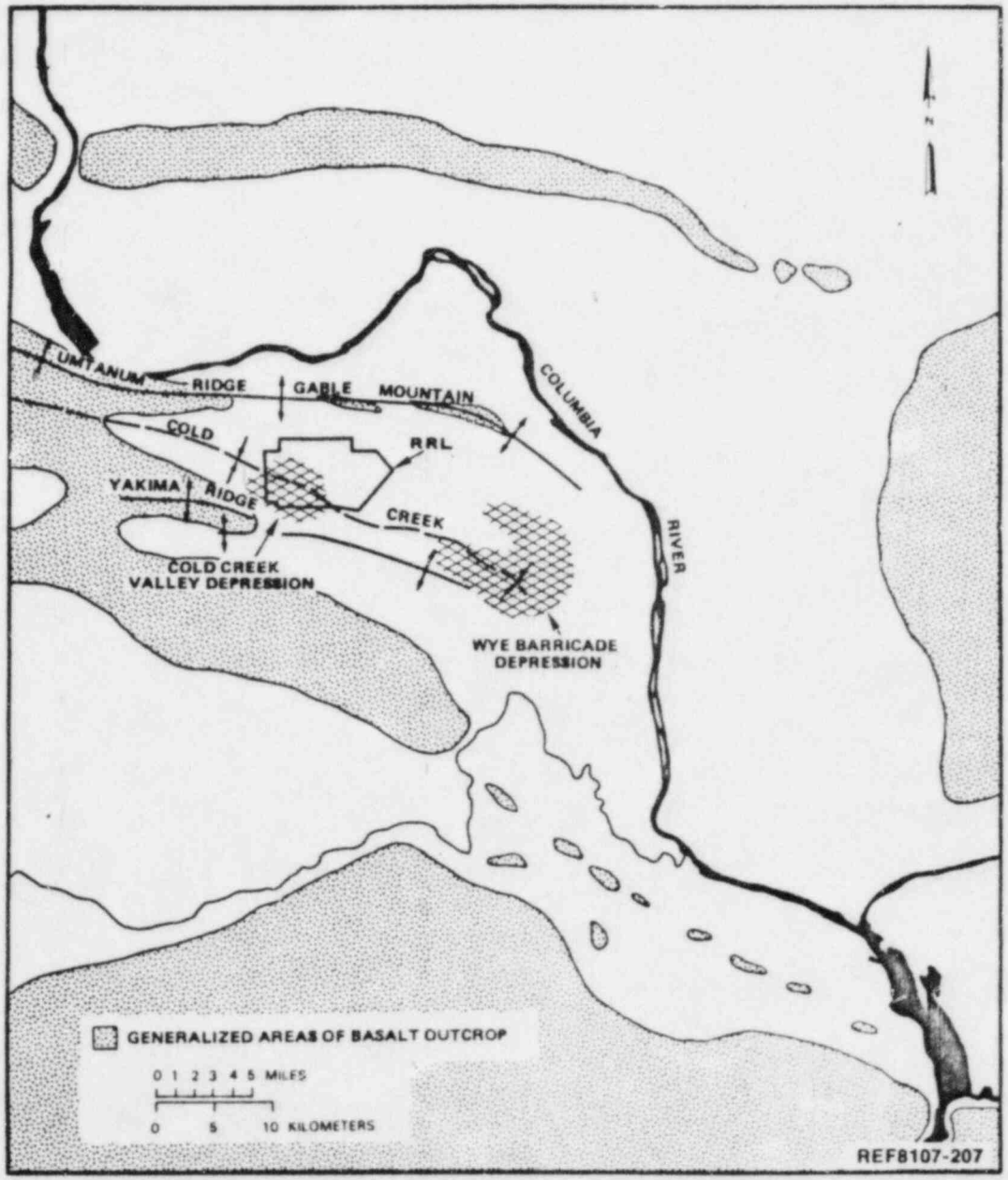



CLAY-FILLED
FRACTURE
BASALT
CORE
CENTIMETERS

COOLING FRACTURE ANALYSIS PLANS

- OUTCROP ANALYSIS
- BOREHOLE STUDIES/TESTING
- LABORATORY ANALYSIS
- EXPLORATORY SHAFT
- CONCEPTUAL MODELING

STRUCTURAL SETTING OF THE REFERENCE REPOSITORY LOCATION



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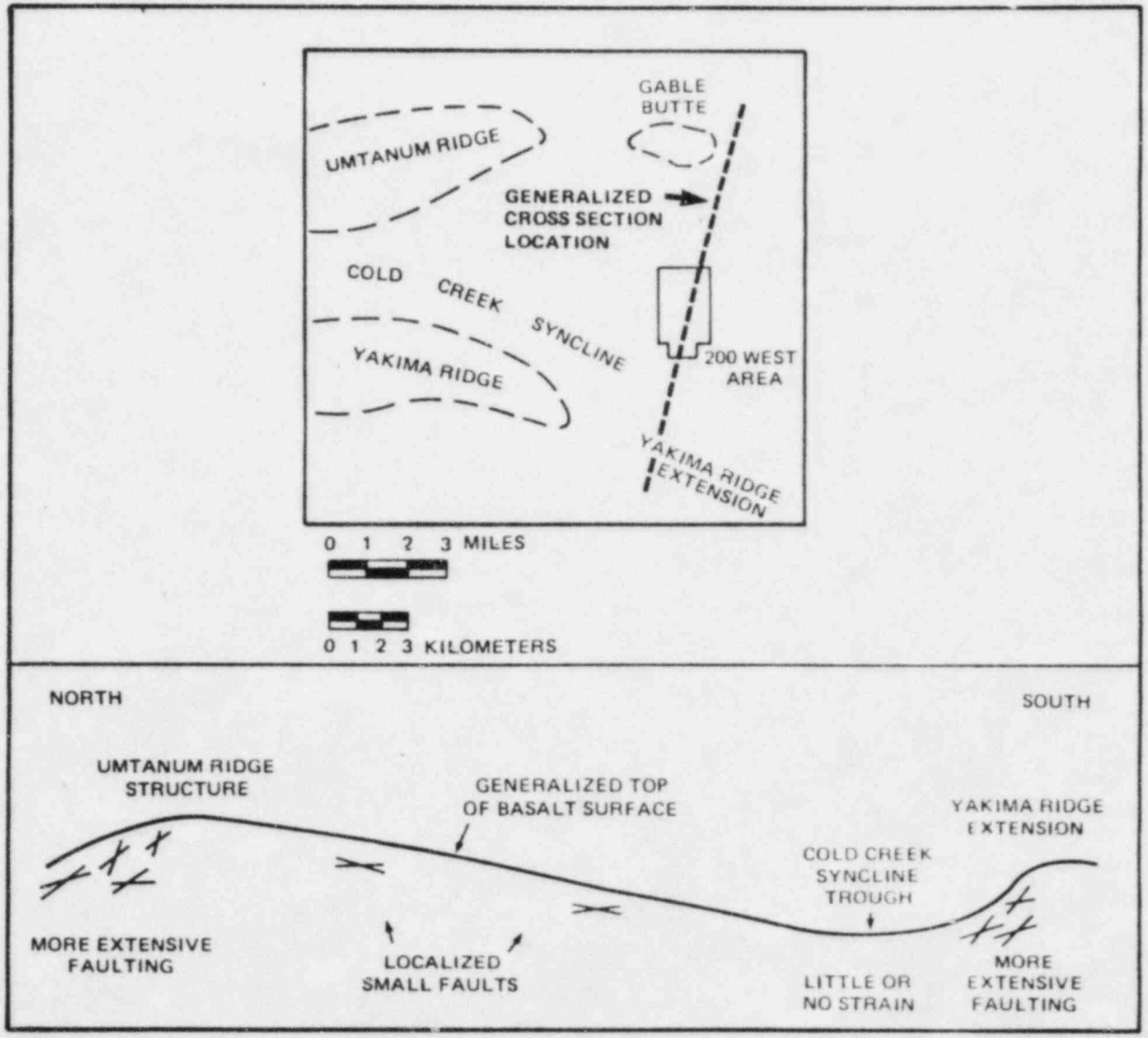
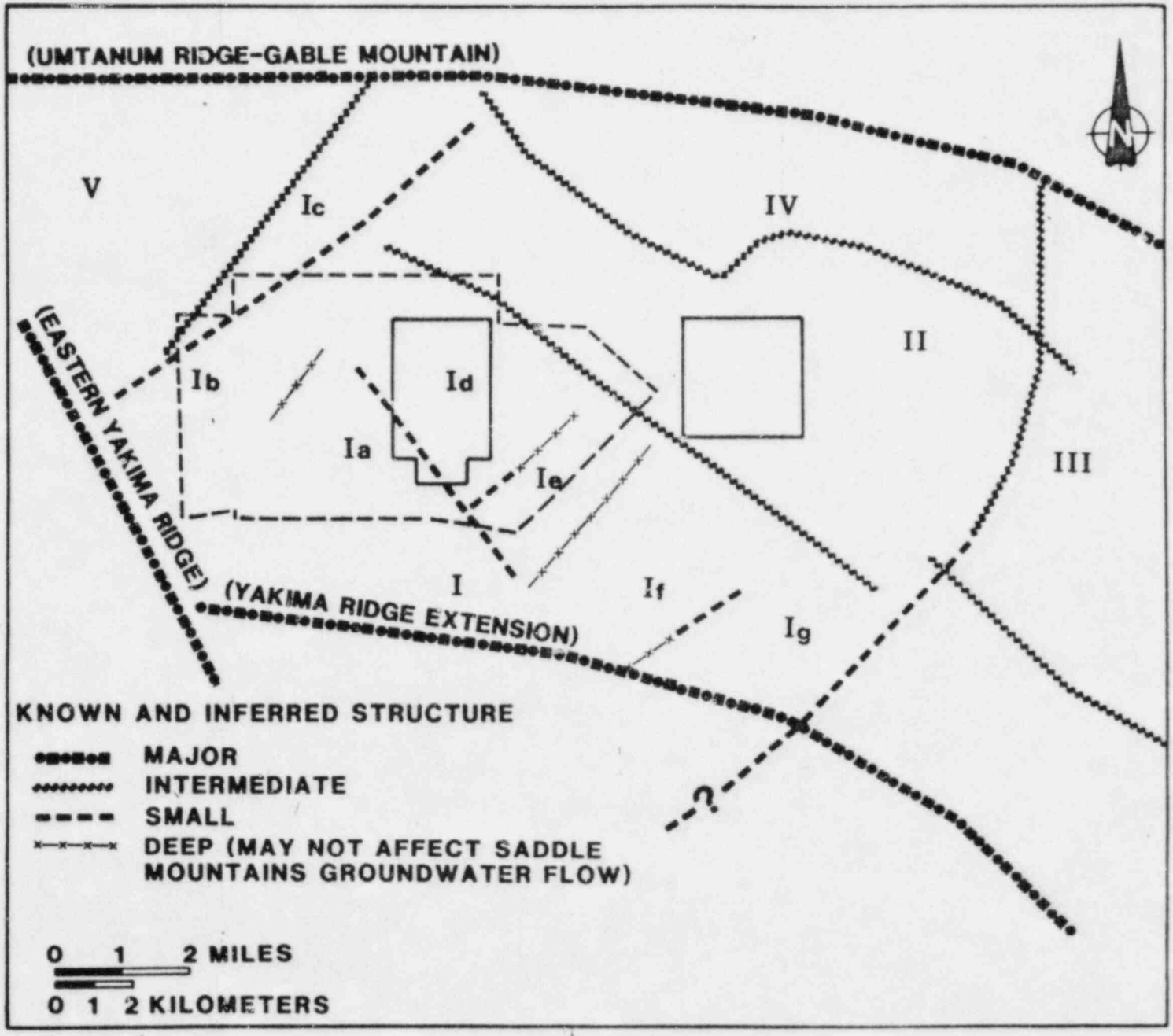
SCHEMATIC CROSS SECTION, COLD CREEK SYNCLINE



TECTONIC FRACTURE ANALYSIS PLANS

- OUTCROP ANALYSIS
- BOREHOLE STUDIES/TESTING
- LABORATORY ANALYSIS
- EXPLORATORY SHAFT
- SEISMIC SURVEILLANCE
- CONCEPTUAL MODELING

INTERPRETIVE BEDROCK STRUCTURES MAP
WESTERN COLD CREEK SYNCLINE



GEOPHYSICAL ANOMALIES

PLANS

- OUTCROP ANALYSIS
- BOREHOLE STUDIES/TESTING
- GEOPHYSICAL SURVEYS
- SEISMIC SURVEILLANCE
- CONCEPTUAL MODELING

TECTONIC STABILITY ASSESSMENT APPROACH

- GEOLOGIC DEFORMATION RATES
  - UPLIFT/SUBSIDENCE/FOLDING
  - FAULT AGE/SLIP RATE
- CONTEMPORARY DEFORMATION RATES/STRESS FIELD
  - GEODETIC SURVEYS
  - SEISMIC MONITORING
- TECTONIC MODEL DEVELOPMENT

TECTONICS WORKSHOP

GENERAL AGREEMENT

- AGE OF YAKIMA FOLD BELT DEFORMATION
- LONG–TERM DEFORMATION RATES
- STRESS ORIENTATION
- "STYLE" OF DEFORMATION
- EARTHQUAKE PATTERNS
- STRIKE–SLIP FAULT DISPLACEMENT

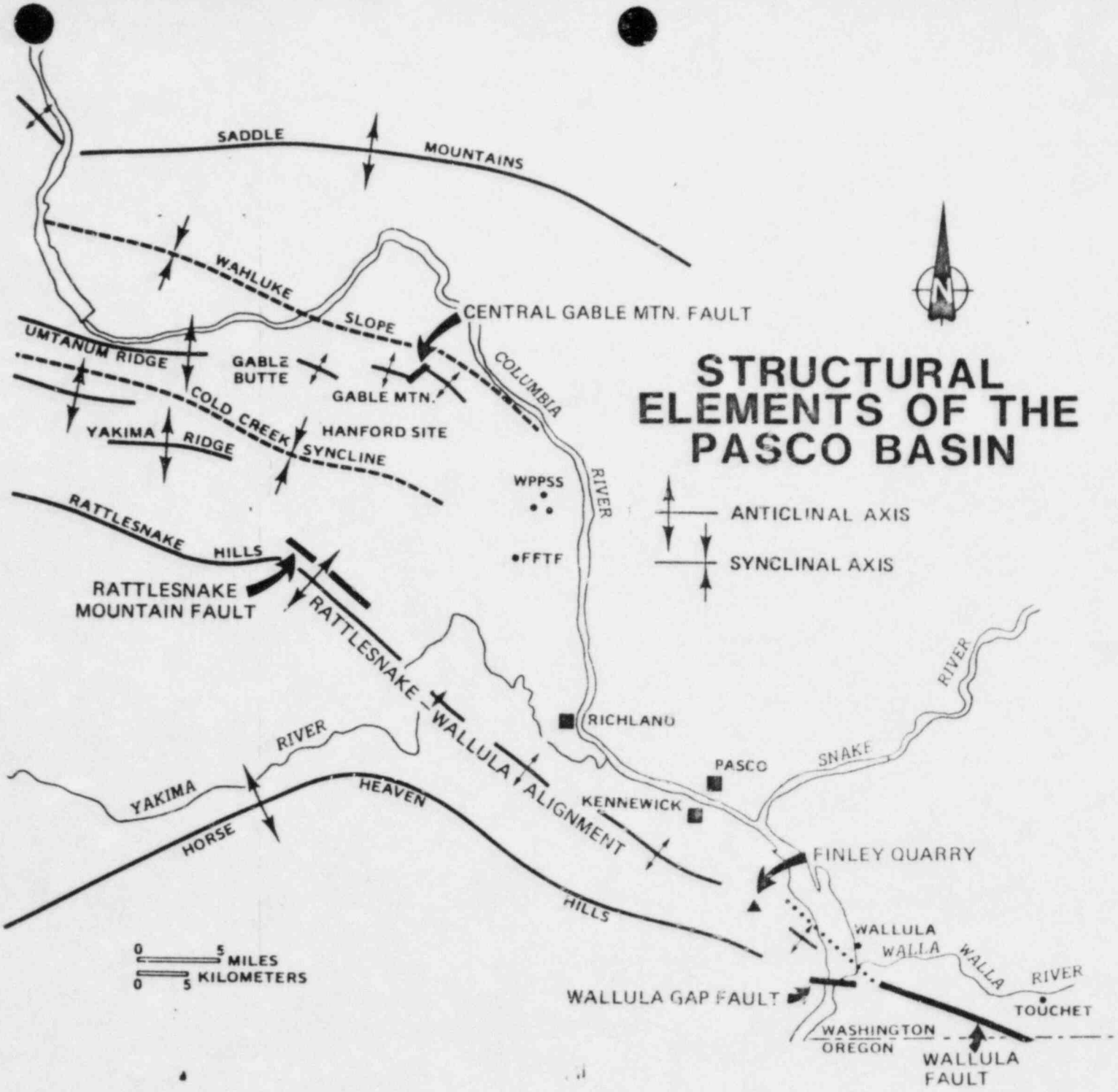
TECTONIC WORKSHOP CONCERNS

- POTENTIAL FOR EPISODIC DEFORMATION
- RELATIONSHIP OF IN SITU STRESS TO STRUCTURES
- OCCURRENCE OF FAULT BRECCIAS
- DETECTION OF POTENTIAL THRUST OR STRIKE-SLIP FAULTS
- EARTHQUAKE SWARMS IN BASALT
- DETERMINATION OF DESIGN BASIS EARTHQUAKE

TECTONIC STABILITY
SEISMIC SURVEILLANCE PLANS

CAPABILITIES OF NETWORKS

Data objective	Earthquake parameter	Existing regional network capability	Existing surface and portable network capability	Proposed borehole network capability
1	Recurrence curves	Limited to 1.6 magnitude events or greater	Limited to 1.0 magnitude events or greater	Limited to 0.0 magnitude events or greater
2	Hypocenter	Limited to 2-4 km	Limited to 1-2 km	Limited to 50-100 m
3	Parameters	Limited to 2.0 magnitude and greater	Limited to 1.0 to 3.0 magnitude	Limited to 0.0 to 2.0 magnitude
4	Ground motion	None	Limited to 0.5-20 Hz Portable: 0.5-50 Hz	Limited to 0.5-100 Hz


SADDLE MOUNTAINS
WAHLUKE SLOPE
CENTRAL GABLE MTN. FAULT
UMTANUM RIDGE
GABLE BUTTE
GABLE MTN.
COLUMBIA RIVER
COLD CREEK SYNCLINE
HANFORD SITE
YAKIMA RIDGE
WPPSS
FFTF
RATTLESNAKE HILLS
RATTLESNAKE MOUNTAIN FAULT
RATTLESNAKE-WALLULA ALIGNMENT
RICHLAND
PASCO
SNAKE RIVER
KENNEWICK
YAKIMA RIVER
HORSE HEAVEN HILLS
FINLEY QUARRY
WALLULA
WALLA WALLA RIVER
TOUCHET
WALLULA GAP FAULT
WASHINGTON
OREGON
WALLULA FAULT
0 5 MILES
0 5 KILOMETERS
N
STRUCTURAL ELEMENTS OF THE PASCO BASIN
ANTICLINAL AXIS
SYNCLINAL AXIS

TECTONIC STABILITY
TECTONIC MODEL(S)

PLANS

- OUTCROP ANALYSIS
- BOREHOLE STUDIES/TESTING
- EXPLORATORY SHAFT
- GEOPHYSICAL SURVEYS
- SEISMIC SURVEILLANCE
- GEODETIC SURVEYS
- CONCEPTUAL MODELING

SEISMIC DESIGN/CONSTRUCTIBILITY PLANS

SEISMIC DESIGN TASK FORCE

DEVELOPING OPTIONS FOR SURFACE AND SUBSURFACE FACILITIES

- CRITERIA/GUIDELINE EVALUATION
- APPROPRIATENESS OF NUCLEAR REACTOR GUIDELINES

SUMMARY

STATUS AND PLANS

- CURRENT GEOLOGIC FINDINGS DO NOT PRECLUDE DEVELOPMENT OF A REPOSITORY
- PROCEEDING TO CONDUCT AND PLAN WORK TO ADDRESS GEOLOGIC UNCERTAINTY

HYDROLOGY

S. M. BAKER

OBJECTIVES

- SUMMARY OF SITE CHARACTERIZATION REPORT HYDROLOGIC CHARACTERIZATION
- DISCUSSION OF PLANS FOR CONDUCTING CHARACTERIZATION OF THE GROUND-WATER FLOW SYSTEM

SITE CHARACTERIZATION REPORT INTERPRETATION OF GROUNDWATER FLOW SYSTEM

- "SNAPSHOT' IN TIME
- BASED ON LIMITED DATA (COMPARED TO THAT REQUIRED FOR CHARACTERIZATION)
- DID NOT ADDRESS UNCERTAINTIES (EXCEPT FOR PLANNING)
- PRELIMINARY ANALYSES SINCE SITE CHARACTERIZATION REPORT SUGGEST SIGNIFICANT UNCERTAINTIES IN PERFORMANCE
- MAJOR SOURCE OF UNCERTAINTY IS IN THE DATA BASE
- FUTURE PROGRAMS DIRECTED AT:
  - UNDERSTANDING UNCERTAINTY
  - REDUCING UNCERTAINTY

FACTORS REQUIRING STUDY FOR HYDROLOGIC ASSESSMENT

GEOLOGIC

- STRATIGRAPHY
- STRUCTURE

} MAJOR FACTORS CONTROLLING GROUNDWATER OCCURRENCE AND DISTRIBUTION

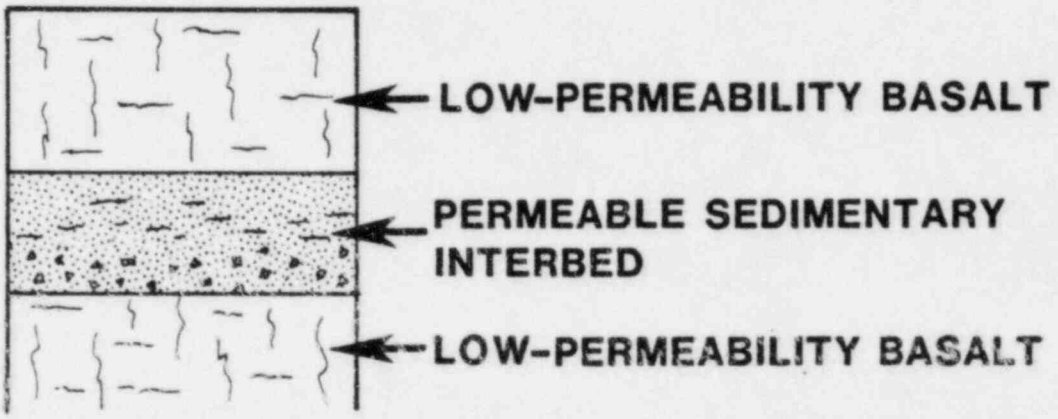
HYDROLOGIC

- HYDROLOGIC PROPERTIES
- HYDRAULIC HEADS
- HYDROCHEMISTRY
- RECHARGE AND DISCHARGE
- INTERACTION BETWEEN FLOW SYSTEMS

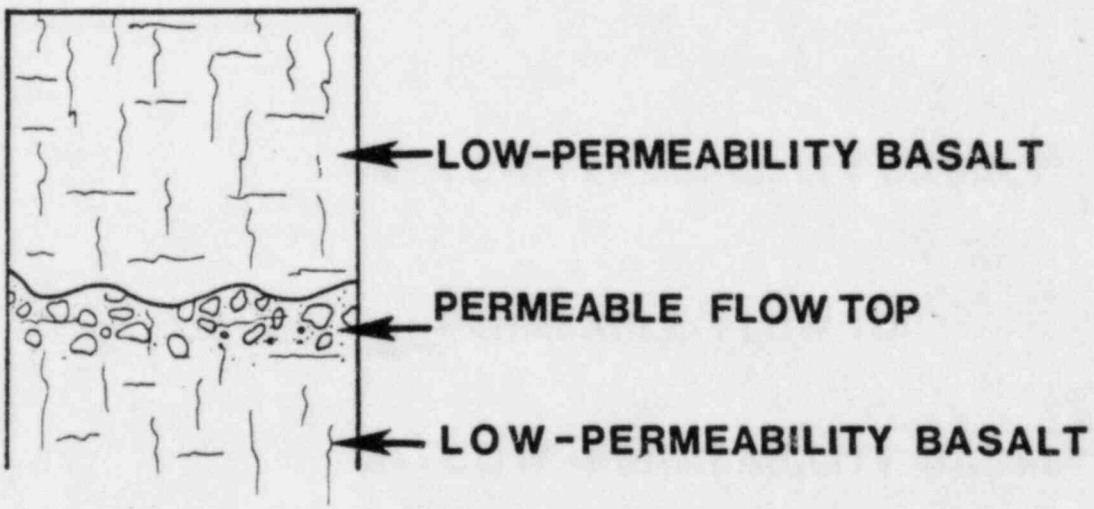
} MAJOR FACTORS CONTROLLING GROUNDWATER MOVEMENT, SUPPLY, AND HISTORY

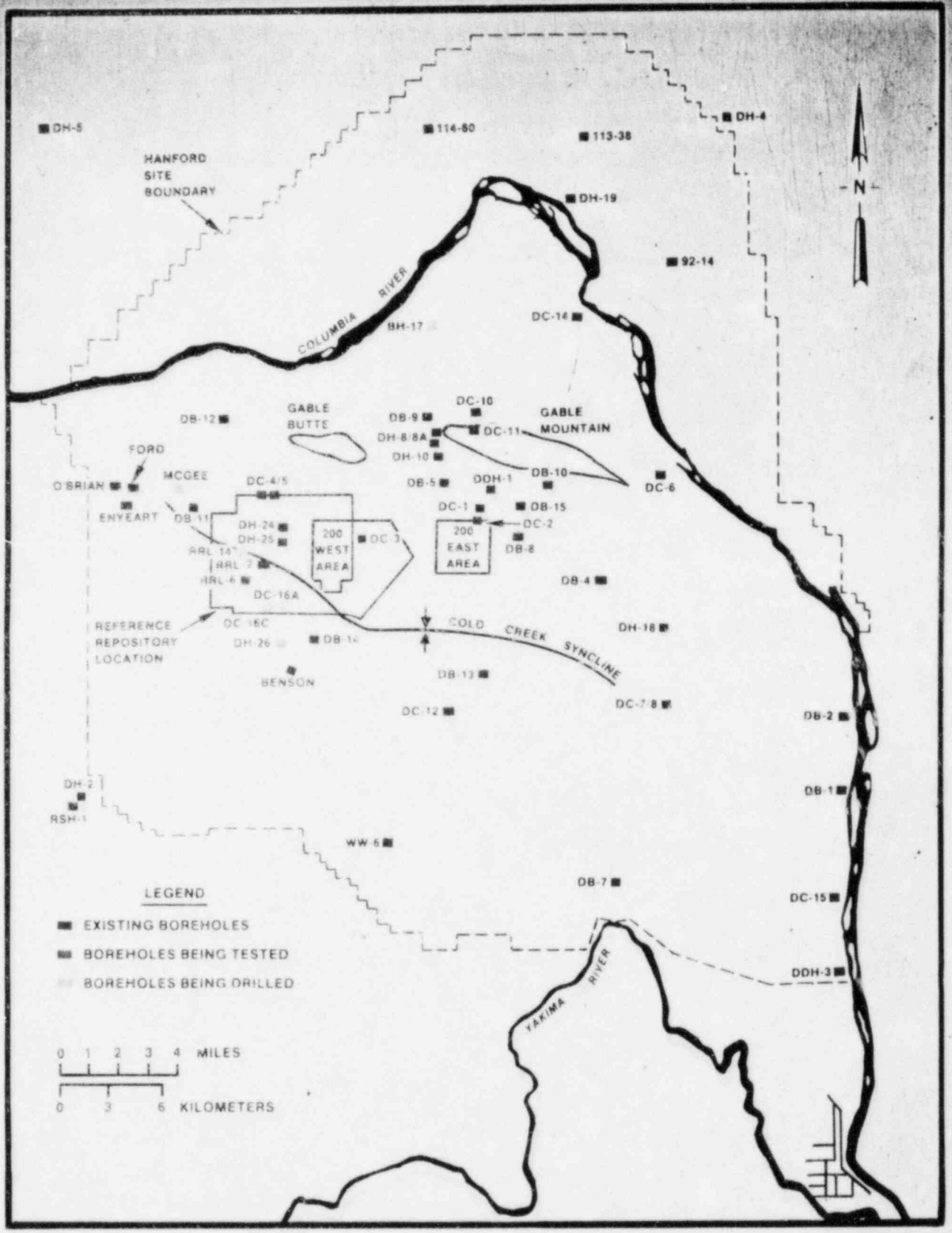
TYPES OF CONFINED AQUIFER SYSTEMS AT THE HANFORD SITE

CONFINED SEDIMENTARY AQUIFER SYSTEM



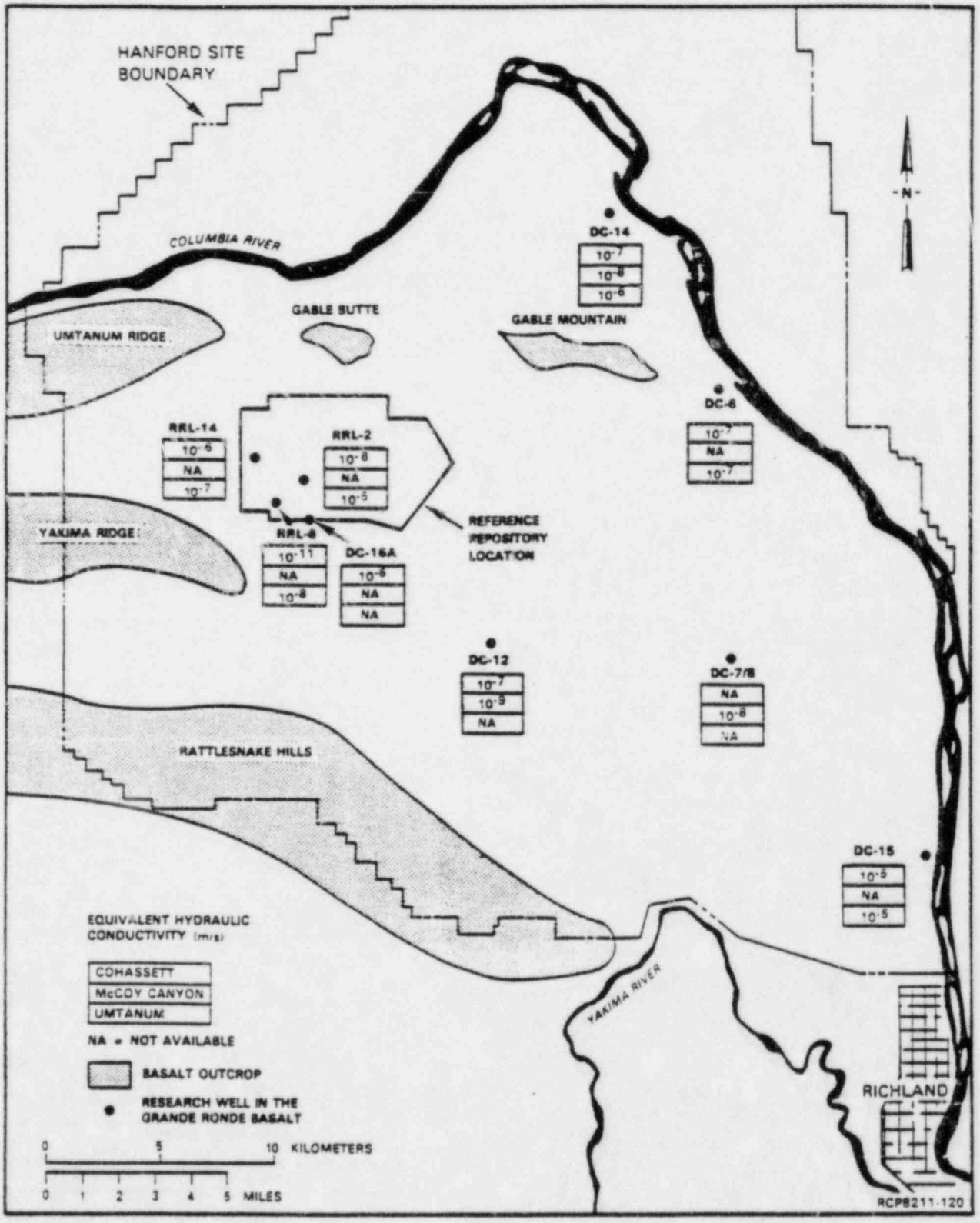
CONFINED FLOW-TOP AQUIFER SYSTEM





MAP SHOWING WELLS CURRENTLY BEING DRILLED AND TESTED.

AREAL DISTRIBUTION OF EQUIVALENT HYDRAULIC CONDUCTIVITY VALUES FOR FLOW TOPS WITHIN THE CANDIDATE REPOSITORY HORIZONS



SUMMARY OF HYDROLOGIC DATA

WITH DEPTH	• GROUNDWATER CHEMICAL BREAKS • OLDER GROUNDWATERS • SMALL HYDRAULIC HEAD GRADIENTS • LESS GROUNDWATER
WITH DISTANCE	• GROUNDWATER CHEMISTRY CHANGES ALONG FLOW PATHS • HYDRAULIC HEAD DECREASES TOWARD EAST TO SOUTHEAST ALONG GROUNDWATER FLOW PATHS

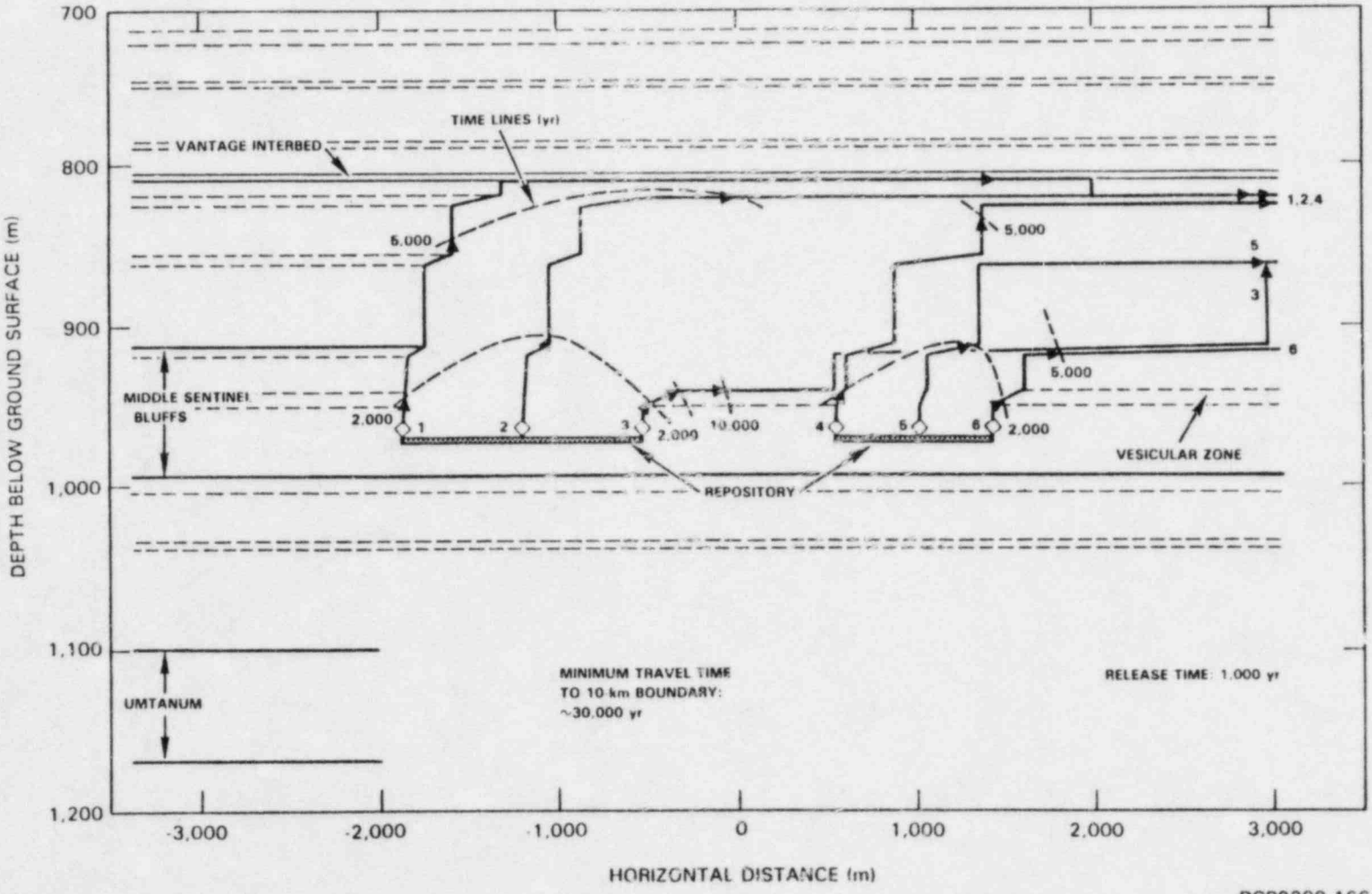
PRELIMINARY MODELING RESULTS

- NEAR FIELD
- FAR FIELD

NEAR–FIELD MODEL INPUT

- CONSTANT HEAD BOUNDARIES (BEYOND THERMAL INFLUENCE)
- STRATIGRAPHY FROM BOREHOLE DATA
- FLOW–TOP CONDUCTIVITIES (HORIZONTAL) FROM WELL TESTS
- VERTICAL CONDUCTIVITY OF FLOW INTERIOR TEN TIMES WELL TESTS RESULTS (HORIZONTAL)
- STORAGE COEFFICIENT FROM WELL TESTS
- THERMAL PROPERTIES FROM LABORATORY TESTS
- REFERENCE POROSITY, DISPERSIVITY, AND RADIONUCLIDE TRANSPORT PROPERTIES
- BWIP REPOSITORY CONCEPTUAL DESIGN
- NWTS STANDARD REPOSITORY LOADING PARAMETERS

GROUNDWATER PATHLINES AND TRAVELTIMES FOR MIDDLE SENTINEL BLUFFS FLOW: NO-DISRUPTION BASE CASE



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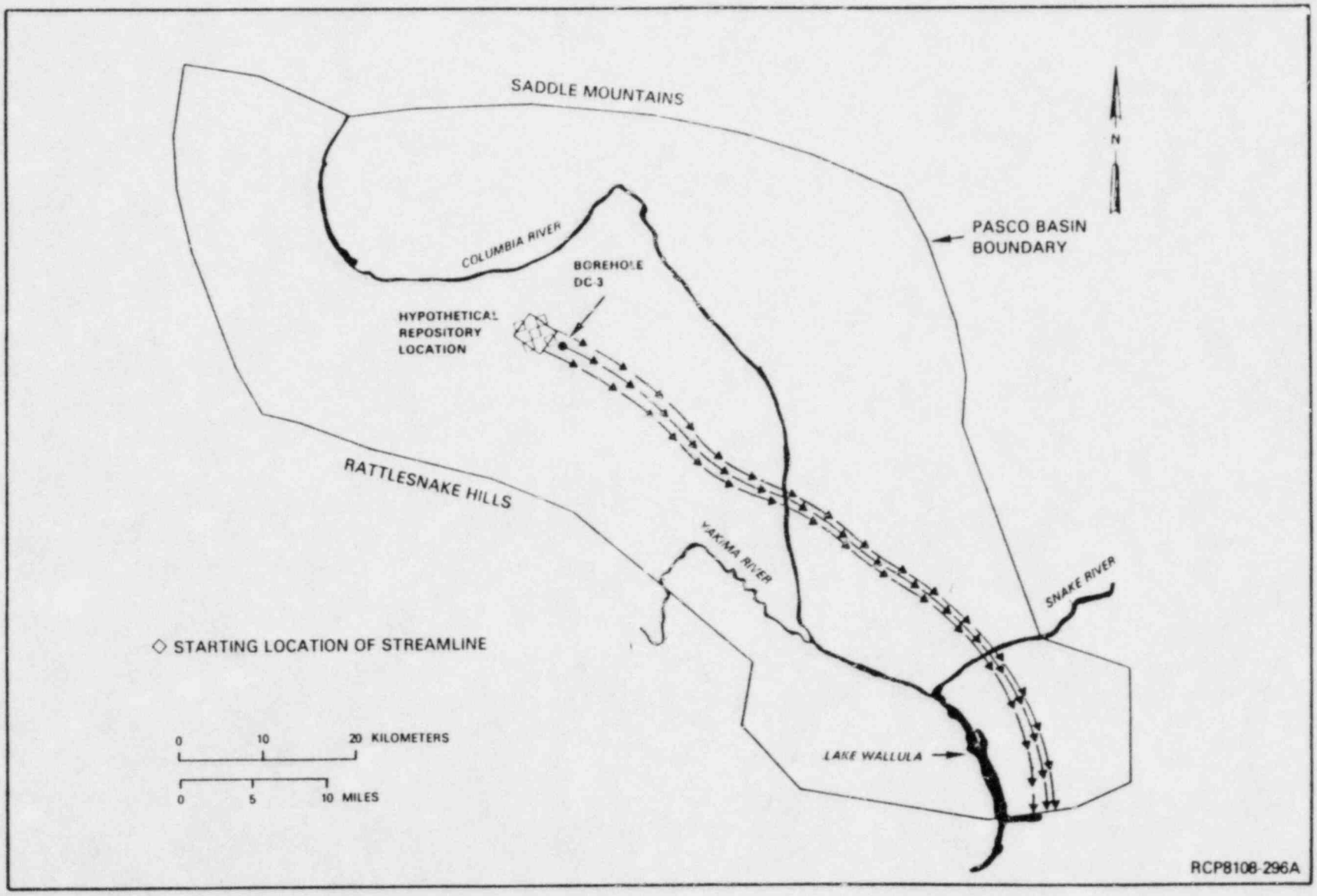
FAR–FIELD MODEL INPUT

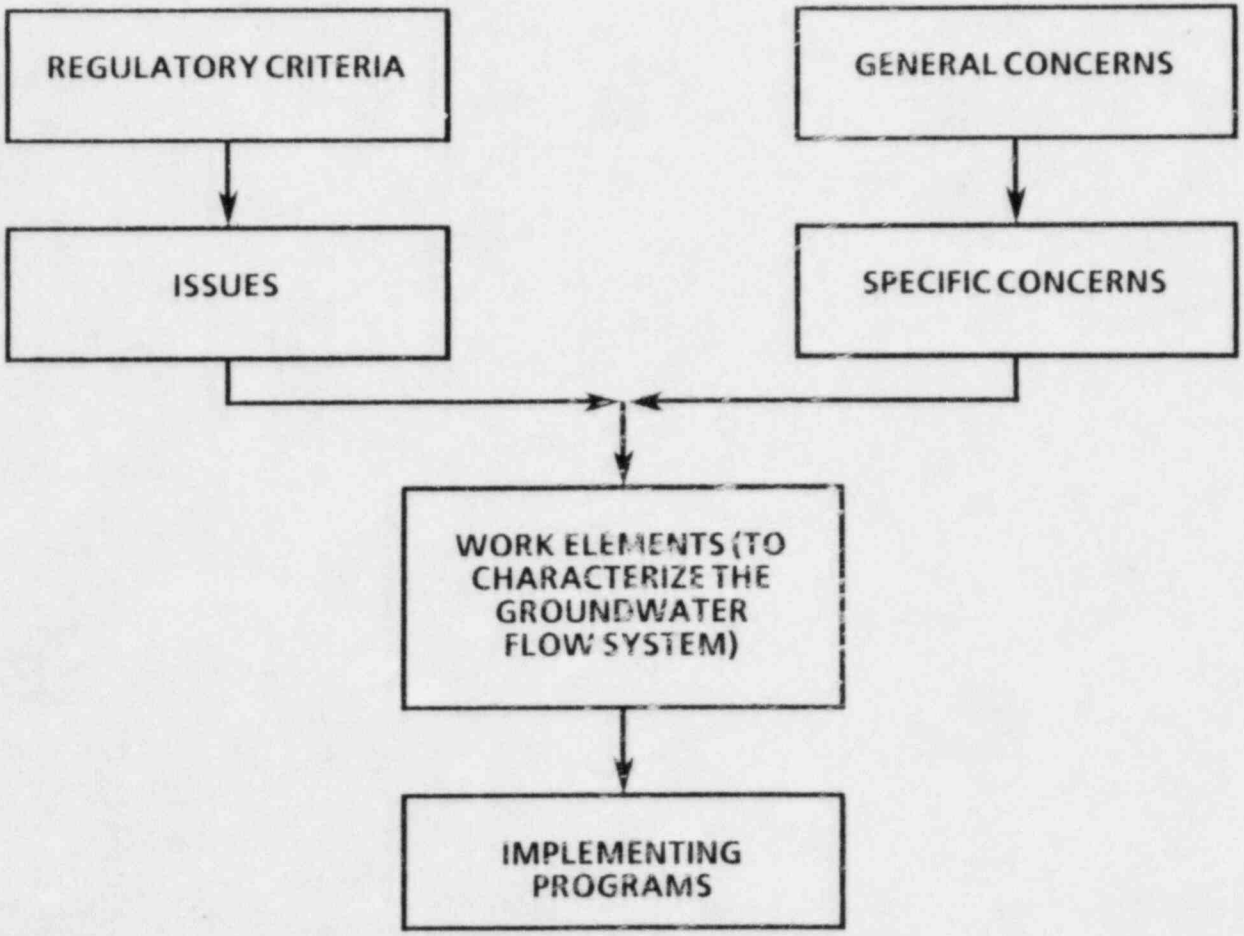
- COMPOSITE FLOW SYSTEMS
- HORIZONTAL CONDUCTIVITY FROM WELL TESTS
- VERTICAL CONDUCTIVITY THREE ORDERS OF MAGNITUDE LESS (INFERRED FROM FLOW INTERIOR CONDUCTIVITIES)
- ASSUMED BOUNDARY CONDITIONS
- ASSUMED HYDRAULIC GRADIENT: 10^{-3} METER/METER
- STRUCTURES NOT MODELED

PLANAR VIEW OF STREAMLINES FROM HYPOTHETICAL REPOSITORY TO BOUNDARY



BWIP PLANS FOR CONDUCTING HYDROLOGIC CHARACTERIZATION

IDENTIFICATION OF WORK REQUIRED TO CONDUCT HYDROLOGIC CHARACTERIZATION



GENERAL CONCERNS ABOUT GROUNDWATER FLOW SYSTEM

- LACK OF DATA—TO SUPPORT UNDERSTANDING OF CONCEPTUAL GROUNDWATER FLOW SYSTEM
- COMPREHENSIVE EVALUATION OF DATA—INTEGRATION OF A BROAD BASE OF GEOLOGICAL, GEOPHYSICAL, GEOCHEMICAL, AND HYDROLOGICAL DATA IN SUPPORT OF UNDERSTANDING THE GROUNDWATER FLOW SYSTEM
- REPRESENTATIVENESS OF DATA—TO ASSURE THAT HYDROLOGICAL DATA ARE REPRESENTATIVE OF THE FLOW SYSTEM (TIME AND SCALE)
- CREDIBILITY OF PROGRAM—TO ASSURE THAT THE SCOPE OF THE HYDROLOGY PROGRAM IS ADEQUATE, THAT THE DATA ARE REPORTED IN AN ACCURATE AND TIMELY FASHION, AND THAT THE INVESTIGATORS ARE IMPARTIAL AND OBJECTIVE

NRC CONCERNS

LACK OF DATA

- EFFECT OF MUD ON LOW- AND HIGH-PERMEABILITY ZONES
- GROUNDWATER MODEL BOUNDARIES NOT WELL KNOWN

COMPREHENSIVE EVALUATION OF DATA

- EFFECTS OF GEOLOGIC STRUCTURES ON GROUNDWATER FLOW SYSTEM
- SOURCE OF RECHARGE—OUTCROP AREAS OR VERTICAL LEAKAGE
- BASIS FOR CONCLUSIONS THAT COLUMBIA RIVER IS NOT A LINE SINK
- IMPORTANCE OF VERTICAL PERMEABILITY IN EMPLACEMENT HORIZON TO POTENTIAL RELASE TO ACCESSIBLE ENVIRONMENT

REPRESENTATIVENESS OF DATA

- SINGLE WELL TESTING IS NOT WELL SUITED TO REQUIRED CHARACTERIZATION OF HIGH-PERMEABILITY ZONES
- GEOCHEMISTRY DOES NOT ADEQUATELY SUPPORT LACK OF VERTICAL GROUNDWATER MOVEMENT
- NEED FOR MULTIPLE BOREHOLE (LARGE-SCALE) AQUIFER TESTS

CREDIBILITY OF PROGRAM

- NEED FOR VERTICAL PERMEABILITY TEST
- DIRECTION OF FLOW TO DISCHARGE AREA

OVERVIEW COMMITTEE CONCERNS

LACK OF DATA

- LACK OF VERTICAL PERMEABILITY TESTS, EFFECTIVE POROSITY AND DISPERSIVITY MEASUREMENTS, GEOCHEMICAL DATA, ETC.

COMPREHENSIVENESS OF DATA

- POTENTIAL FOR HIGH-CONDUCTIVITY PATH TO BIOSPHERE THAT COULD TRAVERSE THE BASALT SEQUENCE

REPRESENTATIVENESS OF DATA

- HYDROLOGIC HEAD DATA ARE INADEQUATE OR QUESTIONABLE

CREDIBILITY OF PROGRAM

- PIEZOMETER DATA DO NOT SUPPORT ROCKWELL INTERPRETATION OF DISCHARGE AREA
- SIGNIFICANCE OF VERTICAL FLOW ACROSS THE LOW-PERMEABILITY ZONES

MODELING TASK FORCE CONCERNS

LACK OF DATA

- LACK OF DATA

COMPREHENSIVENESS OF DATA

- VERTICAL GROUNDWATER MOTION
- RATTLESNAKE HILLS BOUNDARY CONDITIONS
- INTERPRETATION OF HYDROCHEMICAL DATA

REPRESENTATIVENESS OF DATA

- VALIDITY OF HEAD DATA COLLECTION TECHNIQUES
- STEADY-STATE BEHAVIOR

CREDIBILITY OF PROGRAM

- VALIDITY OF LATERAL CONDUCTIVITY MEASUREMENT TECHNIQUES

WORK ELEMENTS

- FLOW SYSTEM HYDRAULIC PROPERTIES
- HYDRAULIC HEADS
- HYDROCHEMISTRY
- INTERACTIONS BETWEEN FLOW SYSTEMS
- VERTICAL GROUNDWATER MOTION
- HYDRAULIC PROPERTIES OF STRUCTURES
- MODELING
- HYDRAULIC STABILITY
- TRAVELTIME (PRE-WASTE-EMPLACEMENT)
- UNCERTAINTY

GROUNDWATER FLOW SYSTEM CHARACTERIZATION

- REQUIRED AS A BASIS FOR ANSWERING HYDROLOGY ISSUES
- NEED TO UNDERSTAND FLOW SYSTEM FOR CONFIDENCE IN CONCLUSIONS

EXAMPLE:

VALIDITY OF HEAD DATA COLLECTION TECHNIQUES

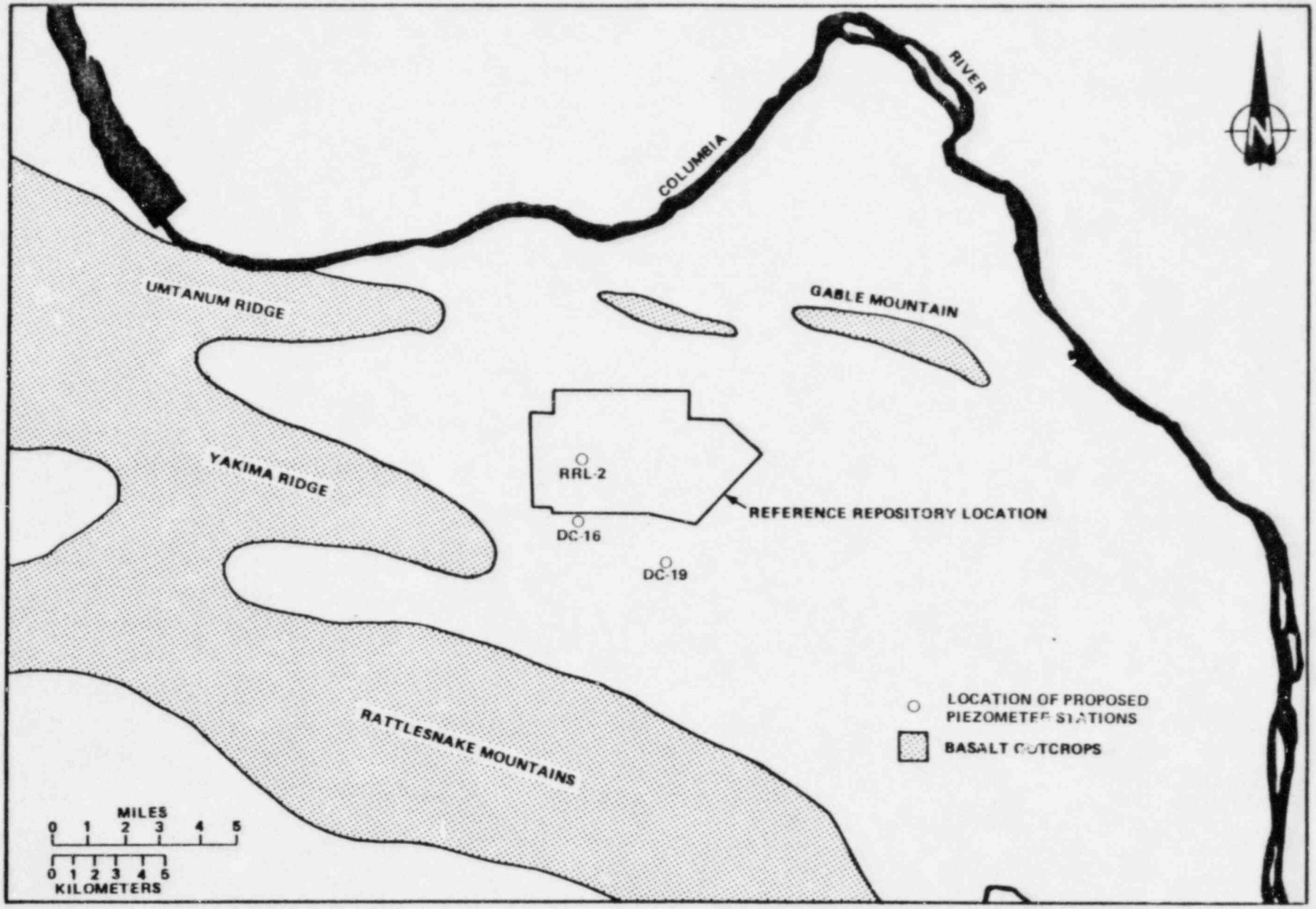
- DRILL AND TEST TECHNIQUE
- EQUILIBRATION TIME
- INFLUENCE OF PREVIOUS TESTING
- TEMPORAL VARIATIONS

PLAN FOR THE BASELINE CHARACTERIZATION OF TIME–VARIANT HYDROGEOLOGIC PARAMETERS

PRINCIPAL TEST PLAN ELEMENTS

- REFERENCE REPOSITORY LOCATION HYDRAULIC HEAD TRANSIENTS
- UPPER COLD CREEK SYNCLINE GROUNDWATER USE
- GROUNDWATER/SURFACE WATER INTERACTION ALONG COLUMBIA RIVER
- TIME-VARIANT HYDROCHEMICAL BEHAVIOR
- SUPPLEMENTARY CONCEPTUAL EVALUATIONS
- REGIONAL TIME-VARIANT TRENDS

PROPOSED PIEZOMETER STATIONS



SPECIAL TEST DEVELOPMENT

EXAMPLE:

EFFECT OF DRILLING FLUID ON TEST RESULTS

- MEASUREMENTS WHICH MIGHT BE AFFECTED
  - TRANSMISSIVITY
  - HEAD
  - HYDROCHEMISTRY
- PROGRAM OF INVESTIGATION
  - LONG-TERM HYDROCHEMISTRY TEST
  - TESTING OF INTERVALS DRILLED WITHOUT MUD

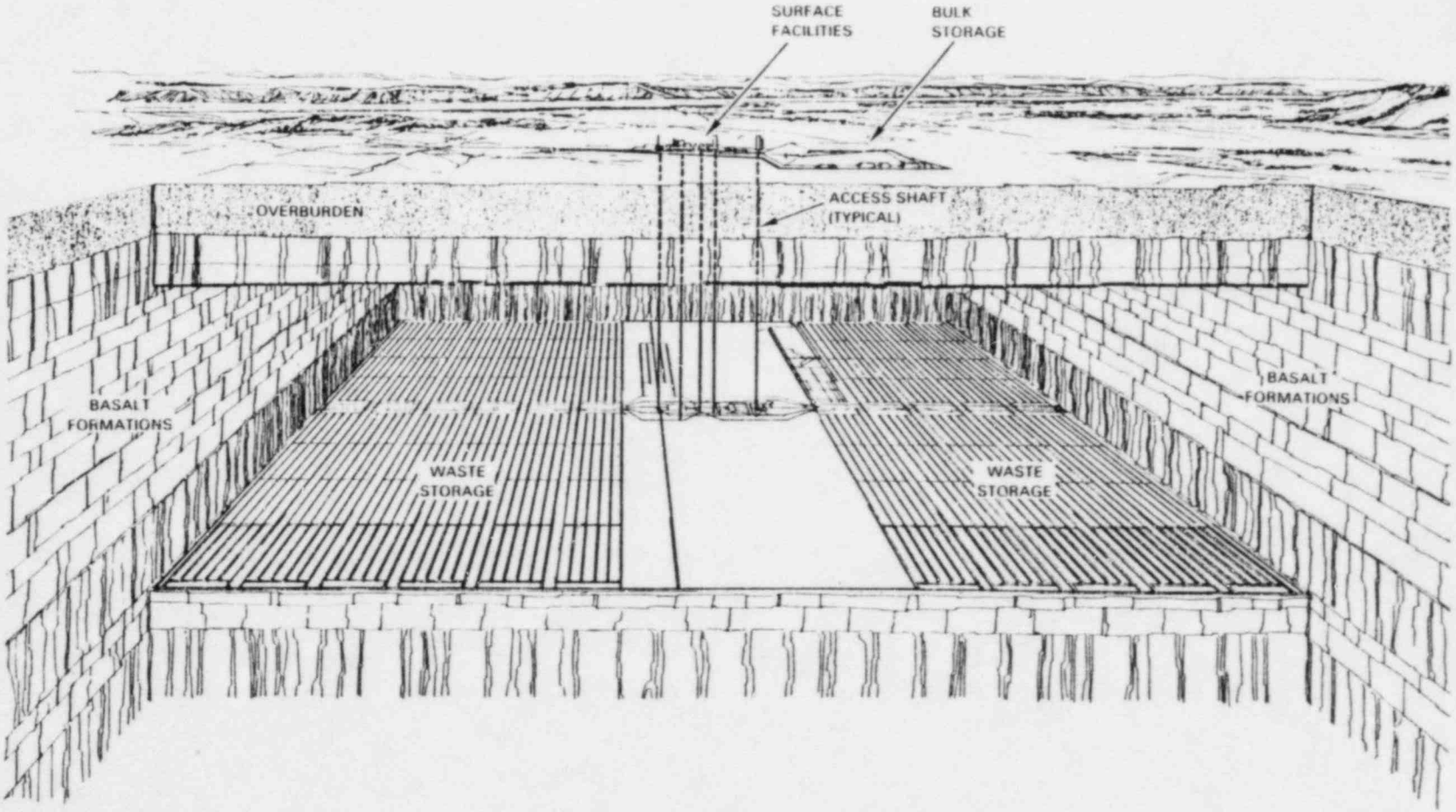
TESTING ACTIVITIES

- LONG-TERM HYDROCHEMISTRY TEST
  - FREE-FLOWING ARTESIAN WELL
  - BASELINE MONITORING
  - INJECTED MUD
  - MONITORING CLEANUP
- TESTING OF INTERVALS DRILLED WITHOUT MUD
  - INITIAL TEST
  - MUD INJECTION WITH DRILLING
  - RETESTING
  - ONE TEST COMPLETED
  - OTHERS PLANNED

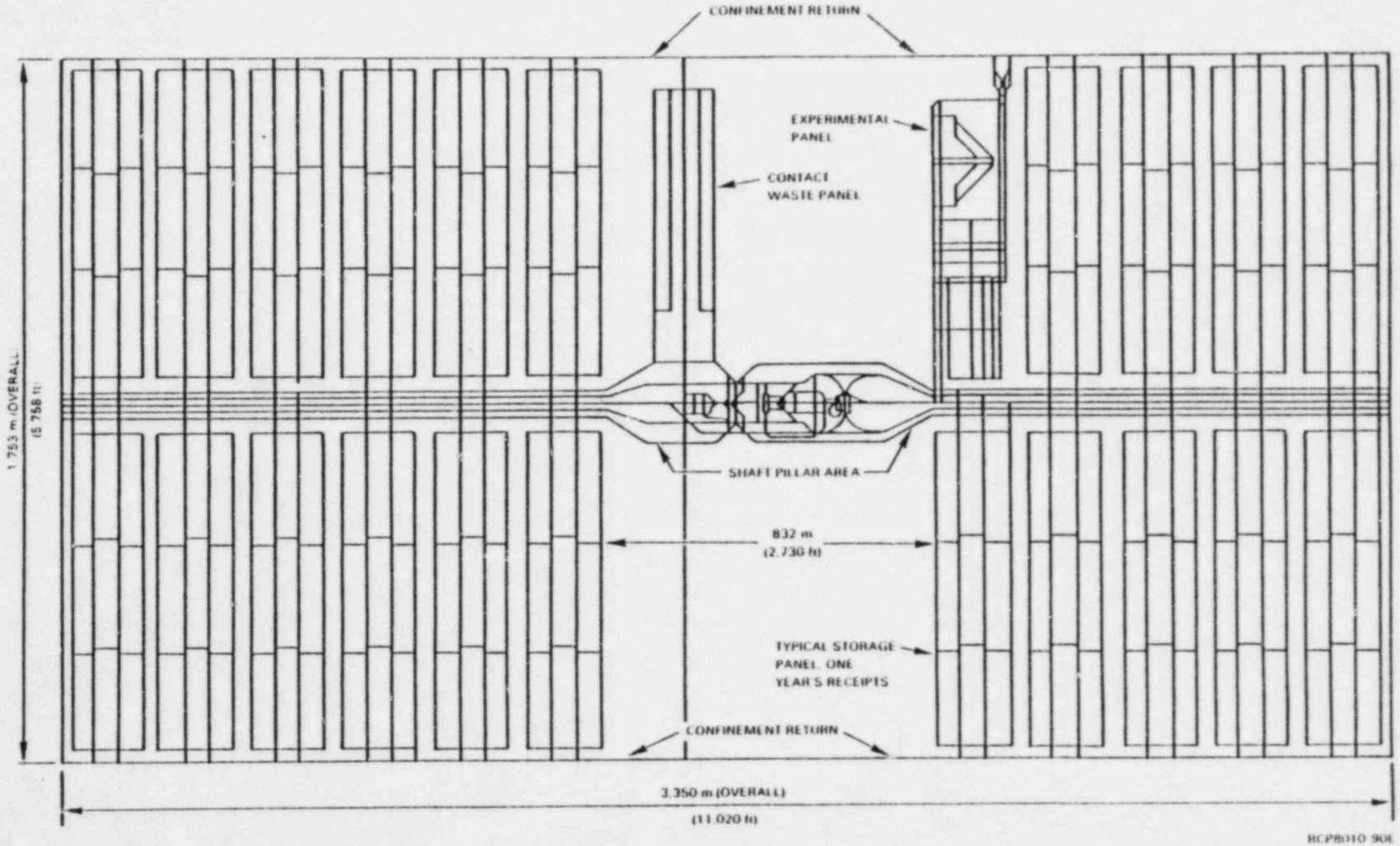
REPOSITORY DESIGN

D. A. TURNER

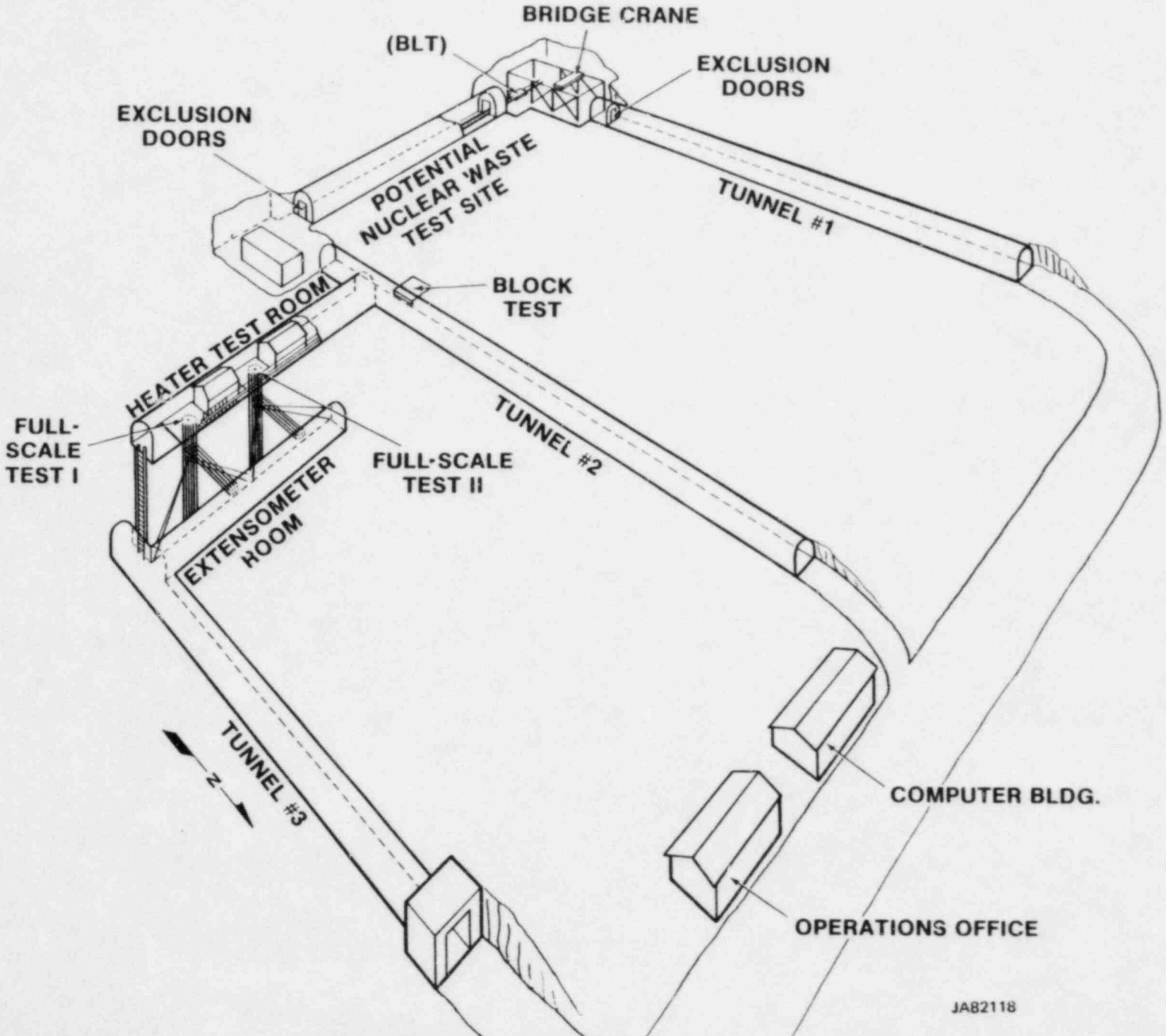
REPOSITORY CUTAWAY



SUBSURFACE FACILITIES LAYOUT (BOW-TIE ARRANGEMENT)



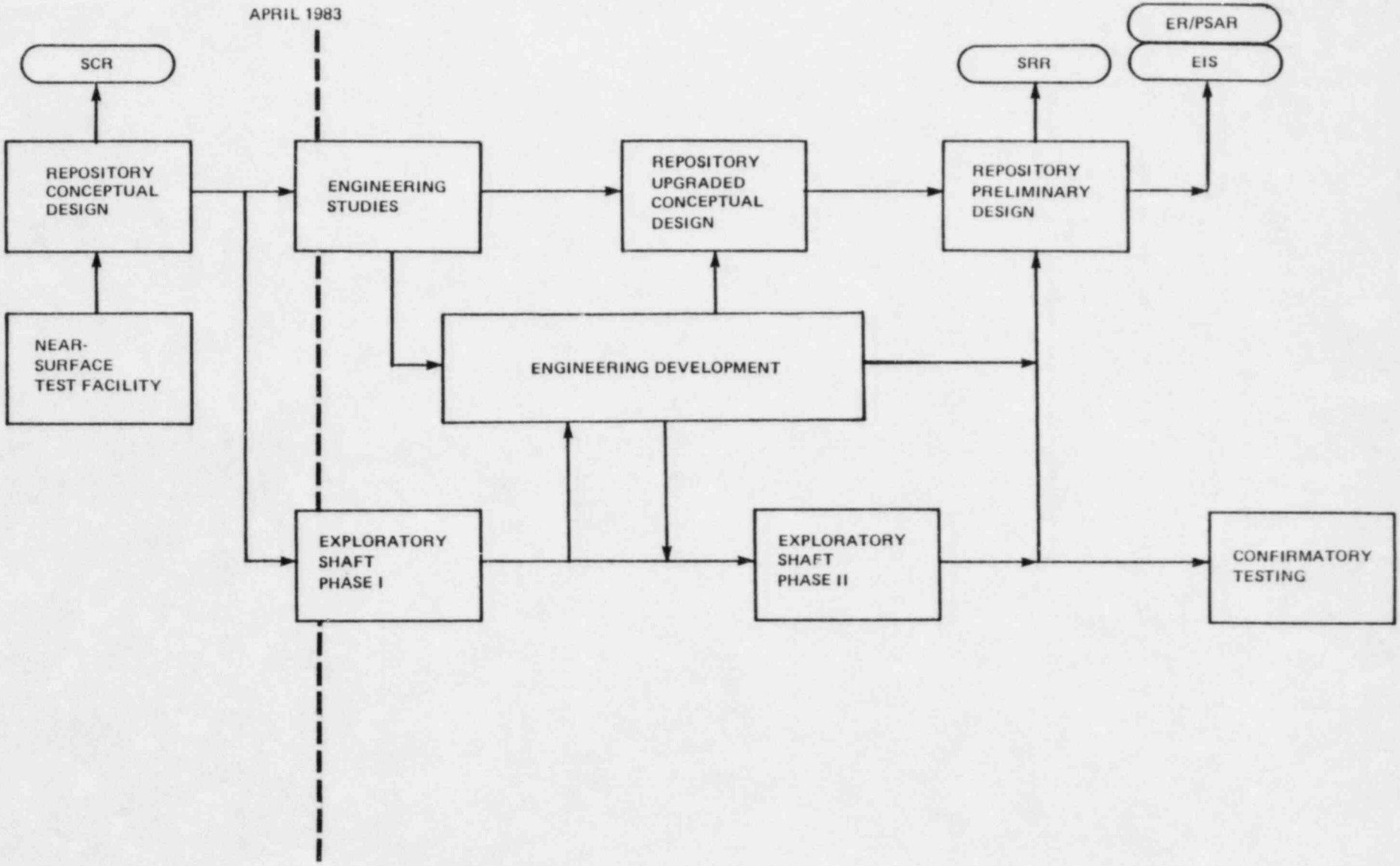
NEAR-SURFACE TEST FACILITY



MAJOR CONCERNS

- OPENING STABILITY
- SEALING AND CLOSURE
- RETRIEVABILITY
- IN SITU TESTING

REPOSITORY ENGINEERING LOGIC



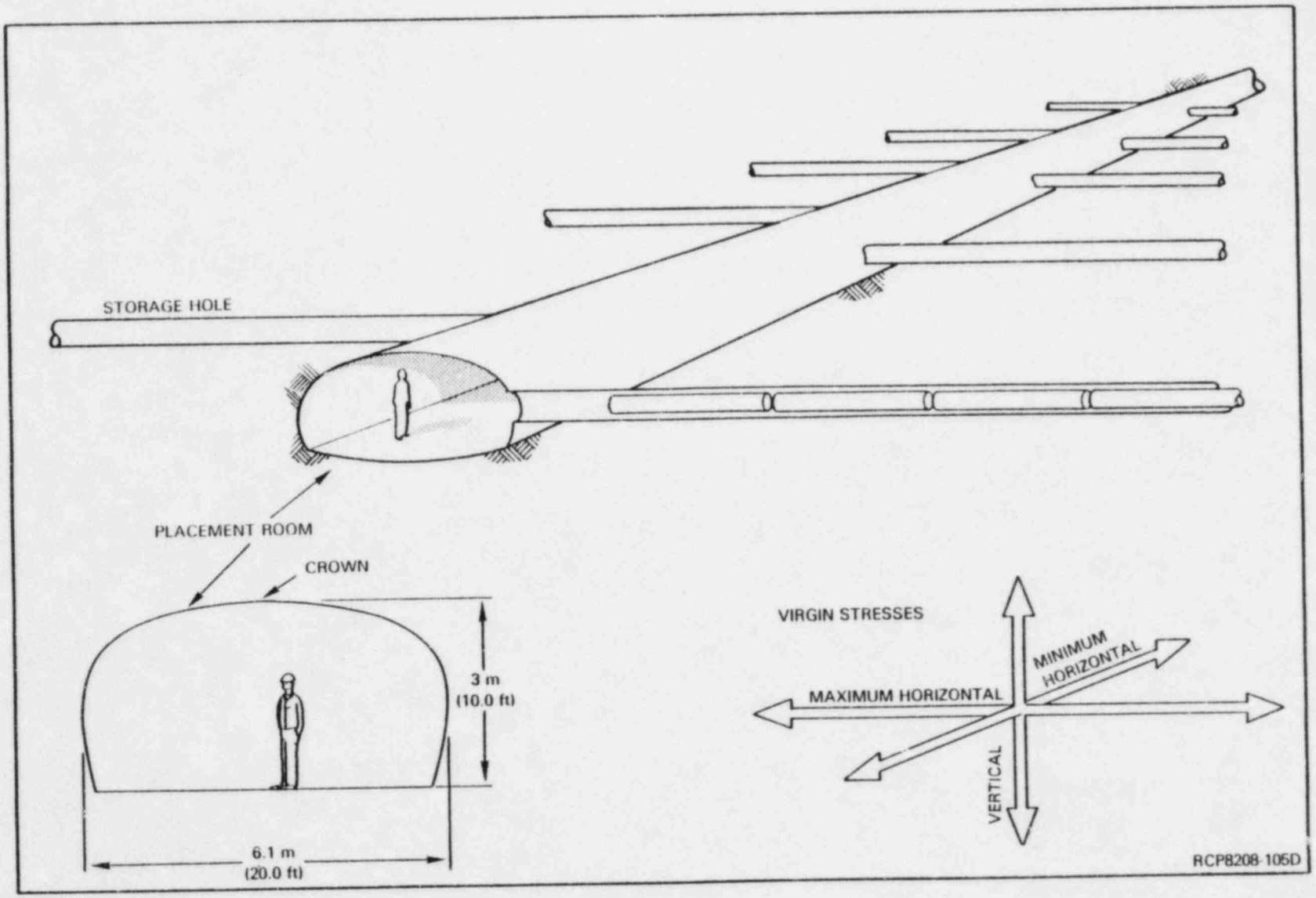
PLAN FOR ADDRESSING CONCERNS

CONCERN \ PLAN	ENGINEERING STUDIES	ENGINEERING DEVELOPMENT	EXPLORATORY SHAFT PHASES I AND II	PRELIMINARY DESIGN	CONFIRMATORY TESTING
OPENING STABILITY	X	X	X	X	X
SEALING AND CLOSURE	X	X		X	X
RETRIEVABILITY	X	X	X	X	X
IN SITU TESTING	X	X	X		X

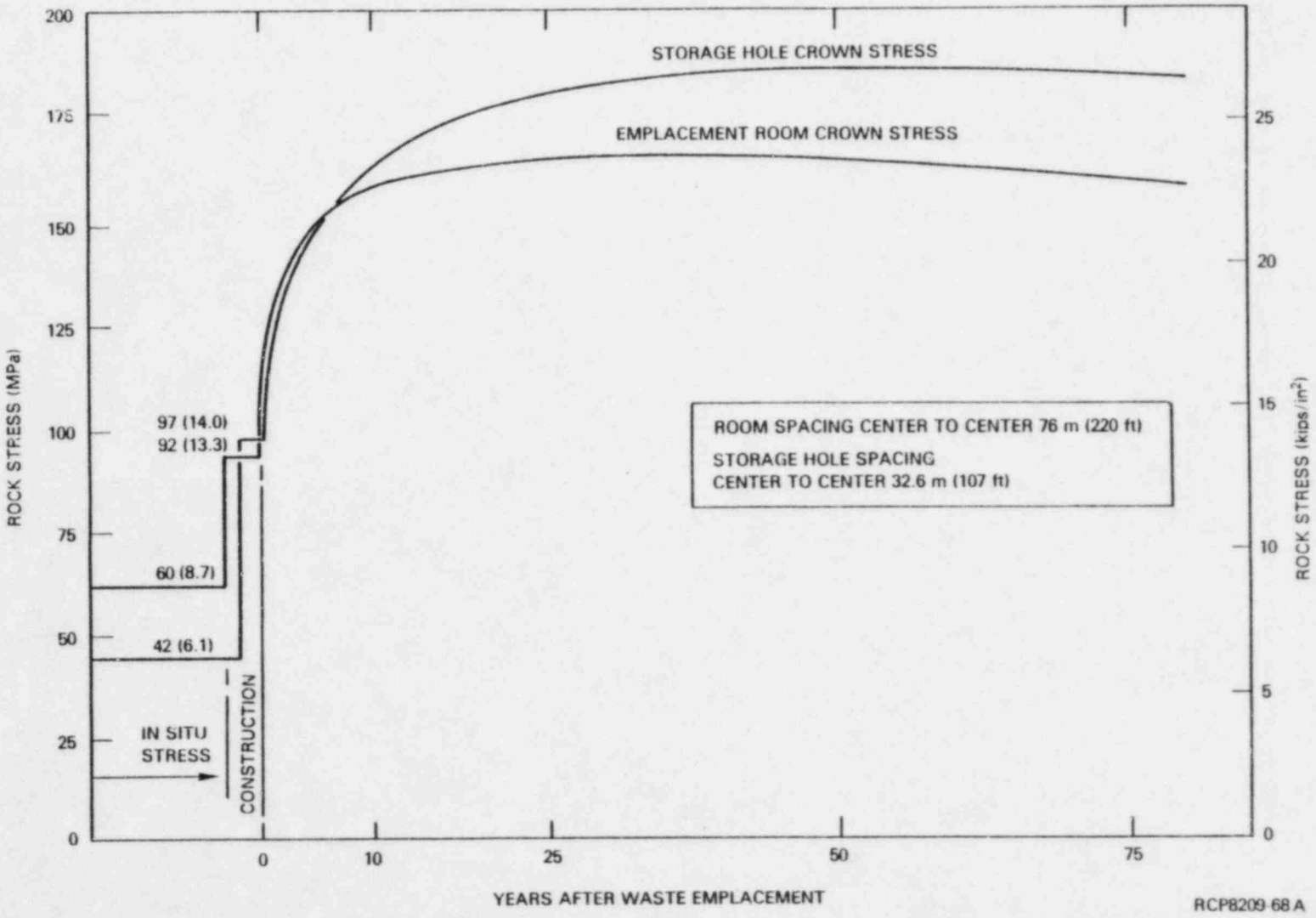
CONCERN:
OPENING STABILITY

- VARIABILITY OF ROCK PROPERTIES
- MODELING ADEQUACY
- AVAILABILITY OF ANALYSES
- STUDY AND DEVELOPMENT PRIORITY

ORIENTATION OF ROCK STRESSES AND EXCAVATIONS



MAXIMUM THEORETICAL THERMOELASTIC ROCK STRESSES, VARIATIONS WITH TIME (2:1 HORIZONTAL TO VERTICAL STRESS RATIO; COMMERCIAL HIGH-LEVEL WASTE)



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ROCK-MASS CONCEPTUAL DESIGN ASSUMPTIONS (UMTANUM HORIZON)

Conditions at Repository Depth
Repository horizon depth: 1,100 m (3,700 ft)
Basalt flow thickness: 62 to 87 m (203 to 285 ft)
Ratio between horizontal and vertical in situ stresses: 2:1
Initial in situ rock temperature: 57°C
Rock Properties
Density: 2.8 g/cm^3 (175 lb/ft^3)
Uniaxial compressive strength: 200 MPa (29,000 lb/in^2)
Tensile strength: 14 MPa (2,030 lb/in^2)
Young's modulus: 67,800 MPa (9,830,000 lb/in^2)
Poisson's ratio: 0.26
Thermal expansion coefficient: 7.45 E-06/°C
Specific heat: 0.95 kJ/kg°C
Thermal conductivity: 2.3 W/m°K
Diffusivity: 6.5 E-07 m^2/s
Joints are tight: 3 to 10/m
Maximum Temperature Permitted
Waste: 500°C for commercial high-level waste and cladding 380°C for spent fuel
Canister and overpack: 430°C
Basalt: 500°C

SUMMARY OF IN SITU STRESS DATA OBTAINED BY THE HYDROFRACTURING METHOD

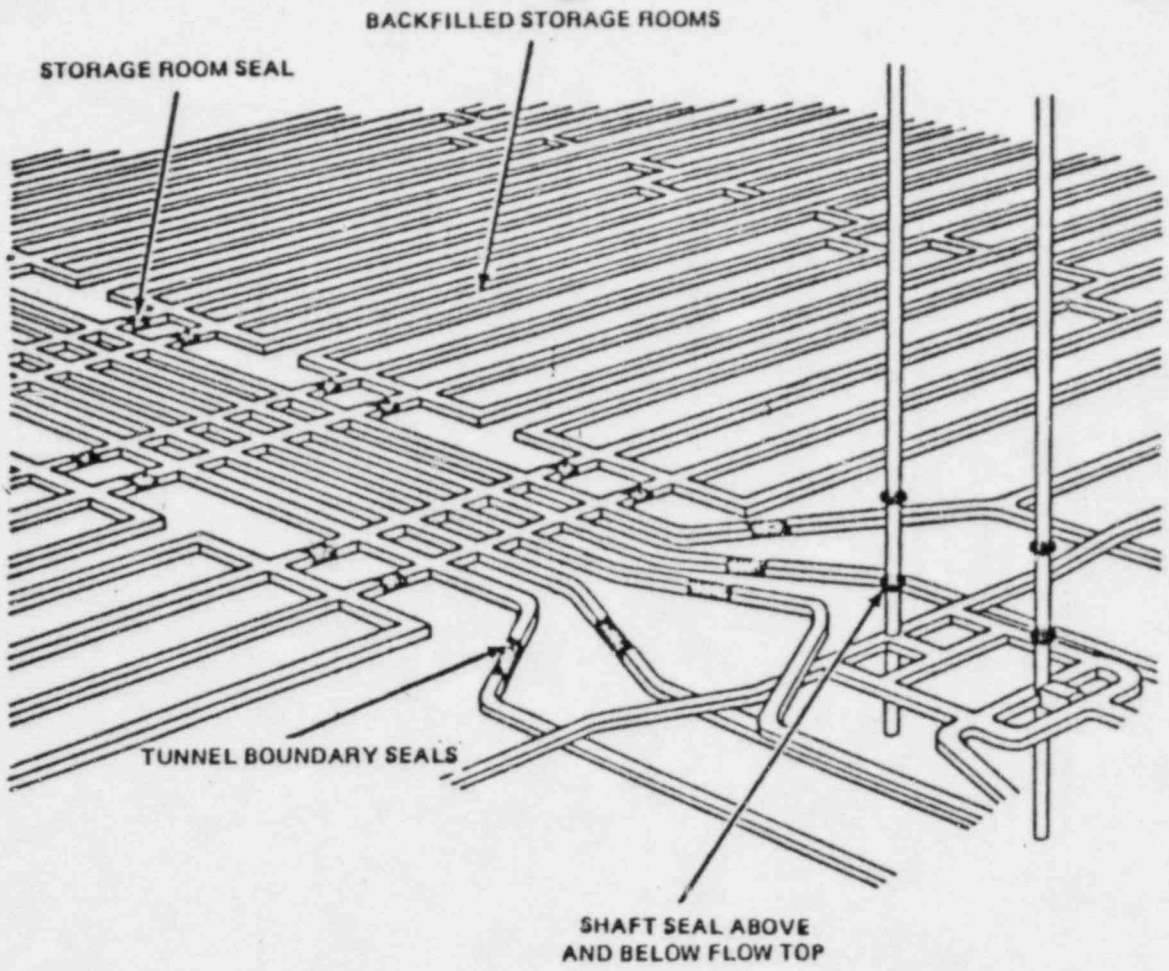
Borehole number	Test depth, m (ft)	σ_V, MPa (E+03 lb/in^2)	σ_{Hmin}, MPa (E+03 lb/in^2)	σ_{Hmax}, MPa (E+03 lb/in^2)	Fracture orientation	$\frac{\sigma_{Hmax}}{\sigma_{Hmin}}$	$\frac{\sigma_{Hmax}}{\sigma_V}$
DB-15 (Roza)	344 (1,128)	8.3 (1.2)	11.7 (1.7)	16.6 (2.4)	N. 20° E.	1.4	2.0
DC-12 (Umtanum)	1,002 (3,287)	25.6 (3.7)	33.3 (4.8)	55.3 (7.8)	--	1.66	2.15
	1,013 (3,323)	25.9 (3.6)	34.4 (5.0)	63.0 (9.1)	N. 40° E.	1.83	2.43
	1,021 (3,349)	26.1 (3.8)	31.4 (4.6)	53.8 (7.8)	N. 09° E.	1.71	2.06
	1,031 (3,382)	26.4 (3.8)	34.2 (5.0)	58.2 (8.4)	N. 01° E.	1.70	2.21
	1,036 (3,399)	26.5 (3.8)	39.5 (5.7)	71.5 (10.4)	N. 42° E.	1.81	2.70
	1,042 (3,418)	26.7 (3.9)	35.7 (5.2)	65.7 (9.5)	--	1.85	2.47
Mean values	1,024 (3,360)	26.2 (3.8)	34.7 (5.0)	61.2 (8.9)	N. 23° E.	1.76	2.33

OPENING STABILITY PLAN

- STUDY
  - DESIGN BASIS DATA
  - PARAMETER SENSITIVITY
  - CONTINUUM MODEL
  - DISCRETE BLOCK MODEL
- DEVELOPMENT
  - ROCK MASS FAILURE CRITERIA
  - NONLINEAR CONSTITUTIVE MODEL
- IN SITU DATA
  - BOREHOLE TESTING
  - EXPLORATORY SHAFT–PHASE I BREAKOUT STATION
  - EXPLORATORY SHAFT–PHASE II REPOSITORY–SIZE TUNNELS
  - EXPLORATORY SHAFT CONFIRMATORY TESTING (POST–LICENSE APPLICATION)
- DESIGN
  - DOCUMENT AND CLEAR ANALYSES

SEALING AND CLOSURE

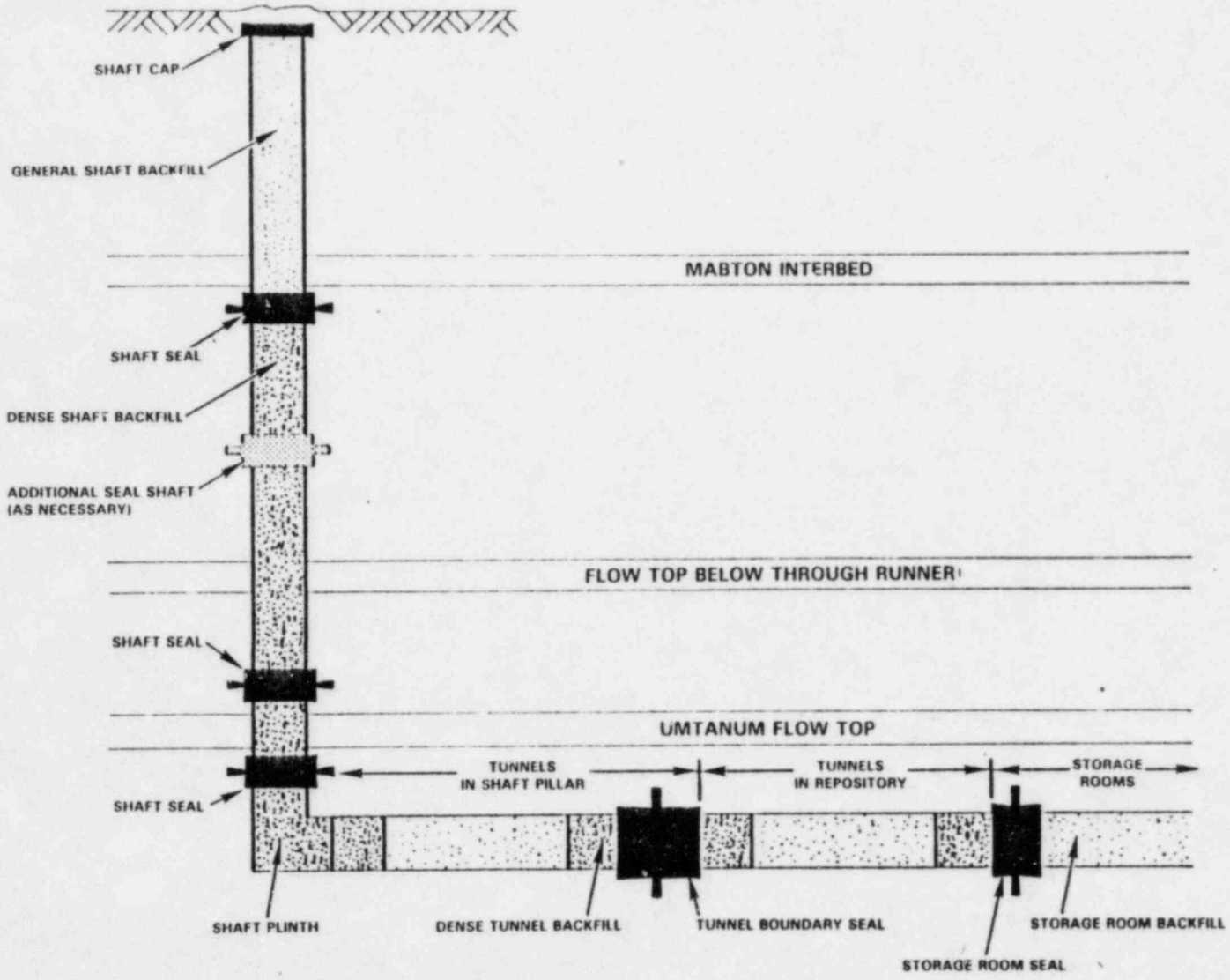
- EFFECT OF THE EXPLORATORY SHAFT AND REPOSITORY SHAFT LINERS ON REPOSITORY SEALING
- ALLOCATION OF PERFORMANCE REQUIREMENTS
- ACCELERATED LONGEVITY TEST
- LABORATORY AND FIELD TESTING PRIORITY



Repository Layout from KE/PB (1982)

TYPICAL TUNNEL – SHAFT SEAL SYSTEM FOR A REPOSITORY IN BASALT

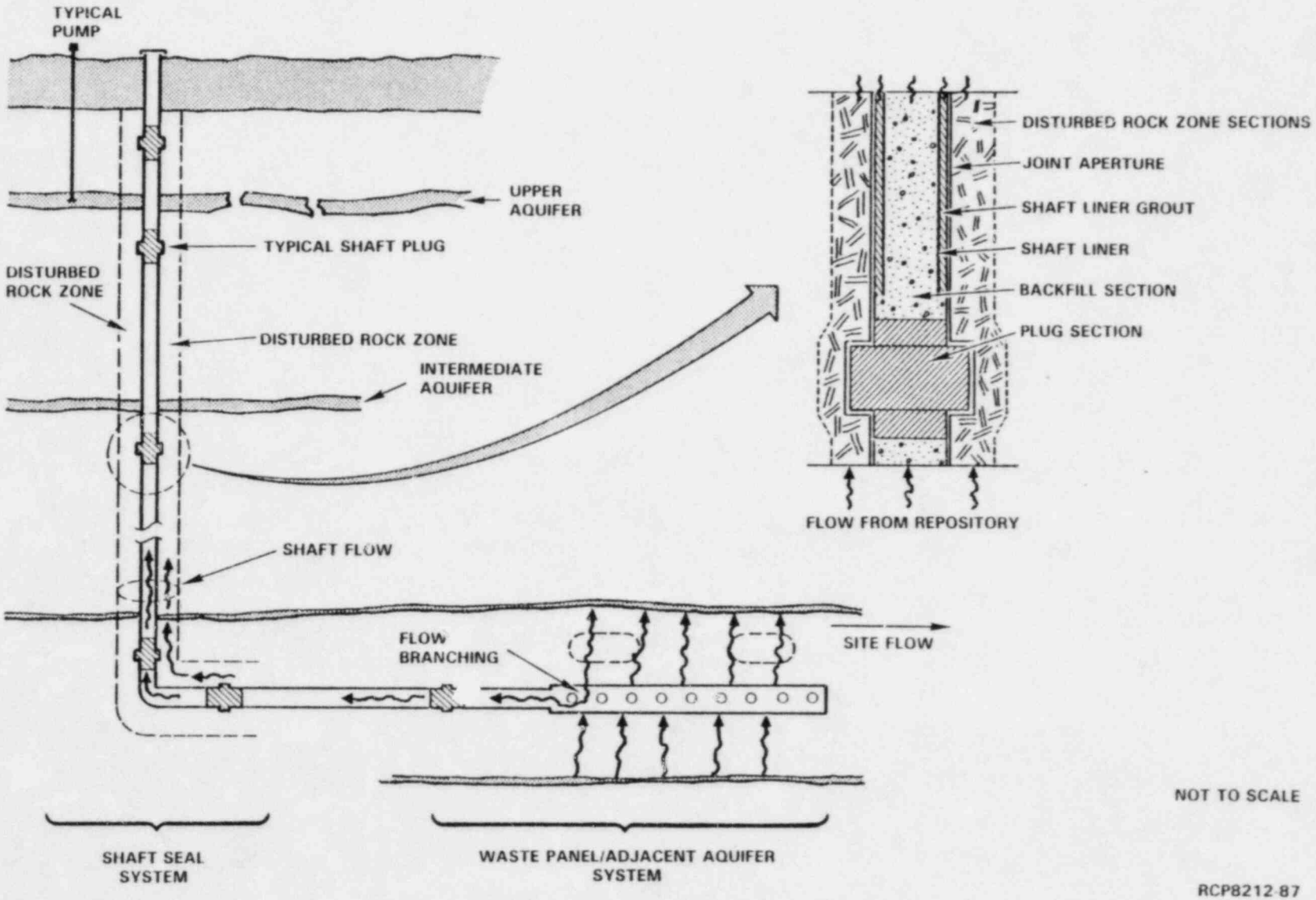
BASIC COMPONENTS FOR SHAFT AND TUNNEL SEALS IN BASALT



NOT TO SCALE

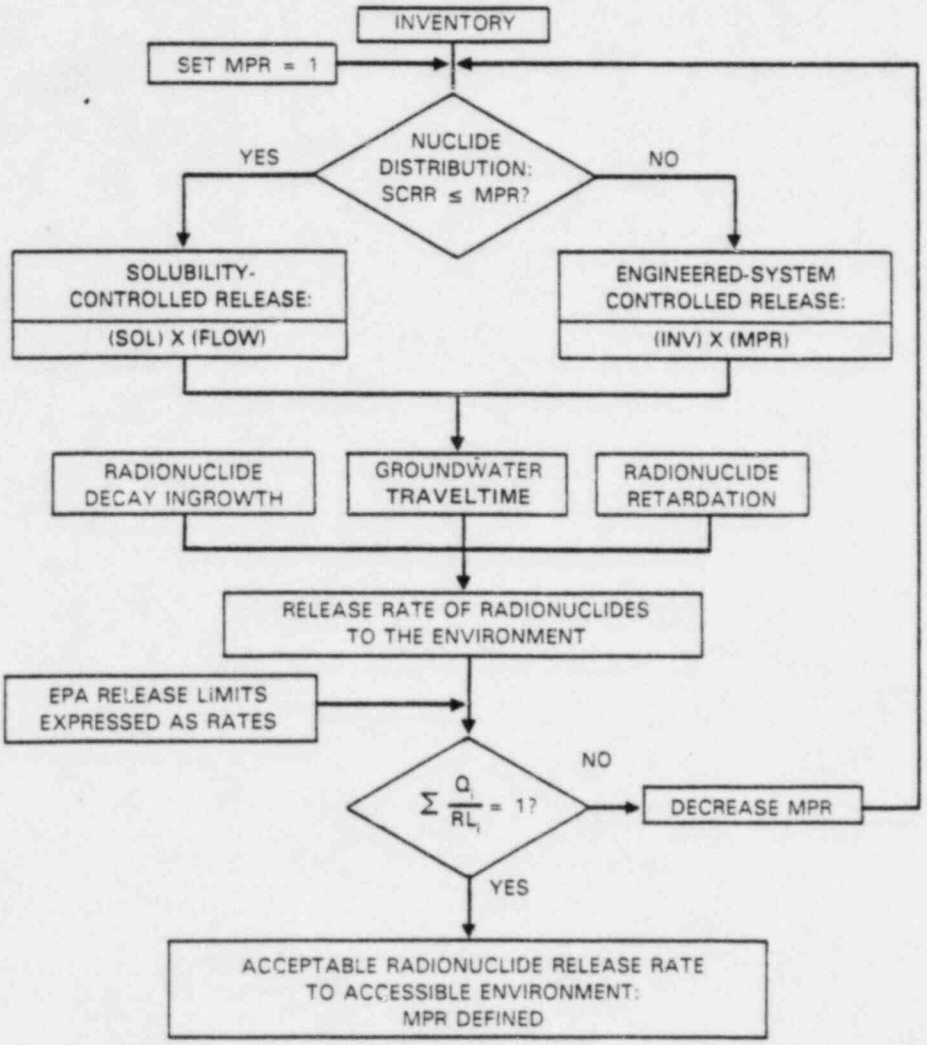
RCP8212-41

SCOPE AND LEVEL OF DETAIL REQUIRED IN FLOW MODELING FOR REPOSITORY SEAL DESIGN



RCP8212-87

DETERMINATION OF MAXIMUM PERMISSIBLE RELEASE



LEGEND:

EPA = U.S ENVIRONMENTAL PROTECTION AGENCY
INV = INVENTORY
MPR = MAXIMUM PERMISSIBLE RELEASE RATE
SCRR = SOLUBILITY-CONTROLLED RELEASE RATE
SOL = SOLUBILITY

$$\sum \frac{Q_i}{RL_i} \leq 1$$

WHERE

Q_i = CUMULATIVE RELEASE OF RADIONUCLIDE i

RL_i = EPA RELEASE LIMIT FOR RADIONUCLIDE i

RCP8208-141A

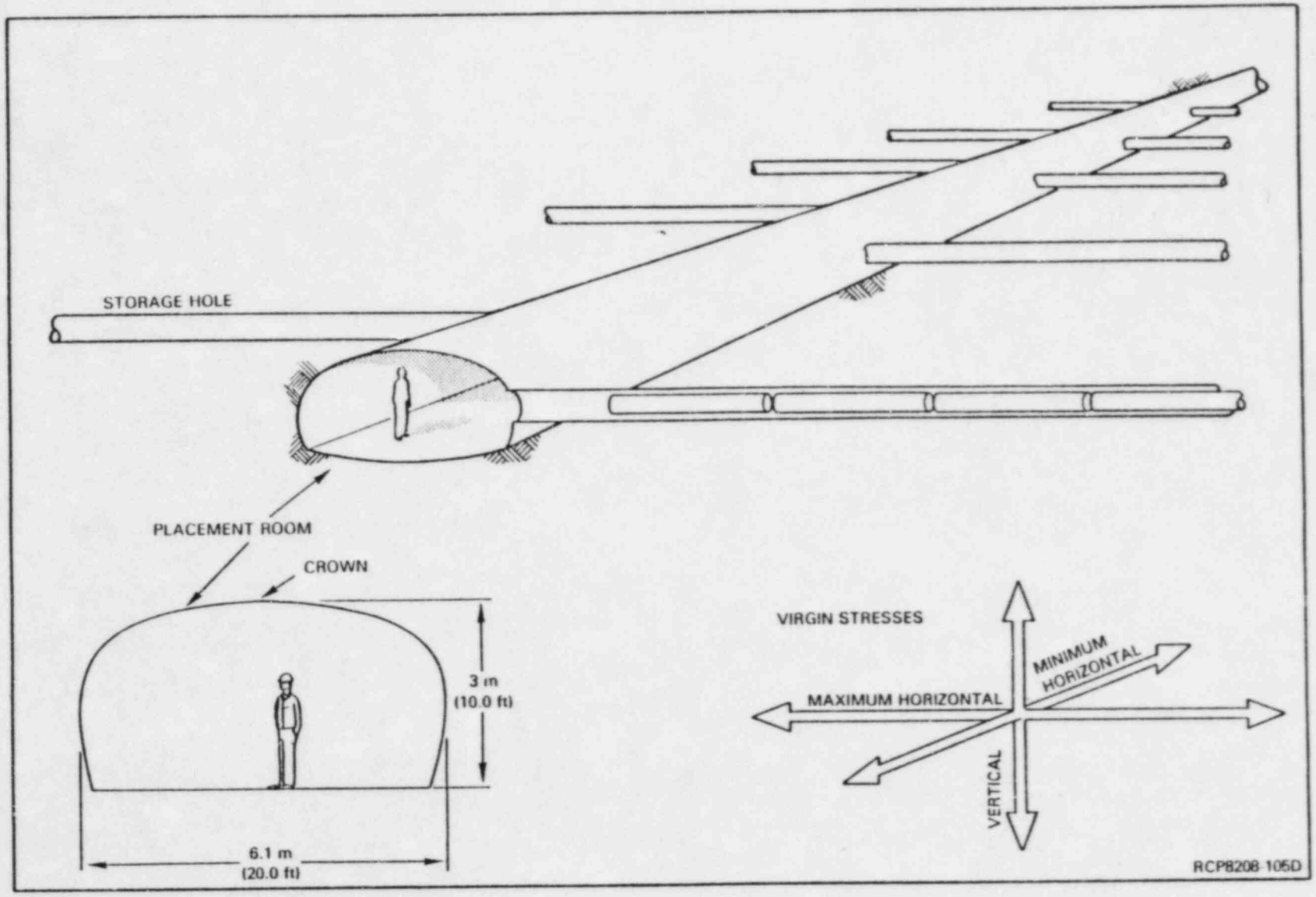
SEALING AND CLOSURE PLAN

- STUDY
  - ALLOCATION OF PERFORMANCE REQUIREMENTS
  - SEAL DESIGN CRITERIA
- DEVELOPMENT
  - DETERMINE SUITABILITY OF CURRENT TECHNOLOGY
  - DEVELOP ACCELERATED LONGEVITY TESTS AND EVALUATION PROCEDURES
  - CONDUCT LABORATORY TESTS ON MATERIALS AND COMPONENTS
- IN SITU DATA
  - EXPLORATORY SHAFT–PHASE I CHARACTERIZE SHAFT DISTURBED ROCK ZONE
  - ENGINEERING–SCALE FIELD TEST PLANNED POST–LICENSE APPLICATION
- DESIGN
  - CURRENT CONCEPT IS BASED ON SHAFT LINER REMOVAL

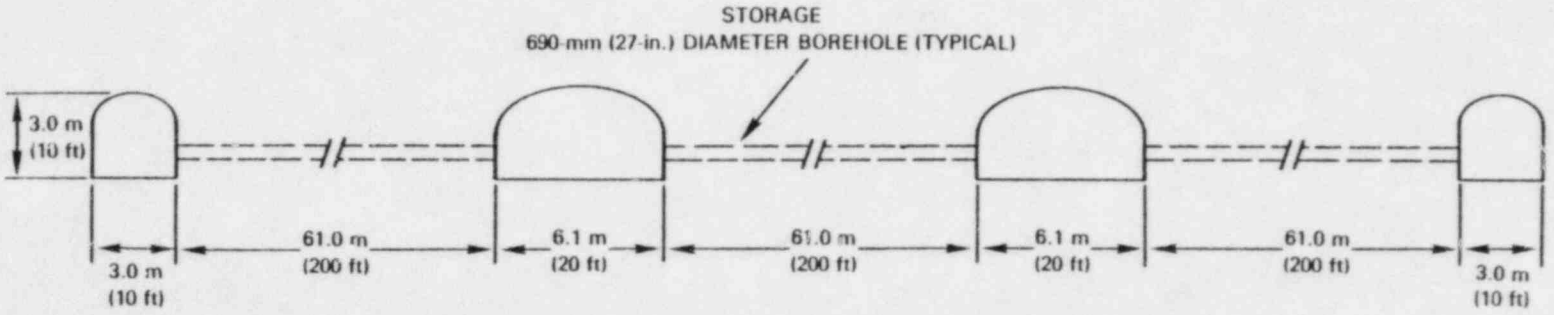
CONCERN:
RETRIEVABILITY

- EFFECT ON REPOSITORY DESIGN
- CONSTRUCTIBILITY OF LONG HORIZONTAL BOREHOLES
- STABILITY OF LONG HORIZONTAL BOREHOLES
- EQUIPMENT AND PROCEDURE DEVELOPMENT
- ISSUE PRIORITY

ORIENTATION OF ROCK STRESSES AND EXCAVATIONS

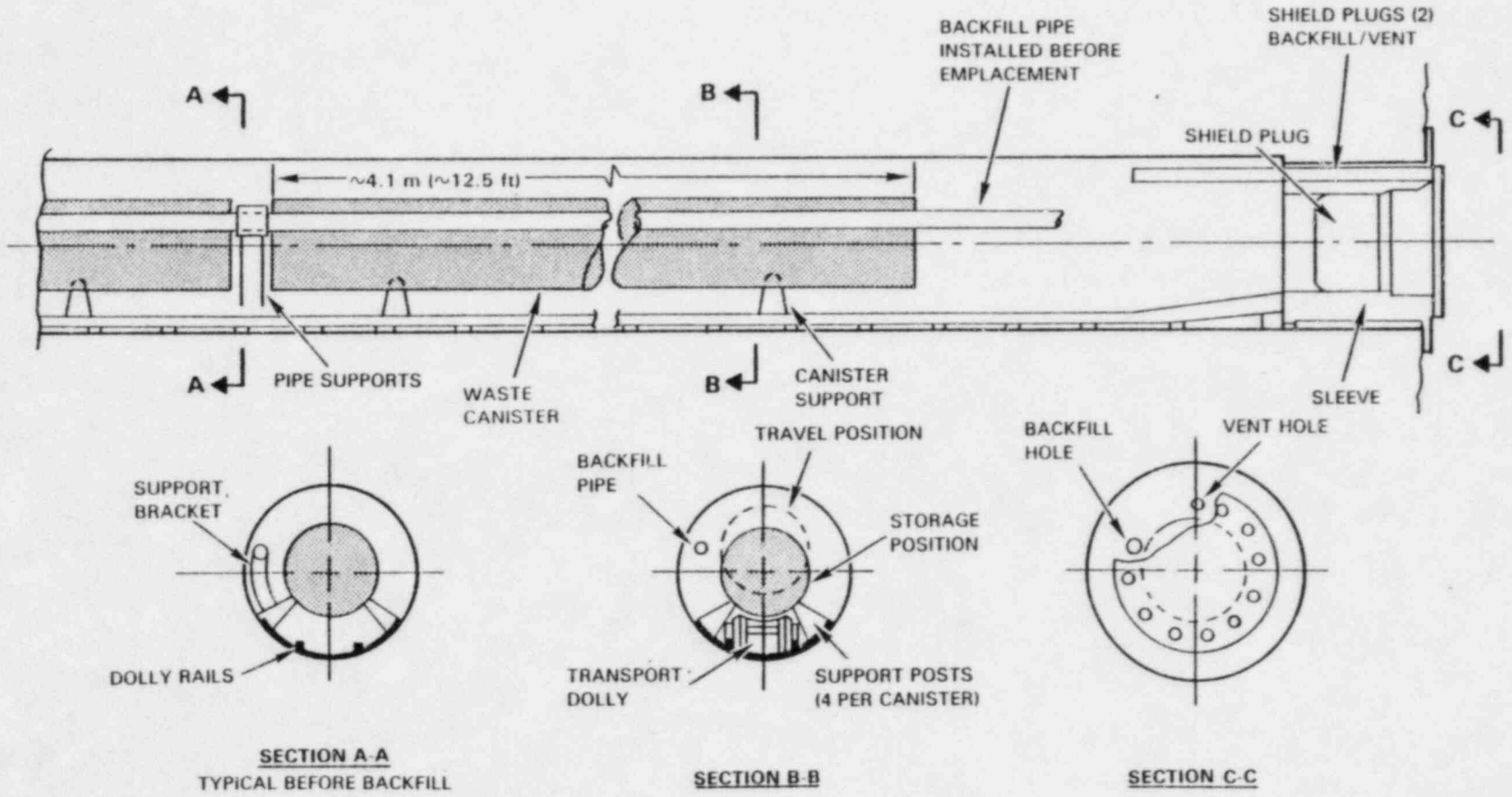


WASTE STORAGE PANEL CROSS SECTIONS



RCP8209-119

WASTE CANISTER IN HORIZONTAL STORAGE BOREHOLE



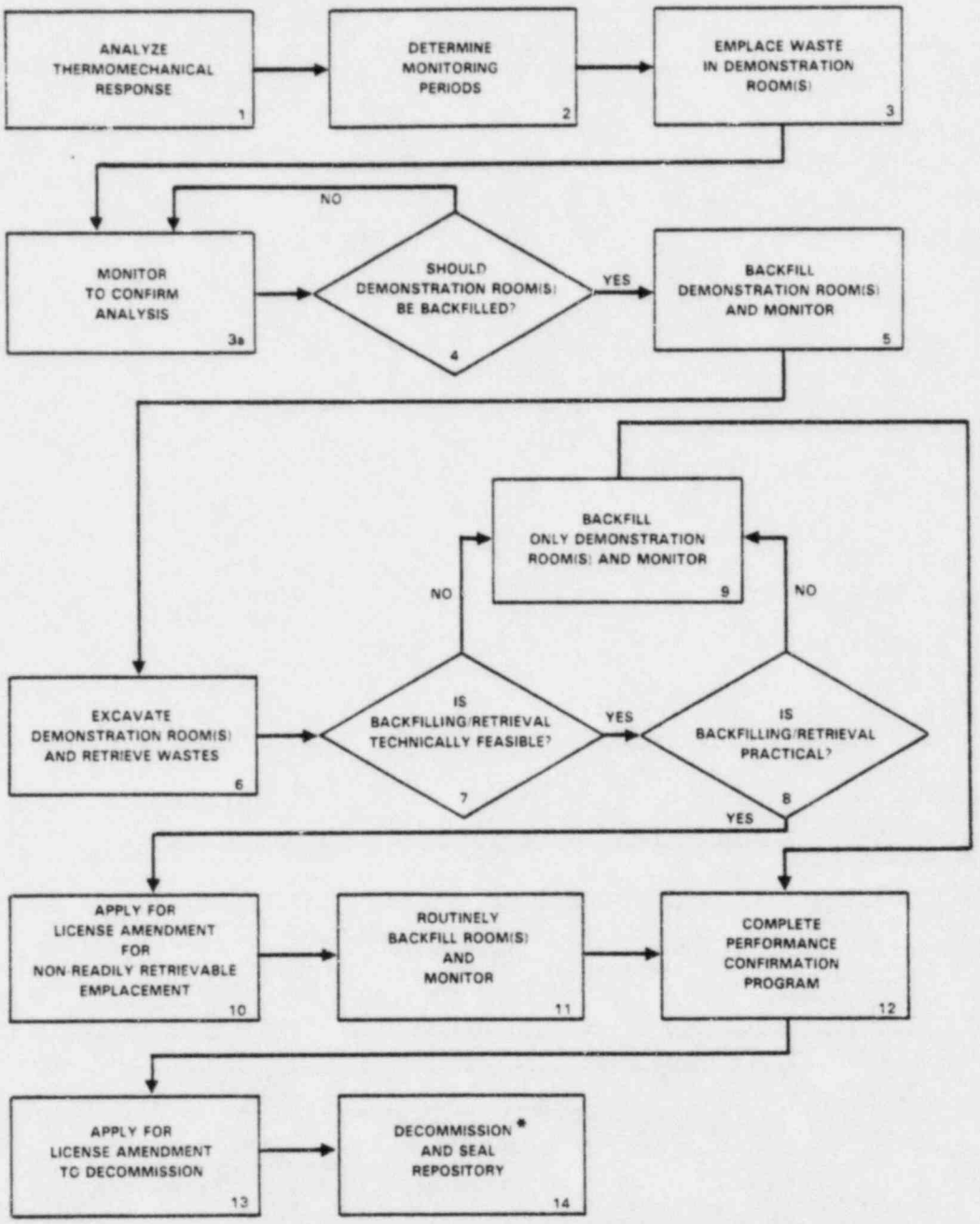
SECTION A-A
TYPICAL BEFORE BACKFILL

SECTION B-B

SECTION C-C

RCP8205-44

BACKFILL/RETRIEVABILITY DECISION FLOWCHART



* STEP 14 WOULD INCLUDE BACKFILLING OF EMPLACEMENT ROOMS IF THIS WERE NOT DONE ROUTINELY DURING EMPLACEMENT OPERATIONS (STEP 11).

RCP8209-163

RETRIEVABILITY PLAN

- STUDY
  - WASTE PACKAGE CONFIGURATION ALTERNATIVES
  - WASTE EMPLACEMENT OPTIMIZATION
- DEVELOPMENT
  - NEAR-SURFACE TEST FACILITY BOREHOLE CONSTRUCTIBILITY
  - NEAR-SURFACE TEST FACILITY EMPLACEMENT DEMONSTRATION
  - NEAR-SURFACE TEST FACILITY RETRIEVAL DEMONSTRATION
- IN SITU DATA
  - EXPLORATORY SHAFT-PHASE II BOREHOLE DRILLING AND STABILITY
  - EXPLORATORY SHAFT-PHASE II HEATED CANISTER TEST
- DESIGN
  - CURRENT CONCEPT IS BASED ON DEFERRED BACKFILL

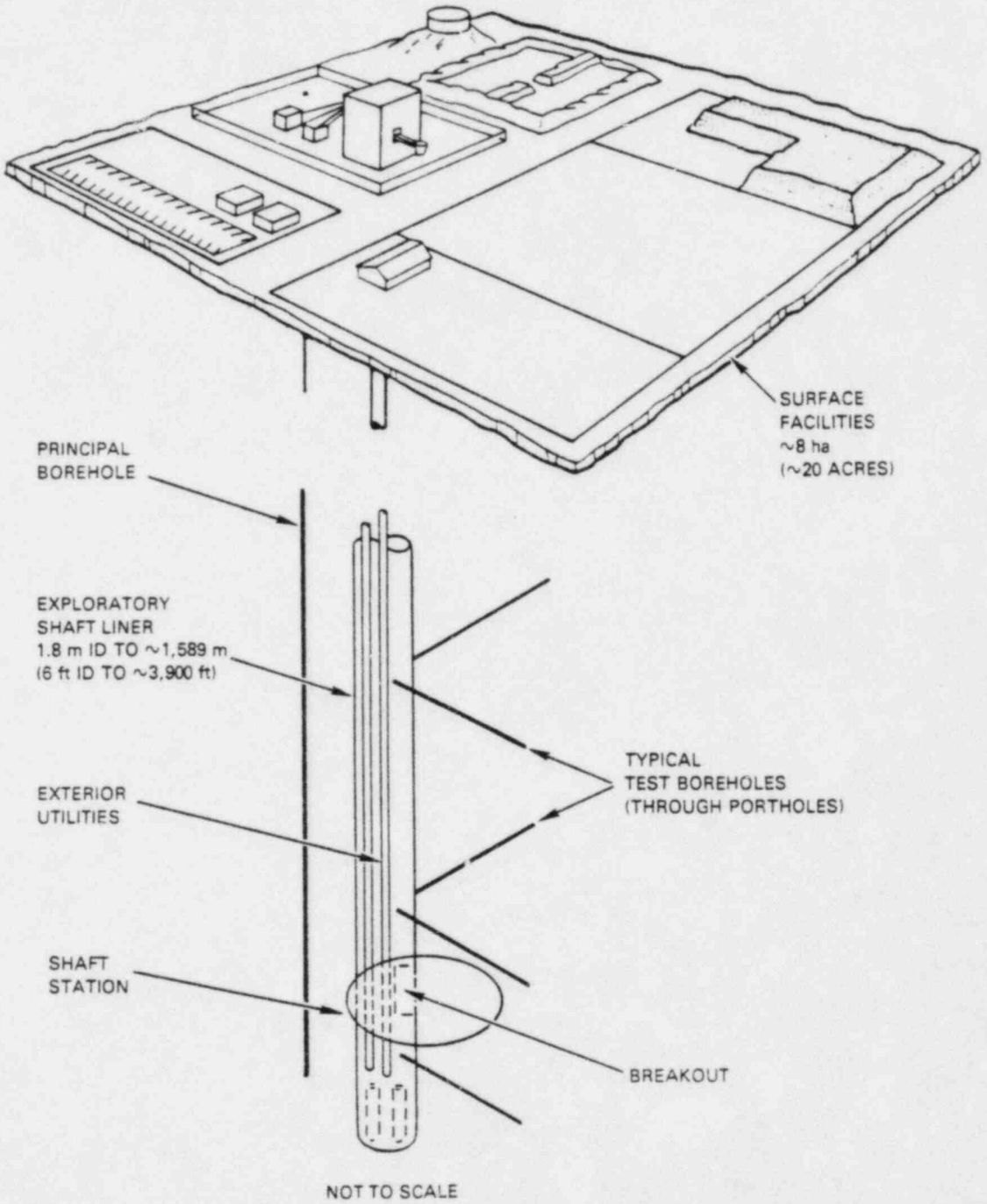
IN SITU TESTING

- IN SITU TEST RATIONALE
- LACK OF SENSITIVITY STUDIES
- DETAILS OF AT-DEPTH TESTS
- KEY TESTS NOT INCLUDED
- TEST ACTIVITY PRIORITY

EXPLORATORY SHAFT TECHNICAL OBJECTIVES-- PHASE I

- PRINCIPAL BOREHOLE TESTS
- SHAFT SINKING CONSTRUCTIBILITY
- SHAFT LINER CONSTRUCTIBILITY
- CANDIDATE HORIZON BREAKOUT SUITABILITY
- SHAFT STATION STABILITY
- SHAFT STATION CONSTRUCTIBILITY

EXPLORATORY SHAFT-PHASE I
CONCEPTUAL ARRANGEMENT



RCP8103-10E

ASCERTAIN SUITABILITY OF ES LOCATION

TECHNICAL OBJECTIVE I-1

DATA NEEDS

TESTS

ACTIVITY COMPLETE

ASSESS BLIND BORING METHOD

TECHNICAL OBJECTIVE I-2

DATA NEEDS	TESTS
R P M	GEOLOGRAPH RECORDING
TORQUE	GEOLOGRAPH RECORDING
DOWN PRESSURE (BRAKE LOAD)	GEOLOGRAPH RECORDING
CUTTER WEAR	CUTTER GAUGE MEASUREMENT
HOLE DEVIATION	SPERRY SUN SURVEY
PENETRATION RATE	GEOLOGRAPH RECORDING
HOLE CALIPER	CALIPER LOG
GROUT INTEGRITY	NUCLEAR ANNULUS INVESTIGATION LOG
WELD QUALITY	RADIOGRAPHY
FLUID LOSS	DRILLING FLUID FLOW METER
GROUT VOLUME	GROUT FLOW METER
GROUT DENSITY	NAIL LOG/LABORATORY DENSITY ON CORE
GROUT STRENGTH	UNCONFINED COMPRESSION STRENGTH

EVALUATE SHAFT LINER SEAL

TECHNICAL OBJECTIVE I-3

DATA NEEDS	TESTS
WATER INFLOW	DISCHARGE MEASUREMENTS ENGINEERING GEOLOGY CORE LOGGING
CORE INTEGRITY	NUCLEAR ANNULUS INVESTIGATION LOG (NAIL) UNCONFINED COMPRESSIVE STRENGTH
CORE/GROUT INTEGRITY	CONSTANT HEAD INJECTION

ASSESS GEOHYDROLOGIC PROPERTIES

TECHNICAL OBJECTIVE I-4

DATA NEEDS	TESTS
WATER INFLOW	OBSERVATION
HYDRAULIC CONDUCTIVITY	CONSTANT HEAD INJECTION PULSE CONSTANT DRAWDOWN CONSTANT DISCHARGE
HYDRAULIC HEAD	MONITORING

EVALUATE OPENING STABILITY

TECHNICAL OBJECTIVE I-5

DATA NEEDS	TESTS
OPENING STABILITY	OPENING DEFORMATION MONITORING ACOUSTIC EMISSION MONITORING
IN SITU STRESS	OVERCORING STRESS MEASUREMENT
IN SITU STRESS (MAGNITUDE & DIRECTION)	OVERCORING (DOORSTOPPER/USBM) HYDRAULIC FRACTURING
EXCAVATION - INDUCED STRESS DISTRIBUTION	OVERCORING (DOORSTOPPER/USBM) SMALL FLAT JACK
STRATIGRAPHY	GEOLOGICAL MAPPING DETAIL LINE MAPPING
STRUCTURE	GEOPHYSICAL LOGGINGS
FRACTURE CHARACTERISTICS	GEOMECHANICAL LOGGINGS
COMPOSITION	T. V. LOGGING

ASSESS SHAFT STATION CONSTRUCTIBILITY

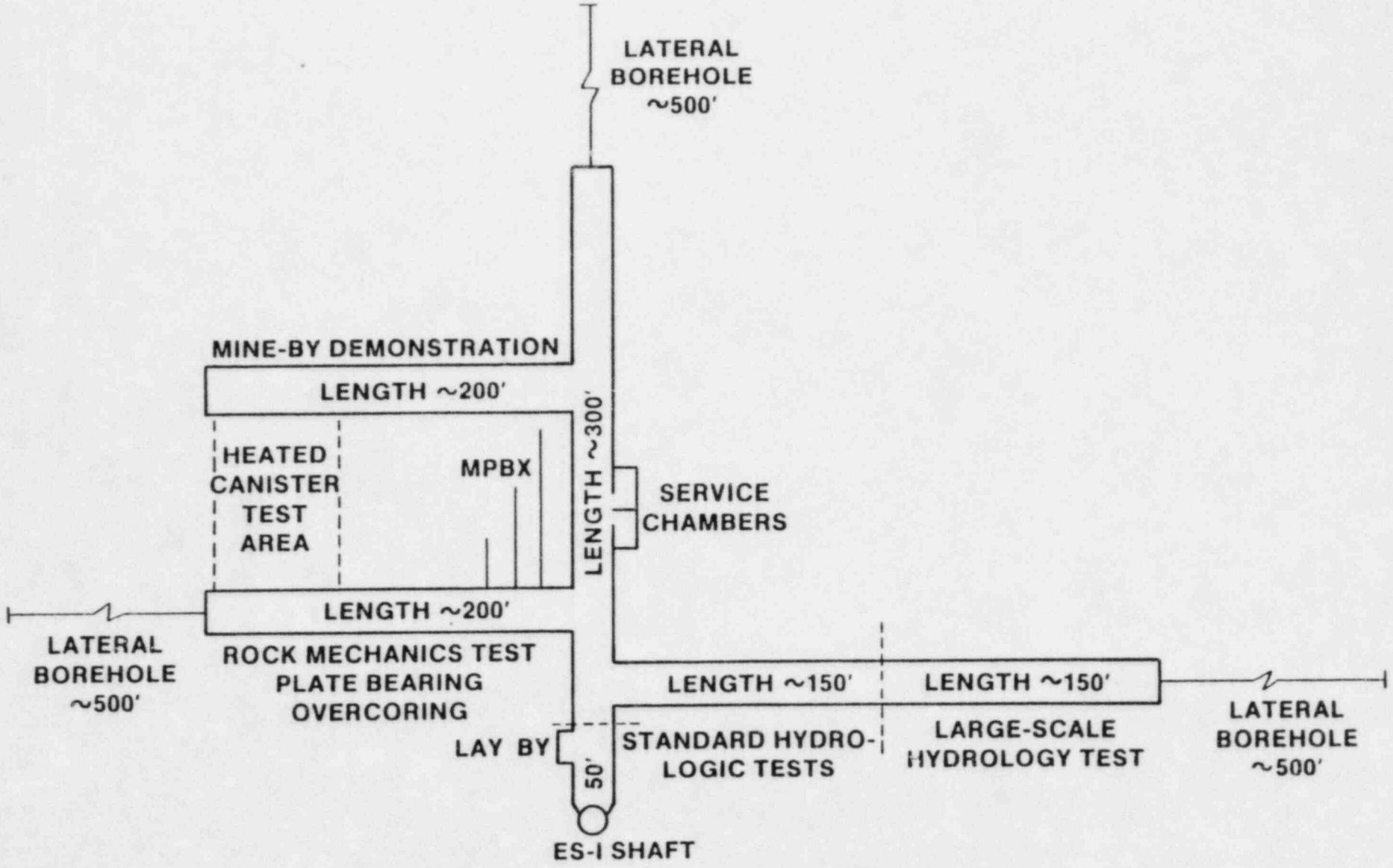
TECHNICAL OBJECTIVE I-6

DATA NEEDS	TESTS
GEOLOGIC MAP	DETAIL ENGINEERING GEOLOGY MAPPING AND OBSERVATION MINE SURVEYING
BLASTING PERFORMANCE	VIBRATION MONITORING OVERBREAK MEASUREMENTS
AIR QUALITY CONTROL	MONITOR AIR QUALITY - PARTICULATE MATTER - CO, CH_4, SO_2 - TEMPERATURE, HUMIDITY
GROUNDWATER INFLOW	MEASURE TOTAL WATER BALANCE
SUPPORT PERFORMANCE	MEASURE LOADS IMPOSED ON SUPPORTS

EXPLORATORY SHAFT TECHNICAL OBJECTIVES-- PHASE II

- GEOLOGIC CHARACTERIZATION
- GEOMECHANICS CHARACTERIZATION
- HYDROLOGIC CHARACTERIZATION
- TUNNEL CONSTRUCTIBILITY

BASALT WASTE ISOLATION PROJECT
EXPLORATORY SHAFT PHASE II CONCEPTUAL TESTING CONFIGURATION



OBTAIN GEOLOGIC CHARACTERISTICS TO DETERMINE SITE SUITABILITY

TECHNICAL OBJECTIVE II-1

DATA NEEDS	TESTS
STRATIGRAPHY	GEOLOGICAL LOGGING
STRUCTURE	GEOPHYSICAL LOGGING
FRACTURE CHARACTERISTICS	SAMPLING DETAIL LINE MAPPING
COMPOSITION	

EVALUATE LONGEVITY OF OPENING STABILITY

TECHNICAL OBJECTIVE II-2

DATA NEEDS	TESTS
ROCK MASS FAILURE CRITERIA	CANISTER HOLE DRILLING FULL SCALE ROOM ENLARGEMENT (MINE-BY) FULL SCALE HEATER OPENING DEFORMATION MONITORING ACOUSTIC EMISSION MONITORING
OPENING DEFORMATION	CANISTER HOLE DRILLING FULL SCALE ROOM ENLARGEMENT (MINE-BY) FULL SCALE HEATER OPENING DEFORMATION MONITORING ACOUSTIC EMISSION MONITORING
ROCK MASS DEFORMATION MODULUS	LARGE FLAT JACK PLATE BEARING BOREHOLE JACKING FULL SCALE ROOM ENLARGEMENT (MINE-BY) CROSS HOLE SEISMIC
ROCK MASS THERMAL CONDUCTIVITY	FULL SCALE HEATER OPENING DEFORMATION MONITORING ACOUSTIC EMISSION MONITORING
LABORATORY PHYSICAL, MECHANICAL, THERMAL AND THERMOMECHANICAL PROPERTIES	VARIOUS LABORATORY TESTS SMALL AND LARGE SAMPLES

ASSESS HYDROLOGIC PROPERTIES

TECHNICAL OBJECTIVE II-3

DATA NEEDS	TESTS
WATER INFLOW	OBSERVATION
HYDRAULIC CONDUCTIVITY	CONSTANT HEAD INJECTION PULSE CONSTANT DRAWDOWN CONSTANT DISCHARGE
STORATIVITY EFFECTIVE POROSITY DISPERSIVITY DISTRIBUTION COEFFICIENT	TRACER
HYDRAULIC HEAD	MONITOR HEADS
GROUNDWATER SAMPLES	SAMPLING

ASSESS METHOD OF CONSTRUCTIBILITY

TECHNICAL OBJECTIVE II-4

DATA NEEDS	TESTS
GEOLOGIC MAP OF OPENING SURFACES	ENGINEERING GEOLOGY MAPPING & OBSERVATIONS MINE SURVEYING
BLASTING PERFORMANCE	VIBRATION MONITORING OVERBREAK MEASUREMENT
AIR QUALITY CONTROL	MONITORING OF AIR QUALITY - PARTICULATE MATTER - CO, CH_4, SO_2 - TEMPERATURE, HUMIDITY

WASTE PACKAGE

M. J. SMITH

SUMMARY

- PROGRAM OBJECTIVE
- GENERALIZED LIST OF NRC AND OTHERS CONCERNS
- PROGRAM STATUS WITH RESPECT TO CONCERNS
  - CANISTER TESTING
  - BACKFILL TESTING
  - WASTE/BARRIER/ROCK INTERACTIONS TESTING
  - SOLUBILITY AND SORPTION TESTING
  - WASTE PACKAGE DESIGN
  - FIELD AND ENGINEERING TESTING

GENERALIZED LIST OF CONCERNS
WASTE PACKAGE AND GEOCHEMISTRY

- LACK OF DATA
  - COMPREHENSIVE LABORATORY AND FIELD TESTS SHOULD BE PLANNED
  - BACKFILL STABILITY AND TRANSPORT CHARACTERISTICS SHOULD BE MEASURED
  - LONG–TERM CORROSION BEHAVIOR OF CONTAINER, CANISTER, AND CLADDING MATERIALS SHOULD BE EVALUATED IN A RADIATION FIELD (STRESS CORROSION CRACKING, UNIFORM AND PITTING ATTACK)

- EVALUATION OF DATA NEEDED
  - DATA BASE SHOULD INCLUDE A COMBINATION OF RELEVANT NATURAL ANALOGS, LABORATORY EXPERIMENTS, AND FIELD TESTING
  - ALTERNATE DESIGNS SHOULD BE EVALUATED BEFORE A COMMITMENT TO A FINAL STORAGE CONFIGURATION IS MADE
  - RELIABILITY OBJECTIVES FOR WASTE PACKAGE SHOULD BE EVALUATED

GENERALIZED LIST OF CONCERNS
WASTE PACKAGE AND GEOCHEMISTRY
(continued)

- REPRESENTATIVENESS OF DATA
  - SORPTION ISOTHERMS AND REVERSIBILITY TESTING NEEDED TO DEFINE TRANSPORT CHARACTERISTICS OF SITE
  - SOLUBILITY TESTING SHOULD INCLUDE EFFECTS OF RADIATION, SPECIATION, AND COLLOID FORMATION
- CREDIBILITY OF PROGRAM
  - SOLUBILITY ESTIMATES NEED TO BE CONFIRMED BY EXPERIMENTAL EVIDENCE
  - EFFECT OF BARRIER MATERIALS AND WASTE FORM ON WASTE PACKAGE RELEASE RATE NEEDS COMPREHENSIVE EVALUATION

PLANS FOR RESOLUTION OF NRC WASTE PACKAGE ISSUES AND CONCERNS

ISSUE \ RESOLUTION	BARRIER MATERIALS TESTING						ENG STUDIES	DRILLING AND TESTING PROGRAM
	SORPTION	SOLUBILITY	CANISTERS	BACKFILL	W/B/R	ENG TESTS		
FIELD TESTS						BACKFILL & CANISTER		SORPTION
BACKFILL STABILITY AND TRANSPORT	X	X		PHYSICAL PROPERTIES	STABILITY	X		
CORROSION BEHAVIOR			X					
DATA BASE AND EXTRAPOLATION	X	X			X	X		
ALTERNATE DESIGNS							X	
RELIABILITY							X	
SORPTION BEHAVIOR	X			X	X			X
SOLUBILITY TESTING	X	X		X	X			
RELEASE RATES					X			

W = WASTE
B = BARRIER
R = ROCK

STATUS SUMMARY WITH RESPECT TO CONCERNS

- COMPLETED
  - NUCLEAR WASTE REPOSITORY IN BASALT WASTE PACKAGE CONCEPTUAL DESIGNS FOR SPENT FUEL, COMMERCIAL HIGH-LEVEL WASTE, AND DEFENSE HIGH-LEVEL WASTE
  - BARRIER MATERIALS TEST PLAN
  - PRELIMINARY ESTIMATES OF EXPECTED WASTE PACKAGE PERFORMANCE
- IN PROGRESS
  - WASTE PACKAGE BACKFILL PROCESS DEVELOPMENT TEST
  - MATERIALS INTERACTIONS WITH FULLY RADIOACTIVE WASTE STARTUP TESTING
  - BACKFILL PHYSICAL PROPERTY TESTS
  - CANISTER RADIATION CORROSION TESTING, SLOW STRAIN AND CRACK GROWTH TESTING
  - SOLUBILITY DETERMINATIONS FOR KEY RADIONUCLIDES
  - PRELIMINARY WASTE ACCEPTANCE REQUIREMENTS
  - WASTE PACKAGE CONCEPTUAL DESIGN UPGRADE CRITERIA

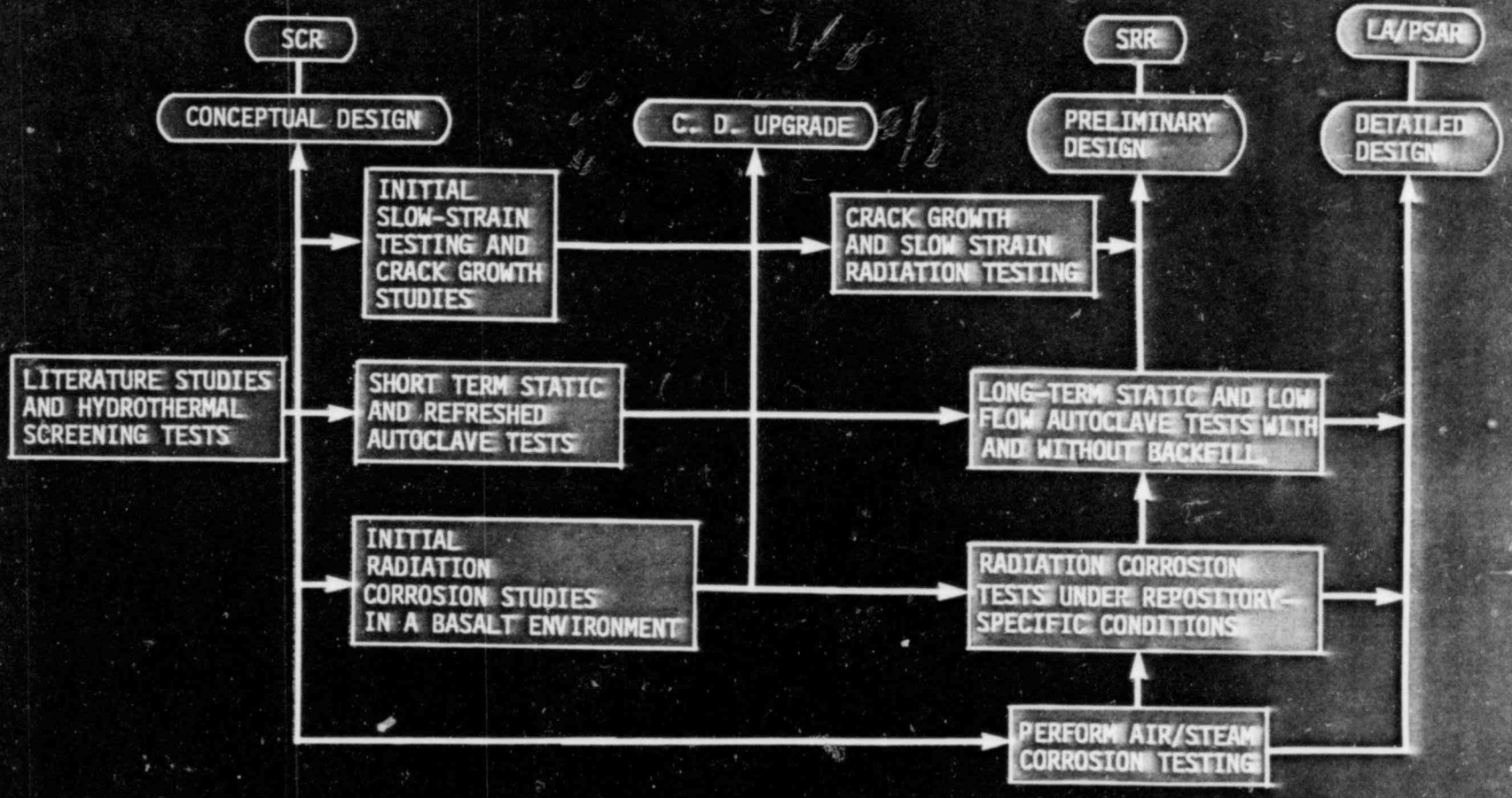
CONCLUSIONS

- BWIP AGREES WITH NRC CONCERNING MATERIALS DEVELOPMENT AND TESTING REQUIREMENTS WITH RESPECT TO WASTE PACKAGE AND GEOCHEMISTRY
- PROGRAM REQUIRED TO ADDRESS NRC'S CONCERNS IS IN PROGRESS
- ALTERNATIVES TO THE WASTE PACKAGE LONG-HOLE-STORAGE CONCEPT ARE BEING EVALUATED AS PART OF ENGINEERING STUDIES IN PROGRESS
- RELIABILITY ASSESSMENTS OF THE WASTE PACKAGE ARE STARTED
- PNEUMATIC BACKFILL EMPLACEMENT DEVELOPMENT TEST IS IN PROGRESS

BWIP WASTE PACKAGE/SITE MATERIALS TESTING

- CANISTER CORROSION TESTING
- BACKFILL TESTING
- WASTE/BARRIER/ROCK INTERACTIONS
- SORPTION/SOLUBILITY MEASUREMENTS

WASTE PACKAGE CANISTER MATERIALS TESTING



WP8303-60C

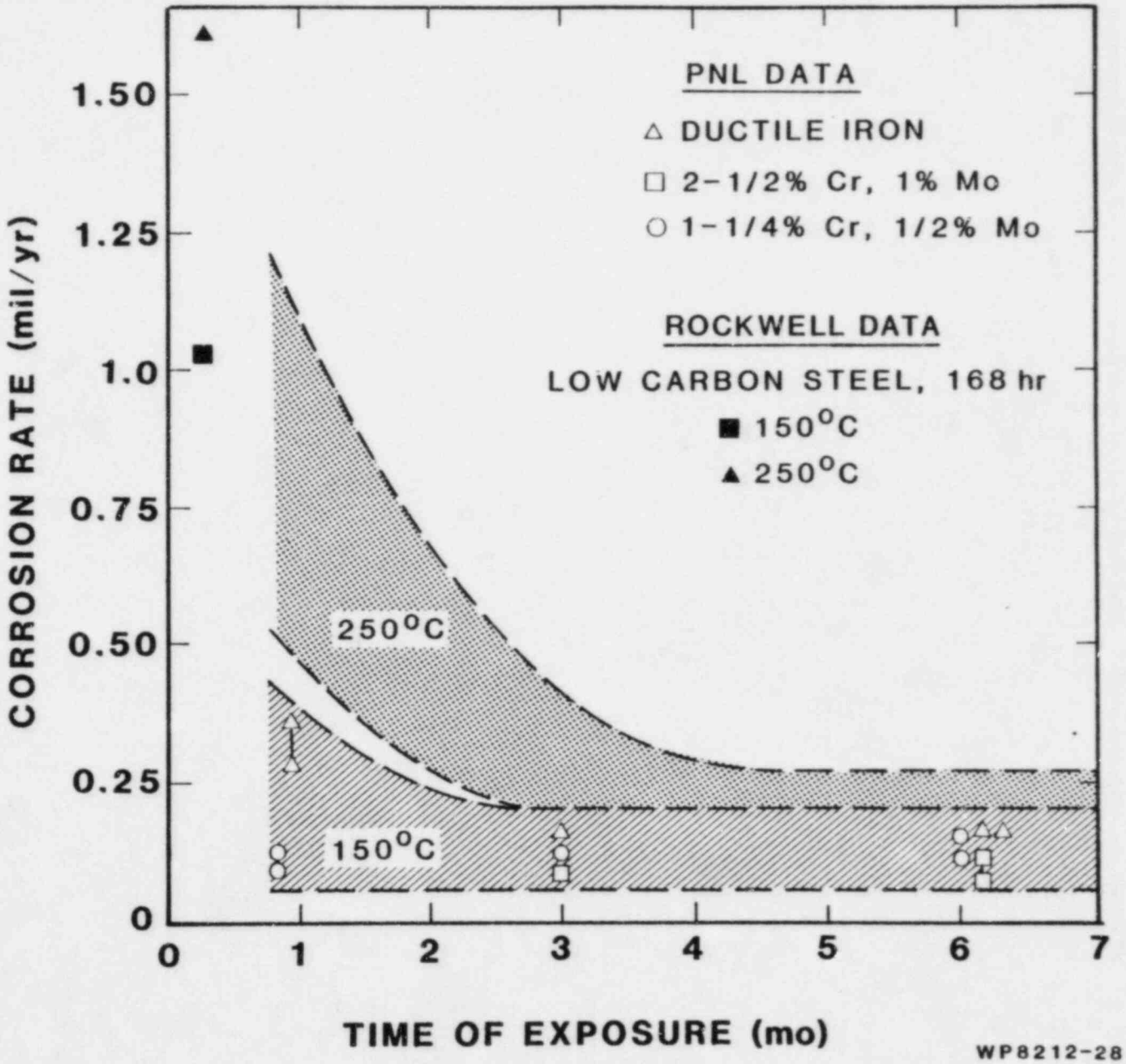
CANISTER MATERIALS CORROSION TEST PARAMETERS

- TEMPERATURE (50° TO 300°C)
- TEST DURATIONS (UP TO 10 YEARS)
- Eh (AS LOW AS –0.45 VOLT)
- pH (6 TO 10)
- GAMMA RADIATION (UP TO 10^6 RADS/HOUR)
- GROUNDWATER CHEMISTRY (VARIATION OF $CO_3^=$, $SO_4^=$, Cl^-, F^-)
- GROUNDWATER VELOCITY (STATIC TO 4×10^{-4} METER/YEAR MAXIMUM)
- MATERIAL CONDITION (WELDMENTS, HEAT–AFFECTED ZONE, SURFACE CONDITION, HEAT TREATMENT, HEAT TO HEAT)
- PRESENCE/ABSENCE OF BACKFILL
- ANAEROBIC BACTERIA EFFECTS

MECHANICAL PROPERTIES TESTING

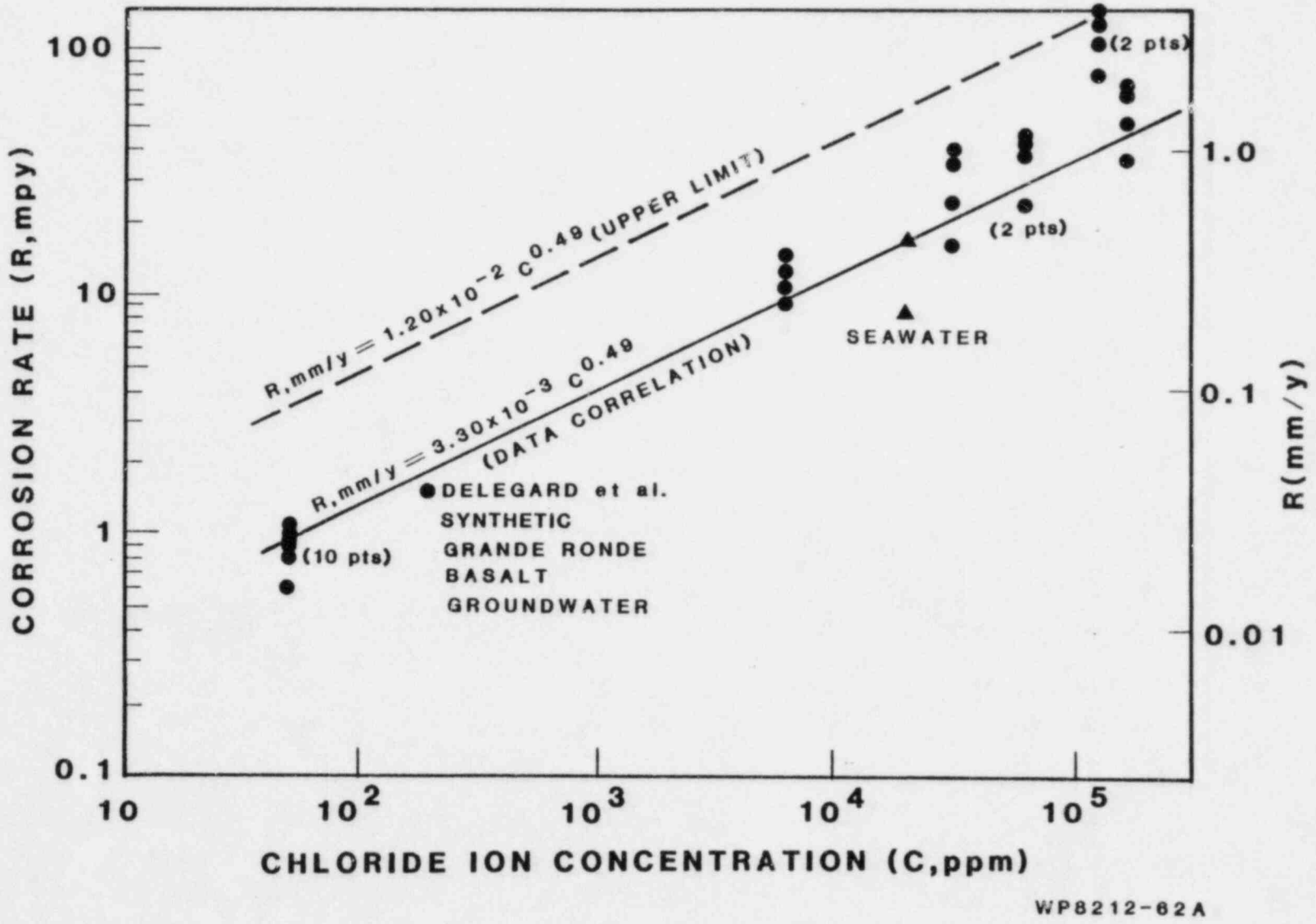
- SLOW STRAIN RATE (STRESS CORROSION CRACKING SUSCEPTIBILITY)
- STATIC AND CYCLIC CRACK GROWTH (STRESS INTENSITY FACTORS)
  (DEFINES STRESSES/FLAW COMBINATIONS THAT PRECLUDE CRACKING)

CORROSION RATES OF FERROUS ALLOYS IN HANFORD BASALT GROUNDWATER

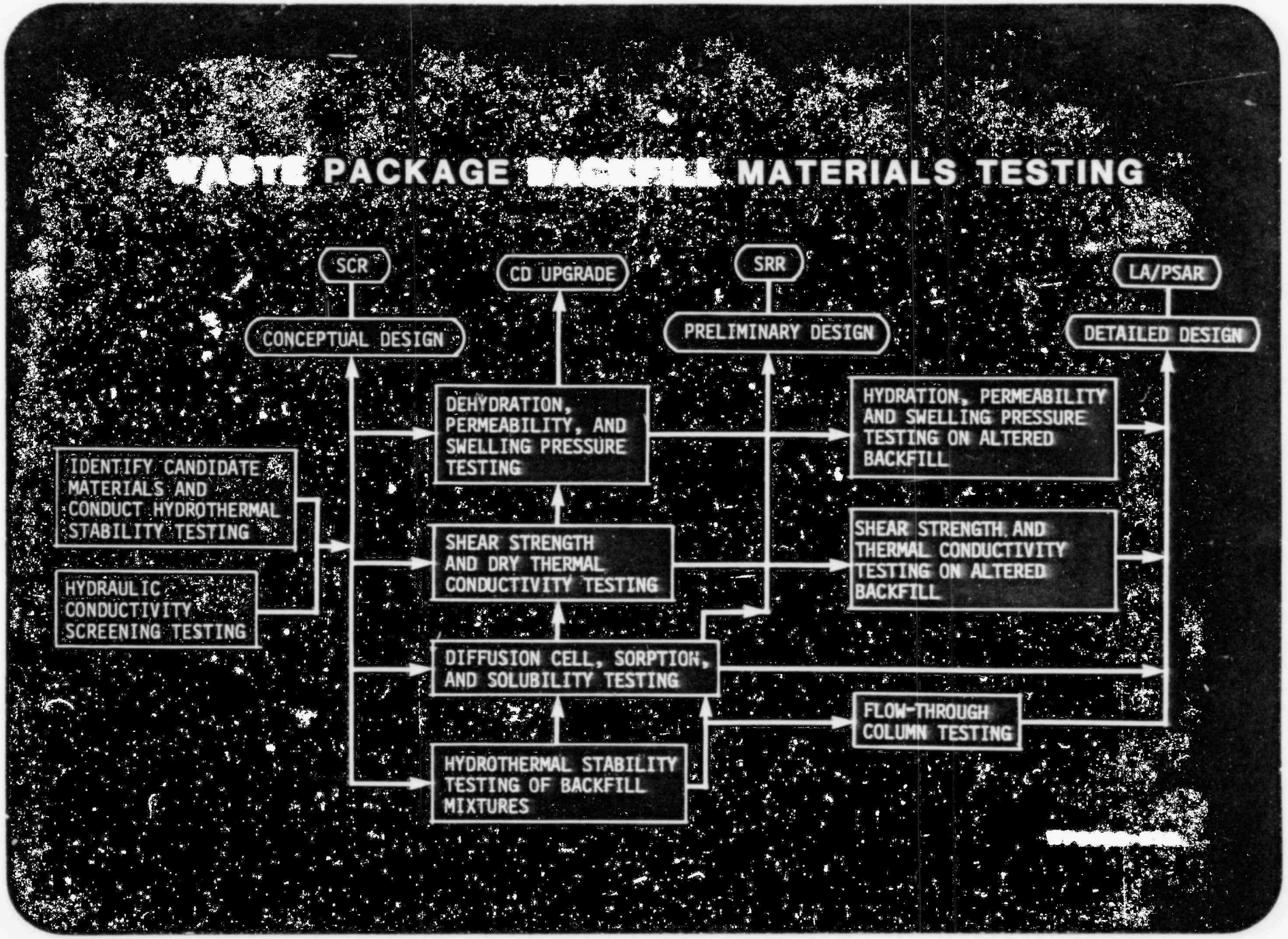


WP8212-28

EFFECT OF CHLORIDE ION CONTENT ON ANOXIC CORROSION OF FERROUS ALLOYS AT 250°C



WP8212-62A


WASTE PACKAGE BACKFILL MATERIALS TESTING
SCR
CD UPGRADE
SRR
LA/PSAR
CONCEPTUAL DESIGN
PRELIMINARY DESIGN
DETAILED DESIGN
IDENTIFY CANDIDATE MATERIALS AND CONDUCT HYDROTHERMAL STABILITY TESTING
HYDRAULIC CONDUCTIVITY SCREENING TESTING
DEHYDRATION, PERMEABILITY, AND SWELLING PRESSURE TESTING
SHEAR STRENGTH AND DRY THERMAL CONDUCTIVITY TESTING
DIFFUSION CELL, SORPTION, AND SOLUBILITY TESTING
HYDROTHERMAL STABILITY TESTING OF BACKFILL MIXTURES
HYDRATION, PERMEABILITY AND SWELLING PRESSURE TESTING ON ALTERED BACKFILL
SHEAR STRENGTH AND THERMAL CONDUCTIVITY TESTING ON ALTERED BACKFILL
FLOW-THROUGH COLUMN TESTING

HYDRAULIC CONDUCTIVITY

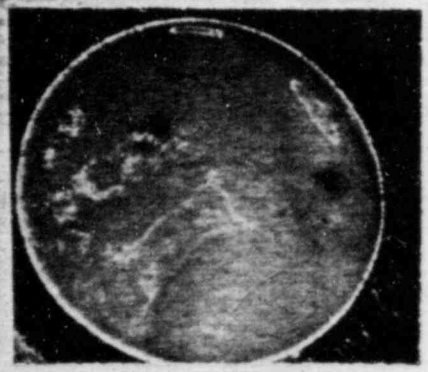
OF 75% BASALT AND 25% BENTONITE BACKFILL

AT 25°C

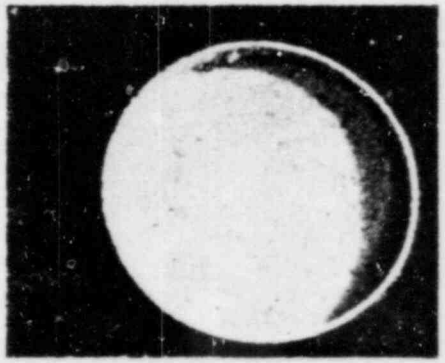
DENSITY (g/cm^3)	HYDRAULIC CONDUCTIVITY (cm/sec)
1.56	4.2×10^{-8}
1.70	9.4×10^{-9}
1.70	4.1×10^{-9}
1.71	1.3×10^{-9}
1.71	6.2×10^{-10}
1.85	2.4×10^{-10}
CRUSHED BASALT	7.6×10^{-5}
REQUIRED HYDRAULIC CONDUCTIVITY	$< 3 \times 10^{-4}$

WP8304-40A

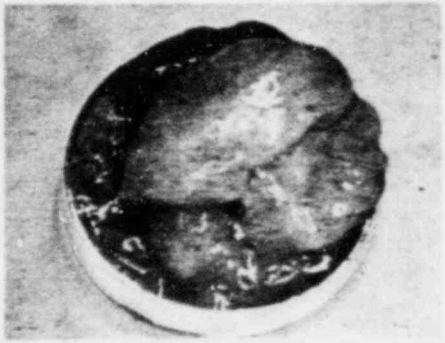
ADDITION OF WATER TO AS RECEIVED AND HEATED BENTONITE



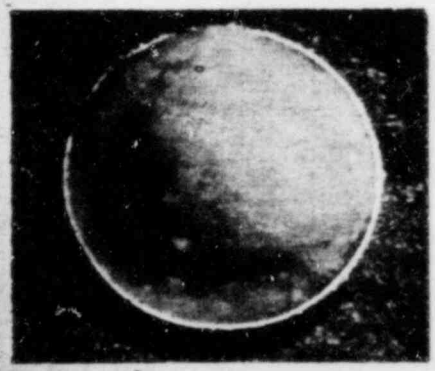
250°C/340 days



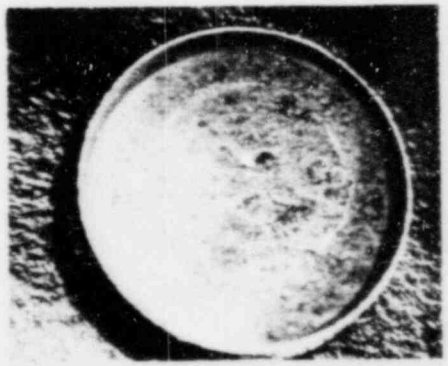
440°C/365 days



AS RECEIVED

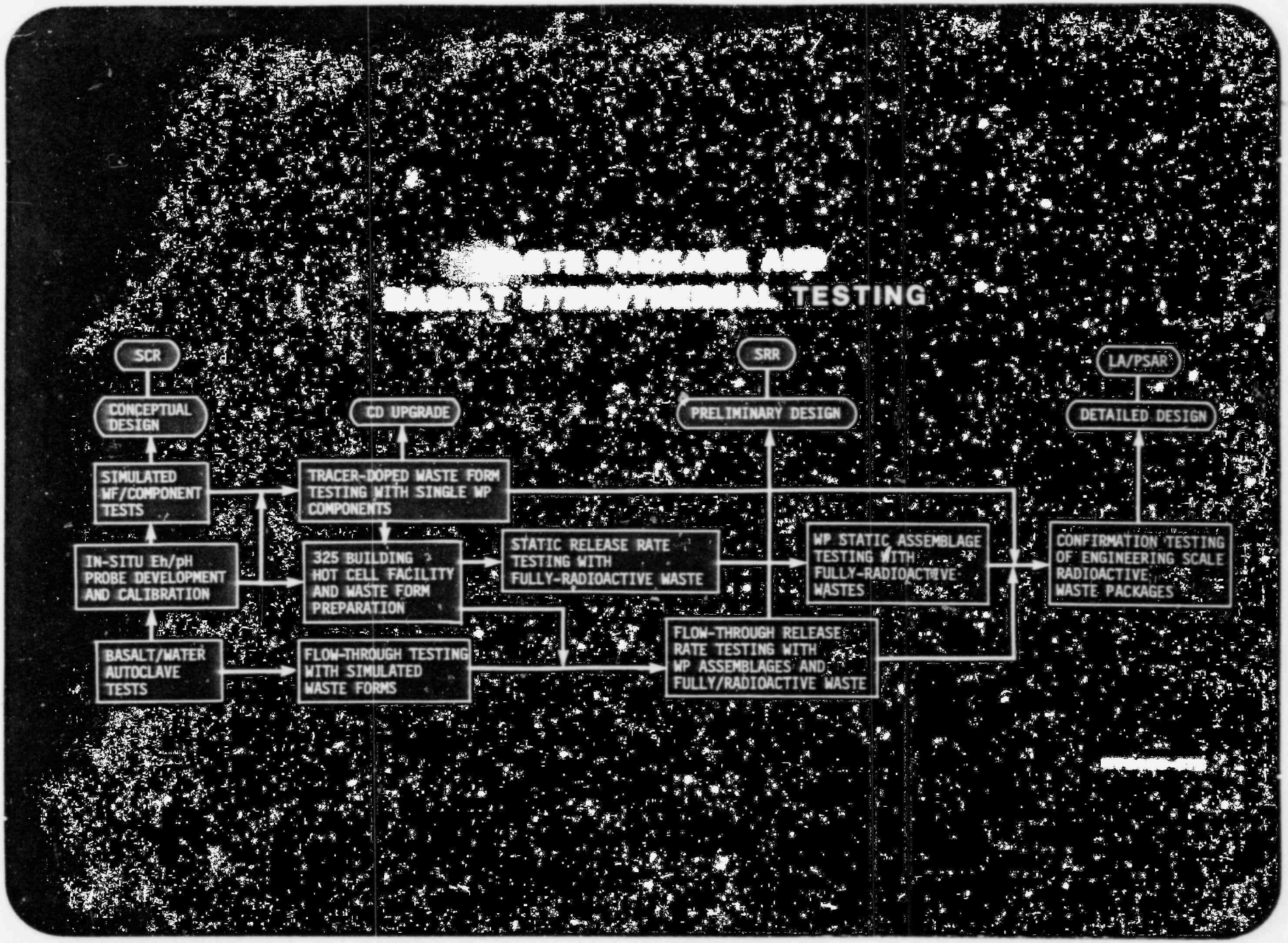


370°C/340 days



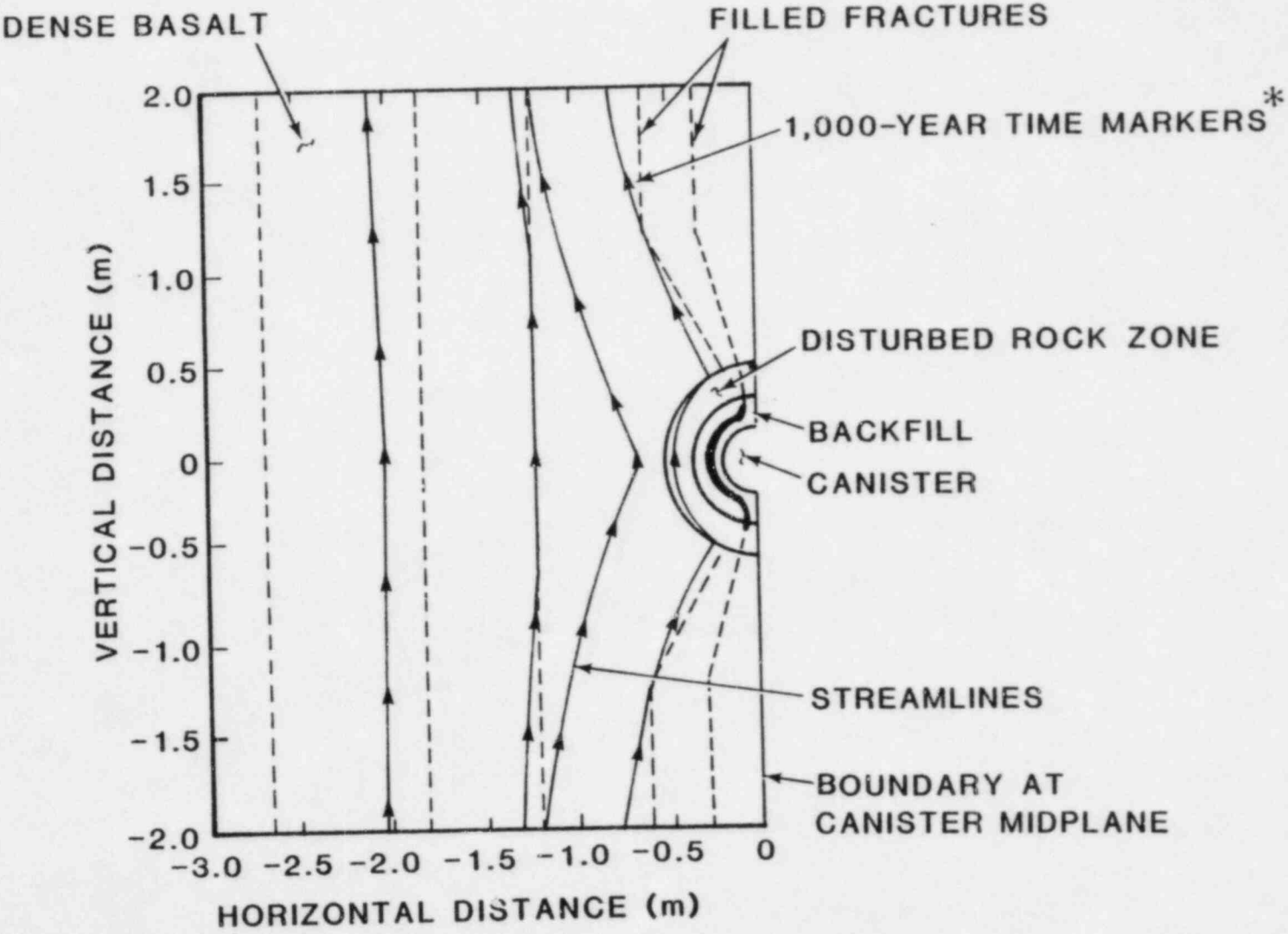
550°C/270 days

WP8304-47


TESTING
SCR
CONCEPTUAL DESIGN
SRR
PRELIMINARY DESIGN
LA/PSAR
DETAILED DESIGN
CD UPGRADE
SIMULATED WF/COMPONENT TESTS
TRACER-DOPED WASTE FORM TESTING WITH SINGLE WP COMPONENTS
IN-SITU Eh/pH PROBE DEVELOPMENT AND CALIBRATION
325 BUILDING HOT CELL FACILITY AND WASTE FORM PREPARATION
STATIC RELEASE RATE TESTING WITH FULLY-RADIOACTIVE WASTE
WP STATIC ASSEMBLAGE TESTING WITH FULLY-RADIOACTIVE WASTES
CONFIRMATION TESTING OF ENGINEERING SCALE RADIOACTIVE WASTE PACKAGES
BASALT/WATER AUTOCLAVE TESTS
FLOW-THROUGH TESTING WITH SIMULATED WASTE FORMS
FLOW-THROUGH RELEASE RATE TESTING WITH WP ASSEMBLAGES AND FULLY/RADIOACTIVE WASTE

WASTE PACKAGE-SCALE STEADY-STATE FLOW SIMULATION

BASED ON PRELIMINARY BASELINE PERFORMANCE ASSESSMENT



*DISTANCE BETWEEN TIME MARKERS REPRESENTS 1,000 YEARS OF PURE WATER TRAVELTIME

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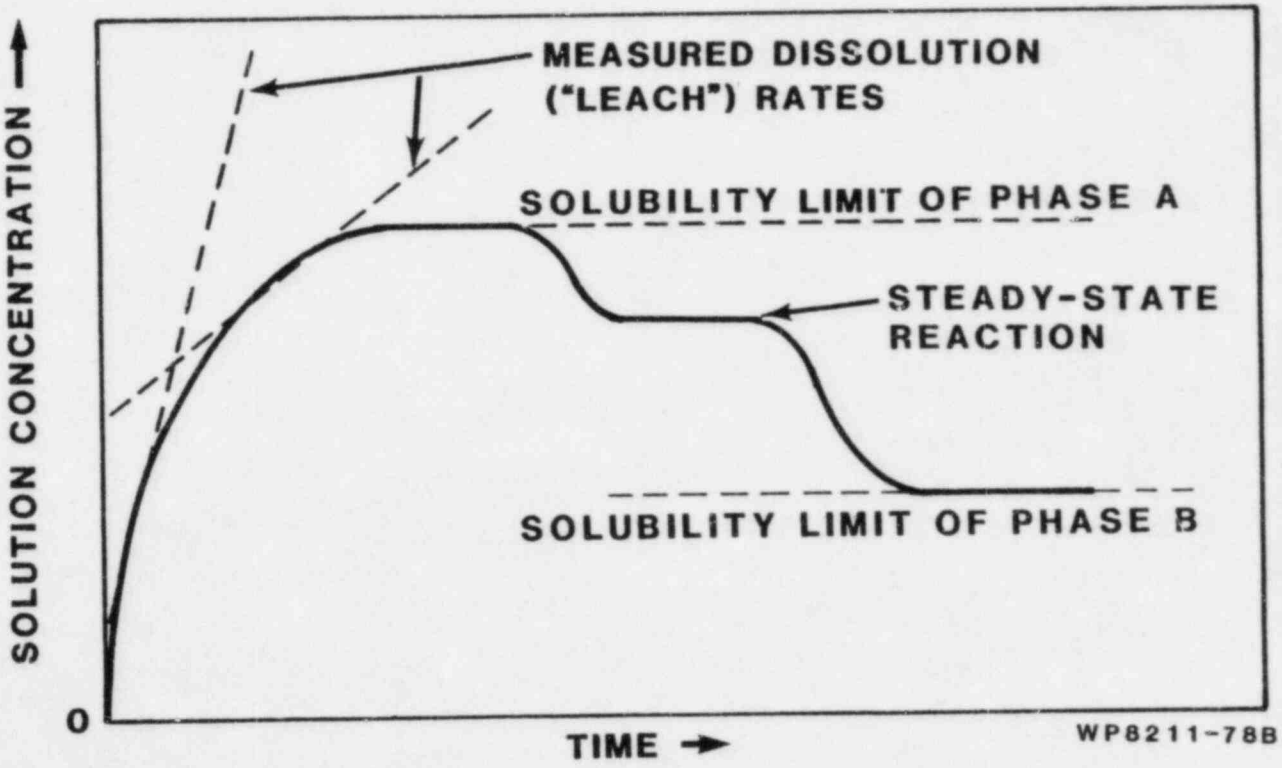
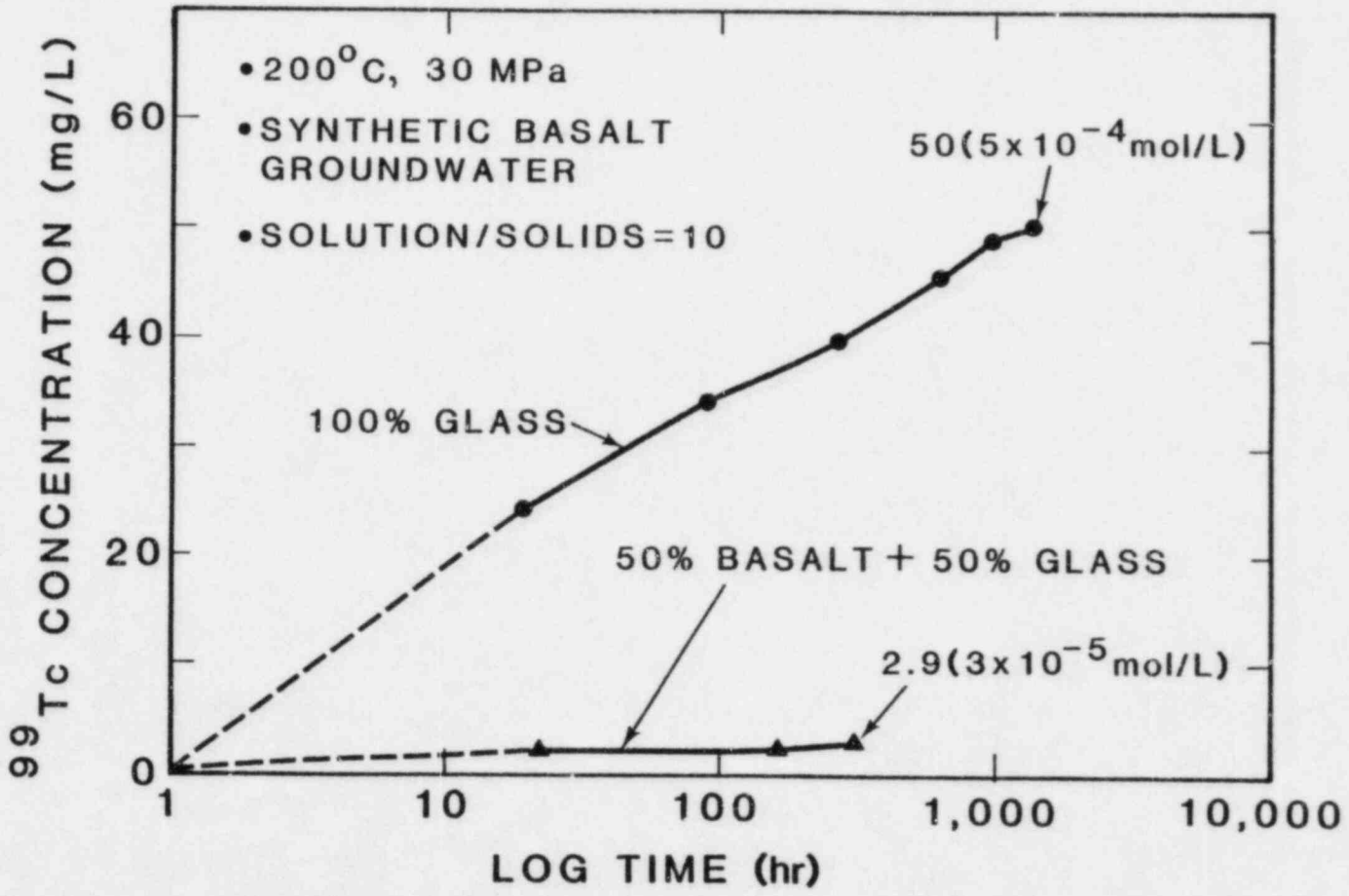
SOLID DISSOLUTION BEHAVIOR AS A FUNCTION OF TIME



^{99}Tc DOPED 76-68 BOROSILICATE GLASS

GROUNDWATER EXPERIMENTS: WITH AND WITHOUT BASALT

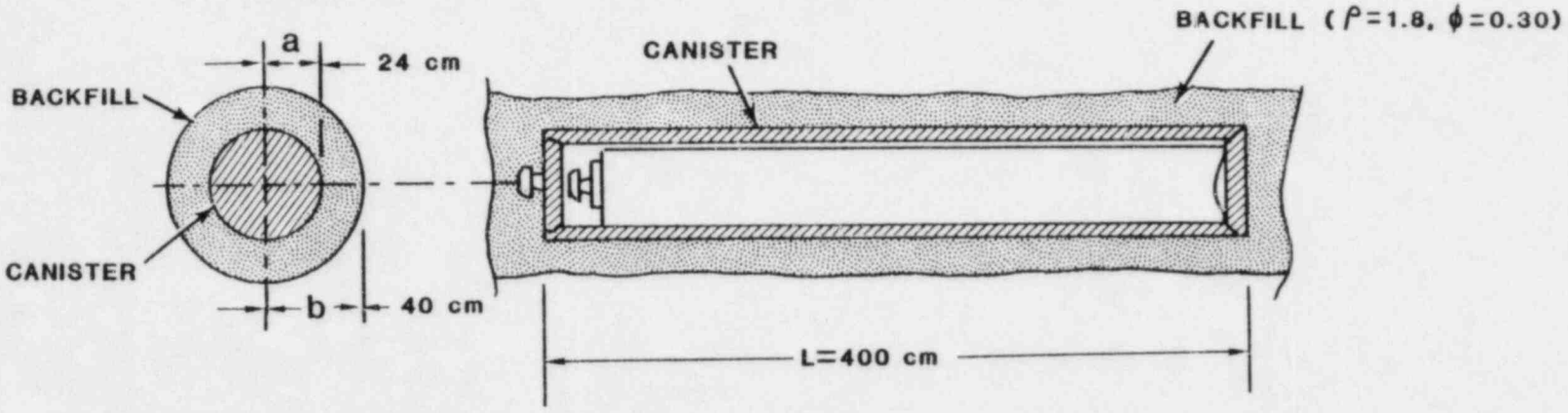


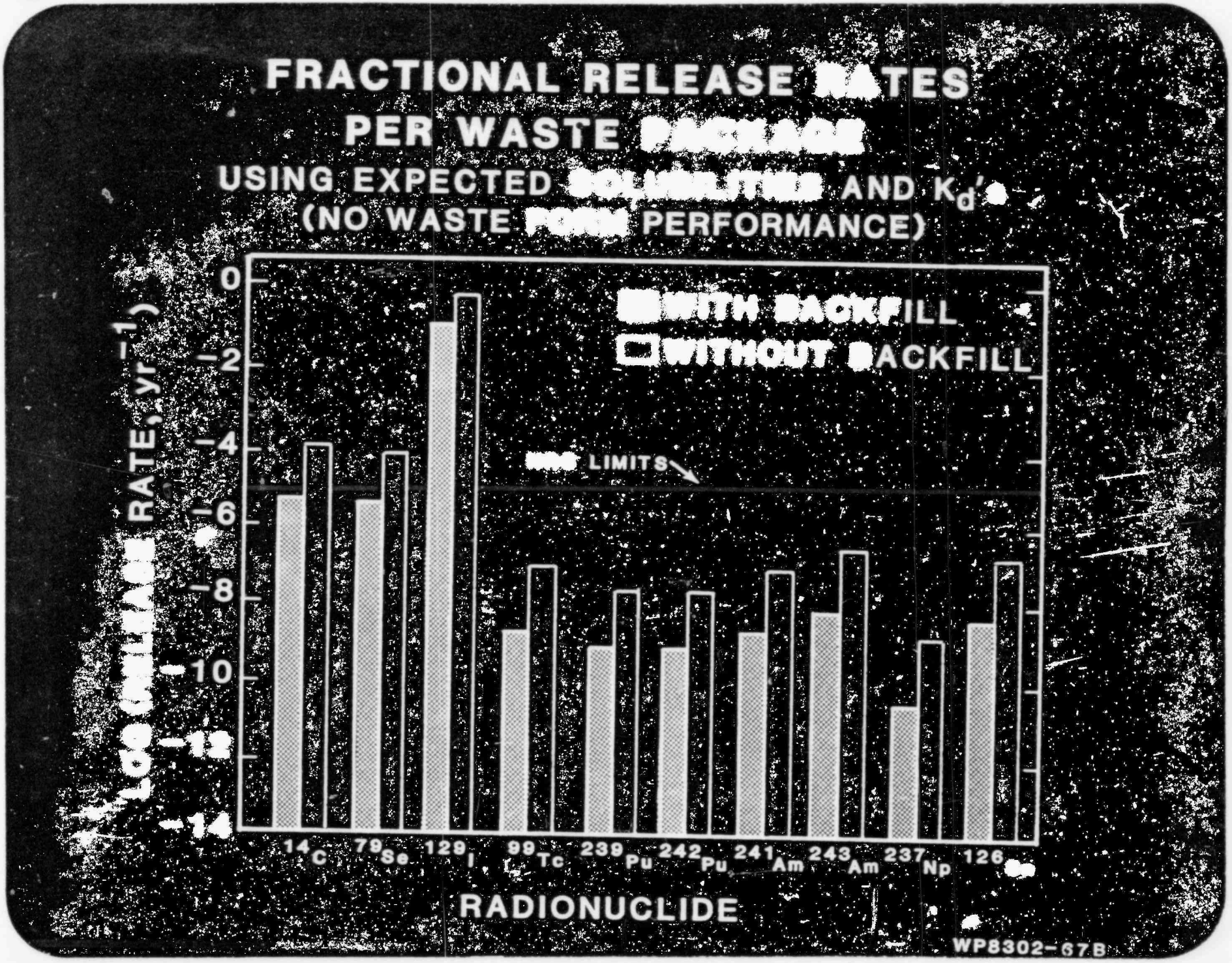
WP8304-5A

PRELIMINARY COMPARISON OF ESTIMATED WASTE PACKAGE BACKFILL RELEASE RATES WITH NRC FRACTIONAL RELEASE RATES

RADIONUCLIDE RELEASE ESTIMATES

- ASSUMPTIONS
  - 100–YEAR–OLD SPENT FUEL OR COMMERCIAL HIGH–LEVEL WASTE
  - TRANSPORT THROUGH BACKFILL DIFFUSION CONTROLLED
  - RADIAL TRANSPORT THROUGH A POROUS CYLINDER
  - RADIONUCLIDE DECAY NEGLECTED
  - ANNULUS ASSUMED TO BE FILLED WITH WATER FOR NO BACKFILL CASE
  - NO WASTE FORM PERFORMANCE

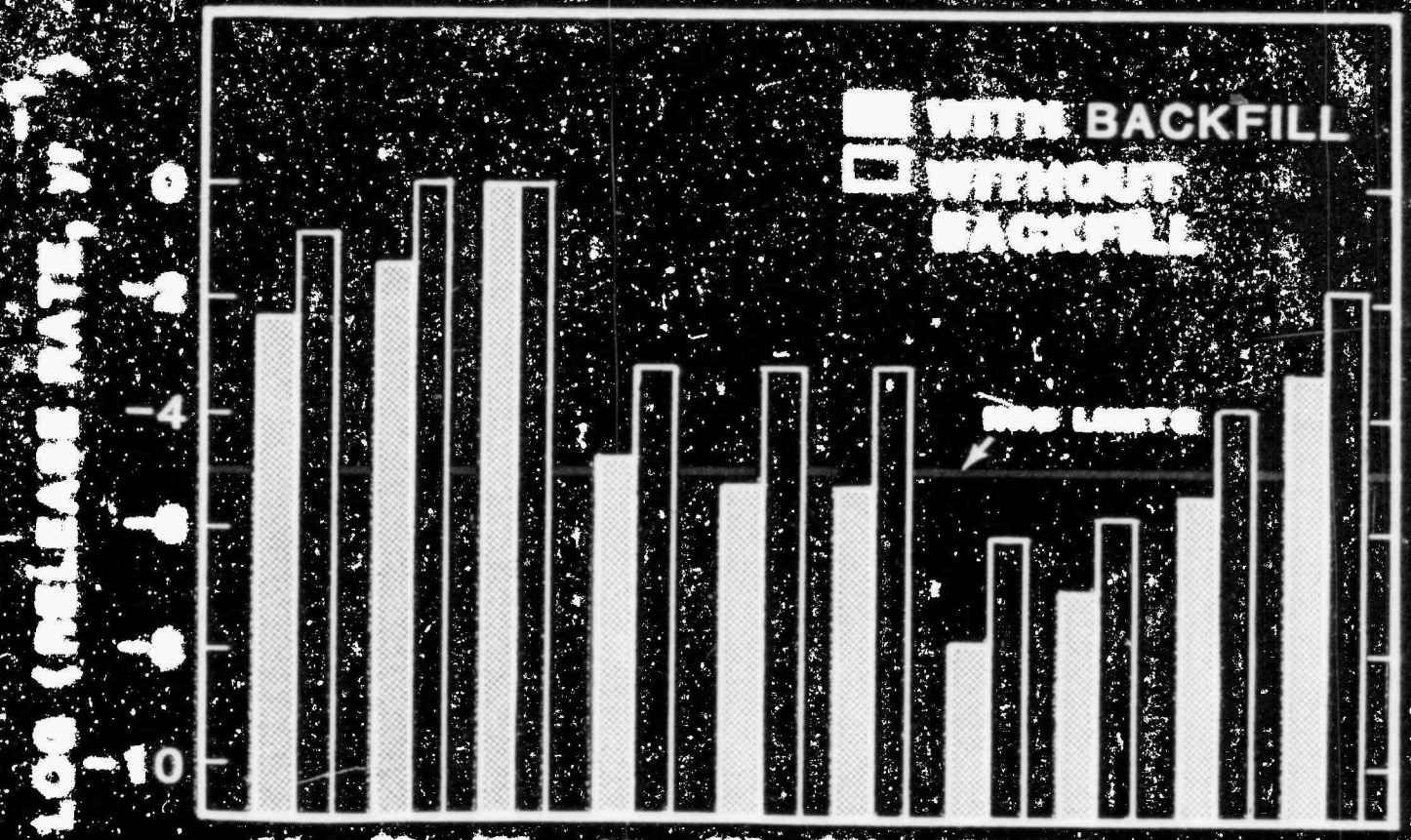



FRACTIONAL RELEASE RATES
PER WASTE PACKAGE
USING EXPECTED SOLUBILITIES AND K_d's
(NO WASTE FORM PERFORMANCE)
WITH BACKFILL
WITHOUT BACKFILL
LIMITS
LOG (FRACTIONAL RELEASE RATE, yr^{-1})
0
-2
-4
-6
-8
-10
-12
-14
^{14}C
^{79}Se
^{129}I
^{99}Tc
^{239}Pu
^{242}Pu
^{241}Am
^{243}Am
^{237}Np
^{126}
RADIONUCLIDE
WP8302-67B

FRACTIONAL RELEASE RATES PER WASTE PACKAGE

USING CONSERVATIVE SOLUBILITIES AND K_d'S

(NO WASTE FORM [illegible])



WP8302-66B

WASTE PACKAGE CONCEPTUAL DESIGN AND COMPONENT FUNCTIONS

FUNCTIONAL REQUIREMENTS OF THE CANISTER COMPONENT

- TO PROVIDE RADIONUCLIDE CONTAINMENT DURING SHIPPING, HANDLING, AND, POSSIBLY, RETRIEVAL

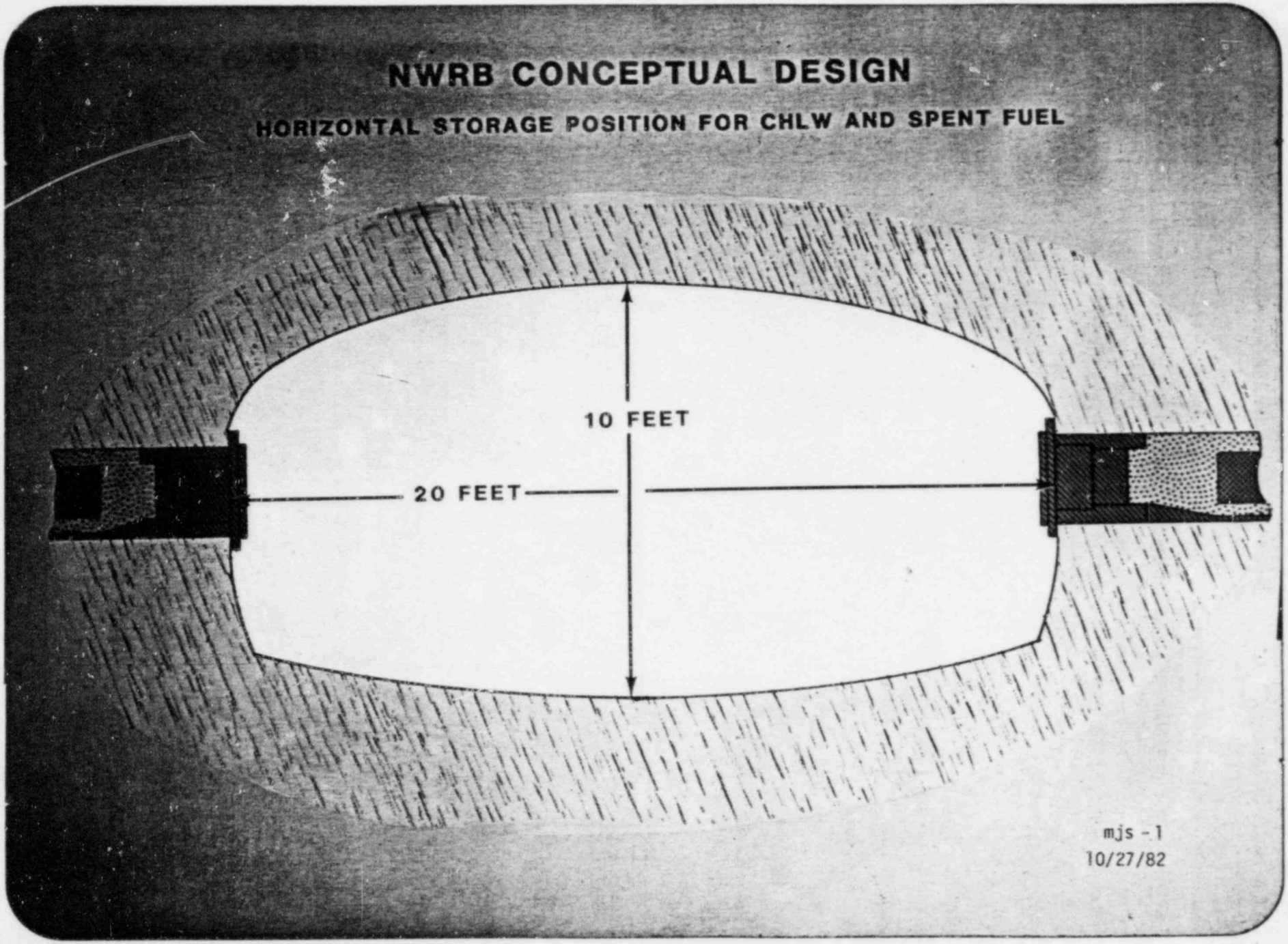
- TO PROVIDE RADIONUCLIDE CONTAINMENT FOR UP TO 1,000 YEARS AFTER EMPLACEMENT

FUNCTIONAL REQUIREMENTS OF THE BACKFILL COMPONENT

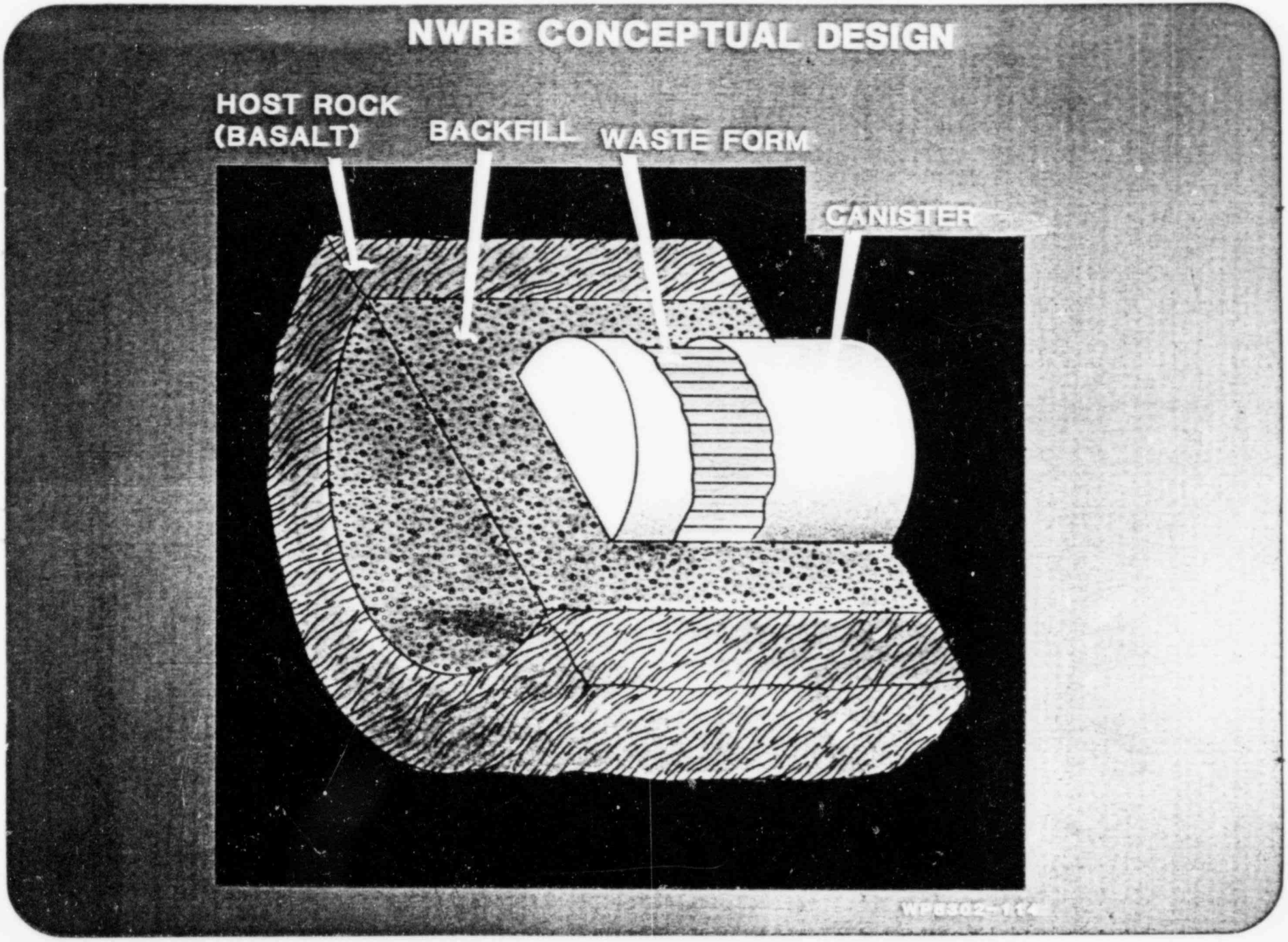
- MINIMIZE CANISTER CORROSION DURING THE CONTAINMENT PERIOD (UP TO 1,000 YEARS)
  - DELAY WATER CONTACT WITH THE CANISTER
  - MINIMIZE GROUNDWATER FLUX PAST THE CANISTER
  - BUFFER OXYGEN CONTENT NEAR THE CANISTER
  - LOCALIZE CORROSION PRODUCTS AT THE BACKFILL/CANISTER INTERFACE
- PREVENT RADIONUCLIDE TRANSPORT INTO THE HOST ROCK DURING THE CONTAINMENT PERIOD IN THE EVENT OF PREMATURE CANISTER BREAKTHROUGH AND WASTE FORM DISSOLUTION
- REDUCE THE RADIONUCLIDE RELEASE RATE TO THE HOST ROCK AFTER THE CONTAINMENT PERIOD

SITE–SPECIFIC WASTE PACKAGE DESIGN LIMITS FOR BASALT

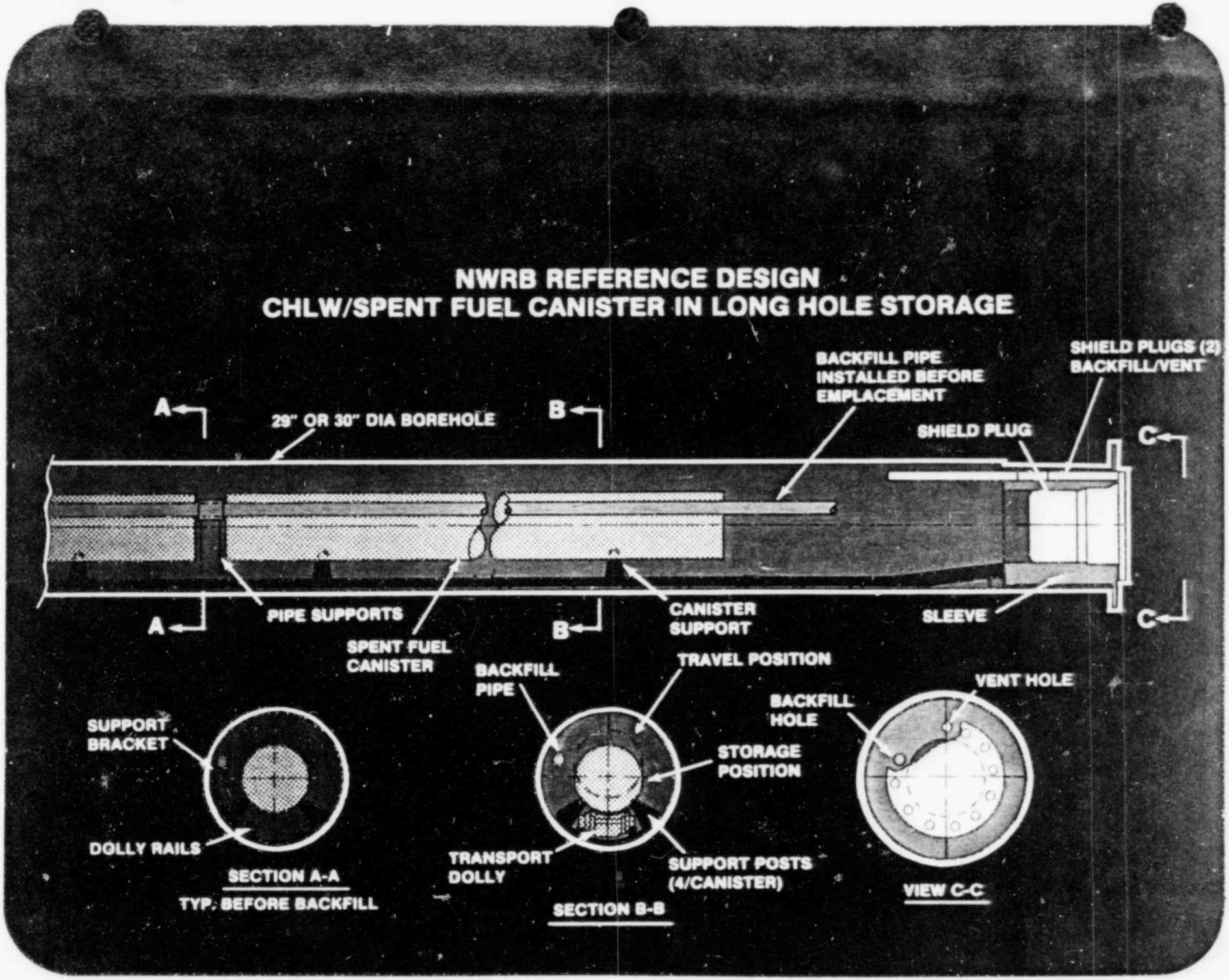
- RETRIEVABILITY SIMPLIFIED BECAUSE REPOSITORY NOT EXPECTED TO SATURATE UNTIL WELL AFTER CLOSURE (UP TO 300 YEARS)
- CANISTER DESIGNED FOR HYDROSTATIC PRESSURE (~1,700 lb/in^2) AT 1,000 YEARS
- REDUCING CONDITIONS PERMIT USE OF CARBON STEEL (0.5–in. CORROSION ALLOWANCE)
- CRUSHED BASALT INCLUDED IN BACKFILL DUE TO Eh CONTROL AND SOLUBILITY LIMITING CAPABILITY
- BACKFILL TEMPERATURE LIMIT 300°C/LITTLE ALTERATION OF BENTONITE
- HORIZONTAL EMPLACEMENT OF PACKAGES MUST BE POSSIBLE
- ADVANTAGEOUS TO KEEP BOREHOLE DIAMETER LESS THAN ~3 FEET
- ROCK STRESS DUE TO HEAT DETERMINES SPENT FUEL AND COMMERCIAL HIGH–LEVEL WASTE CANISTER SPACING


NWRB CONCEPTUAL DESIGN
HORIZONTAL STORAGE POSITION FOR CHLW AND SPENT FUEL
10 FEET
20 FEET
mjs - 1
10/27/82

WPS211-36A

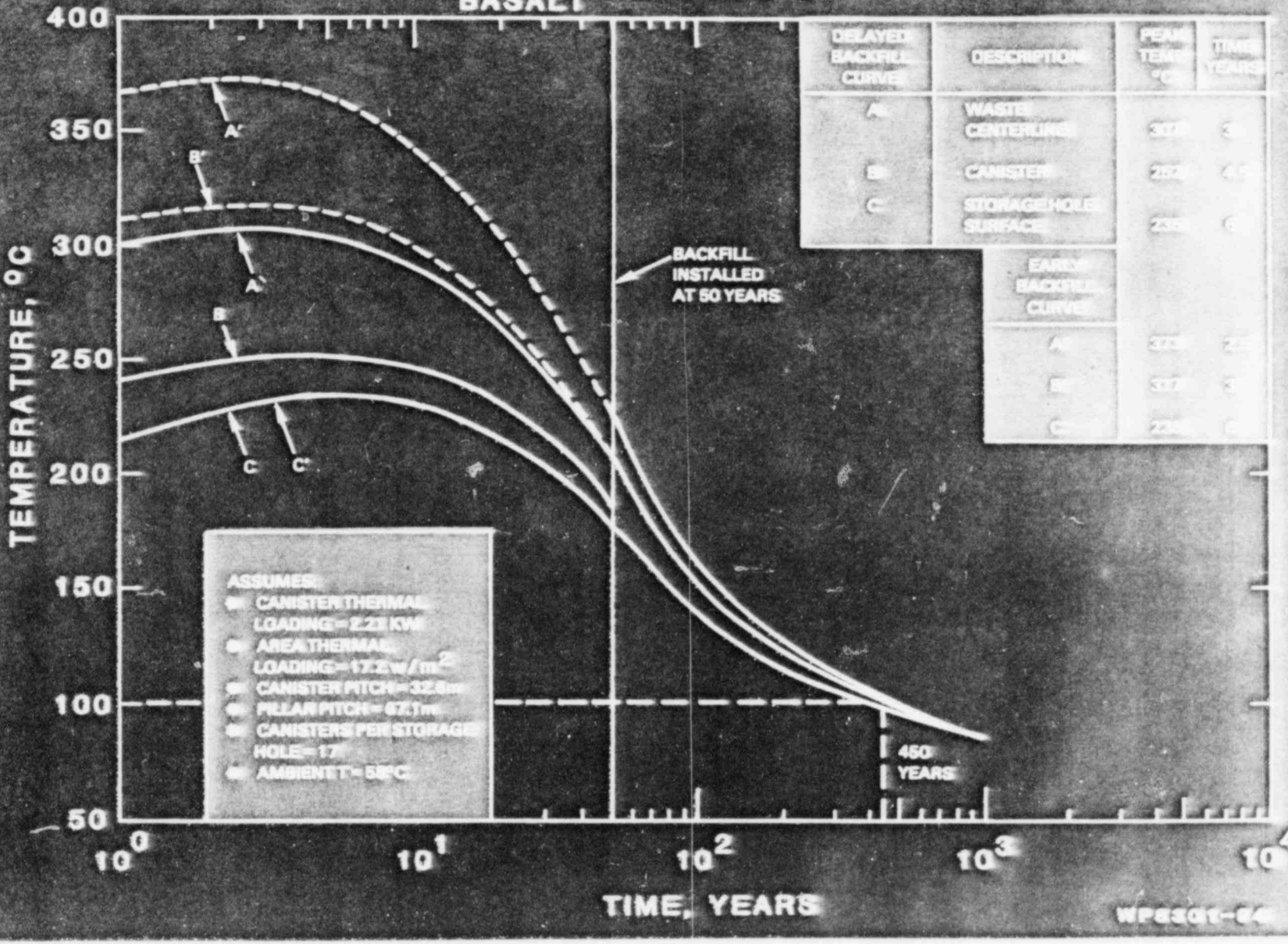

NWRB CONCEPTUAL DESIGN
HOST ROCK
(BASALT)
BACKFILL
WASTE FORM
CANISTER

WP8302-114


NWRB REFERENCE DESIGN
CHLW/SPENT FUEL CANISTER IN LONG HOLE STORAGE
A
B
29" OR 30" DIA BOREHOLE
BACKFILL PIPE
INSTALLED BEFORE
EMPLACEMENT
SHIELD PLUGS (2)
BACKFILL/VENT
SHIELD PLUG
C
PIPE SUPPORTS
SPENT FUEL
CANISTER
CANISTER
SUPPORT
SLEEVE
BACKFILL
PIPE
TRAVEL POSITION
VENT HOLE
BACKFILL
HOLE
SUPPORT
BRACKET
STORAGE
POSITION
DOLLY RAILS
TRANSPORT
DOLLY
SUPPORT POSTS
(4/CANISTER)
SECTION A-A
TYP. BEFORE BACKFILL
SECTION B-B
VIEW C-C

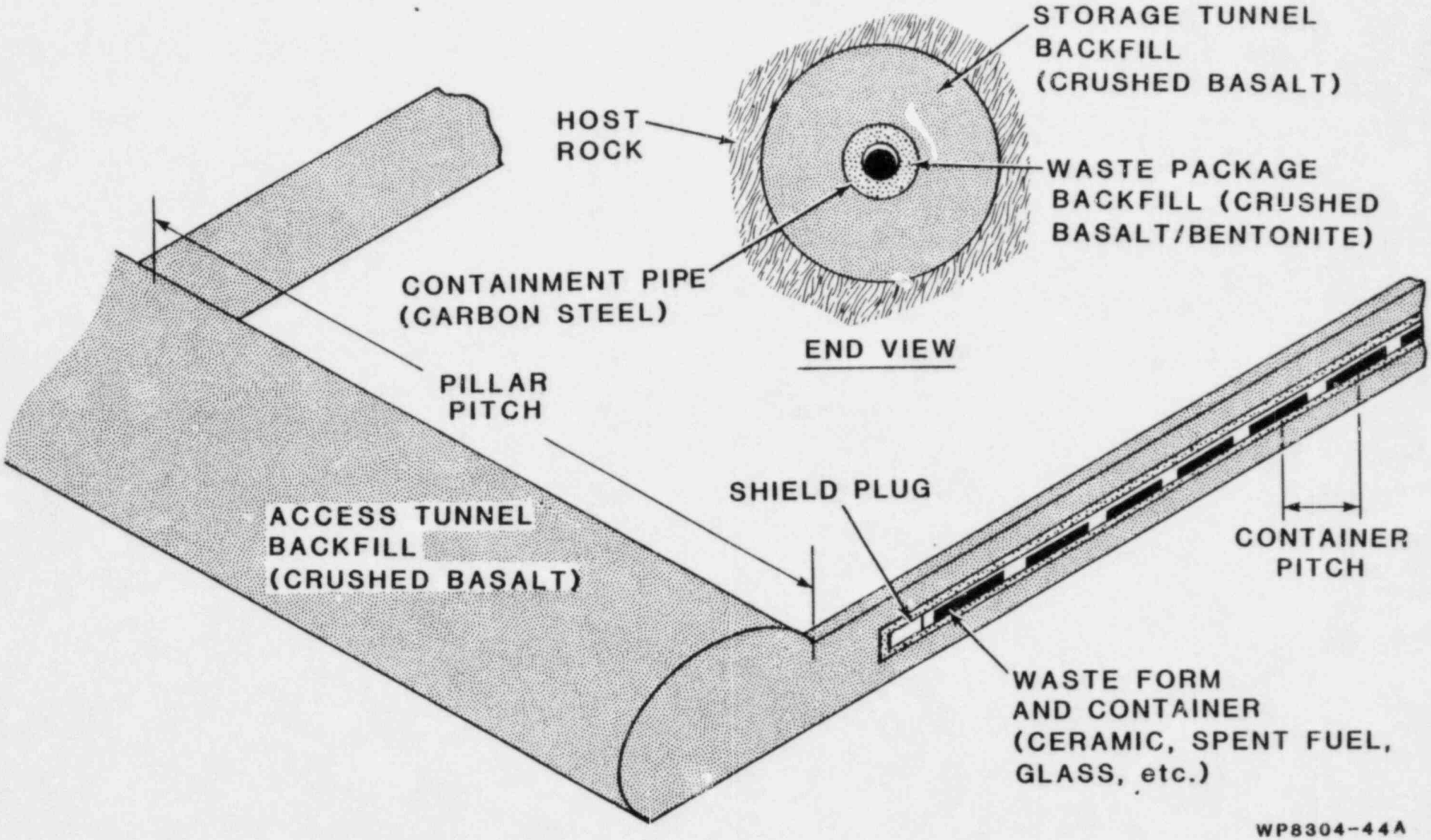
COMMERCIAL HIGH-LEVEL WASTE PACKAGE TEMPERATURE ESTIMATES

(K_{BASALT} = 1.78 w/m°C)



WP82G1-84

IN-TUNNEL WASTE PACKAGE
ALTERNATE EMPLACEMENT CONFIGURATION



WP8304-44A

FIELD AND ENGINEERING TESTING

WASTE PACKAGE FIELD AND ENGINEERING TESTING

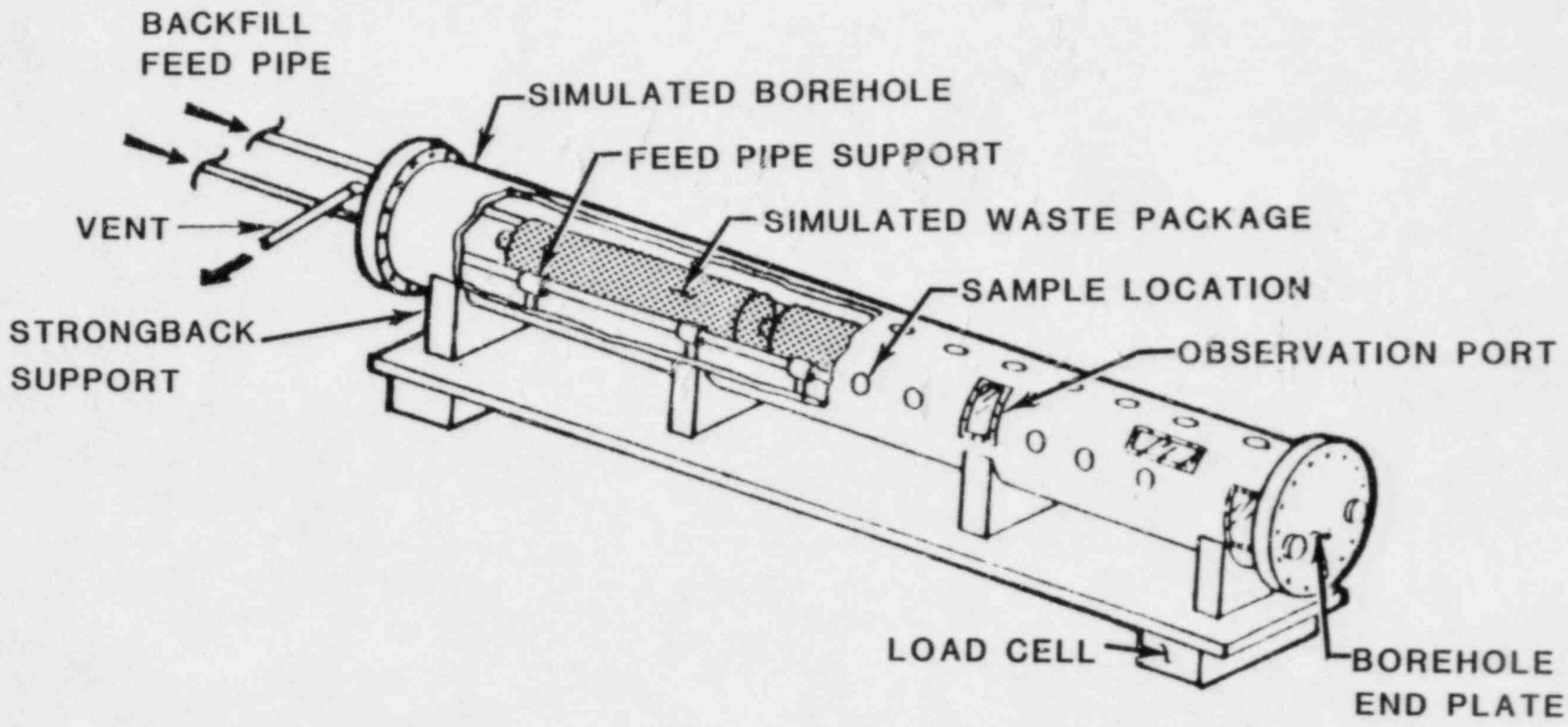
ENGINEERING/FIELD TEST	OBJECTIVE	DATA DEVELOPED
BACKFILL PROCESS DEVELOPMENT TEST	DEMONSTRATE IF BACKFILL MIXTURE CAN BE PNEUMATICALLY EMPLACED IN BOREHOLES OR TUNNELS	• PACKING DENSITY • MASS RATIO • MASS FLOW RATE • FEED PIPE WITHDRAWAL RATE • PNEUMATIC EQUIPMENT SETTINGS
WASTE PACKAGE BACKFILL PERFORMANCE TEST	VERIFY BACKFILL RESATURATION RATES UNDER A TEMPERATURE GRADIENT	• TEMPERATURE PROFILES VERSUS TIME • WATER CONCENTRATION PROFILES VERSUS TIME • SWELLING PRESSURE
WASTE PACKAGE EMPLACEMENT/RETRIEVAL TEST	OPTIMIZE EQUIPMENT AND TECHNIQUES FOR EMPLACING/RETRIEVING WASTE PACKAGES USING CURRENT REPOSITORY BOREHOLE CONCEPTUAL DESIGN	• OPTIMIZED HANDLING EQUIPMENT • PROCEDURES/TECHNIQUES FOR EMPLACEMENT/RETRIEVAL

WASTE PACKAGE FIELD AND ENGINEERING TESTING (continued)

ENGINEERING/FIELD TEST	OBJECTIVE	DATA DEVELOPED
WASTE PACKAGE MATERIALS DEGRADATION TEST	MEASURE DEGRADATION RATE OF CANISTER AND BACKFILL UNDER CONDITIONS SIMULATING A NUCLEAR WASTE REPOSITORY IN BASALT FOR COMPARISON WITH LABORATORY DATA	• VERIFY LABORATORY CANISTER CORROSION BEHAVIOR • EFFECT OF TIME, TEMPERATURE, AND SATURATED CONDITIONS ON BACKFILL:* – HYDRAULIC CONDUCTIVITY – GROUNDWATER DISPERSION/ DIFFUSION – EFFECTIVE DIFFUSION COEFFICIENT – RADIONUCLIDE RETARDATION FACTOR – ALTERATION PRODUCTS – SHEAR STRENGTH – GROUNDWATER COMPOSITION
RADIONUCLIDE MIGRATION TEST	VALIDATE PREDICTIVE TRANSPORT MODELS AND SORPTION/SOLUBILITY BEHAVIOR IN BASALT	• VERIFY FLOW-THROUGH AND BATCH SORPTION TEST DATA • OBTAIN FIELD DATA, WHICH INCLUDES Eh, pH, AND GROUNDWATER COMPOSITION

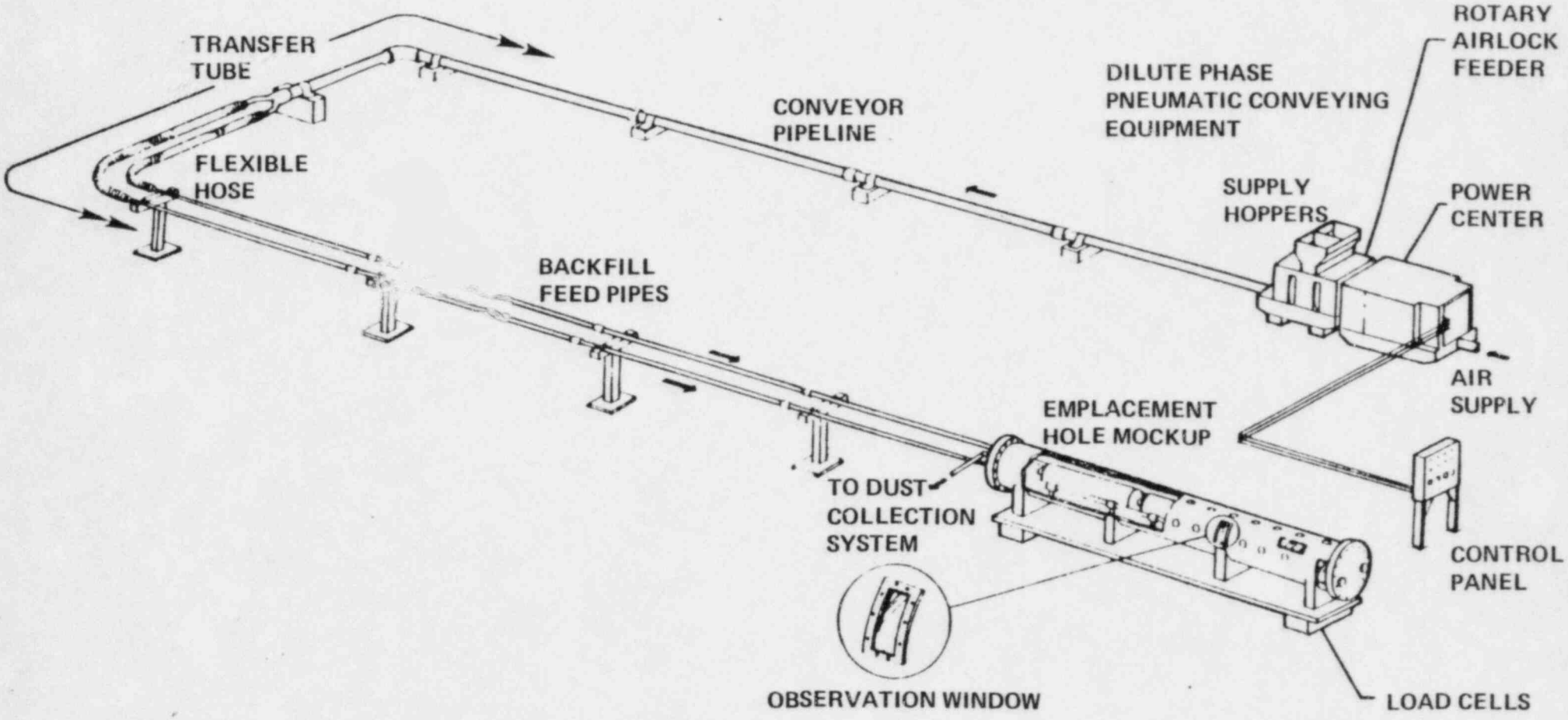
*FROM POST-TEST LABORATORY ANALYSES.

WASTE PACKAGE BACKFILL PROCESS DEVELOPMENT TEST



WP8303-69

TEST HARDWARE AND EQUIPMENT ARRANGEMENT FOR BACKFILL DEVELOPMENT TEST



WP8303-70