UNITED STATES

NUCLEAR WASTE TECHNICAL REVIEW BOARD

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FALL 1997 BOARD MEETING

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Hyatt Fair Lakes
1277 Fair Lakes Circle
Fairfax, Virginia 22033

Tuesday, October 21, 1997

The above-entitled matter commenced, pursuant to notice at 8:40 a.m.

BOARD MEMBERS:

JEFFREY WONG, Presiding
JOHN ARENDT
DANIEL BULLEN
NORMAN CHRISTENSEN, JR.
PAUL CRAIG
DEBRA KNOPMAN
PRISCILLA NELSON
RICHARD PARIZEK
ALBERTO SAGUES

STAFF:

DAVONYA BARNES
DANIEL FEHRINGER
LINDA HIATT

ATTENDEES/PRESENTERS:

KJELL ANDERSSON
D. WAYNE BERMAN
STEPHEN BROCOUM
MELVIN CARTER
STEVE FRISHMAN
ROBERT L. KIMBLE
ARJUN MAKHIJANI
PHILLIP NIEDZIELSKI-EICHNER
ABRAHAM VAN LUIK
ENGELBRECHT von TIESENHAUSEN

P R O C E E D I N G S

[8:40 a.m.]

DR. WONG: I think we need to grab our coffee and our chairs and start up. Good morning, ladies and gentlemen. Welcome to this meeting of the Nuclear Waste Technical Review Board Panel on environment regulations and quality assurance. My name is Jeff Wong, and I'm the chair of this panel, and luckily I get to chair this meeting.

Let me begin by going through some introductions of panel members and other board members that are here today. As you know, the board has undergone some transition so it would be important for me to give a little background of each one of the board members that are here.

First, John Arendt. John, raise your hand? John began his career as a research engineer for the Manhattan Project. Since then he has acquired extensive experience in uranium processing, accountability, packaging, transportation, as well as the management of engineering projects related to the various aspects related to the nuclear field cycle. Mr. Arendt is the founder and principal of John W. Arendt Associates, Incorporated, a consulting firm located in Oak Ridge, Tennessee.

The next member of the panel is Norm Christensen, Junior. Norm is professor and dean of the School of the Environment at Duke University, at Durham, North Carolina.

Dr. Christensen brings to the Board special expertise in biology and ecology. One of his research interests, the effects of disturbance on the function and structure of populations and communities within the ecosystem, is particularly relevant to evaluating the possible ecological effects of the Yucca Mountain project.

Our next member is Dr. Paul Craig. Paul? Dr. Craig is professor of engineering emeritus at the University of California-Davis, and is a member of the University's graduate group in ecology. His expertise and research interests include energy policy issues associated with global environmental change. His current work includes developing the Presidio Pacific Center, a new institution emphasizing sustainable development in the Pacific Rim nations.

The next member of the panel is Debra Knopman. Debra is the director of the Center for Innovation and the Environment of the Progressive Foundation in Washington D.C. Her previous experience ranged from free lance science writing and editing, to Congressional staff member, to staff and management positions at the USGS, to deputy assistant secretary for Water and Science at the U.S. Department of Interior. Her expertise and interests lie in hydrology, environmental and natural resource policy, systems analysis, and public administration.

And there is myself. Again, my name is Jeff Wong. My day job is with the California Environmental Protection Agency. And there I am the chief of the Human Ecological Risk Division, and I deal with the toxicology and the risk associated with the regulation of hazardous waste.

Also with us, right now there is only one of them, but we also have three other Board members who are not members of this panel but are here in attendance today.

And the first person is Dr. Dan Bullen. Dr. Bullen is the director of the Nuclear Reactor Laboratory, and is an associate professor of nuclear engineering at Iowa State University.

He has extensive experience in performance assessment modeling for radioactive waste disposal facilities, engineered barrier systems, performance assessment, radiolysis effects in spent fuel dry cask storage environments, radiation effects on materials, and materials degradation in severe service environments.

Later on today, hopefully, Dr. Priscilla Nelson will be here. She is the program director of the Directorate for Engineering at the National Science Foundation, and previously was a professor of civil engineering at the University of Texas at Austin. Her expertise is in rock engineering and underground construction. Her current research interests lie in the development of probabilistic risk analysis approach to the prediction of underground construction project performance.

Later on, also, Dr. Richard Parizek will be with us. Dr. Parizek is a registered professional geologist. He is also a professor of geology at Pennsylvania State University. His expertise is in hydrogeology and environmental geology. His research interests include hydrogeology of carst fractured rock found in glaciated terrains, factors controlling groundwater currents and movement, and the relationship between land use and groundwater pollution.

So that's the Board members that are here today. Before we begin the meeting there is one administrative announcement. On the agenda today we have reserved time to receive comments from members of the audience. I would ask you that if you are interested in making a comment, please sign up with Linda Hiatt or Devonia. They are sitting back there in the corner.

Everyone will get a turn and have an opportunity to speak. We do ask that you limit your comments to five minutes. And if you have any written records or written materials you wish to submit, please give them to Linda and Davonia in the back.

Now that we've gotten past the introductions, let's turn to the purpose of today's meeting. As most of you know, the nation does not have an environmental radiation protection standard against which to judge the performance or the projected performance of the Yucca Mountain repository.

The U.S. EPA was assigned this responsibility and they are still working on it. And I don't think we need to delve into the reasons why we don't have that with us today to discuss.

Our concern today is that of the efforts of the U.S. DOE, and their efforts to move forward toward the assessment of the viability of Yucca Mountain as a potential repository. And this assessment will be done within approximately a year. One component of this viability assessment will be the total system performance to project how well the repository at the site will isolate radioactive waste from the environment.

And today we want to review the performance measures that will be calculated in DOE's performance assessment. One question, or our question is a fairly simple one, though I think very difficult to answer. Do we agree that DOE is calculating an appropriate measure of repository performance or would some other measure be better? If we disagree with DOE's plans, it is important for us to let them know before the performance assessment is completed.

It is difficult to evaluate DOE's performance measure without having some context of how it will be applied. To provide that context, we will begin this meeting with a presentation describing the biosphere near Yucca Mountain, especially the agricultural features of the nearby Amargosa Valley.

Our first speaker is Mr. Steve Frishman. Mr. Frishman is the technical policy coordinator for the State of Nevada's Nuclear Waste Project Office. Mr. Frishman is a geologist whose previous experience includes work on in situ uranium mining and mine restoration.

He also has experience in hazardous waste management and coastal and marine resources management. Prior to assuming his current position, Mr. Frishman was the director of the Texas Nuclear Waste Program Office, where he was responsible for the state's oversight of the search for a high level repository in the State of Texas. Mr. Frishman?

MR. FRISHMAN: Thanks, Jeff. This morning before we started, Tom Cotman and I were thinking back about 15 years ago to what we were doing then, relative to the Waste Policy Act which hadn't quite passed yet. And we came to a very somber conclusion, and that's that we're not any smarter than we were then but we know a hell of a lot more.

This morning I've been asked to talk about what you don't see from the top of Yucca Mountain. And that's the people whose future generations will be the beneficiaries of whatever performance Abe comes up with.

When you stand at the top of Yucca Mountain, you look out and you see what looks like desert floor stretching to other mountain ranges. When you stand down on the desert floor you look back and Yucca Mountain is very prominent. The Lathrop Wells cone is very prominent. And in many places from that desert floor you are surrounded by green and water, something that you don't know from the top of Yucca Mountain.

Let me just check. I've been curious about this, I've talked about this before at other groups. How many people here have actually travelled around in Amargosa Valley and seen what's there?

[Show of hands.]

MR. FRISHMAN: Well, it's getting better. A year and a half ago that wasn't the case. I wanted to just sort of give you a sketch of what is there, how it operates, and a few of my thoughts about how maybe this ought to be thought about in the performance system and in a regulatory system. And I'll just go through sort of statistics with some discussion. This is not my what-do-your-babies-eat survey. You'll hear more of that later from the M&O.

The population in Amargosa Valley is about 1,250 people and is growing fairly fast. A number of those people are active in farming or agricultural pursuits. It's becoming -- there is a slightly increasing number of people who live there just because they want to live there and they work in Beatty and Pahrump. Some of them are actually in Las Vegas because it's not that far to go.

And I think we can expect, just as everything else is happening in southern Nevada, we can expect that the population will continue to grow. Depending on economics, we can expect there will be some growing economic activity in Amargosa Valley rather than it sort of blossoming up into a bedroom community.

Water is sort of the key to the whole situation, the population situation in Amargosa Valley. And Amargosa Valley, from the water administration standpoint, is what is called by various names but it's a closed basin, closed in the sense that all the water has been appropriated by the State. And, in fact, from what almost everybody knows, it's over-appropriated. There is about 22,000 acre feet of water appropriated right now.

Of that, on the order of 5,000 acre feet is used every year. And that's the amount that we can account for. And that is used in agriculture. Another smaller amount is used in domestic wells. And we don't know how much it is because domestic wells don't have to be reported. But anybody who owns a piece of property is entitled to a domestic well. If you are going to use it for farming or any commercial purpose, then you have to acquire a water right.

If you look at just the depth of water, at Lathrop Wells the water table is on the order of about 300 feet. As you go south in Amargosa Valley the water table comes closer and closer to the surface. Farmers quite a ways south, about 10 or 15 miles south of Amargosa Valley, are drawing water from anywhere from 45 to a little over 100 feet.

I know of one farmer who is drawing water from about 40 feet. I asked him if he had draw down problems because his family has been farming there for at least 40 years. And he said that the water is about 10 feet lower than it was when they first started irrigating

But there is some question about whether that's draw-down or whether it's a result of some faulting activity in Ash Meadows that may have resulted in a drop of the water table. And USGS is not sure what happened. They are not sure whether it's a draw-down or whether it's due to seismic activity.

Much of the irrigated farming is done on what are called pivots. They are circular fields that are roughly 130 acres. And you can see these from the air, and they just look like big green circles when you are flying over them. And I'll show you in a few minutes a very short video and you'll see how they are irrigated. The other way some of the fields are irrigated is just by either ditch or drip irrigation.

On these pivots they're using about 2 acre feet per year per acre. So it comes out that they are actually putting a lot of water on these fields. One of the reasons for that is that they have a long growing season. They have a growing season of a little over 200 days, which means for the primary crop, which is alfalfa, they can get about seven cuts a year. So for the land that is actually in cultivation every year, which is 2,500 to 3,000 acres, they are producing about 25,000 tons of alfalfa a year.

And there is about 5,000 acres that actually is in cultivation but the land is rotated. So sometimes a portion of it is out of cultivation for a year or two and then they bring it back in. So at any given time, we are looking at 2,500 to 3,000 acres out of approximately 5,000 acres that are right now either have been farmed or are being farmed.

Just as everywhere else in southern Nevada, most of the land is not in private hands. In Amargosa Valley there is only a total of about 19,000 acres that is privately owned out of -- and it's about 30 square miles out of a much larger valley. But, as history has shown and we'll continue to see in the future, the land that's held by the Bureau of Land Management can go into to private hands. Land trades are depending on who is thinking about it when, but land trades are fairly common and will probably become more common.

And also, if you recall when you were in the county, where the cover of Time magazine pictured the chair of the County Commission insisting that the Federal Government return the lands. And that's primarily a ranching mentality but I think that it can spread to farming, if that's the way people are so inclined in the future. So it's not out of the question that much more land in Amargosa Valley could be farmed in the future.

As I said, alfalfa is the primary crop. And if you want to sort of break it down, I'd say it is about 25,000 tons a year that's produced. Just to sort of give you a sense, they get about a ton and a half per acre per cut. And right now this year the price of alfalfa is way up because of the floods in California last year. But depending on demand and availability, alfalfa can go anything from about $80 a ton up to -- I know some people in the northern part of the state right now who are getting as much as $150 a ton.

Now most of the alfalfa is baled, but there are people who find other innovative ways of dealing with their crops. Now a few years ago, some people -- one of the implement manufacturers invented a way to cube alfalfa. And what it does is it compresses it after it's cut, and actually produces cubes that are about this long [indicating] and about an inch on the side. And so this makes it very much denser and it makes it a lot cheaper to ship.

But the problem has been that this equipment is very hard to maintain and keep working. And it became really inefficient. There is one guy in Amargosa Valley who is some kind of a mechanical wizard because he's figured out how to keep his cubing machine working and is able to make money at it. And part of the reason he is doing this is because alfalfa when you can ship it easily, you don't have to ship in large bales, when you can ship it in cubes is a good product to ship overseas.

Well, he's got a market through a broker in Los Angeles where he's shipping about 4,000 tons a year of cubes to Japan for some of the very high-priced beef that's raised in Japan. So he's found a specialized market. He's got about 400 acres where every year, as I said, about 4,000 tons go to Japan. So I think you are going to see, as I go along, that what we're doing is we know that there are pathways that go far out of Amargosa Valley. This is just one.

Another one is something that is fairly new to

Amargosa Valley and the condition is increasing. And that's that there is a very large dairy there and there is plans for another. And I asked the manager of the dairy, you know, "Why did you set up here?" And he said, "It's real simple. There is a lot of feed available and there is a lot of water available."

So what's happening is many of the farmers in Amargosa Valley are raising alfalfa, selling to the dairy. The dairy right now is milking just over 4,100 cows a day. They are shipping about 32,000 gallons of milk a day to Los Angeles for processing and distribution. So the primary output of this valley is to Los Angeles in the form of milk.

There are other agricultural activities that are much smaller, but some of them approach commercial when the markets are right. Some of them are working into commercial markets that exist. The climate is right for growing pistachios. And there are at least two big orchards, one of them with over 2,500 trees that is now in production.

Garlic and onions are a rotation crop for alfalfa, so when they are growing those go into a commercial market. There are also some sort of small garlic producers that grow some very specialized, very large garlic. And they have local markets for it, but it's not a real big market. There are other places in Nevada that are large garlic and onion producers compared to Amargosa Valley.

Oats is another rotation crop. It produces small amounts, but they do go into the market. There is one place that has in the past commercially raised hogs and will be doing it again soon. It's just how the people are about getting in and out of the market.

And then there is a new sort of interesting market that's been experimented with in a lot of places, and it looks as if the experiment probably will pay off in Amargosa Valley. And that's that some people are beginning to raise ostriches. And they are taking sort of the smart way. There has been about 10 years of experience with it in the southwest. And what they are doing is raising breeder birds, rather than raising birds for meat.

But there is a large world demand for ostrich meat that South Africa has not been able to meet. And so people in this country are getting into it. There are just some logistics problems with it but they seem to be getting over it. One of the large demands is Switzerland, which I found kind of surprising. But the world market looks pretty good for it, so there are people who are interested in playing with it. And there is good money in it, if you can make it work.

So I think what you see is, you can chase pathways around all you want. You can talk about critical groups, you can talk about the maximally exposed individual. But you have to recognize, when you are trying to work out pathways, is this area that the primary product that could contain radionuclides from not only Yucca Mountain, but also from water associated with the Nevada test site, and also water associated with the Beatty low level site.

The primary recipients are people outside of Amargosa Valley. And there is no reason to think that this will not continue. And, if anything, agriculture could probably increase because the water rights are there. It's just whether the people want to use them for agriculture or not.

There has been at least one attempt to sort of force a change in the use of the water. And that's since there is about on the order of 15,000 acre feet of water that is appropriated and not used and, as I said before, maybe some of that shouldn't be used anyway, but there is on the order of about 15,000 acre feet.

A few years ago a bright group of people went to the State engineer and told the State engineer they wanted him to exercise his right to forfeit water rights that were not being used by those who owned one. And what these people had in mind was they wanted the State engineer to forfeit 15,000 acre feet of water per year to this company so this company could build a pipeline and ship that water to Las Vegas.

Well, we don't look too kindly in the State of Nevada on interbasin transfers of ground water. And also, Las Vegas has access to water from other ways. And it would also most likely turn into mining water out of Amargosa Valley that probably would not be recharged because we really don't know what can recharge in that basin.

So the State engineer just denied the whole thing and those water rights are still sitting there, owned but to some extent not used.

Just so some of the Department people don't think that I don't read the paper, I noticed that you've just applied for a very large amount of water compared to the temporary water right that you acquired back in 1992. The Department had applied for something over 2,000 acre feet per year when right now their permit is for 95 acre feet. So that will not go unnoticed. I did have to read it in the paper, so thanks for the information.

There is one other feature in Amargosa Valley that is noteworthy, and that's the wildlife refuge and the springs in Ash Meadows. The springs in Ash Meadows are discharging on the order-- from the carbonate aquifer, discharging on the order of 25,000 gallons per minute. Large springs.

Crystal Springs, which is one I'll show you quick glimpse of a video in a minute. Crystal Springs alone is discharging about 10,000 gallons a minute, and that's the surface expression in Amargosa Valley of the water table.

The Amargosa River flows through the southern part, well, flows from Beatty down through Amargosa Valley. Most of the time, it doesn't flow. But when it does, it's in a flash flood condition. About the only way you can find the Amargosa River most of the time is watch for what looks like sort of a straggley line of trees and taller brush. You know, most of the time that's about the only way you'll recognize that there is a river there. But when there is a flash flood, it becomes a really raging river. And that happens maybe once a decade, maybe not even that often.

One of the things that is worth thinking about relative to Yucca Mountain and water and the surrounding area is that I've been watching the developing information on El Nino for this winter. And looking at any of the maps that I can find for forecasts shows that southern Nevada this winter is going to be considerably higher than normal rainfall.

And it has occurred to me that if from what we are thinking we see relative to Chlorine 36, maybe this is a good time to start planning some tests. Because it's possible that this is going to be one of those winters when we actually have episodic flow both in the fractures in Yucca Mountain and some heavy surface flows. So it seems to me that the project ought to be thinking about how to get ahead of that and collect some worthwhile data, rather just lose trucks in a 40-mile wash again.

That's, I guess, a general description of what's there. I think it's important to sort of keep it in context when you are thinking about the concept of what constitutes a reasonable standard. And if you'd look at the pathways, look at where the agricultural products go, it's going to be very difficult to come up with a convincing argument that you can identify a critical group where if that group is protected, everyone else is protected. It's going to be very difficult to work that out.

And this is the same message that I left with the NRC's Advisory Committee and I'd like to leave that message with you as well. Just in terms of how are you going to, in a very conservative way, convince people that any standard will protect people, out in the general global population, who are the recipients of the performance or lack of performance of Yucca Mountain in the future.

Let me put on just a very short video tape so those of you who have not been around can see these scenes, get a less than a five minute feel for what it looks like in Amargosa Valley sort of looking back at Yucca Mountain.

[Presentation of video.]

MR. FRISHMAN: Pump fish. Some of them are threatened, some of them are endangered. And for Devil's Hole there is an endangered species. And one of the keys to the whole question of water production in Amargosa Valley and Ash Meadows is that there was a law suit to preserve that endangered species. They ended up at the Supreme Court. And at this point the rule is that there is a mark in Devil's Hole, on the side of the spring on the rock wall, and the water level can't go below that. And we know that it will be pumping that takes it down if it goes below that. So that's a constant monitoring point.

And if the water table will start dropping, something is going to give. What's going to give is people are going to have to stop pumping in areas that are even possibly related to the discharge at the spring.

The reason for that water level is that there is a rock shelf in the spring, very near the surface, which is where the endangered pump fish breed. And if the water gets below the level of that shelf, they won't reproduce because that's the only area where they do reproduce.

So you've got sort of a walking tour of Amargosa Valley. And I'll be glad to take any questions or just sort of let the pictures settle into your heads so with the next talk you can think about the relevance.

DR. WONG: Thank you, Steve. Any questions from the panel? Dan.

DR. BULLEN: Bullen, Board. Steve, you mentioned that there is 20,000 acre feet that are currently available. So is alfalfa the best example of a crop that uses a couple acre feet per acre so you basically have a limit of like 11,000 acres cultivatable per year, or do you expect that to change?

MR. FRISHMAN: The only other crop that takes an equivalent amount of water would be onions and garlic. And they are rotation crops. I think the situation right now is one that is best suited for alfalfa just because it markets better within a system. People can make more money on it and more easily. I don't know of another crop that would take more water.

DR. BULLEN: I guess the question I'm asking is, could you bound the maximum number of people and tillable acres that you could have, based on the amount of water that's currently available, and do you expect the amount of water to change or do you expect that that 22,000 acre feet is the maximum you are ever going to have?

MR. FRISHMAN: That 22,000 acre feet is probably the maximum that will be appropriated. My guess is if it started being used at that level, we would see draw down and there would be some adjustments made.

DR. BULLEN: So you could bound it and put a limit on it?

MR. FRISHMAN: You could put a limit on it. But at this point you could double the agricultural production and it would still be well within available water and maybe even triple. Also, this question came up before. They are drawing from fairly shallow wells. As you go up gradient towards Lathrop Wells, you are still in a range where it's not out of the question that you can lift water.

Lifting water 300 feet is something that people do all the time. It's just that it's cheaper if you don't have to. But if the markets are there, if land trades are desired and can be accomplished, it's not at all out of the question that you can see agricultural production right next to Highway 95 at Lathrop Wells, because the water lift is not that limiting.

DR. KNOPMAN: Knopman, Board. Steve, could you walk us through the population changes over time? What approximately was the population of the valley at, say, the turn of the century, what was it, let's say, after World War II? I don't know if you know these numbers --

MR. FRISHMAN: I don't know the numbers --

DR. KNOPMAN: -- but if you could say just approximately. And, again, the last part of the question would be, suppose you had no agricultural production going on in the valley and all the water available currently were used for municipal purposes, municipal and commercial? What would be the approximate carrying capacity of the area, if you weren't importing any water and you weren't --

MR. FRISHMAN: I'd have to do some fast arithmetic in my head here.

DR. KNOPMAN: If you want to get back to us on that, that would be fine.

MR. FRISHMAN: Okay. I'd rather do that because I can do the numbers in my head but I'd have to think about them and I'd probably miss by an order of magnitude. But I will calculate that out for you.

I don't know actual numbers. I think the population is probably larger now than it's ever been. In the past the stable population were farmers. There are a lot of absentee land ownership. There was a proposal at one point, in fact, what led to the lawsuit over the endangered species, there was a proposal to put in a residential development for about 5,000 people. And its location, it was determined, would result in a draw down of the water table.

But my guess is that the population there has probably grown 300 or 400 people in the last 10 years, and they are probably all people who are not farming. But I will try to calculate out what the available water would support in population.

DR. KNOPMAN: I think it'd be good just to get a sense of history over the last 100 years or so.

MR. FRISHMAN: Okay. And you are very well aware of what Las Vegas Valley has done. And it's a much larger valley. But at the same time even 25 years ago I don't think anyone would have predicted that we would be looking at over 1 million people in Las Vegas Valley now.

DR. WONG: Steve, I have a question. This is Jeff Wong. You were talking about the alfalfa production. You said there is 25,000 tons per year being produced. And you said approximately 4,000 tons is destined for Japan. What happens to the remaining 21,000 tons?

MR. FRISHMAN: A good part of it either goes to the dairy in Amargosa Valley or it goes to dairies in California. It just gets shipped -- it's baled and you see it on the doubles and the triples heading down the highway.

There is an interesting 100 tons that I was really surprised to hear about. It's an alfalfa that has a very weak stem and very large leaf. And about 100 tons of it a year is actually cut and picked up by a company in California that uses it as a filler in herbal tea.

And I asked the farmer, "Isn't this stuff really hard to handle? It doesn't bale." And he said, "Well, I get the same per ton as everybody else is getting and all I have to do is water it." People come cut it and pick it up and haul it off.

But that's certainly another novel use for it because it's just a particular type where the herbal tea people are looking for the leaf. The people who bale alfalfa need to have the stem in order to make it bale. And that's about 100 tons a year. You know, every year you are going to see something different.

DR. WONG: One last question. In terms of the production of alfalfa what's the limit? Is it the water that's the limit or is it the market demand currently?

MR. FRISHMAN: It's how much land you have in production. You can sell all the alfalfa you can grow.

DR. WONG: Okay. Thank you, Steve.

Before we move on, I'd like to point out that Dr. Parizek has arrived. And I have been remiss in forgetting one member that's with us, and that's Dr. Dan Fehringer. He's senior professional staff. He's right here. And Dr. Fehringer has been key to arranging and putting together this meeting, so if it weren't for him this would be running much less well.

So now we will turn our attentions to modeling the biosphere that Steve has just described to us. Our goal is to project how any of the radioactive materials that might be released from the Yucca Mountain repository could enter the biosphere, move into drinking water, into the food chain, and ultimately reach human receptors.

Today we have Robert Kimble, who is the assistant vice president for program management and department manager with the Science Applications International Corporation. He is a member of the management and operating contractor for Yucca Mountain site characterization activities. He will describe for us today the M&O's effort to develop models of the biosphere near Yucca Mountain. Please, Mr. Kimble?

DR. KIMBLE: Can everyone hear me? You already did the introduction so I'll skip on past that.

As indicated, my presentation is related to effort to get my project to model the biosphere in the vicinity of Yucca Mountain. The efforts we have undertaken the last year and a half or so to work with the environment Mr. Frishman described.

DR. KIMBLE: A brief schematic of total system performance assessment as it's being done for the Yucca Mountain project. And following TSPA-1995, they began work on the biosphere modeling, which is virtually the last total system performance assessment once the radionuclides have passed through the unsaturated zone and the saturated zone and reached the accessible environment biosphere. And at that point, we've been working at essentially that area above the root zone where people might be living, using that water for agriculture, using contaminated water for domestic purposes.

And then the final product of the biosphere modeling is biosphere dose conversion factors which are fed back to the performance assessment group and they do the dose calculations. Here is the definition of biosphere that we're using, a section from the National Research Council Report, commissioned by the Environmental Protection Agency. I'm going to read this one. "The bio is a region of the earth in which environmental pathways for the transfer of radionuclides to living organisms are located, and by which radionuclides in air, ground water, and soil can reach humans to be inhaled, ingested, or absorbed through the skin. Humans can also be exposed to direct irradiation from radionuclides in the environment." Again, that's from the recommendations report from the National Research Council.

The objectives of the biosphere modeling efforts project of the Yucca Mountain project are relatively straight forward. We are attempting to model radionuclides movement through the site-specific environmental pathways. And there are obviously a number of those that need to address. We are calculating the biosphere dose conversion factors for each radionuclide expected to enter the environment from the repository.

And those factors are unit concentrations and the total effective dose equivalent for in-ground water. The unit of measurement is milli-rems per year, per picoCurie, per liter. The total system performance assessment group is providing us with the radionuclides of interest. We are comparing the biosphere dose conversion factors which are literally per unit calculations. And then back in the performance assessment effort the conversion of those factors to a total dose is concluded.

The factors we are looking at are scenario-specific. In particular, we are looking at the population in Amargosa Valley and the immediate vicinity of Yucca Mountain. We're looking at the hypothetical subsistence farmer. While that individual does not exist in the real world out there, it's obviously an issue of some interest.

We're looking at the potential residential farmer which probably is the population characteristics that Mr. Frishman was assessing. And we're also looking at the average person within the area. And I'll discuss a little bit later biosphere food consumption surveys we've recently completed.

We're also looking at three precipitation scenarios. The actual precipitation currently in the Amargosa Valley area, as well as double and triple precipitation possibilities. Those scenarios were added as a result of a review process that we went through in the June-July time frame.

Again, a brief schematic of the process, as we started it, again, relatively straight forward. We were assigned a task to look at the biosphere in the region and develop a way to model the effect of the repository on the biosphere. We began that process with the development of a scientific investigation implementation plan.

The next step in the process was to develop a site-specific assessment context. In other words, looking at the region, the Yucca Mountain project itself, and determining exactly what factors, what scenarios, what issues were relevant in the process of biosphere modeling.

From that we built a conceptual model, again, trying to identify exactly what issues would be key to the biosphere modeling process. And also to enable us to then look at the available computer codes for biosphere modeling to see which one or ones of those available programs would address our particular needs.

The initial work with the selected code, and I'm going to address that a little bit later, the initial work was to do some sensitivity analyses to try to better identify the key parameters, where we should focus our resources in looking at additional data acquisition to drive the biosphere modeling effort. We conducted some of that data, did the acquisition analysis effort.

We, at this point, are in the process of calculating preliminary biosphere dose conversion factors.

We are rerunning the analyses to verify that the parameters that we thought would be included are, in fact, the ones that are most interesting and useful for the modeling process. And we will shortly be developing a set of biosphere dose conversion factors to hand back to the performance assessment group for use in total system performance assessment for viability assessment.

One of the early steps in the process, that I just showed you, was developing a site-specific assessment context and a conceptual model that would allow us to go forward with some of the other steps. To do that, we formed a team within the Yucca Mountain site characterization project, and started looking at the relevant site-specific features, events, and processes that would need to be considered in the biosphere modeling efforts.

We looked at environmental compartments of interest. Obviously, right at the top, those are the plants, the animals, the humans that would be potentially affected by contaminated ground water. And then we are also starting to look at that point at available transport mechanisms to determine how, in fact, those pathways would work, what pathways needed to be examined.

Now, based on that, we've established a conceptual model of the issues that we needed to address.

The human exposure pathway for a ground water release scenario is a simplified schematic of what we're looking at. The radionuclides of interest and the ground water unit concentrations, again, from our perspective, as far as the modeling, we are just dealing with units rather than concentrations at this point. Potential contamination of a well that is used for drinking water, irrigation water from that same well to another well in terms of potential concentration of radionuclides in the soil and external radiation sources. Those result in a potential for livestock uptake, crop uptake, re-suspension from the soil.

As Mr. Frishman was alluding to, from the crop uptake you may, in fact, have a pathway where humans consume crops, humans also consume animals that have consumed those crops. And that leads to that ingestion dose. From the soil we have the potential for an inhalation dose. And we also have the potential for an external dose of radiation. All of these together lead to the final biosphere dose conversion factors for each radionuclide of interest.

Evaluation and selection of computer code was the next step in the process. Selection criteria for the model that we wanted to use is that it had to be an existing, essentially off-the-shelf model. We didn't have the time or the resources to undertake code development process. We needed to find a model that had been used in a regulatory environment, some indication that it would withstand the test of a project like this. And it also had to be capable of handling a multitude of scenarios.

At that point in the process, we had a reasonably good understanding of what scenarios we would be dealing with, but we also had to deal with the possibility of additional scenarios would be added along the way. And, in fact, they were.

The codes evaluated. I won't read through a bunch of acronyms, those are on the screen. The computer program that was selected is the GENII-S program that was originally developed at the Hanford site.

The next step in the process involved some data collection and sensitivity analyses, again, to identify the parameters and pathways of interest. Initially, we used the generic data that was available with the model, as well as generic information available from other sources, to conduct that initial sensitivity analysis. We used that analysis to identify the parameters and pathways of interest.

The next step then would be to collect data in the area, site-specific information that would better inform the model regarding that particularly sensitive information. Then repeat the analyses and finalize the input parameters.

Based on those initial runs, we determined that there was certain information that we probably need to develop a better understanding of. And some of these processes have already started, some of them have been completed, others are just in the works now.

But we initiated a program of far-field water monitoring to determine background radiation in in-ground water in the area. We put the biotransport mechanisms and processes, we did a soil types and characteristics survey just this past summer in the Amargosa Valley area and north of the area that's currently being heavily used or heavily used for agriculture, looking at the possibility of that agricultural practice expanding to the north.

And we also did a pretty robust survey of consumption patterns of locally produced food.

It is, in fact, my area of interest, food consumption. I'm going to use it as an example of exactly what was done, what site-specific information for the biosphere modeling effort.

Back in the spring, actually back last fall, almost a year ago, we initiated work at the University of Nevada-Las Vegas, to identify some of those issues that needed additional research in the Amargosa Valley area.

The first effort was a focus group where we were in Amargosa Valley and discussed with a small group, 10 or 12 local residents, including some of the major agricultural producers, discussed with them the issues that they considered relevant. What kinds of questions we would need to ask to determine how much locally produced food was consumed in the area.

Following that focus group we did a pilot survey again utilizing the resources of the University of Nevada-Las Vegas to make sure that we had an survey instrument that was capable of getting the information that we were seeking.

And following that process, in June we completed 1,079 interviews of households in the immediate vicinity of Yucca Mountain. And the distribution by the community in the area is shown here. The concentration in Amargosa Valley, the survey of the respondents there represent almost half of the population in the Amargosa Valley.

The disconnect with the information Mr. Frishman gave us is that our respondents were households rather than individuals. So 195 households represents upwards of 700 or 800 residents.

We used the inverse gradient sampling process to focus the survey results in the immediate vicinity of Amargosa Valley, less so when you get further afield. And then, at the end of that process, we also at that point had been asked to look at the double and triple precipitation scenarios, which obviously are very difficult to do in the Amargosa Valley area because it is the 1x scenario.

So we added about 400 surveys, in addition to the one shown here on the screen, in the Lincoln County area, Pioche, and Canaca, and Caliente in Lincoln County have annual average precipitation rates that approximate double and triple what's current in Amargosa Valley. That information gathering effort has just been completed and the results from that should be available within the next couple of weeks.

One of the interesting aspects of the survey, in fact from the pilot study, we identified a not particularly large but nonetheless significant Hispanic population in the Amargosa Valley area. As a result of that, we asked NLV to create a spanish language version of the questionnaire, and have an interviewer who is a telephone survey interviewer or interviewers for people to administer the survey in spanish. As a result of that, of that 1,079, 21 of the surveys are in spanish.

The other thing that we did as a result of this process was some relatively rigorous test result assessments. We went back and we tried over and over again to interview some of the people who had initially refused to participate in the survey. As a result of that, we got 33 additional respondents, and it also gave us a set of responses that allowed us to address the question of non-response bias.

Here, we did a number of surveys in the four principal communities in the area and the percentage of the total population that they represent. In Amargosa Valley, it's about 43 percent of the households in the community, unincorporated town of Amargosa Valley were surveyed. Beatty it's a little bit less, about a third of the households. Indian Springs and Pahrump, less still.

Preliminary results from the survey analysis to create biosphere dose conversion factors. The first columns here represent all the respondents to the survey. The figures here are in kilograms of locally produced food, or liters of locally produced water or milk. And the first set of columns represents an average for all the column respondents in the survey.

The second set of columns, which show a little bit more consumption of locally produced commodities, represent those folks that indicate they eat some significant portion of their diet from locally produced sources. And the last set of columns is essentially a hypothetical construct that we developed. Over the course of the survey we found that individuals who would be at subsistence level for one or another of the food groups, no individuals that were subsistence level for all of those food groups. In other words, no respondent who was surveyed indicated that they consumed nothing but locally produced food.

But, nonetheless, based on the responses by particular food groups, we were able to construct the hypothetical subsistence individual in the area. The next page is a presentation of the results of that table, and I'm not going to go over those.

This is a graphic depiction of the same information that was on that previous table. And as you might expect, as you go through the different scenarios differences are relatively dramatic. That in the total population the average individual consumes less locally produced food for each of the food groups than this hypothetical construct with the subsistence individual. The partial subsistence group is in between those.

Some of these processes have been gone through so far. The attempt here is to calculate the biosphere dose conversion factor and uncertainty for each of the radionuclides of interest. There were 39 radionuclides that were identified in TSPA-1995 that we are currently working with. We're looking at the three receptor scenarios, the average individual, the partial subsistence individual, and the subsistence individual.

And the three precipitation possibilities, current annual average precipitation in Amargosa Valley area, as well as doubling and tripling that. And we're evaluating the uncertainties in terms of the sources of uncertainty and the range of uncertainties for each of those biosphere dose conversion factors.

A couple of examples of the preliminary output from the biosphere modeling process. This is representative of Iodine 129. And it shows the efforts and culmination of the efforts, and the kind of product that we will be providing to the Performance Assessment Team. One more of those, and it actually has a label on the top of it. This one represents the biosphere dose conversion factors for Technicium 99.

In summary then, to indicate where we are in the process at this point, the biosphere modeling team has completed the process of developing the scientific investigation implementation plan, the site-specific context, and the selection of the model.

We have conducted the initial sensitivity analyses and data acquisition. We have completed that data collection and evaluation for the first runs.

We are scheduled to deliver the preliminary biosphere dose conversion factors to the performance assessment group next month. Following that, we will do some refinements. We may look at the possibility of enhancing some of the site-specific information, as necessary. And we will provide the final dose conversion factors to the Performance Assessment Team in March for use in TSPA-VA.

DR. WONG: Thank you, Mr. Kimble. Questions from panel members? Debra.

DR. KNOPMAN: Let me just try and make sure I understand what you are delivering to the Performance Assessment Team. You said you are calculating the biosphere dose conversion factors for 39 radionuclides, 3 receptor scenarios, and 3 precipitation states. That's 350 conversion factors you are giving them.

Now what do they do with 350 conversion factors, in terms of some kind of summarizing? Is it a distribution then of -- how do you take 350 pieces of information, in effect, and get it into the performance assessment in a meaningful way?

DR. KIMBLE: I'm smiling and looking at Abe Van Luik who --

DR. VAN LUIK: This is Van Luik, DOE. The way that we will use these, the team will have the look-up tables, and depending on the scenario that we are calculating at any given time, the precipitation or other scenario, we will go to the table with the distribution function, of which you saw some examples, that's appropriate for that scenario and select from it.

If they are creating a very large data set for us with uncertainties evaluated and distributions, then we will sample from those distributions in the actual calculations. And there will be a chapter in the TSPA-VA that outlines this whole process.

DR. KNOPMAN: You generate distribution from the 350 factors? Do you sample from the factors or are you sampling from something else? Each factor has a distribution.

DR. VAN LUIK: Yes. It's my opinion at this point, and I haven't delved into this in the greatest detail, my opinion is that, for example, if we are in an enhanced climate, you know, scenario where we have double or triple precipitation, we will go to the PDF, of which he showed a couple of examples, for that precipitation state and sample off of that distribution. Does that answer the question?

DR. KNOPMAN: Somewhat.

DR. VAN LUIK: Somewhat. So we will have multiple distributions and they are scenario-specific depending on which scenario we happen to be calculating at the time, we will go to that PDF and sample from it.

DR. KNOPMAN: And when you are sampling from the probably distribution function do you have a sampling rule that you're following, or is this simply random sampling?

DR. VAN LUIK: It's my impression that it's random sampling at this point. We could, you know, of course as time goes on, get a different set of rules put together.

DR. WONG: Norm?

DR. CHRISTENSEN: Christensen, Board. With regard to the trends in precipitation, and this may be what Debra was getting at, will there be or are there predictable relationships going from one 1x, 2x, to 3x? And the reason I ask that, because another likely scenario would be 1/2x. Would you be able to infer that?

DR. KIMBLE: I think you probably can. My understanding of the modeling process, that the intuitively appealing answer is that as you increase precipitation you are going to reduce the requirement for, for instance, irrigation on the alfalfa that has been alluded to.

Therefore, less of the crop will be watered with potentially contaminated water, and therefore, as you increase the precipitation you probably reduce potential radionuclide concentrations in those rocks.

At this point I'm not sure that there is a linear relationship but there is certainly something we are interested in examining, because at one point in the process we also were asked to look at 5x precipitation scenarios. But the likelihood is that other scenarios are certainly there, and we'd like to develop an understanding what kind of relationship there is.

MR. CHRISTENSEN: It does seem to me like the assumption is that we're as dry as it ever gets. I suspect that that's not the case. And that, and I'm going to bracket on the other side as well, if you have higher evapotranspiration, greater irrigation needs, if the assumption is that these are linear relationships than maybe you can extrapolate but you will be outside the domain of your data.

DR. KIMBLE: I'm not sure that's the assumption. We, quite frankly, don't know enough at this point to make that assumption. That is something we are looking at.

DR. BULLEN: Bullen, Board. As a follow on to that, isn't a bounding case just 0x precipitation, where you completely irrigate, and the complete irrigation case would give you the highest dose? And wouldn't it make sense to at least do that so that you know what the bound is, what's the worst possible scenario?

DR. KIMBLE: Actually, that's probably correct. Given the annual precipitation out there, we're not talking about dramatic shifts either. You know, our information would suggest that, in fact, the irrigation of alfalfa which is the cash crop of interest out there is much heavier than Mr. Frishman has indicated.

The agricultural operators we talked to out there have been putting upwards of 5 acre feet a year per acre on their alfalfa. And so when you are talking about is it 6 inches of precipitation, or none, or three times that, it doesn't make a particularly dramatic difference.

DR. BULLEN: A couple of quick questions about your dose calculations. Did the bounding cases that you use, you noticed it for the average adult, are you taking into consideration infants, for example, in milk consumption, or teens in total caloric intake, when you do your analysis?

DR. KIMBLE: No. We are looking strictly at adults in the households.

DR. BULLEN: Okay. And I guess the follow-on question to that would be how you address cumulative dose effects. Do you talk about things like bone seekers and radionuclides that are uptake by the body and not discharged. Do you take a look at committed cumulative dose effects?

DR. KIMBLE: I'm going to turn that question over to one of our modelers who is here. Ning Liu.

MR. LIU: Ning Liu, with SAIC. I think we have to in the cumulative dose, the dose factor, we are calculating the total effective dose equivalent which accounts for the accumulation in the human body.

DR. BULLEN: What's your dose scenario then? Is it a 50-year committed dose so it's 50 years of exposure and 50 years of dose?

MR. LIU: That's correct.

DR. KNOPMAN: You said you did the sensitivity analysis to drive your additional data calculations and then it led to four different, I guess, you thought out additional data in four areas. Among those four was far-field water monitoring, biotransport mechanisms, soil types, consumption of locally produced food.

What was the single most important, what is the parameter your model is most sensitive to than the next parameter down? I'm trying to get a sense of magnitude here on importance, what's driving the model?

DR. KIMBLE: I'm going to leave the answer to Ning, also. He's the one who's been actually performing the model work.

MR. LIU: The defence of the parameter highly depends on the radionuclide. For example, with iodine 129 the most sensitive, the driving pathway would be beef and milk. Whereas, the other radionuclides, for example, technicium 99, there would be water consumption, vegetables, fruit. So it depends on radionuclide. Does that answer your question?

DR. KNOPMAN: So you are talking about the actual activity of the radionuclide itself is what --

MR. LIU: That's right. It depends on each radionuclide.

DR. KNOPMAN: I realize it's dependent. I'm just trying to understand. You have lots of steps along the way in processing some concentration here of the radionuclide until it gets to its exposure endpoint. What along the path is having the greatest effect on your endpoint dose, what parameter?

MR. LIU: That also depends on the radionuclides. I'm still using the example of iodine 129 because beef and milk is the most sensitive pathway. And all the parameters along this pathway, for example, transfer coefficient from soil to plants, from plants to animals is most sensitive parameters.

DR. KIMBLE: Is there one in particular or is the transfer mechanism from soil to plants or from plants to animals, for example?

MR. LIU: Those two are basically the most important parameters. Could I show you a couple of slides? If you are interested, perhaps we could discuss this later.

DR. KNOPMAN: Perhaps you could just provide us with hard copies of your slides?

MR. LIU: Yes. We have breakdowns how much toxicity each parameter contributed to overall toxicity.

DR. KNOPMAN: If I can just follow up. And the reason for asking this, in all of the modeling that we are looking at here we are trying to understand what's in fact driving the results. And then the obvious question is what kind of data do we have to estimate that parameter?

MR. LIU: Yes. If you can give me one more minute, I can show that very quickly. I have those slides in my briefcase. It's an overhead.

DR. KNOPMAN: Well, if we could quickly look at the overhead.

MR. LIU: Or I can send you a copy later on.

DR. KNOPMAN: Well, if you have a summary overhead, I think it would be helpful. While we're waiting for that, I guess the other related point has to do with how one tests your model. How do you know this is a good model?

Do you have some independent set of results of the independent and dependent variables here in which you can, in a sense, calibrate your model so you have some idea of its goodness of fit with real data?

DR. WONG: If we could hold that question.

MR. LIU: We see annual optic scale, which is the parameter used by this model, GENII-S model, to change the transfer coefficient from plants to animal. So in this case you see -- is that better -- here the cracks are, how sensitive a parameter is.

So you can see from here, the most important parameter is the annual optic scale and the crop interception question. So you can see that the pathway from soil to plants and then from plants to animal, it's the most important pathways. They are the parameters.

DR. KNOPMAN: So is this one big, is this just a regression model you have?

MR. LIU: Actually, the sensitivity analysis we did is we used Monte Carlo technique to sample each input of parameters. And then we used in the step rise regression, I tried to establish the relationship between output and input parameter. And then we identified most important parameter.

DR. KNOPMAN: Okay. That's a huge difference between the top two parameters and everything else.

MR. LIU: That is correct. In most cases there is only a few driving parameters for each scenario.

DR. BULLEN: In the GENII-S analysis stochastic variability, and you've pictured distributions, do you do a deterministic approach also where you basically just set the parameter that you are going to evaluate?

I'm a little bit familiar with the GENII-S code, and so the question I'm asking is, you know, are there a couple of switches that you can set, one of which basically doesn't allow you to do the sampling but pegs it as a certain number so you can essentially do the bounding analysis by forcing it to the ends of distribution? Have you done those sensitivity analyses also?

MR. LIU: No. Right now we're taking the stochastic approach, but in order to get a conservative conclusion you can take, you know, for example, 95 percentile from your output as the upper limit. You can do it that way or you can, like you said, using the upper bound input parameter and then using the deterministic approach to calculate end dose.

DR. BULLEN: How does the stochastic nature of your calculation get transferred on to TSPA-VA where that's also going to be a stochastic dose and so, essentially, what you are doing is you are compounding, aren't you?

MR. LIU: That's correct. What we're doing now is calculated dose from unit concentration. And performance assessment people will combine the radionuclide concentration in ground water and a dose conversion factor to come up with the final dose.

DR. BULLEN: So is there a probability associated with your dose also?

MR. LIU: That's correct.

DR. BULLEN: And so there will be another probability -- but that's same --

MR. LIU: Yes. There would be another random sampling exercise when they come down to PA for the final dose calculation.

DR. BULLEN: I have two last questions.

DR. KNOPMAN: Jeff, excuse me. There was one more question about the model verification.

MR. LIU: Okay. Previously, the VA in this project's language is classified as conventional quality, which is we do not have to do the QA for the model for VA. And lately we decide to switch this VA into a Q program. In that case, we have to do a VME for the model. And actually we're doing the model verification at this time.

DR. BULLEN: Okay. Again, I have two last questions. One is, for your values up there, let's say the crop interception fraction, how did you arrive at the range of values? And then, number two, not related to the slide but related back to overhead number 7, how did you arrive at the drinking water exposure pathway being limited just to ingestion? That's the two questions.

MR. LIU: Okay. The first question, like Bob pointed out earlier, is the parameter sensitivity analysis, we used generic data basically that either comes with the model itself, or it's published in the literature, or it comes from other site, or other similar studies. And that's the range in this right side of the slide. What was the second question, again? I'm sorry.

DR. BULLEN: The other question I had which goes back to Mr. Kimble's presentation on slide number 7, it shows the drinking water pathway limited totally to ingestion. And my question was, how did you arrive at excluding other potential pathways and focusing only on the ingestion pathway?

MR. LIU: This drinking water, I'm not sure what you refer to other possible pathways for drinking water? My understanding is drinking water is only for drinking. Obviously it's ingestion.

DR. BULLEN: Inside a home there are other domestic uses of water.

MR. LIU: Oh, you mean external exposure?

DR. BULLEN: Right.

MR. LIU: Yes, we did the screening calculation for external exposure for domestic water usage. Basically for other radionuclides the external pathway is fairly minimum compared to other pathways. So most of the pathway comes from ingestion.

DR. BULLEN: So ingestion is the dominant dose?

MR. LIU: That's correct.

DR. BULLEN: Thank you. Any other questions? It's now 10:00. According to the agenda, we're scheduled for a 15 minute break. So I suppose that puts us a little bit behind schedule, but at 1:25 we'll get back together and listen to a presentation by Steve Brocoum and Abe Van Luik.

[Recess.]

DR. BULLEN: If we can take our seats, please? It looks like we have a few tardy board members. I guess the last board member in is going to buy doughnuts for everybody. Okay. I guess we'll just get under way. We have a series of presentations, and then one after lunch, and then later on this afternoon we'll have a round table discussion.

So related to our next presentation, as I mentioned before. The DOE has defined an interim performance measure that it intends to use for performance assessment for a potential Yucca Mountain repository. To describe that performance measure and its rationale, we have a tag team presentation by Steve Brocoum and Abe Van Luik, both with DOE.

Dr. Brocoum is the assistant manager for suitability and licensing. Dr. Van Luik works with Dr. Brocoum as a team leader for the Technical Synthesis Team. Dr. Brocoum, Dr. Van Luik, I look forward to your presentation.

DR. BROCOUM: I will be talking about the DOE postclosure performance measure, sometimes people refer that to the interim standard. That's politically incorrect. And the reason that's politically incorrect, of course, is because DOE doesn't set standards. Our job is to implement whatever standards are set by the regulatory agencies, in this case, that will be set by EPA. So we call that our interim performance measure. I'll be talking about a little background, what that measure is, and our rationale for it.

Most of us know the background. Basically, in

1987 the U.S. Court remanded EPA's 40 CFR 191. Since that time the Yucca Mountain project has been without an applicable postclosure standard. In 1992, Congress directed the EPA to promulgate a site-specific standard for Yucca Mountain.

And there was a whole National Academy of Science study that started in 1992, 1993 time frame and we're still waiting for that standard. We developed our internal interim performance measure to help guide the technical program.

I need to make one comment at this point because at the introduction to this meeting, Jeff Wong related the interim performance measures to the viability assessment and they are not related. The viability assessment will state how the site might perform. It will not necessarily compare it to a standard or a measure.

Interim postclosure performance measure. The measure. Expected annual dose to an average individual in a critical group living 20 kilometers from the repository shall not exceed 25 milli-rems from all pathways and radionuclides during the first 10,000 years acre feet closure.

You also have a goal, to conduct analyses beyond 10,000 years to gain insight into longer term of system performance. For this period, the expected annual dose to an average individual in a critical group living 20 kilometers from the repository should be below the 10,000 year performance measure. And that is the goal, i.e., not a requirement.

Our rationale. We believe that 10,000 years is a sufficiently long time period for public protection. There is lots of regulatory precedence, for example, RCRA. And we believe that a time frame greater than 10,000 adds to the regulatory complexity without providing added public safety and protection.

Time frame. Post 10,000 year calculations can provide insight regarding how a system may behave in a long time frame, and they can help us evaluate potential engineered barrier enhancements that may allow us to improve performance. The post 10,000 goal was established to complement the 10,000 year performance measure, which in a sense would be a requirement. And it's based on new information regarding time of peak dose.

When all of this started back in the '92 time frame, when the Act was passed and the National Academy began their study, our performance assessments at that time showed a peak dose occurring somewhere between 4 and 600,000 years in the future. Several hundreds of thousand years in the future.

Since that, due to increasing percolation, due to we're using more current data on solubility of neptunium, the peak doses in the area from 20 to 30,000 years, so that when we started the National Academy of Sciences process we felt that 10,000 years was the appropriate time frame for regulation.

The goal at that point seemed very realistic since we were talking about many hundreds of thousands of years in the future. Now we're talking about peak dose in a few ten thousands of years in the future.

With regard to the dose limit, we feel a dose limit on the order of 100 milli-rems a year is protective of the public. This is consistent with all of these regulations and the EPA generic draft Radiation Protection Guidance which was never actually issued but was in draft form. They all recommend 100 milli-rem or 1 mil li-sievert.

We selected a dose limit of 25 milli-rem a year for our interim performance measure. It represents a fraction of the 100 milli-rem limit. We think it provides for some reasonable assurance, and it is consistent with the NRC Commissioner Jackson's testimony to the House Subcommittee on Energy and Water on April 29th of this year. And it is consistent with the recent NRC rule on license termination which refers to the decommissioning rule which has a limit of 25 milli-rem per year for unrestricted public access.

I'd like to read to you her testimony on this issue. "With respect to proposed performance standards for the repository HR 1270, the Commission does not object to a single overall performance standard for a 10,000 year period following commencement of repository operations.

"The Commission considers that 10,000 years is a sufficient length of time to demonstrate the isolation capability of a system including contribution of engineered and natural barriers.

"The Commission notes the standard in HR 1270 of an annual effective dose of 100 milli-rem per year, 1 milli-sievert to the average member of the general population in the vicinity of Yucca Mountain. It views that standard as consistent with the protection of the public health and safety.

"The NRC believes that within the context of implementing the 100 milli-rem annual dose limit specified in HR 1270, it has the flexibility to implement the internationally accepted average member of the critical group approach using a reference biosphere as recommended by the National Academy of Sciences for application at Yucca Mountain repository.

"To provide reasonable assurance that the 100 milli-rem limit will be met, the Commission anticipates that the expected, again, the expected value for the average member of the critical group would be constrained below 100 milli-rem on the order of 30 milli-rem a year."

So that is the Commission's statement on the subject. In fact, that 30 milli-rem, that statement was made in April, the final decommissioning rule came out a couple of months later. It came out at 25. So we are consistent with the Commission's statement on our interim performance measure.

With regard to location, we believe that the critical group would be located down gradient from Yucca Mountain where that's the group most at risk. And that the characteristics of this critical group should be established based on present day knowledge using cautious but reasonable assumptions.

That was the recommendation of the National Academy of Sciences panel and is consistent, and we believe that protecting future population way in the future, would be very speculative and insupportable. So we think we are being consistent with the panel recommendations.

We believe that based on present day characteristics, the critical group would located in the community which we heard about this morning. There are 30 farms in the repository, that's where the people are living today, that's where the majority of the wells are located, if you look at a well distribution map.

The ground water is relatively shallow there and it gets deeper as you approach closer to Yucca Mountain. The water is used for farming and personal use and the soil conditions are conducive to farming.

Let's see here. This just illustrates what we're talking about here. That is the repository, that's the Nevada Test Site, this is 20 kilometers, this is 30 kilometers, farms in Amargosa Valley, Ash Meadows, that you heard mentioned, and Franklin Lake Playa which is the closed basin. The valley kind of goes like this and ends up in Franklin Lake Playa.

We chose 20 kilometers, that is in compliance with our performance measure. That's conservative, as we believe the actual -- as I noted the community is 30 kilometers. There are several wells located at Lathrop Wells Junction, although we don't think that's representative of current day characteristics for a critical group.

So we believe for our program today that the interim postclosure performance measure provides a reasonable target to guide our program. And we believe that it is also protective of public health and safety, and we think we are consistent with the NRC comments to the Congressional committee.

That's the first half. Abe follows me here. Are

there any questions up til for now or should we let Abe go?
DR. BULLEN: Why don't we let Abe go.
DR. BROCOUM: Okay.
[Beginning overhead presentation.]
DR. VAN LUIK: When I looked at the panel's request for information, Steve Brocoum just gave an explanation for the overall content and context of the performance measure. And then I thought well, they're asking, "This is cute, you've done a good imitation of EPA, now do an imitation of NRC and tell us how you are going to implement this."

So I thought that these questions basically were implementation questions. And so my outline basically tries to answer these questions. When we talk about undisturbed performance, we have to recognize a couple of things. The interim performance measure is a target to guide the technical program. One of the reasons we needed that target is because of design activities, they need a high level performance goal in order to specify their lower level design goals.

System and component design performance goals address the undisturbed case. Now, the undisturbed case however, does include climate change effects, the thermal effects from the repository itself, and design basis seismic events. Higher probability scenarios, in other words, those features, events, and processes with a higher probability, are considered part of the undisturbed case.

If we go to disturbed performance and human intrusion, all lower probability events like vulcanism, major seismic events, and criticality in package near-field and far-field, are part of the disturbed performance cases. And human intrusion, we are addressing, as was recommended by the National Academy of Sciences work on behalf of the EPA. It'll be treated separately as a sensitivity study to evaluate the potential effects on system performance.

To get to the heart of the question that I think was being asked, the interim performance measure includes both disturbed and undisturbed performance. The expected annual dose language that we used is basically based, as Steve made clear, on Chairman Jackson's wording.

And the way that we are interpreting this for implementation is that it's expected right now, the 50th percentile value on a probabilistic dose distribution function curve. We will also look at the mean value, the statistical mean value comparison. And we will include both the undisturbed case with its uncertainties and the perturbations from low probability events with their uncertainties.

Bob Kimble just talked about the biosphere definition and gave a description, which is misspelled, for which I apologize, for the critical group. And the modeling that is described in that presentation, and just to remind you that he talked about this modeling chain here, this is the modeling that you heard of this morning that will be part of TSPAs from now on.

We looked at an average individual at 20 kilometers. The statement, as Steve read it, was to calculate dose to an average individual in a critical group within 20 kilometers from the repository. We decided it would not, you know, we could take our own little goal and interpret it in such a way that would just look at people at Lathrop Wells, but that doesn't quite fit the bill.

The average individual defined in the biosphere modeling, that you heard about this morning, is more representative of a critical group centered at 30 kilometers. The biosphere modeling, we have to remember, prepares for addressing a critical group based on current locations and practices. And the regulatory requirements are the implementation requirements of that requirement that are set by the NRC are not presently known.

So the right thing to do is to look at the total population there and define it that way. That our taking the reference individual for that critical group, which is more representative of the 30 kilometers and artificially moving that person to 20 kilometers is somewhat conservative since there is less home or business activity at 20 kilometers. And we expect that ground water concentrations will be slightly higher.

This is approach that we're taking for the TSPA-VA. The TSPA for the license application will be based on the applicable regulations which will be in place by then, or at least we hope so. As Steve pointed out though, we are not going to say we meet our performance goal if we don't meet our performance goal. We will show a series of impacts in various different settings.

Like we will evaluate at 20 kilometers, we will evaluate at 30 kilometers, and we will do sensitivity studies given the different biosphere pathway modeling that you heard about this morning, and show it all in TSPA-VA. And that others can make a decision as to whether this is viable or not and move forward.

This is the map that we have referred to a couple of times already. Copies are available in the back. It's not in my presentation per se. And you can see that the 20 kilometers of the NTS boundary, approximately, we just rounded up. It's about 17 kilometers to the boundary.

This is not, however, what's driving us to that location. What's driving us to that location is we think that even in a slightly enhanced rainfall scenario, 20 kilometers is about the limit of where you can practice agriculture and pump water unless, of course, economic conditions change significantly.

So this is the place where the people are currently. If we were basing everything on current practices and locations, this is where we would be. For conservatism's sake, we moved it up a little bit.

Steve had something on one of his viewgraphs about protecting ground water and I wanted to make a statement. Ground water protection standards specifies a limit of radionuclide concentration to protect the drinking water pathway. That's one pathway. We are looking at an all-pathway dose goal and therefore all pathways includes that one pathway. So to us the groundwater protection standard adds nothing to public health protection, it's redundant and unnecessary.

In summary, we think that we have provided, for ourselves to guide the technical program and predictably design a reasonable target, we think that it protects public health. Modeling of the biosphere is addressing the current population and practices of the area. They are resulting in an average member definition that's pretty good for 30 kilometers. We're evaluating that person at 20 kilometers to be conservative. And at this point we do not know what our actual regulatory requirement will be at the time of licensing.

Now, Steve and I will be happy to entertain any questions.

DR. BULLEN: Thank you. Questions from the Board? Debra.

DR. KNOPMAN: Maybe you won't be so happy with this question. How would you characterize right now, based on what you know, the orders of magnitude of uncertainty that you have in estimating performance in the biosphere component of TSPA?

DR. VAN LUIK: You make a good point. The point is that if we look at all the uncertainties and roll them up and follow them through the calculations, if we go from the expected value or the 50th percentile to the 99.9 percentile there are probably a few orders of magnitude involved.

And this is one reason that I like the bill that the Senate passed last year because they said, "Take the average of the 95th percentile distribution," meaning you lop off the first two and a half percent and the last two and a half percent of the basically insupportable uncertainty. And, you know, I like that approach because the thing that you point out is that the tails of the distribution could look pretty wild because of the uncertainties involved.

DR. KNOPMAN: And even when you truncate the distribution and your 95 percent of your probability, what's your range of spread in performance? How many orders of magnitude, even when you are cutting off the tails, are you left with?

DR. VAN LUIK: I hesitate to answer that because if I answer it based on the calculations that we've done to this point, it would still be plus or minus two orders of magnitude. However, the calculations that we are preparing for TSPA-VA are based on different models than we've used heretofore. In fact, you will see some of the very preliminary results of some of the subsystem modeling, in this coming full Board meeting.

And so the answer that I might give based on previous ones may not be as true as it used to be. But my gut feeling is that if you go to the 95th percentile, you are probability looking at close to two orders of magnitude, maybe not quite, plus or minus, on that distribution.

DR. KNOPMAN: Okay. I'm just trying to put that in perspective with uncertainties of some of the physical, the other aspects of site characterization.

DR. VAN LUIK: Okay, now, in my answer to you, I did not say that this is just a swing introduced by the uncertainties in the biosphere modeling. When you do your fully probabilistic analysis, it's that very far field that looks at the extremes of every PDF, you know, the 3 or 400 PDFs that go into the calculation. That may be even more extreme than that.

But a reasonable, like 95th percentile, I would think, given all of the uncertainties, that's not too bad a swing, especially if the doses stay well below that goal.

DR. KNOPMAN: I'm sure that we'll be following up with you.

DR. VAN LUIK: Yes. You will be following that up. And don't forget that in January, February time frame we will have our first actual calculations for you to look at. And so that question can then definitely be answered.

MR. LIU: Okay. Thank you.

DR. WONG: Dan Bullen?

DR. BULLEN: Bullen, Board. I just want to make sure we're getting the semantics right here. All your doses for the 25 are total effective dose equivalents?

DR. VAN LUIK: Yes.

DR. BULLEN: Which is a cumulative dose?

DR. VAN LUIK: Using the modeling that was described to you just a while ago.

DR. BULLEN: Now the follow-up question to that is that you were saying that you picked the 25 primarily because you had to set an interim performance measure for the design activities.

DR. VAN LUIK: That was one of our largest drivers. The other one was that we had other questions, of course, ourselves, yes.

DR. BULLEN: Right. Would you expect a significant change in the design if the 25 turns into 15 and 4? Fifteen total and four drinking water?

DR. VAN LUIK: I believe the answer to that would be, no.

DR. BULLEN: Okay.

DR. BROCOUM: I think Abe gave you the right answer. Mr. Snell is in the back of the room, if you want to contribute to that answer. But let me make a point. There is a much bigger change if we go from 20 or 30 kilometers. At least past calculations showed a half order of magnitude of difference, as an example. So a 15 to 25 is really not significantly different, but it is consistent with what the NRC has done for their decommissioning.

DR. WONG: Any other questions from the Board? I have one question. You emphasized the fact that moving a potential receptor from 30 to 20 kilometers from the repository is a conservative assumption, or adds additional conservatism. How much conservatism do you think is, order of magnitude 10 fold, 2 fold?

DR. VAN LUIK: Steve just answered that question. In the previous calculations that we did it looked like a half order of magnitude difference, and so that's about what we expect it to remain at.

Our next two speakers, Dr. Mel Carter and Dr. Arjun Makhijani. Both of their presentations are designed to provide some view or response to your presentations. And so Dr. Makhijani would like the opportunity to ask you a few questions. And so I would like to afford him that opportunity and, on the same hand, I'd like to afford that opportunity to Dr. Carter, if he so chooses. So, Dr. Makhijani?

DR. MAKHIJANI: Thank you very much. I really appreciate your clarifying what is the ratio of the dose of the maximum to the minimum exposed person in your critical group?

DR. VAN LUIK: I believe that I'm not aware of that. I don't know if that modeling has been done.

MR. LIU: Ning Liu, again, with SAIC. I think I can answer, in part, to that question. The only part I can't answer is in the biosphere part. From what we see so far, it depends on the radionuclides, the range between the 5th percentile and the 95th percentile is between a factor of 5 and a factor of 10. But it depends on the radionuclides.

DR. MAKHIJANI: Now, is this averaged out over the whole population so you are not considering a population that's relatively homogenous but you're considering a population -- how homogenous is the population from which you are sampling, in terms of their lifestyles?

MR. LIU: The assessment end point is the total effective dose equivalent or TEDE, to an average individual in a critical group. So that's individual dose, it's not a population dose.

DR. MAKHIJANI: No, no. How varied is the lifestyles of the critical group of the people in it? Are there farmers, for example, computer operators and farmers in the critical group, or how varied is it?

MR. LIU: I'd like to direct this question to Bob. He is an expert in this.

DR. KIMBLE: Bob Kimble, M&O. Obviously, in the critical group and the whole survey we did of the area there is a wide variation in lifestyles and occupations. But in the important characteristics, particularly food consumption pattern for locally produced food, the variation is relatively minor, not dramatic changes from one place to another, or one household to another in terms of comparing, for instance, the four communities.

Food consumption of locally produced food in Amargosa Valley tends to be a little bit higher than it is in Beatty on the order of a few percent rather than an order of magnitude.

DR. MAKHIJANI: I have two other, these are all just clarifying questions. Now the NRC regulations about the 100 milli-rem dose, at least as I understand them, are that a maximum of 50 milli-rem can be delivered by the water pathways, and 55 milli-rem by the air pathways. And the DOE practice is to take 100 milli-rem undifferentiated, and you seem to be following that in your presentations.

I understand you set a limit of 25 milli-rem, but you are citing NRC as the eventual regulator, and you said this is a fraction of 100 mill-rem. But since the dose is primarily by water, is it true that it's only a factor of 2 away from the limit of 50 milli-rem that NRC has for the water pathway, or am I making a mistake about that?

DR. BROCOUM: I'm not sure what you are talking about.

DR. MAKHIJANI: I'm talking about 10 CFR 20. This is how I understand 10 CFR 20, and perhaps you can clarify later on.

DR. BROCOUM: No, but I think Abe said two or three times during his talk, we don't know what the implement in regulations will be and that will depend on the NRC.

DR. MAKHIJANI: Okay.

DR. BROCOUM: But it think this is an important conversation here because it's showing you the debates. We can get into huge debates about the biosphere, future assumptions and all this other stuff. And that's why we've always argued these things ought to be in a regulation so we know exactly what we have to do and they're not debatable once they're in the regulations.

So these kinds of questions, some of these that have come up, we can debate forever and there is no right or wrong answer, you see, so that makes it very difficult. In the regulatory environment you defend your position.

DR. MAKHIJANI: My last question is also about a regulation, about 40 CFR 190. 40 CFR 190, as I understand it, limits doses from the uranium fuel cycle to 25 milli-rem. And since you are using a 25 milli-rem limit here, one would assume that there would be no other sources from the uranium fuel cycle to this critical group for a 10,000 period. Is that sort of an operating assumption that you are using?

DR. BROCOUM: There's been some debate within the project on this, and I think, yes, you are correct. I think the operating assumption now is that there is no other sources like, for example, from NTS which I don't think flows down towards Amargosa Valley.

DR. MAKHIJANI: Or from Beatty. So there are two potential sources currently of doses from the uranium fuel cycle to this critical group that you decided to ignore for the present, for your viability assessment?

DR. BROCOUM: No. We're not using this for the viability assessment.

DR. MAKHIJANI: For these calculations.

DR. BROCOUM: For these calculations, we will show what the impact of our repository is on the down stream population, which is the whole purpose of the viability assessment. But you're right, I think the recommendations that I was quoting earlier on the milli-rem are from all man made sources of radiation.

DR. MAKHIJANI: Right. So it would be in violation of the EPA regulations if your critical group got 25 milli-rem from this and then anything at all from Beatty or NTS?

DR. BROCOUM: I'm not a lawyer so I don't think I'll give a legal answer on that one.

DR. CRAIG: I'm not a lawyer either but that's a very good question. Can I throw out a question here?

DR. WONG: Paul?

DR. CRAIG: This is a question that was sort of working in the back of my mind. Paul Craig, Board. In going through Steve's presentation and then the later remarks, I'm confused on the role that you see the DOE playing. A portion of your presentation was an analytic role providing the context.

And I can understand how you need to make some assumptions in order to deal with whatever EPA comes out with. On the other hand, you are taking a very clear position that a water standard is not needed. And there was a statement that you believe it was not needed. That's not a baseline position, that's an advocacy position.

DR. BROCOUM: We've had that position since 1992.

DR. CRAIG: I'm just trying to understand the stance of the DOE with respect to the interaction with the regulatory process.

DR. BROCOUM: Yes, we are taking the position that a separate groundwater protection standard is not needed. And I believe the NRC has taken that same position.

DR. CRAIG: Oh, boy. I think you need to talk to EPA on that also. There are some EPA people in the audience here, if they want to contribute to this conversation.

DR. WONG: Dr. Carter, did you have any comments?

DR. CARTER: Let me comment on a couple of things. The EPA standard 40 CFR 190, my interpretation of this is when they came out it it indeed dealt with 25 milli-rem limit but they excluded three specific things when they did. They excluded mining, they excluded transportation, and they excluded waste disposal, so those three items were not part of that standard.

The other thing is that overall the standard for members of the public is 100 milli-rem, and that's the controlling standard. And if you allocate then various parts to it, the sum should be less than 100. So I think that's an important point. As far as I know, no one divides the pathways as far as 50 for the air pathway and 50 for the water pathway. As far as I know, it's 100. The only people that are using a specific pathway is EPA with ground water, drinking water standards.

DR. WONG: Thank you. Any more questions from the Board. Thank you, Dr. Van Luik. Thank you, Steve. It looks like things are getting a little more lively. We must be drinking more coffee and we're all waking up. And I'm coming off California time and joining you on east coast time.

We just had two folks come to the microphone and ask DOE some questions and they happen to be our two next speakers. Our next two will offer views on DOE's interim performance measure presumably from a somewhat different perspective.

First, we will hear from Dr. Melvin Carter who was just at the microphone. Dr. Carter is an international consultant on radiation protection who's been involved in high level waste issues for many years. Among other things, Dr. Carter was a member of the Committee on Technical Bases for the Yucca Mountain Standards. He is member of the National Academy of Sciences Board on Radioactive Waste Management, and is one of the original members of the

Nuclear Waste Technical Review Board.

Dr. Carter is also the past president of the International Radiation Protection Association and the Health Physics Society, and was on the Board of Directors of the National Council on Radiation Protection and Measurement. Dr. Carter, we look forward to your views and the presentation that's ahead of us. Thanks.

DR. CARTER: Can everybody hear me? Mr. Chairman, members of the panel and members of the Board, I'm very pleased to be here, having been steeped early on in the responsibilities and the work of the Board and also in the sense of being an alumnus of the Board.

While I mention that, let me indicate that I'm really travelling under false colors. I'm a Neely Professor Emeritus from Georgia Tech and not part of it at the moment. So my biggest affiliation with the University at this time is going to ball games, football games that is, and hopefully winning a few, and also tapping into the retirement system.

[Beginning overhead presentation.]

Now what I'd like to do is start out and talk a little bit about background exposures of the public to radiation and radioactivity. To give you some idea of the system in which regulations are established in this area, and this is the milieu that you have to deal with.

Now, to begin with we normally divide up exposures from items in several ways. And the natural background, we split it up and usually do this by taking a look at cosmic radiation, terrestrial radiation, and internal radiation. And these are some of the things that are involved. And, by the way, this is a simplification of the area because it is indeed quite complex.

In both internally, as far as the body is concerned, and from the terrestrial standpoint, we normally are concerned with these three series.

You may remember each of these is headed by a very long line of radionuclide. It decays through several dozen transformations, and finally ends up with stable lead. So when you talk about one of these series, there is several dozen radionuclides that contribute to exposures. And these, by the way, are listed in the order, that's the uranium series, the actinium series, and the sopa thorium series.

In addition, we have to concern ourselves with individual radionuclides that are not part of this series thing, and several of the important ones are rubidium 87 and potassium 40. Now, these are both long lived and then decay to stable elements eventually.

They also happen to be,

potassium 40, in particular, is both a beta and a gamma emitter, so it's of concern from a terrestrial standpoint, outside the body. It's also a problem internally. In fact, a fair amount of the internal exposure that people receive come from this single radionuclide.

And if you run in a lab, for example looking at environmental things, you'd be amazed at the amount of radioactivity that are in, for example, milk, grass, and lots of other things. And a lot of that is due to potassium 40. In fact, as I recall a normal liter of milk contains on the order of 1200 or so picoCuries per liter of potassium 40.

We in laboratories these days, if you are interested in the environmental side of it, are looking for a couple of picoCuries of things like strontium 90, cesium 137, and so forth. So you are looking at a milieu that contains well over a thousand and you are looking for just a few parts of this. The cosmogonic radionuclides are listed there, tritium carbon 14 and sodium 22.

There are a number of other ones and probably one other one from a dosimetric standpoint that makes a significant contribution would be beryllium 7. Now we have a fair amount of variability listed here for terrestrial and cosmic things, not all of them in one instance, but at one time or another.

You have to worry about the location, the elevation, whether you are on a mountain top or at sea level. The sealing of structures you may live in or spend time in, the amount of time you are outdoors, the season of the year, whether there is snow on the ground, and this sort of thing, whether you have sun spots, and also the weather.

And I've indicated here that cosmic radiation in the U.S. varies by over an order of magnitude, if you take picoliter exposed to the smallest amount of this component to maximum. And also, I might add, that terrestrial radiation varies by a factor of about 3 in the U.S.

And, for example, if you spent a year in Washington D.C. versus a year in Denver, Colorado, you'd get about 30 milli-rem per year if you spent it in Denver versus here. As far as I know, I know of no one that I'm aware of that makes these conscious decisions based on whether or not they are going to visit Denver, a skiing resort, or something of this sort based on the amount of radiation or increased radiation that they would receive by doing so.

And quite often these differences, this variability is quite large compared to some of the standards that we have already discussed to a limited extent this morning and undoubtably will discuss a little bit later on.

Now, this is a pie chart I hope you can read. I'll just mention a couple of things about it. This was put together by the NCRP about 10 years ago. It took a look then at all sources that irradiate members of the population. The biggest chunk of this, shown at the bottom, is radon, and it's some 55 percent of the total.

Then the cosmic, terrestrial, internally there, they are about 27 percent. Man made medical, therapeutic as well as diagnostics, about 15 percent. There is roughly 3 percent devoted to consumer products. And the other things concern occupational exposures, fall out, nuclear fuel cycle, and so forth. All of those constitute considerably less than 1 percent of the total.

Now we'll take a look at a table that shows the actual milli-rem or micro-sievert activity. These are the same items that were shown in the pie chart except now we've got listed the milli-sieverts per year and the percentage of the total. So you look then at the natural, look at radon. I mentioned it was 55 percent of the total, that's shown as the first item there, some 2 milli-sieverts or 200 milli-rem.

The rest of the material you can see it gives what I mentioned earlier, you can see the things that we discussed at the bottom, the occupational and the nuclear fuel cycle, and so forth, are extremely small. The interesting thing about this now, the total is around 360 milli-rem per year, or 3.6 milli-sieverts per year. That's roughly 1 milli-rem per day.

So when you are talking about the drinking water standard, for example, of EPA, at 4 milli-rem you are talking about the equivalent of 4 days of background average in the United States. Not a year, not a month, but about 4 days.

Now the general standard, and I mentioned that in the comments at the microphone a few moments ago, and I've seen this develop by the way, over many, many years, but it seems to have reached the consensus now that on the order of 100 milli-rem per year, and that excludes medical and background or radioactivity, and it indeed is a consensus.

At one time that was not the case, each agency had their own regulations. And back in the old days -- certainly the EPA, when the media programs were quite strong, and by "media" I'm talking about air, water, and so forth -- we complained in the radioactivity radiation part of the Public Health Service and EPA for the simple reason that this ought to be looked at uniformly.

For example, all pathways, all radionuclides, and not have individual water, individual air, and so forth. So this is still being discussed, obviously, after an awful lot of years. But the standard is supported by groups that make recommendations, they certainly don't set standards, but they do a lot of the leg work, the studies, the analyses, and so forth.

The International Commission on Radiological Protection, the National Council on Radiation Protection and Measurements in the U.S., the International Atomic Energy Agency, the United Nations Scientific Effects of Atomic Radiation, the World Health Organization.

And then from what we are talking about here, EPA in their guidance for the general public and the environment and some others, the Nuclear Regulatory Commission in 10 CFR 20 and DOE actually addresses this in DOE Order 5400.5. That looks at radiation protection for the public and the environment.

And I might add, in a way it sort of predisposed dividing up this 100 milli-rem because that standard in that order sets 100 milli-rem per year as the allowable level for members of the public. It also admonishes the directors of the field laboratories or field offices of the DOE that it's their responsibility to keep the public exposure below that.

Not only that, but to know what's going in the area, whether there are other sources, that Dr. Makhijani mentioned earlier, that might make contributions to this. And actually sort of be the steward, if you will, for the public in that area to make sure that the total, if you add up all the pieces, is less than 100 milli-rem per year.

Now the apportionment of dose. I'll talk a little bit about this. It's somewhat broader than the discussion we're having on the performance measure but since I feel fairly strongly about it, I'll leave this in. We need to do this, and to some extent EPA has done this, if you look at their 40 CFR 190, their fuel cycle standard.

They actually looked at a number of parts of this thing and come up with the exposures that are caused by that aspect of it. And that in a way is a forerunner now of apportionment. They've also endorsed this in their guidance that came out in the Federal Register, as far as members of the public is concerned.

Again, the basic standard being 100 milli-rem, or 1 milli-sievert per year, and then allocate this as far as the sources. Again, though, if you do this the sum of all these pieces must be less than 100. And, by the way, as far as I know, we're not anywhere close to this. And, in fact, many of the sources that we're dealing with, major sources, are sort units standing. There's nothing nearby that contributes to them.

On the other hand, there is a case in Nevada where, indeed, there are some other potential sources and these will obviously have to be considered in the evaluations and assessments that go on.

Now, internal examples for waste disposal, these are numbers that other countries are using at least on a planning basis, run from .05 to .3 milli-sievert per year. And there are some roughly 10 countries, or so, that are this far along that they've actually got numbers. And those numbers, of course, run from 5 to 30 milli-rem per year.

So DOE selection of 25 milli-rem per year, as far as I'm concerned, is a fairly appropriate number to take for design purposes, the basis of evaluations and assessments. And if that number should change, for example, I think it's fairly simple in many cases to extrapolate directly from that, either up or down, whatever way that number may move.

The compliance time. The NAS technical bases for Yucca Mountain standards suggests that a period of -- essentially a very long period, and we suggested a period of maximum risk be covered by the standard. I think that report basically says that if you don't do this, then it's a little difficult to see how you are going say you are protecting the health and safety of the public, if you exclude that.

Now, on the other hand, at that time, and I think it was Dr. Brocoum that indicated some few years ago, and it's not been too many, that the expected maximum risk was to occur at on the order of a half a million years. So I'm very pleased to see that the DOE has made enhancements in the repository design, that they are doing several things.

They've decreased that maximum dose considerably.

And they've also moved the period that the maximum dose will occur to a much shorter period. Now instead of half a million years we're talking on the order of 20 to 30,000 years.

These are the things that I've essentially just indicated. Now, the ICRP recommends the selection of a critical group. The group should be either real or hypothetical.

Now if you read their reports carefully, and there are a number of their reports that deal one way or the other with critical group, average individual in the critical group, or average member of the critical group, and so forth. And they give some directions, for example, on the statistical variability of a homogenous group, and so forth, so they've pretty well covered this.

But what they essentially say, if at all possible, you use a real group, you don't conjure up a hypothetical group when you've got some real groups to work with. So what you are really interested in is locating the critical group. And I think there may be some confusion between what I'll say and what Esmond said about the critical group.

As far as I'm concerned you have to evaluate a number of groups to determine what the critical group is. He might be lucky and throw something at a dart board and say, "We hit close to what the critical group is." You've actually got to go through the analyses or assessments before you can do this.

So, for example, whether the critical group, in my opinion a real critical group is going to be at Lathrop Wells or is going to be at the Amargosa Valley area where the people are living, is quite moot at this point when you make the evaluations of these. This sort of thing, by the way, the selection of critical groups and so forth, goes on all the time.

You know, it's been pushed by a lot of people, so there are a lot of people who've had a fair amount of experience in this sort of thing. And, again, if you want to worry about location, the habits, and so forth, then these are things now that directly affect the amount of exposure, dose, risk, whatever you want to call it, that are involved in the process. So you want to maximize these as far as the critical group is concerned.

That basically says that same sort of thing, with a couple of bullets. Okay. I say here DOE has conservatively selected Lathrop Wells. In my opinion, at the moment when you look at that in detail, I don't know whether that's going to be a good one or not. It may be the people living down the -- some 1200 or whatever in the total group and then select a critical group out of that number.

Critical group now is on the order of two tens of people or a few people. It's not 1200 or 291 or something like that. It's a number like two handfuls, or that sort of thing. Now, the reason I say this, as far as I know they have a few wells at Lathrop Wells, in spite of the name, that take water and use it essentially for domestic purposes, for drinking, and so forth, at the establishments there.

And, by way, people were talking about the growth in that area. I happen to have been fortunate enough to have spent 8 years as a resident of Nevada, part of that divided about 4 years in the early 50s to mid 50s, and the other from '68 to '72. Now, I visited these areas off and on for that period of time, so it's some roughly 40-something years since I was first out there in 1953.

So I've spent a fair amount of time there and I probably know more about that area than any other area that I've lived in for the simple reason that part of my job was to be familiar with what went on and I did monitoring in the old days around Mercury, Indian Springs, Lathrop Wells, Death Valley Junction, and so forth.

We were talking about changes that have occurred, so I was quite interested in Steve's slide show, looking at some of the things have gone on. And I can tell you from first-hand experience that the population growth in some of those areas has been nothing but spectacular over that many years.

I can remember, for example, Pahrump was really just a place that had a funny sounding name. I mean, people really didn't live there, and the first people that did I think primarily raised cotton. And now I've got friends that have retired and live in Pahrump and grow pistachio trees as a hobby and perhaps as a money involving process as well.

Now, getting back to this point. I'd like to make the point very strongly. When you select the critical group, you have got to go through the analysis and the critical group essentially selects itself. It might be at Lathrop Wells, but the chances are that if they only get drinking water there, they are not irrigating crops, they're not feeding domestic animals, and this sort of thing, then the chances are it's not there, it's probability down where they do these other things.

On the other hand, it's closer so you'd expect it to be somewhat higher as far as the amount of contamination in the ground water, and so forth. And by the way, the other thing is that over a period of time, certainly the time periods we're talking about, the critical group can well change, you know, any number of times. So I might move from Lathrop Wells, if it happened to be there, the next thing you might know, it might be in Pahrump or somewhere else.

So this will change over this lengthy period of time that we're talking about. So in my opinion, right now like I say just on quick blush, it might be more appropriate to have it in the Amargosa farms area where one has the people that does all of these things. But you don't know that until you go through the analysis and find out. We've obviously got people that are working on exactly that. Next slide, please.

And it is a real population, they've got ground water and this is what they tend to do with it. And, by the way, I think Steve said it's very difficult but we've done this for fall out over many years, business of sampling milk and other environmental media. I wouldn't say it's an art now but there has been an awful lot of experience that goes into this.

And I was involved certainly from a lab standpoint, EPA lab in Las Vegas, from not only knowing where the people lived out there but knowing what they were doing and what their routes of exposure were in various parts, and not only Nevada but several other states as well.

When you are talking about milk, you've got to get into the milk industry and find out how it operates. And, you know, growing alfalfa, feeding it to cattle, and milking those cows, and shipping the milk to Los Angeles, that's not unusual at all that it goes that far. There are a number of areas supplying Las Vegas, for example, in the Las Vegas Valley. They also get a lot of milk from Utah and so forth, that milk that leaves any particular dairy, whether it's 4,000 cows or whatever.

Now, how much percentage would that be of the Los Angeles milk supply, for example? Probably a drop in the bucket. So that milk, if it should happen to be contaminated, it would be diluted I suspect thousands of times in that particular milk market.

Okay. You can read the rest of this. But very important, the critical group sort of has defined itself on a statistical basis and, by God, it's hopeful that it's been advocated primarily by the ICR.

Again, as far as I'm concerned, you should look at all pathways. One of them might be critical but the standard, if you deal with 100 in the sum allocation of that, you are going to find that you are taking a look at all pathways, hopefully. And certainly the water pathway is one of those and the water pathway may indeed be the critical one. But you won't know that until you go through the analysis.

And then, hopefully, this would help focus the effort so when we talk about hundreds of radionuclides or even dozens of them, a lot of these are not going to merit an awful lot of work, they're going to fall out of the equations pretty early and you'll be left, hopefully, with a handful of critical radionuclides that you've got to do a real detailed analysis of.

Okay. Essentially the same thing as far as the radionuclides, you need to look at them. And, again, some of those will fall out as well as the pathways. And, again, that'll help you focus your effort. And by the way, one of the things that a lot of people don't talk about but it turns out to be in the ICRP publication, Number 60, that deals with waste disposal.

And, basically, it addresses in a paragraph or two the fact that your efforts in this sort of thing ought to go in important things and not be diluted or wasted by chasing minute details. And they then tend to address, you know, some level of de minimus, or below regulatory concern, or whatever. That's in there and it's probably a good admonition.

You know, if you are chasing something blindly and you are looking for really things that are inauspicious, as far as importance, as far as significance is concerned, it's important that you make a division of your resources and allocation of these on a live basis. Next slide, please.

Okay. I'd like to make several recommendations and I'm going to do this in two different areas. One of these deals specifically with what we are going to address today, and there are a couple of them, like I say, that are somewhat broader than this. So let me do this.

Like I said a little earlier, that the selection of this interim performance measure, as far as I'm concerned, looks reasonable. At least the number that we use now we recommended in the Academy's study that risk be used. As far as I'm concerned, you can basically use three things on the standard. You can either use health effects, you can use dose, or you can use risk. But somehow or other, you've got to relate them to one of these.

This is why we took a dim view, for example, of release limits that EPA had provided earlier. Because without some idea of how a source term interacts with people, you have no reality about what you can evaluate. Just so you remember that.

And like I say, if you take a number whether it's 25, the risk equivalent of that, or you are talking about a 10, or a 2, or 100, or whatever it might be, a lot of this can be based on sliding it one way or the other, so it can be based on taking a look at that.

Now, I'd certainly like to admonish DOE while I have the opportunity, to continue working on this thing. And I had a couple of questions and maybe these will come up during the discussion as far as the panel is concerned.

Well, let me mention these and a couple of them that I was interested in is, what, basically, from an engineering standpoint -- I'm not going to ask these guys to respond now, but I'll bring this up a little bit later on, maybe this will be one of the items -- allowed you to do this not only to basically flatten the peak dose or peak risk and also to reduce the time at whether this occurs? I assume this is probably due to the corrosion of canisters, and what not, but that's just my guess. So I'll ask you guys that later.

The other one, for example, how well does DOE know the hydrology of the system out there? We talked glibly that it comes under Yucca Mountain and it goes down and dribbles out at these places. How do I know that some of this hasn't channeled over and is coming out now at Pahrump, for example? Do you have any idea of this or is this speculation?

So those are two questions I certainly would like to have answered. But, anyway, whatever the reason, I'm pleased to see that they are doing this and I certainly would hope that they would continue looking at new designs as far as tightening up the repository, perhaps lowering the exposures that are involved.

I went through the reason for this. It's not only there but it's elsewhere as well. Like I say, this could be some other location. And like I say, when you get the data, then, yes, you can dismiss some of these sites as of no further concern at the time. But you can't make the decision a priori before hand.

So just arbitrarily saying, "Let's move it closer to the test site," it may help and it may not help in terms of identifying or defining the critical group. I'm interested, obviously, in when the maximum occurs does this reduce uncertainty? It does all sorts of useful things for you. Okay.

These are the two that are somewhat broader than this. I've been interested since I've been in this business 40 plus years, I guess, and the fact that we finally now do have a consensus, not only nationally but internationally as far as the 1 milli-sievert per year for members of the public. This has taken a long time coming.

Like I say, at one time there was all sorts of numbers out there and no two groups had the same numbers. So it's interesting to see some degree of uniformity, and so forth, developing here. And I can say the EPA did somewhat close to this in looking at the fuel cycle as far as allocation within them or what they produced in terms of dose.

And I might say that to some extent it's going on now when we come out with 10 CFR 20, for example, it's got numbers in there. We've got numbers dealing with decommissioning and decontamination, and so forth. But these now, and there are several regulatory bodies, as you well know, that are involved in this, but you find that they are making these decisions on an ad hoc basis or on a piecemeal basis, and I personally feel that that's the wrong way to go about it.

If you are not careful, if we get enough sources, you are going to find, you know, you start adding them up and there might be over 100. So you want to make sure you stay well below that. You want to make sure you've also got some reserve.

So in the U.S., if someone were to ask me how to do this, I would suggest that the regulatory groups that are involved, EPA, the DOE, NRC, and perhaps several others, would do this on a real broad basis involving the public, environmental, lots of other people. And I suspect involving the Office of Science and Technology Policy as being the arbiter for the Administration as far as these sorts of matters are concerned, and they also happen to have some radiation radiological expertise there.

That's the way I would go about allocating the 100 milli-rem to make sure that you take care of the things that are necessary, and that you also have some left over for either emergencies or miscellaneous things that will deal with unknowns that could occur later.

And the second part of this, if you think about it, we don't have, as far as I know, a performance assessment now dealing with what we've got in the way of a mish mash in terms of high level waste at the moment. It's being stored, managed, at any number of places, as you know, probably on the order of 100 or so, if you include the high level waste of the DOE and include reactor waste from the civilian side of the house.

And the question is, what's the risk to the average member of the public from this, and what would that look like if it were compared with the system that had Yucca Mountain as it's centerpiece? In other words, are we going to reduce the risk, are we going to reduce the dose, are they about the same, or what not?

So it's almost like looking for the critical group and when we do this you probably don't know what the answer is. So I would have some admonition that we do this sort of thing one of these days. I think it would be very helpful. And with that I think I will close and see if the Board members and the panel members have any questions.

DR. WONG: Thank you, Dr. Carter. Questions from the Board?

DR. CRAIG: Paul Craig. You gave a fairly philosophical talk there, Mel, so let me ask you a philosophical kind of question. And it goes back to the earlier question about the difference between water and other kinds of things. And the important thing to me about water, as contrasted to air, specifically, has to do with reversibility.

To what extent should our generation be constraining choices of future generations? If it's an air emission, you can do something about it fairly easily. But once you've got the water table filled up with material, it's very difficult to reverse it. So that's the framework.

And the question that I'd like you to reflect on a little has to do with the allocation of the 100 milli-rem per hour. One can think about that in terms of what we do today but now we're asking a question about generations a long way down the line. And I'd like to understand a little better how you think about the legitimacy of passing on various fractions, or using up various fractions of this allocation for generations far down the line.

It's not even obvious to me whether the right policy is to say we should save a lot for them or whether we should assume that they will have better technologies and we don't need to save very much. How do you think about this problem?

DR. CARTER: Well, certainly I have no problem with intergenerational equity. And that is I don't think we should expect them to have more risk than we have, have more dose, if you will. So I would also flip that over and say that, you know, you certainly ought to take care of the resources that you have and not turn over things that they can't reverse, for example.

I think the biggest problem, by the way, with the drinking water standards has to do with something entirely different, but let me mention that as we answer the question. One is that those drinking water standards now refer to drinking water as such, and this is water that came out of the tap as defined by EPA. So it didn't deal directly with ground water per se.

So they were derived in an entirely different arena, the same with whether treatment was involved, whether it wasn't water treatment now that was involved. So these are the two kinds of things that people have a problem with the drinking water standards, is the appropriateness of those to here.

Having said that now, I think that you probably know there is an awful lot of ground water under our earth's crust that is completely unsuitable for drinking water. It will probably remain that way for a long, long time. All this is caused by salt, some of the individual chemicals that are in it, and so forth. Now I don't know the ratio of the good stuff to the bad stuff, but we're obviously interested in the good water and the water that can be used presently and, like you say, passed down.

So as far as I'm concerned, I don't want to see us commit ourselves to allocating that kind of resource that's going to affect adversely future generations. I think we ought to do everything we can to protect it. Whether you can break it down that neatly between water and air, I'm not too sure. Obviously, both are necessary for existence.

DR. WONG: Okay, any further questions? All right, thank you, Dr. Carter.

Our next speaker will be Dr. Arjun Makhijani, from the Institute for Energy and Environmental Research. Dr. Makhijani has authored or co-authored several articles and studies, including a critique of the United States Waste Management Policy titled, High Level Dollars, Low Level Sense.

Dr. Makhijani was the leading critic of the report Technical Basis for the Yucca Mountain Standard. And we look forward to hearing his views in the DOE's interim performance measure. Please, Dr. Makhijani.

DR. MAKHIJANI: Thank you very much. I think the leading critic of the technical report, Technical Basis for the Yucca Mountain Standard is actually a member of the panel. He's not here. Dr. Pigford. But I know him, he was one of my teachers when I was in graduate school, and we've talked about this quite a lot.

I want to thank you for inviting me, and especially Dr. Fehringer for inviting me and reassuring me as to the nature of the forum, and I appreciate being invited and asked to make a presentation.

I want to make a comment on Dr. Carter's natural background thing. It's a very common display but it didn't always have the same content, so far as I know. You go farther back, Dr. Carter, so you might correct me if I'm wrong.

Until a decade or so ago, it wasn't common to include indoor radon in natural background radiation, and I think in the last decade or so the addition of 200 milli-rem into the natural background makes natural background look a lot bigger.

And I think it's an illegitimate addition because if you live in an apartment, then of course you don't get this indoor Radon. And if you live in an unremediated that you didn't know enough to pay attention to when it was being built, for the most part that's the case, and so you get a couple of hundred milli-rem, you may get a couple of rem, you may get some more. It's an artifact of construction, and I don't think artifacts of construction and living styles ought to be included in natural background.

I have one other philosophical comment on this business of natural background and voluntary choices and potassium 40, and so on. I was in a debate about a low level waste facility in California and the vice president of U.S. Ecology was there and he said, "Well, you get about as much radiation from the potassium 40 sleeping next to someone as you would get from this facility."

And my response was that as a person in the business, I am fully aware that when I sleep next to someone, depending on how close, I am getting zapped. But I thought that the industry's cost benefit calculations were completely wrong because I didn't know anyone to get the kind of benefits from sleeping next to a dump that I got from sleeping next to --

DR. CARTER: Let me interject something. You missed the main point of the difference. I can't avoid giving you --

DR. MAKHIJANI: Go ahead. You are privileged, Doctor.

DR. CARTER: -- peerless advice. And that's the main point of the discussion. The discussion involved the amount of potassium 40 in men or women --

DR. MAKHIJANI: Yes, I didn't miss it. I just wanted to tell an interesting anecdote --

DR. CARTER: Okay. You didn't allude to it though, but you get a lot more radiation if you sleep close to a lean bodied man than if you sleep with a woman.

DR. MAKHIJANI: Well, I think I've made the appropriate choice for risk reduction in that way.

I think underlying this there is a very serious issue because natural radiation is put there by God, and God is going to kill us all one day, and God gave us birth, philosophically speaking, whether you believe in a specific kind of God or not.

But if your neighbor came up to you and punched you in the nose and said, "God is going to kill you one day," this is a much smaller dose, you'd want them to be locked up, and society does tend to agree that this is an illegitimate kind of comparison.

But somehow in the radiation business the legitimacy of this comparison has not been systematically questioned, and I do believe that it is an illegitimate comparison to compare natural background. Perhaps it is because of the birth of the nuclear age and Oppenheimer and what he said that nuclear folks feel more or less in the position of the gods, and so they compare radiation doses that they impose on society with what the gods are doing to us.

I do think that it's time to stop that kind of comparison and let's deal with the facts as they are, and the risks as they are, and not pretend that these are comparable kind of risks. We're imposing risks from choices that we have made, that certain layers of society actually have made, not even the full society, on generations far into the future where we have really no idea how to understand things.

This country prides itself on longevity. It's only 200 years old. Less than a century into this country's history there was a very brutal war in which more people died inside the war in this country than have died in all the foreign wars in this country's history. I think some kind of recognition of this reality is absolutely necessary because it is a fact.

You cannot avoid this reality by saying this is simply a discussion milli-rems deep in the ground, because we're talking about institutional things, first of all, and I'll talk a little bit more technically about institutional issues briefly, shortly.

I think in regard to the critical group, I cannot agree with the approach that is being taken. I do think there is a way to deal with long term futures, other than looking at current life styles. In fact, I will say that looking at current life styles is completely wrong because there are a lot of different tendencies in society and we have no idea how they will play out.

Just as 1,000 years ago people had no idea how the tendencies in society would play out 100, or 200, or 1,000 years from then, I think we have no idea how tendencies will play out. And I will give you two completely different tendencies that exist that we can see today and we don't know how they will play out.

On the one hand we have a tendency toward urbanization, and factory food, and factory water, and a completely artificial environment. On the other hand we have also a clearly expressed and very strongly growing for people to want to control their food, to eat more natural food, to eat more food that has been more close in contact with the earth. And if you go to the farmers' markets, you see them proliferating and prospering.

These are two completely tendencies in society that have grown up in the last 50 years in reaction to the same kind of technical developments. That is the growth of urbanization and they are diametrically opposed tendencies. And I don't think it is very sensible or rational to try to say that people will not want to live very close to the land 10,000 years from now or 1,000 years from now, or that subsistence farming won't be an extremely productive enterprise.

Just because peasants haven't been very technically productive before, doesn't mean that 500 years from now peasants cannot be technically production in the future, and that this won't be an entirely satisfactory way of living. So I think that it is really completely wrong technically, based on what we know and what we can see today in society, to take an existing group as a critical group.

I do think that what Professor Pigford has been saying is a more reasonable way to look at the critical group, by very strictly examining the subsistence farmer question. And I think there is a very solid technical basis for it and I will try to present a part of my own reasoning about that.

I cannot agree with the National Academy 1983 publication nor this report that the focus should be solely on individual dose. I agree that there are lots of uncertainties about low dose radiation, especially at milli-rem type of doses. We don't know how to sort out the technical issues right now. I'm not among the environmentalists who claim that we know this very well and, therefore, I do think that we don't know it very well and we should leave some elbow room to learn a lot in the future.

I think that my own speculation is, and this is just my own speculation based on what I have seen about radiation related studies which is not a negligible amount, is that I think response of people to radiation, like other environmental factors, is likely to be highly genetically dependent.

And that individual people respond differently within any population, this is not a racial or ethnic thing, that within any population group in the same way that we are all differently responding to spring season and all the pollen in the air, that within any population group you are likely to have quite a lot of variation in the response to any environmental factors. And we have no idea what the vulnerabilities about radiation are.

But we certainly should not presume that population dose is irrelevant. I do think that the EPA standard, which has been sidelined by arbitrary legislation that said there should be a special standard for Yucca Mountain, is wrong because the EPA legislation does have in the form of absolute limits on emissions, a population dose limit.

They are really the only technically verifiable thing that you can say about repository performance, and I think this technically verifiable thing is being completely ignored in favor of a lot of models with 300 and odd probability distributions. And I will come to how many orders of magnitude that I think you might have to deal with from examples that we've already got.

I don't think two orders of magnitude anywhere near covers it. I think we have got and history often says that we must have measurable ways of assessing performance.

The EPA has put forward a measurable way of assessing performance by limiting releases of radionuclides in absolute quantity from a repository.

And I am amazed to see that on a technical basis the only measurable things that are there, total releases of radionuclides and concentrations of radionuclides in water, have been completely thrown overboard in this discussion as primary criteria in enforcement, but the models with huge numbers of distributions that are full of speculation should be a substitute for protecting generations that we do not even properly know how to count.

So I would encourage the DOE and I encourage the Board to insist that some kind of population analysis be done. In this context I think the carbon 14 issue is quite important. I think there is absolutely no reason to ignore the carbon 14 issue because it is an important population dose issue.

The reason it has been thrown overboard is very clear. It has been thrown overboard because the population doses are very high and there was no guarantee the Yucca Mountain repository can meet the standard.

However, the EPA committee which looked at this issue did conclude that there are lots of other repositories that could meet this standard. And so I think a comparative assessment in this regard, whether there are repository environments that can meet the standard, is very important.

In this regard, let me mention the 1983 Risk Panel Waste Isolation Systems Panel Report of the National Research Council. I think it was an excellent report. In that report there was a suggestion for exploration of a repository type that could answer many different objections to repositories and the many uncertainties that they face.

One of the biggest problems with repositories that has not been addressed is the problem of intrusion, either inadvertent intrusion or deliberate intrusion. Deliberate intrusion would be resources and inadvertent intrusion, of course, would be because we lose track institutionally of where we put this stuff.

The recommendation in that report, in regard to intrusion, particularly that I liked was that the repository environment should contain brackish water, the kind of water that we don't think future generations will use, rather than consign what we know is a very scarce resource in an area where people are highly likely to use it.

We have selected the area that is probably the most problematic area, from the point of view of likelihood of use of resources, which is a deserted area with very little surface water dilution potential with a very small and scarce ground water resource so concentrations of radionuclides will be high and a very high likelihood. It's the worst possible site you could pick.

And completely taking away from future generations the choice of using the resource when we've got plenty of places now, and I must admit they happen to be in east where there is brackish water in granite, and I'm not advocating this or my environmental friends would be very unhappy and my neighbors would be too. But I think in fairness, we have to look at these repository sites and we cannot avoid looking at them these geologies because they are politically inconvenient.

The other question in regard to uncertainties, and this we can see on the horizon today, is that all of these models and standards even though there is a consensus about them are based on 70 kilogram standard man. And I think this is an inappropriate choice, even in the case of one of the sensitive radionuclides that has been discussed here, iodine 129. Standard man is a completely inappropriate technical choice.

I noted that the milk consumption that has been written down in the model and is .03 kilograms, I think -- I've lost the place here -- your milk consumption variation is .03 to .08 kilograms or something like that from the chart, if I remember correctly. And this is a standard man milk consumption.

We know from a controversy that is going on right now in society about iodine doses from testing that children's doses are an order of magnitude higher. And there is absolutely no reason, when we know these technical facts, to have selected standard man just because it -- we know why this is done.

And in regard to the orders of magnitude of uncertainty, let me kind of just reel off what have been calculated in the last 15 years in relation to Yucca Mountain maximum doses. 2,000 rem, this was published in 1983 by the National Research Council as the worst case dose. 30 rem was their best case dose. 1993 we had published by a DOE contractors doses in the 1 to 10 rem range. So that's already you are two or three orders of magnitude right there. And of course the peak dose was in the several hundred thousand range.

Now we have got an order of magnitude change in peak dose 20,000 years, and this was presented in September, is it Steve? This is from September, DOE contractor calculation peak dose is 200 milli-rem, about, if I'm reading it right, approximately log scale. Now we have lost a factor of 20 here in one month and peak dose is 10 milli-rem.

DR. BROCOUM: Of those one chart is at 5 kilometer the other one is at 20 kilometer.

DR. MAKHIJANI: Yes, it's a different distance but what is the basis -- allow me to carry on with my presentation. After all I'm holding it up for you to read it. I'm not keeping it secret from you.

The basis for choosing a 20 kilometer site is that people live there now. And we have amply heard that within the memory of Dr. Carter that places where there was nobody are teeming today. And we know that places that 50 years ago where there were people are empty today of people.

Now the basis for choosing something 5 kilometers away and making a factor of 20 go away, this is an illegitimate basis for calculating for 10,000. I think this is another illustration of how uncertainties for the future are being wished away by modeling.

Now let me say something. You asked a question about how many orders of magnitude and models. These models, since Oppenheimer started the whole nuclear business by making reference to the Hindu gods, I might as well make reference to Hindu mantras. Models are being used like holy mantras. They are somewhere there.

But we have tried to look at some specifics of models. Now, I looked at the list of the models that was up there. Cap 88 was one of them. Now, my institute is involved in monitoring an independent audit of Los Alamos National Labs compliance with the Clean Air Act as part of a settlement Los Alamos made with a local community group over a Clean Air Act lawsuit.

They used Cap 88 to assess compliance. Cap 88 assumes uniform emissions throughout the year. But as soon as you look at their measured sources, you find that one of their most important source from the chemical and metallurgical building is a source from which more than 80 percent of the emissions came out during one week.

We don't know if they came out in one second in that week or during uniformly 7 days over the week. Probably likely they came out in a very short time.

Now if you just change that single assumption, based on the data available to you from Los Alamos, and then choose an appropriate location of the maximally exposed individual, you arrive at a dose difference of four orders of magnitude. So they are using what is manifest it is allowed by the EPA, it is within the regulatory parameters, but it is four orders of magnitude off. All right.

How about water models? The Science Application International Corporation which is doing these calculations also did calculations for depleted uranium for the Louisiana Enrichment Services case where the enrichment plant was to be built. They did calculations that I find don't comport with common sense or anything else I know about uranium doses.

If you drill a well in your backyard where there is 2 picoCuries per gram of uranium in the soil, and maybe a couple of picoCuries per liter of uranium in the water, you get, I don't know, a milli-rem, a couple of milli-rem, something like that, dose. They calculated that the dose from disposal of depleted uranium in wooden boxes, that is no engineered barriers, would be 9 orders of magnitude less than this. We have absolutely no reality check.

You asked about, you know, how are you going to validate this model? And they haven't done it yet. I really think that may be, in regard to models, the most important thing. These models have no reality check.

At Savannah River they use a plutonium migration model into the ground water that assumes that it will be bound up in soil for hundreds of thousands of years, but at Savannah River and other places, Hanford, Oak Ridge, they have had migration due to organic complexing of plutonium and transuranics into the water that's five orders of magnitude, 10 to 20 years.

So you can see we've got 10 orders of magnitude right there, 5 orders of magnitude from modeling, 5 orders of magnitude. Okay. It's not a surprise that from pure depleted uranium disposal they are getting doses that are 9 orders of magnitude less than a backyard well. And I think that does not comport with common sense. I haven't gotten in all the details of their model. What's the staff at the

NWTRB? How much help do you have, Doctor?
DR. FEHRINGER: Ten technical staff.
DR. MAKHIJANI: Ten people. I think it's going to be very, very difficult to check these things. I have a staff of 10 people also, sort of like yours. Not 10 technical, half your technical staff. A total of 10. It's a very difficult job to keep up with this and to get into all the fine print.
I do think that 2 radionuclides are of great concern to me in regard to adult doses, they are carbon 14 and tritium. Both of these radionuclides cross the placenta. I think the doses from these two radionuclides should not be calculated in regard to adults or even infants. I think doses to these two radionuclides and iodine 129 should be calculated to fetuses at the most sensitive time of their development.
I think, in regard to fetuses, there should be special attention to female fetuses and the time of development of the eggs of the female fetus. You know there are a part of us that are as old as our mother's fetus. Right. If you think about it. I'm as old as -- the egg I came from was made 79 years ago. And that is a very particular time at which the exposure should be calculated for sensitive radionuclides, even though there is not complete consensus that 100 milli-rem is the appropriate

standard because 70 kilogram man is not the appropriate standard.

Now I want to say something about institutional issues. Because the regulatory apparatus and especially the Board's kind of apparatus and apparatus like ours, public interest groups cannot possibly have the resources to look into every single thing that you need to look into.

The integrity of the institution that is doing this work is very important. And in my experience, the institutional issues are the most important issues because I do not trust the integrity of the process. The DOE has thrown out all the inconvenient things as very often and whenever convenient to ignore the inconvenient advice and to take only the convenient advice.

And this technical panel report is one example. So Pigford got ignored, fine. But this report also says that there should be no time limit. This report does say that there should be no time limit. The 1983 report also said there should be no time limit. So in that regard we are going to accept what the EPA said, 10,000. EPA said carbon 14 should be limited but in that regard EPA is really not good, we are going to take this.

Well, in 1986 the DOE published an eastern area recommendation report. In the east, the National Academy has recommended the kind of repository that I mentioned to you should be investigated. On page 1 of that -- not page 1, the first three pages of that were actually torn out before it was sent to the public. I don't what was in that -- page 1, that I could find, and we have still no explanation of why they tore three pages out of 1,000 copies of this thing before giving it to the public -- [holding up a copy of Technical Bases For Yucca Mountain Standards]. They said that they are not going to investigate this kind of repository because it would take too long.

One issue that is very important. All of the calculations are focused on spent fuel. This is also a very convenient thing. I think a lot of the calculational resources should be focused on borosilicate glass and what is going to happen to borosilicate glass. Argonne National Lab has done quite a lot of work on hydration aging. Hydration aging shows the formation of colloids, and the collapse of surface layers of glass into the water.

Until a month or so ago when that news about plutonium migration from the test site came out, there had been some more uncertainty about what would be the fate of these colloids and whether there would some absorption on the rock surfaces sufficient that even a colloidal form of transuranic dissolution or transuranic migration into the water from glass would not be of great concern.

But I think it is very clear now that there is some evidence that colloidal transport is taking place from the test site, that this evidence about hydration aging cannot be ignored. It was published in 1982 by Argonne National Lab the same year in which DOE decided to select borosilicate glass for high level waste disposal.

And it did not systematically pay attention to Dr. Bates' research until after the Yucca Mountain legislation had been passed because Yucca Mountain is really the only repository site of all the repository sites at which hydration aging would be a very serious concern. But hydration has been ignored.

Now I will give you one more example in which inconvenient evidence was ignored. At the Hanford site, which also wound up in the top three of repository -- sorry to dig up this ancient history -- it goes to institutional integrity questions. There was a question about horizontal to vertical stress ratios. And these stresses are causing core disking and shattering of the rocks in the repository and the most inconvenient ratio numbers of that data was ignored even though it was published by the National Academy of Sciences.

Now in regard to institutional memory, I'd just like to give you an anecdote that we found that -- how many people know that the definition of Curie for natural Uranium was changed in 1960? Does anybody here know this?

[Mr. Fehringer raises his hand.]

DR. MAKHIJANI: One person. We are all in this field.

I was surprised to find a few years ago that the definition of a Curie that only applied to natural uranium was changed by the regulations in 1960. It didn't apply to enriched uranium, it didn't apply to anything else, and wasn't designated in any way so if you look at uranium emissions statistics from a mill in 1963, it may be twice as much as you think it was. There is no way to tell.

It was changed back in 1970-something at the request of General Electric.

I could not find anybody in the EPA DOE or NRC who had an institutional memory of this or who could produce for me the set of regulatory records that went into these decisions. Our librarian has to painstakingly collect all of these records so we could go back and assess doses from historical operation of a Uranium mill. That's how it came up.

I think that construction of a repository in this whole of viability assessment and doing things rapidly and having totally unrealistic deadlines is grievously wrong and it's a serious technical injustice. You cannot do serious technical work in this way, you cannot do serious scientific work in this way, you cannot do any justice certainly to future generations by setting completely -- the U.S. has for no reason the fastest deadline for repositories of any country. That's because in the U.S. my economic theory of how the U.S. Government, let me share it with you and then stop there.

The U.S. Government appears to be an economic machine to do two things, convert public assets into private profits, and to convert private liabilities into public liabilities. And what is happening now is to take these private liabilities and to convert them into public liabilities as fast as possible.

Now, I am not against the Government taking charge of these particular private liabilities because I recognize the Government made some commitments in this regard. I also recognize that this stuff contains plutonium it has been useable material, society will have to look after it, whatever your opinion about nuclear power and the creation. We've got this problem. It's here, we have to manage it.

I am for the most responsible way to manage this. I don't think that the kind of calculations standards and assumptions that are being presented are anywhere near realistic or near sensible to fulfill the responsible that we have and so we should not be only 50 years down the line, let alone 10,000 years where our children will say, "iodine 129 didn't they have the fallout scandal in the same month that this viability calculations were presented to this Board and they said 70 kilograms?" I don't think that you want that to happen. I certainly don't want it to happen.

And I think that you're confronted with a monumental job in the Technical Review Board of making sure that this kind of -- I don't think you can even put a bound on the number of orders of magnitude if you are going to have 300 distributions 95 percent, What is the basis for choosing 95 percent?

95 percent is from these everyday confidence limits of how sure are you that you are going to arrive on time to your meeting. It's not a sensible way to cut off the tails of the distribution for 100,000 years from now. It's not at all sensible to say 95 percent.

I think this whole process on which we are using the familiar and ignoring history -- I know that in the U.S. it is a tradition to ignore history. "It's history" means it's irrelevant. We can look back 10,000 years and see what has happened. We can look forward at least 500 years and try to project. Thank you.

DR. WONG: Thank you, sir. Questions from the Board? Dan Bullen.

DR. BULLEN: Just a quick question. You talked about the carbon 14 issue as being important and you said that the population dose was high, or did you say the individual dose was high?

DR. MAKHIJANI: Well, on a global basis, if you assume carbon 14 becomes carbon 14 dioxide and becomes part of the air, the individual dose is extremely small. The population dose is very high. And there is an EPA Science Advisory Board Report on this where these doses are laid out which came to the conclusion that it would assure that it would meet the carbon 14 release limits that were then set in the EPA standard.

DR. CRAIG: Given the framework that you set up. I'd like to ask you to talk a little bit about what you consider a reasonable program for the DOE? Specifically, if you were designing the DOE program for the next five to ten years, how would you structure it?

DR. MAKHIJANI: Yes. I passed out our newsletter in which exactly this question is answered. Because I do take this seriously in that I don't think it's enough for those of us who oppose the current program as unsound to say nothing about how we should manage this.

I think the first element in a sound program is to stop the bad things. This program is unsound. The doses that have been calculated from this repository are at best very marginal, within a factor of 2 of the best case doses within a factor of 2 of your limit.

There is absolutely, and this has been brought down in all kinds of funny ways that I tried to outline, I think from a number of points of view, it's necessary to stop the program and abandon these unrealistic deadlines and have on site storage.

Under those conditions I think it's also proper for the U.S. Government to fulfill its responsibilities partly at least to the utilities by paying for that on site storage. I think on site storage for 50 to 100 years, coupled with a delay of decommissioning of reactors is very important, because there is a vast decrease in decommissioning wastes if you wait for 50 years. That way the amount of low level waste you have to deal with is decreased by more than 90 percent and there are actually a great many economic advantages from combining the delay of decommissioning with on site storage.

I think the Swedish approach of putting equal emphasis on engineered barriers and repository performance is a good one, rather than the approach the NRC has chosen. I think we should have sub-sea bed disposal research, because from the point of view of resources we are likely to use, that is probably the least dangerous or the safest way to do it. I'm not advocating sub-sea bed disposal because we have not done sufficient research to know whether it is a good option or not within the framework of all bad options, whether it is the best or not.

I think that we need to have a waste reclassification that makes sense. Only talking about what is called spent fuel and high level waste now doesn't make sense. There is a quite a lot of other repository destined waste which should go to a repository, depleted Uranium, for example, 300 nanoCuries per gram should go to a geological repository.

In Europe intermediate deep geologic repositories contain everything essentially about Class B waste is this country which we put in shallow land burial. And so I think the repositories should be designed according to that. So that would be my program. And we should got to scientific research rather than looking at specific places.

I think we should emphasize at this time extremely serious work so that we are confident 50 years from now that we know what we are talking about when we talk about doses from a repository. Right now I am confident that we don't know what we are talking about because if in 15 years bodies have calculated 6 orders of magnitude difference in doses, 5 or 6 from the same repository, and 1 order of magnitude of difference in peak dose time, although this is a little bit of a disingenuous because after the peak dose time it is flat for a million years. So it's really a peak dose going out to a million years.

I think we don't know what we are talking about yet. I am confident that we can know what we are talking about if we do better science than what is being done now. I'm very unhappy with the quality of science in the DOE.

DR. WONG: Dan Bullen.

DR. BULLEN: Just one last quick question. You mentioned that you wanted on site storage. Do you think in your analysis that the risks associated with on site storage are less than a central interim storage facility? And why?

DR. MAKHIJANI: Well, I think that the risks associated with on site storage are a tiny fraction of the risks associated with reactor operation for one thing. So the main risks are not coming from storage of spent fuel, they are coming from operation of the reactors.

DR. BULLEN: But just a question to focus it. If you had 100 years of on site storage that reactor is not operating after

DR. MAKHIJANI: That's right, I agree. So that's not the only point. Secondarily, waste are not going to get magically to centralized storage place, so there are transportation risks and you don't know where the repository is going to be although a lot of people wish that it would be in Nevada, not everybody. And so you have to take the transportation risk before you have decided where the repository is going to be. And I think right now based on the evidence, I think Yucca Mountain is a bad place, so I think transporting it to an interim storage would be a bad idea.

There is also an extremely grave political and proliferation risk in centralized storage. I think once you have centralized storage the industry pressures for reprocessing will only grow because you've got all the fuel there. As it is, we are hearing quite a lot of talk about reprocessing commercial fuel to take to Savannah River site, put it through the F canyon and the H canyon. All of these factors have to be taken into account.

Then, finally, you put it into a centralized place and because nobody wants it it will be the place which will automatically have the best performance of any repository site in the country because it will be most politically convenient site. This is not a total hypothetical construct. This has already happened once before when they had the crisis in Denver, in Rocky Flats with the fire in 1969, and AEC was doing research in Lyons, Kansas.

After they promised the Governor of Colorado they take away this waste they announced that Lyons, Kansas was one of the best sites in the country, even though it was full of holes and where they established only two years later that it was a lousy site.

So I think that we can't examine centralized storage as an artificial construct in which we are going to look at certain technical risks and ignore all other technical risks.

And, finally, I would say that while we have seen a lot of movies of these transportation casks, and so on, the real world when those movies are converted into mass manufacture of thousands casks the quality control on these thousands of casks -- I'm not against transportation of waste, and I truly have a lot of arguments with my environmentalist friends that you should not frame transportation arguments in the way they are being framed, and I'm saying this for the public record now, since you have raised this question.

I want to be very frank with you and give you the best benefit of my thinking at some political risk to myself. But I think we must not couch transportation issues in a way that forecloses us from saying, We've got to move this stuff because I think we can't leave it on site indefinitely. That would be very wrong and very risky.

However, I think institutional constraints can be placed for 50, 60 year periods which we need to do a sensible job. I think if you rush building thousands or hundreds of casks, you are likely to have bad casks, bad quality control, a bad centralized site, and a bad repository. That's a lot of reasons to oppose a centralized storage.

DR. BULLEN: Just a quick follow on. If you've quantified the risks, I'd like to see.

DR. MAKHIJANI: I have not quantified the risks, and I don't think a sensible quantification of this list that I have presented to you is possible. That's why we have not attempted to do it.

And I don't think -- can anybody quantify for me the risk of reprocessing if we centralized storage and what the proliferation consequences of it might be? Or is it to be dismissed because we can't quantify it? Would you dismiss it --

DR. BULLEN: I don't dismiss it. I was just wondering, at what point do you think you might be able to quantify it?

DR. MAKHIJANI: I don't quantify -- can you quantify this? If you can provide me with some guidance as to how this is to be quantified then I will do it for you.

DR. BULLEN: Okay.

DR. MAKHIJANI: You provide me with guidance as to how some of these risks are to be quantified. When you have to do thousands of welds, instead of one for the TV movies, what kind of quality control are you going to get, under political pressures? This may be possible to quantify, after a great deal of study.

The risks of reprocessing, I don't think can be quantified. And the risks the political risks that a repository would be found to be a shining example of technical performance once all the fuel is there, granted we are seeing because it was selected.

I call it a double standard standard, what is happening with Yucca Mountain. We got one repository standard, it didn't fit so we got another standard. We have can have a triple standard standard. That's what is going on with this viability assessment.

So the National Academy recommends something, it's not a very convenient, EPA doesn't like the indefinite time, DOE doesn't like the ground water limit, they can't agree, there is a political impasse, so we have a triple. This is the third standard. We have got one legal standard, we have one recommended standard which Congress said we would be sent, and now we have a triple standard.

How can you put a calculation to this kind of political environment which is without any serious thought to 10,000 years from now? Although we're talking about it all the time. I don't trust the system for 10 years. What has happened in the last 10 years to this, what were we told in 1982? So the industry was given a promise in 1998 that this would be taken away.

But the public was also given some promises as to the integrity of the process. And I have been following the integrity of the process since 1984, very close to it. And I haven't any. So what about all those promises to the public, so we have even more promises that this won't be a temporary storage. You know, Brooklyn Bridge can be privatized but this, you can't buy it.

DR. WONG: Thank you, Dr. Makhijani. That's a nice high level, high energy presentation. I think this afternoon is going to be a lot of fun. It's now 12:30. It's time for lunch. I suggest that all of you watch and manage your time better than I can, so please be back here at 1:30.

[Whereupon, at 12:30 p.m., the meeting was recessed, to reconvene at 1:30 p.m., this same day.]

AFTERNOON SESSION

[1:40 P.M.]

DR. WONG: We have one more prepared presentation on today's agenda. And it's Dr. Wayne Berman. He is one of the authors of a study conducted by the Electric Power Research Institute to examine the requirements for disposal of non-radioactive waste. And, hopefully, he may identify some possible lessons that might apply to the Yucca Mountain repository.

Dr. Berman received his Ph.D. in physical chemistry from the California Institute of Technology. And since then he has amassed 16 years of experience developing, performing, and managing site investigations and risk assessments for both government and private clients. So, Dr. Berman?

DR. BERMAN: I want to thank Dan Fehringer and the Board for inviting me today. Although I will be talking quite a bit about a number of the regulations and interpretations of the regulations from EPA and other agencies, these are my personal perspective. I am in no way a spokesman for any of these agencies.

DR. BERMAN: As Jeff mentioned, I will be talking about requirements for disposal of non-radioactive waste and possible lessons for Yucca Mountain. The study actually, that Chris Whipple, Mike Easter and I conducted for the

Electric Power Research Institute, had the purpose to learn what existing regulations and their implementation for environmental carcinogens suggest for the proposed high level waste repository at Yucca Mountain.

Although I might mention that I probably will be recovering some ground that has already been discussed earlier today, but I believe it will be from a very different perspective, so I hope that people find that useful.

The study questions that we looked at were, one, do the existing regulations address problems that are sufficiently similar to those faced at Yucca Mountain to provide useful comparisons? In other words, we wanted to provide a framework for doing this study.

And that, if so, what parts of the existing regulations are potentially informative to the development of future HLW standards, high level waste standards? And then what are the details, what are the regulatory approaches, and the underlying policies that may usefully inform policy makers regarding regulations or standards that might be developed for Yucca Mountain?

With regard to answering the first question, we examined the similarities and differences in the characteristics of chemical and radiological wastes themselves, as well as the kinds of sites where chemical wastes are deposited in comparison to Yucca Mountain. We also looked at the nature and magnitude of the hazards that are posed by chemical and radiological carcinogens, and the kinds of exposure pathways that need to be controlled to mitigate risks from chemical waste sites and from Yucca Mountain.

Now, the kinds of risks posed prospectively by hazardous chemicals and by radionuclides. Chemicals potentially pose both carcinogenic risks and non-carcinogenic risks. Radiological risks, at least the chronic radiological risks, are due primarily to the induction of cancer. However, radionuclides also are chemicals and therefore they have chemical effects. And so they may also pose non-carcinogenic risks that is entirely incidental to the radiological hazards that they pose.

Typically, the non-radiological risks that are posed by radionuclides are small relative to the carcinogenic risks posed by their radiological properties. There are exceptions to this, however. For example, Uranium is primarily a hazard due to the fact that because of its chemical properties it interrupts kidney function. And that the carcinogenic risks posed by its radiological properties are in fact relatively minor compared to the hazard it poses to the kidney.

And just to put this in perspective, I put together a little table here. And what this list is a selected set of radionuclides. Except for uranium I tried to select the ones that I believe are expected to pose or contribute most substantially to the long hazard potentially posed by Yucca Mountain. And I've also selected from a broad range of the kinds of chemicals that are typically evaluated at chemical sites.

And what I've done is, based on the internal radiological hazards that are posed by these radionuclides, I've estimated cancer slope factors for the radionuclides that can be compared directly to the published cancer slope factors for the chemicals that I have here. And I've done that both for the ingestion pathway and the inhalation pathway.

And I think the main take-home lesson that one might glean from this is that you can see very quickly that the range of risks that are covered on a per weight basis by radionuclides and by chemicals overlap to a large degree. They are roughly similar. They cover a very broad range.

And I think the main reason I wanted to point that out is that there really is not something new, something mystical about radiation hazards. That you can manage these just like you can manage chemical hazards and it's a function of being able to manage the concentrations to which people are exposed.

One other thing is, I didn't put the half-lives up here for the radionuclides. And, as you can see, I put question marks next to the chemicals. Now, chemicals tend to be, when they evaluate risks from chemicals at chemical waste sites, they tend to but not always assume that the chemicals are stable and will last forever. And that, in fact, is not true in general.

Arsenic is a metal that will not, within any reasonable period of time, transform and so that is, in essence, stable. On the other hand, the organics I've listed here, particularly vinyl chloride and the lower chlorinated polychlorinated biphenyls, those are the PCBs. There is good literature that shows that they do degrade in the environment at reasonable rates.

And even 2378 petrochloride dybenzodioxin, which is everybody's favorite carcinogen, will degrade at some rate in the environment. And, in fact, based on my experience, I believe that the half lives for these materials in the environment will be relatively short compared to the hundreds of thousands of years or so that most of these others, radionuclides, tend to take to decay.

DR. KNOPMAN: Dr. Berman, excuse me. Would you just explain to me what a cancer slope factor means exactly?

DR. BERMAN: Okay. Yes, they have very strange units also. It's basically the relationship between dose and risk. And because we tend to use what's called a non-threshold -- I'm going to cover this in a little more detail later, but we tend to use an assumption for both radionuclides and chemical carcinogens of linear non-threshold model.

Then, basically, it's a proportionality factor between dose and risk. And in this case you can see the strange units of reciprocal milligrams per kilograms per day. These numbers are based on an assumed daily dose that one might take over a 70 year lifetime. Okay?

DR. KNOPMAN: So the higher the number, the worse?

DR. BERMAN: Yes. The higher the number the more potent, yes. Okay. In fact, that's the reason I put the TCDB up there, is that's one of the most potent carcinogenic chemicals to deal with.

Now, like I said, we also want to look at some of the properties of the facilities themselves. And what I've tried to do here is put in perspective the scope of the kinds of problems that the chemical waste regulations deal with and try to compare them to what you might see at Yucca Mountain.

Let me just point out a couple of -- there is a lot of information on this slide, but let me point a couple of what I think are particularly important and interesting features. One is that you have to recognize that the chemical waste regulations were developed to deal with the thousands to tens of thousands of chemical waste sites that exist around the country. Whereas standards that will be developed for Yucca Mountain will apply to one facility or at most a very small number of facilities.

The volume of waste, chemical waste that's produced annually in this country is huge relative to the volume of nuclear waste that's produced. In fact, I can't confirm this at the moment but I believe that the volume of chemical waste produced annually is probably larger than all of the nuclear waste that currently exists.

Another very important difference is that, typically, at chemical waste sites you are dealing with materials in which the hazardous components represent no more than a few hundreds to a few thousands of parts per million. Whereas, my understanding is that the wastes that are going to be deposited at Yucca Mountain, that the radionuclides that are potentially important there may represent as much as several percent of the material.

There are also differences in design, typical design features, deep disposal versus relatively shallow disposal, and the fact that the chemical waste regulations are largely, at least initially were largely retrospective, because they knew they were dealing with sites that already existed all around the country, many of which were poorly designed and not controlled.

Whereas the standards will be prospective, meaning that they will be designed and the facility will then be designed to comply with the standards.

I'm going to present the next two slides out of order from the package. Like I said, we wanted to look at the exposure pathways that one needs to look at and evaluate to look at the hazards associated with these facilities. And they are similar, generally, between the Yucca Mountain and between chemical waste facilities with a few exceptions.

First of all, some radionuclides emit gamma rays. And this leads to a direct exposure pathway called "shine," which is unique to radionuclides. It's not associated with chemical waste, therefore this pathway, the shine pathway, is unique to Yucca Mountain. At the same time, because most chemical waste facilities tend to be shallow, you have pathways such as erosion and dust entrainment which may be largely considered to be unique to chemical facilities.

But overall, at least generally, the framework of the types of pathways you need to consider should be similar for the two types of facilities, although they certainly vary in the site-specific details that you'd have to evaluate.

Now going back one overhead from the package, the special exposure considerations associated with shine is something that needs to be looked at, because when intrusion occurs in a chemical facility, typically the wastes are not immediately hazardous to life and health. That's a term of art from the Occupational Safety and Health Administration, actually. What this means, basically, is that simply by coming into contact with these materials, your life is not immediately threatened.

And it's my experience that, even though it's not formally listed in the regs in this way, that that's prohibited, that I doubt that there will ever be a case where chemicals will be deposited in a facility at such concentrations where they would be immediately dangerous to life and health. And that's in contrast to the Yucca Mountain facility where, at least for the first 300 to 1,000 years after disposal, due to shine these materials may be immediately hazardous to life and health.

So the conclusions that I draw from this quick summary, to provide a framework from which we could evaluate the chemical waste regulations, is that there are clearly similarities in the types of problems that are addressed by these regulations. And so they are worth evaluating. And it would be important to focus on carcinogenic risks. However, one does need to consider the differences in site designs and also needs to consider differences in concentrations.

Now what we did then was we tried to identify the components of the existing regulations to find those pieces which we thought may provide some useful information vis a vis Yucca Mountain. Since we were looking at risk-based type of analyses, it is true that there are many regulations that exist and policies that are associated with them where there is an attempt to set acceptable risk levels. And these should be transferable across a wide of exposure considerations, and so there are a number of lessons that can be learned on how these risk levels were set.

At the same time, the primary requirements that apply the chemical waste disposal facilities derives specifically from two regulations from the Comprehensive Environmental Response Compensation and Liability Act, or CERCLA, also known as the Superfund Law, and the Resource Conservation and Recovery Act, or RCRA.

RCRA, the Resource Conservation and Recovery Act, does deal specifically and primarily with engineered waste facilities. So that, at least initially, we thought that this might be the regulation that would be potentially the most applicable to Yucca Mountain. However, it turns out that the RCRA regulations are largely proscriptive and therefore they don't necessarily deal directly with risk, although they tend to be conservative.

There are sections that deal with corrective actions and for requirements for closing a site. And those sections are probably the most relevant of the RCRA regulations. And they deal with risk-based decision making. However, the rules for the risk-based decision making in those sections of RCRA derive from CERCLA. Okay.

Now, CERCLA addresses existing contamination at both controlled and uncontrolled sites. A controlled site is an engineered facility, a facility where you've designed it to be protective of the environment and you've put things in that you know something about.

An uncontrolled facility is basically a hazardous waste site that you may have some or no information about but you know that there are hazardous chemicals that are present. This may also include orphan sites which are sites that don't even have any identifiable responsible party for them.

CERCLA does incorporate risk-based decision making. And the procedures under CERCLA that address permanent waste disposal, i.e., the remedies at uncontrolled sites which would include leaving waste in place where you've showed that the risks associated with leaving the waste in place are acceptable, or if you actually dig up those wastes and construct a permanent engineered facility on the site to then deposit those wastes.

Again, there are procedures for doing that and deciding whether the risks associated with that facility are acceptable. Those parts of CERCLA are the most useful for looking at to try and find lessons that you might extrapolate to Yucca Mountain.

The opportunities for lessons concerning regulatory approaches and their underlying policies includes, as I mentioned before, the setting of target acceptable risks. And I'm going to talk about that in some detail in a moment. The application of these target risks to setting quantitative standards and then the scope of the exposure scenarios that are considered for compliance, how you comply with these standards once you set them.

And there are some special features here that I want to touch on, specifically. One is include the time frame over which you evaluate risks, another is the assumptions concerning future land uses, and the last is assumptions concerning institutional controls.

One other area that I will try to touch on briefly is the approaches that are incorporated into these regulations for controlling uncertainty. Typically, when regulators set an acceptable risk target, this is a policy decision and that's important to keep in mind. What they are setting is they are setting an absolute number and the number has no error associated with it. Okay.

And it's typically based on some concept of the levels of concern that might be placed on that level of risk that deal, for example, with various levels of risk, with perceived differences between voluntary and involuntary risks. Now a voluntary risk is a risk that people tend to take willingly because there is a direct benefit associated with it. An example of that is we're willing to take the risk associated with having an accident because we like driving our car, or some of us are willing to take the risk of developing cancer because we like smoking.

Interestingly, at least I think it is interesting that work place hazards are considered to be voluntary risks under most Federal regulations. Involuntary risks that we are subjected to but that we do not perceive as being associated with any direct benefit, an example of that would be living near an airport, or living near an industrial facility, or a hazardous waste site. Generally, the setting of an acceptable risk is established through a politically accountable process.

I want to give a brief history now of how acceptable risks have tended to be defined. And this since it started with the Food and Drug Administration, this is an FDA story. Initially the FDA discovered it, or at some point it was discovered that there are certain chemicals that at that time were shown to be carcinogenic that were found to be in the food supply.

And so, initially, the FDA set what they called safety factors where they looked at the lowest observed effect levels in various animal and chose an arbitrary factor of between 2,000 and 5,000 to divide that observed effect level and then to apply that as a safe level for humans.

However, by the 1950s it was concluded that there was no safe level for exposure to carcinogens because it turned out that the no-observed-effect level was simply a function of the size of the populations of the animals that you exposed these materials to. As you increased the size of the population, then you could get effects at lower and lower doses.

So in 1958, because of that, Congress established a policy of zero tolerance, the Delaney Amendment. And what that said is, basically, that there would be no carcinogens in the food supply. And the Delaney Amendment was based on two, what turned out to be erroneous, assumptions. The first assumption was that there are a small number of bad chemicals. In other words, that there were really a very limited number of chemicals that exist that cause cancer.

The second assumption was that it would be easy to eliminate these few chemicals from the food supply. What happened was is as these debates continued, analytical detection limits improved. And because analytical detection limits improved, we found these chemicals in more and more foods at lower and lower concentrations.

Also, additional toxicity studies were being conducted. And as they were being conducted, it turns out that there were a much larger number of quote, unquote, "bad" chemicals than the very few that were initially identified when the Delaney Amendment was first promulgated.

And now the rest of the story. Leaping backwards for a moment. In 1961 Mantel and Bryon proposed an approach for setting a virtually safe level combined with a defined statistical assurance. In other words, we were assuming that basically there is no threshold for cancer. That no matter how low the dose, there would be some probability of developing cancer if you are exposed to a carcinogen.

However, that doesn't mean that you can't set an acceptable risk level. And what Mantel-Bryon proposes is if you could set an acceptable risk level where the chance of getting cancer would be sufficiently small as to not be important in most people's daily lives; at the same time they would establish a procedure for assuring that if you comply with that requirement, that there a statistical confidence that you would not underestimate the risk to which you were subjecting the public.

By 1970 it was recognized that it wasn't possible to eliminate all carcinogens from the food supply. And so, in 1977, the FDA adapted the Mantel and Bryon approach and actually -- let me back up for a minute. Mantel and Bryon, in their original paper, proposed a virtually safe level of ten to the minus 8th risk, which is a one in a hundred million chance of getting cancer, as being the virtually safe level.

And just to provide something to compare that to, the background cancer rate in the U.S. is one in five. So basically, one in five people die of cancer. But they were suggesting that we should prevent introduction of cancers from controllable chemical sources at one in a hundred million.

In 1977 when the FDA adopted the Mantel-Bryon approach, they set a target lifetime risk on it of ten to the minus six, one in a million. By the way, it is important I point out that all the risk levels that I'm going to be talking about today are lifetime risks. And the reason I wanted to mention that is because I know that in the field of radiation people tend to talk about annualized risk. And so you have to make the conversion. Okay.

In 1988, the EPA also adopted the FDA approach, and they also established a one in a million level of lifetime risk as de minimum. In other words, the level, any risks below that they would figure were not important and not worth regulating.

I want to spend a little bit of time talking about the application of these risk targets. Let me go through this. If you want to apply these risk targets, typically the first thing you have to do is you do this in a risk assessment. And the first thing you need to do is you need to relate this risk to a dose through some kind of a dose response model. And here is how you generate slope factors.

You usually take either animal toxicity studies or human epidemiology studies. And especially if you assume a linear no threshold relationship then it's basically a proportionality factor that relates dose and risk.

And doing this introduces error because you are taking an absolute number that someone set as a policy, and you are now relating it to measurements that have some errors associated with them and to a model with which you are interpreting those measurements. And so you are introducing uncertainty and error and you need to control that uncertainty and error. And the procedures that are used to convert risk to dose typically, to a greater or lesser degree, try to incorporate some kind of control of this uncertainty.

Now, once you do that, then that's called the toxicity assessment part of the risk assessment. Then what you need to do is you need to relate the doses to environmental concentrations so that you can then regulate facilities or other things that you are interested in. And how you do that, basically, is you then take the dose and you relate that to an exposure point concentration.

That's the concentration in the environment that a person would experience. And then, due to the way they take up either through inhalation, or ingestion, or whatever, some model of that would relate the actual dose that gets into their body through the external concentration. And there is additional error associated with that model.

Then especially for regulating facilities, you have to then also relate an exposure point concentration back to the source concentration using some type of fate and transport model. And, again, there is additional error introduced in the use of those models.

Now, let's talk a little bit first about the toxicity assessment part of risk assessment. As I mentioned before, the model that was adopted in the 1950s for radiation was a linear non-threshold model. And what that means, once again, is that by non-threshold it means that the line for the relationship between risk and dose goes through the .00. So that any non-zero dose would be related to a non-zero risk.

It's linear at low doses. That's considered to be conservative, in fact. And that's an assumption. And the reason that it's important to state what the shape of the curve is at low doses is that, typically, the experiments that we have to establish these dose response factors are at relatively high doses, but we're interested in extrapolating them down to very low doses to determine what the risks are associated, let's say, with the Yucca Mountain facility, or so on, and so forth.

This same model was adopted generally for chemicals in the 1970s, so at least the same kind of model in general is common. We apply both to radiological agents and to chemicals. The parameters for these models are typically selected to a greater or lesser degree to control for uncertainty. And, typically, the greater the uncertainty the more conservative the selected parameters. And the slope factors I mentioned before could be derived either from epidemiology studies or from animal toxicity studies.

It's interesting, just to give an example, typically when you are using an animal toxicity study to set a slope factor, the point you select is what's called a 95 percent upper bound of the estimate of the slope factor. And the reason you use that as your estimate, again, is to control for the uncertainty between extrapolating from an animal species to humans.

When epidemiology studies are used to establish slope factors, they typically take what's called the maximum likelihood estimate, the best estimate of the slope factor you derived from the data. So that you are not accounting for the uncertainty because theoretically there is no inner species extrapolation. And that's true.

However, there is still is uncertainty associated with the model that you apply to the epidemiology data and there is still uncertainty or error associated with the finite amount of data you have from the epidemiology study as well. And so there is inconsistencies in how one tries to control for uncertainty in the way the slope factors are derived.

If one wants to set quantitative standards, one can actually do this at any point in the risk assessment. And I want to emphasize this. And let's first talk about the options for setting quantitative standards. And then I'm going to go back for minute to go, over once, more the relationship between risk and various kinds of environmental concentrations.

Regulatory options for quantitative standards. They can be prescriptive. And prescriptive standards have to be prospective. An example of prescriptive involve, for example, design specifications, limits on the total mass, the total volume, or the maximum concentration of the material that can be placed in the facility. And these are usually not directly risk-based, although they tend to be designed so that they are conservative.

Another set of options are called performance based options, and these can be either prospective or retrospective. If they are prospective than the compliance will be based on some type of modeling. That'll be required because the facility will not have been built yet. If theyou are retrospective then, theoretically, you can base compliance on actual measurements at various points in the environment.

And these examples of performance-based standards might be limits on peak exposure point concentrations or limits on release rates at defined locations. Or you could simply model the estimated risk from source concentrations going through the entire chain that I mentioned before. And then do that on a site-specific basis, and then compare the estimated risk that you've come up with, presumably using a procedure that controls for the uncertainty in that risk estimate to the acceptable risk level that you've set. And that, in fact, is the paradigm that's used in CERCLA for site-specific assessments, and these are typically risk-based.

Now to go back to this one last time. As I mentioned before, you establish an acceptable risk level at the bottom. The risk level is an absolute number, it has no error associated with it. And then through modeling you can establish a dose that can be basically equivalent to that risk level, or in exposure point concentration or source concentration. And in all cases these are all connected by various kinds of models that have various sources of error in them and they are all based on various kinds of data that have various sources of error associated with them. When you are setting a quantitative, you can do it at any point in the ladder. You can go up this ladder or down this ladder. The point is, it's conservation of the complexity of the problem. What happens is, you know, for example, if I decide to set a quantitative standard as an exposure point concentration, then I'm taking an absolute of risk that has no error, modeling up to an exposure point concentration and introducing error into my estimate of the acceptable exposure point concentration. And then I would take a source concentration from the field, model that down to an exposure point concentration with error associated with it and make my comparison there.

The point is, wherever I do that or however I set the quantitative standards you can't get out of the fact that you are introducing error in these steps. It's just a question of whether the error is going to be introduced in the standard or it's going to be introduced in the estimates you've derived to compare to the standard.

Current quantitative standards at EPA. They are remarkable consistent due to the bootstrapping effect. Basically, when they found that something works for one regulation, they simply applied it then to the later regulations. Actually, I should do this in chronological order. In the Clean Air Act, in the Clean Water Act, in the Safe Drinking Water Act, and then in CERCLA they all incorporate currently the same acceptable risk range which is a range of one in a million to one in ten thousand.

And, again, the standards, however may be in terms of environmental concentrations and so I'm just talking about the risks that these concentration standards are theoretically equal to, given the models that they use in the various regulations. So this risk range is defined such that below the lower end, below one in a million, the risks are generally considered acceptable.

At above one in ten thousand, risks are generally considered unacceptable and something needs to be done. And risks that fall within the range may be acceptable depending on site-specific conditions and on cost considerations. At least that's how the risk range is applied under CERCLA.

Importantly, these are risks to individuals. My understanding is that EPA does not deal with population risks and it's because of the fairness issue. Basically, EPA does not want to be viewed as being more protective of a person simply because he lives in New York City than because he may live in Lee Vining, which is a very small town in eastern California. And that's why they regulate risks to individuals.

In the attempt to help provide a frame of reference, what we've done here is we've developed a table where we've converted some of the existing regulations and standards for radiological hazards to lifetime individual risks. And so you see on the right, these are some of the converted numbers.

Now, the first number there is actually quite large. It's certainly well above the risk range of 10 to minus 4, ten to minus 6, 3 times 10 to the minus 2. However, there is a very practical reason for that and that is that EPA decided it wasn't in the business of trying to regulate nature.

These other numbers, many of them you can see are above 10 to the minus 4. Now you might conclude from this that that would suggest that chemical hazards are regulated more stringently than radiological hazards. And if you did conclude that, I would say you were probably wrong.

And the reason is that you have to understand there are differences in the procedures that are used, first of all, for deriving slope factors between radiological agents and chemical agents, and the uncertainties are different there. Plus, the way that these are applied are different.

And until you work through those details and understand how uncertainty is controlled and what the relative magnitude of the control of that uncertainty is with each of the models that are used to apply these different standards, you can't make a judgement as to whether these are more stringent or less stringent than the standards that are applied to chemicals. And at this point in time, I'm not prepared to tell which I think are more stringent because I don't know.

Application of EPA's quantitative standards under CERCLA. Risk assessments are performed for three purposes at a site. One is to determine whether remediation is warranted. That's called the baseline risk assessment. The second is to derive cleanup levels, if remediation is required. And the last one is to support an evaluation and selection of remedial options.

Now, interestingly, during a baseline risk assessment, as I mentioned before, nowadays typically if the risks that you find for a site are less than 10 to the minus 4, typically remediation is not required. However, if you conclude that remediation is required then typically cleanup standards are set equal to 10 to the minus 6. So if you have to cleanup anything, you've got to clean things to 2 orders of magnitude greater than the decision that you use to decide whether cleanup is required.

However, one is allowed to adjust those cleanup levels, if it can be shown that cleanup to that level is technically infeasible. And with growing experience, it's turned out that in a lot of cases EPA has had to back off because it has been shown that in a lot of cases cleanup targets at one in a million are just not feasible at a lot of sites.

To continue with this. Usually EPA's quantitative standards are applied using conservative models, this is in the exposure assessment side, and that are very likely to underestimate risk. And this is to control uncertainty.

Typically, they assume that the nearest individual is subject to the highest risk, and that others are adequately protected if the nearest individual to the site is adequately protected. This is not usually the real nearest individual, it's usually a hypothetical individual at defence line of the site.

They do allow use of more realistic models than the ones that they offer in the guidances. As long is still adequate statistical assurance that the risks are not underestimated. And I believe, based on some research that I've done recently, that there are problems with these models that are typically used because there is a mismatch between the characteristics of the data that are typically evaluated and the way that the data are being evaluated.

And this results in the fact that the desired level of assurance is not consistently achieved across sites. In some cases it's more than achieved, and in some cases it's a lot less than achieved.

A brief word about the evolution of standards under CERCLA because this is interesting. The National Contingency Plan, which is basically the document that describes how the standards and the requirements of CERCLA are to be implemented, has formally been revised three times, in 1982, in 1985, and in 1990. In addition to those three formal changes, there have been a tremendous number of informal changes in the guidelines and practices that have been adopted over the years.

And the trends are as follows. Initially, when CERCLA was first promulgated in 1981 and we started doing site risk assessments, first of all the pathways that were evaluated for each site, they considered every conceivable possible future land use. What this meant is, basically they assumed that whatever site they were looking at initially, that some point in the future someone would build a house on it because residential exposures tend to be the most conservative.

They also initially adopted a risk range of 10 to the minus 7 to 10 to the minus 4. And there was a really strong preference not to allow risk greater than 10 to the minus 6 to be left in place. There are also strict cleanup requirements again, to risks below 10 to the minus 6, if cleanup was required.

There was also a strong emphasis on what are called permanent remedies. These are remedies where either the hazardous materials would either actually be destroyed or be removed from the site or at least the mobility of these materials would be severely restricted by chemical modifications.

Now, with time and with experience it turned out that many of these goals were overly optimistic and so that some of these have had to be relaxed. Nowadays they consider for most sites only the most likely future land uses. The risk range is now from 10 to the minus 6 to 10 to the minus 4. And, more and more, the decision point at most sites seems to be on the order that cleanup is not required unless the combined risks from all pathways is greater than 10 to the minus 4.

There are now flexible cleanup requirements that are based on technical feasibility. There is a vastly reduced emphasis on permanent remedies, and there is a much greater emphasis on the use of institutional controls. And I'm going to talk about a few of these in greater detail because I think they are interesting.

Time frame considerations. RCRA design and monitoring requirements typically extend for an initial period of 30 years. So you might think they are only looking 30 years into the future. That's not true.

Regulators have discretionary authority under RCRA to determine the extent, and frequency, and duration of further monitoring and for sites that are not clean closures.

Clean closures are sites where you've removed all known waste from the site. In other words, if you leave any waste in place, there are perpetual five year reviews that are required at these facilities. And during these five years reviews it may be concluded that additional actions can be triggered, either cleanup actions or additional monitoring actions under with RCRA or CERCLA, and whatever might be required to protect health and the environment. Therefore, basically they are assuming that these sites will be maintained in perpetuity.

The other thing is, under CERCLA when you do a risk assessment, you typically have to evaluate the risks over a sufficient period of time to be sure that you've included the peak exposures. And they tend to be, for some sites, especially those that have long ground water pathways, they tend to go out maybe as much as few a 100 years. They don't tend to go out much longer than that for chemical sites.

Regarding land use considerations. Under CERCLA the exposure pathways considered are defined based on the current and anticipated future land use for the site. And historically, like I said before, they considered all possible land uses. Nowadays land uses that are considered are defined based on a combination of current use, zoning restrictions, and the local master development plans.

And in some cases also interviews with local community leaders to see what the consensus is about what is likely to happen in this area in the future. In some they are also part of negotiated settlements. Certain land uses can be excluded from consideration at a site, if the owner of the site agrees to incorporate a deed restriction. Basically, they'll say in the deed directly that this site will never be used for residential use, for example.

Now the fact that they incorporate institutional controls basically come from what I believe is an underlying assumption that I could not find stated anywhere, although it's very consistent with the way the regulations and both written and the way they are applied, and also has basically been confirmed by interviews with a number of EPA staff were directly involved with the development of regulations.

That is that existing regulations incorporate the assumption that social institutions will be stable and dependable for the long term, i.e, forever. And like I said, although this is not formally written in the regulations it seems to be a tacit assumption.

The consequences of this assumption is that, as I mentioned before, institutional control, such as deed restrictions, are routinely incorporated into allowable remedies for sites. Chemical wastes are also typically allowed to remain in place even at uncontrolled sites as long as the risks are acceptable for the anticipated future land use. And that obviously incorporates the assumption that the land uses will not change in the future beyond what was considered.

Sites that are closed with residual waste on site are assumed to be subject to perpetual five year reevaluations, as I mentioned before with a perpetual ability to conduct corrective actions, if needed. Again, this assumes that the institutions will be around, both to have the memory to know where these sites are and to enforce the requirement for reevaluating them and making any changes that are required.

Now, we found this interesting and so we tried to delve into this a little further and understand what the apparent difference is in the way institutional controls and institutional memory are considered for chemical waste regulations and the way they seem to be headed for Yucca

Mountain. And with talking with a number of EPA staff, we've come up with a number of hypothesis.

We couldn't get an absolute answer to this, but two are inferential. One is that, as I mentioned before, times to peak exposure for most chemical hazards at most chemical facilities are much shorter than for the proposed Yucca Mountain and those facilities. Therefore, over a horizon of maybe a few hundred years, it may not be unreasonable to assume that our government will remain stable and that institutional controls can be maintained.

Another idea potentially is that, and this is ironic in fact, is that since chemical wastes are assumed to be infinitely stable whereas it's known that radiological agents decay with time, the idea of time was introduced into people's minds when they started to look at these hazards. And so, ironically again, regarding the agents that are known to decay with time, they started to look more carefully about what will happen over longer periods of time.

There is also a practical consideration here. The practical consideration is that the United States may simply not have sufficient resources to handle the volume of chemical wastes to the same degree of rigor as the more limited volume of high level waste.

Finally, the existing regulations incorporate both formal and informal procedures for controlling uncertainty. I already talked somewhat about how they control uncertainty to some degree in setting slope factors, and at least for animal studies they incorporate formal statistical bounds. But also on the exposure side, when concentrations are estimated, like source concentrations, and so forth, they formally incorporate use of upper bound estimates of those.

Informally, they also incorporate conservative assumptions for parts of models when the input values for those parameters cannot be reasonably defined for measurement or formal derivation. And, once again, typically the greater the uncertainty, the greater the degree of conservatism that is incorporated. Questions?

DR. WONG: Thank you, Dr. Berman. Questions from the Board?

DR. CRAIG: Back at the beginning of the talk, you made a reference to the difference between voluntary and involuntary. And you also made reference to perceived risks. And then those important concepts didn't show up later on in the presentation. So what I'd like you to do is go back and talk to us about those, particularly the way in which the regulatory process deals with perceived risks which, as we all know, are critically important in the area of concern to us.

DR. BERMAN: That's a difficult question to answer. Let me try answering it this way. First of all, the part of the talk that I introduced, those concepts had to do with the policies with which acceptable risk levels are set. Once you set acceptable risk levels then it becomes more of a technical problem in how you are going to derive quantitative standards and how you are going to apply them. And so that's why I introduced the concept early on.

The problem is that, at least to the level that we were able to delve into this, there is not a lot of formal documentation on these kinds of considerations. I believe that there were considerations, with regard to perceived risks, in setting acceptable risk levels. First of all, at least initially, people just simply set the lowest levels, as I showed at the history of the FDA story.

People started by setting the absolute lowest levels that they could even think of because they figured they could punt on the problem then and not have to worry about making more realistic decisions. But as time progressed and they realized these had to be applied in real situations they had to back off on those. And so then they did start looking at comparative risks, you know. And there are a number of published studies I know, that I'm sure that people who set risk levels have looked at.

For example, relating to the difference between certain contributions to risks and the magnitude that is perceived for those contributions versus the actual contributions to risk in daily lives. And there also is clearly a difference in the acceptability of a risk whether it's voluntary or involuntary.

And, for example, in the case since it is known that the risk associated with living near a hazardous waste site is clearly an involuntary risk, they, I would say rightly, decided that that had to be regulated more stringently than the kinds of consumer protections, for example, which tend to fall under the categories of voluntary risks, and people are willing to accept larger voluntary risks.

DR. CRAIG: So in some fashion there is a hidden assumption in regulatory process that allows for different standards to be set for involuntary and voluntary risks. Does that show up in your interviews?

DR. BERMAN: I wouldn't go so far as to say that. And I certainly wouldn't speak for the regulators. But I will simply say the way I would phrase it is simply that I think that the regulators who set these acceptable risk levels, that we are now living with, were cognizant of those differences and the sensitivities that the public showed towards the difference between voluntary and involuntary risk.

DR. WONG: Debra?

DR. KNOPMAN: Could you tell us a little bit more about EPA, the folks in the EPA for whom you did this, who are using your analysis? I think it's an interesting comparison to do and I'd like to know how it's informing their own --

DR. BERMAN: First of all, we did this analysis for the Electric Power Research Institute.

DR. KNOPMAN: But you said you spoke with EPA.

DR. BERMAN: I interviewed various EPA staff who were identified as having been involved with the development of the policies for a lot of these regulations so we could try to get a feel for the history. But at this point in time, they are not yet familiar with the results of this study.

DR. KNOPMAN: Okay.

DR. BERMAN: A lot of this, by the way, is based on my own experiences because I started, basically I was with a group at Clement Associates who pioneered the development of procedures for site risk assessments right after CERCLA was promulgated. And I've been working under Superfund for the last 16 years since that time so that I've seen how it's evolved with time.

DR. KNOPMAN: For whatever it's worth, when you get outside of the hazardous waste area, EPA is involved with setting risks on a population basis rather than individual basis. The Clean Air Act is a good example. It's very clear legislative history that its' populations as opposed to individuals.

DR. BERMAN: That's a point well taken.

DR. WONG: Any more questions: Okay, thank you, Dr. Berman. At this point in the agenda it's called for that we have a break for about 15 minutes while we set up for the round table. So 15 minutes let's have everybody back here.

[Recess.]

DR. WONG: Let's try to start. We'll begin the round table portion of the meeting. As you can see, we divided up into like teams, like a debate, with Dan and I in the middle. So, again, we will begin our round table discussion.

First, we have some participants with us now that did not make formal presentations earlier at this meeting. And I'd like to offer them each an opportunity for a short opening statement.

First, I would like to turn to Dr. Kjell Andersson. Kjell has been very kind to travel all the way from Sweden to join us today. Dr. Andersson has extensive experience with nuclear waste programs in european nations, especially Sweden. Among other projects, Dr. Andersson has served as a consultant to the Swedish National Council for Nuclear Waste, which is the advisory body very similar in organization and function to the NWTRB.

Dr. Andersson, given your familiarity with environmental and safety standards for radioactive waste disposal in Europe, we would enjoy your thoughts on DOE's performance measure that you've heard about today. Please.

DR. ANDERSSON: Thank you. I appreciate being here and being invited by the Board to discuss these issues. First of all, I will address three issues, but as background maybe a little bit of a perspective. You have three varieties of regulation. You have the existing one, you have the proposed one, and you also have the DOE sort of interpretation of the situation which I've heard about today.

In Sweden we have a sort of equally confusing situation in that we don't have specified regulation for a repository. We do have regulations for releases from existing nuclear installations in operation. But for a repository there is no official criteria set, although there have been a number of advisory documents to the responsible bodies.

And also there is draft regulations which have been sent out from the Radiation Protection Institute and the Swedish Nuclear Power Inspectorate. They have been sent our for comments and are being commented on, and probably not too far into the future there will be regulations in Sweden.

But, of course, we can say that the same kind of issues come up in my country as we heard about here. One is the issue of time limit, whether you should have a time limit or not, it's also a discussion in Sweden. In a way it's easier for the Yucca Mountain case because for Swedish repository we would expect to have an ice age where the ice would actually cover the area of the repository in Sweden, which certainly is a much more difficult situation to evaluate. If I understand it rightly, in Yucca Mountain you would expect during an ice age you are talking a factor of two or three increase in precipitation which is something different than having an ice cover over the repository.

Still there are arguments that there should be no time limit in the regulations. And my personal comment to that is this is rather an issue of value judgements which should be discussed rather broadly and not just among the experts. I observe that you have now, which have been discussed by the DOE here, a 10,000 year performance measure, but then also a post-10,000 year goal, I saw in one of the papers. I have also seen calculations for millions of years.

And I've seen in the papers and we've heard it today that you would expect the peak doses to come, say, within 20,000 to 30,000 years from now. So then one could ask, why not have a time limit of 50,000 or 100,000 years and you would cover the expected peak doses, or just performance measure for the time of peak dose?

The second thing I would like to address is, transparency of performance measure assessment. How do you make it understandable to the public? Because, as we have discussed in Sweden, we cannot get a repository if it's not acceptable and accepted by the public. And to get it accepted you must establish some sort of public dialogue.

And the probablistic approach which is entirely being used here adds a dimension of complexity versus a more deterministic analysis because you talk about regression analysis and so on. These are not really issues which you are so easy to discuss with the public.

Of course, I realize the probablistic assessment is comprehensive and takes care of, in principle at least, all the uncertainties, provided that you can assign probabilities to them. But my personal reflection would be that the probablistic analysis would need to be somehow complemented with deterministic approaches to discuss some sort of "what if" scenarios, and so on, with the public.

And then the third reflection concerns that we have, I would say, value judgements behind what is being done in performance measure in setting criteria. Another probablistic analysis presented here, it's done in a way that it seems to take care of everything in a very technical manner.

But there is a danger then that you hide the underlying value judgements in the analysis behind the assumptions, figures, and so on, being used.

The issue of time scale is just one such issue, and whether to include human intrusion in the performance assessment or not is another, and if you should do it, how?

So there are a number of ethical issues that need to be discussed and we need to invent some sort of procedures for doing this. It does not mean that science is not important, of course. Still we have things which are factual issues that you must be able to discuss between experts, but you also have uncertainties where you need to take care of with some sort of expert judgements.

And when you put the expert judgement into the probablistic assessment, how do you discuss them, and also the value judgements which are behind the basic assumptions? So my advice then would be to put this upper layer on the table, make it transparent to public dialogue.

DR. WONG: Thank you. Next we have somebody representing Nye County, Phil Niedzielski-Eichner, the home of Yucca Mountain. And Phil has been following the site characterization work for many years. And, Phil, would you like to share with us any comments?

DR. NIEDZIELSKI-EICHNER: Thank you. Nick Stellavato, at this point will not be here. He will be here this evening and enjoying the activities tomorrow. He asked me to step in on his behalf. I'll just note that Nick is Nye County's on-site representative, essentially the eyes and ears for the County at Yucca Mountain.

And beyond just monitoring the work of DOE and its contractors, Nick has designed and implemented a program of kind of proactive site investigation of his own, on behalf of the County, which includes data collection. And he has done some fine work and we'd commend any of that work that's done under Nye County's oversight program to those in the room.

I thought what I would do is just very briefly highlight the fact that there is great uncertainty about the future when you come to the point of trying to predict population. Nye County's own vision for example, of what will happen in Nye County is substantially different than what you see out in the population centers now, even as Steve described this morning.

For example, the County within the past four months, has designated the 95 corridor running from Indian Springs in Clark County north to Tonopah as the Nevada

Science and Technology Corridor, an explicit economic development strategy to take advantage of or better advantage of the Federal activities that occur within Nye County.

Now, one might say that the aspiration is wishful thinking, but we recently completed some scenarios that would look at a low end population growth perhaps exceeding 50,000 population within the southern Nevada rural areas, this is separate from the urban center in Los Vegas, going up to 180,000 with a much more diversified economic base.

The plans the County has begun implementing include development centers, for example, towns that have been referenced this morning, Beatty, Amargosa Valley, Pahrump, and again, Indian Springs. And there are those of you who might be involved in economic development might appreciate the possibilities that exist along the corridor, and I won't elaborate on them today.

Just to emphasize though that the uncertainty as to what will happen in Amargosa is significant. It could stay the same, or it could be significant -- one bounding factor of course, is water. And what that remaining unappropriated water, what happens to that unappropriated water and how it's used by the community is going to be an important in this development in the future.

The second I'd make is with regard to ground water. And we agree with the assessment that there is an inadequate characterization of the ground water whether it be the flow, for example, what basins flow from certain basins, or whether closed basins are now complete, that there is an inadequate characterization leading also to volume.

Steve referenced what was perceived to be available at this time, but we really believe that additional characterization of the ground water will tell us a different story than we know now, to the point where the County has completed a comprehensive look at the currently existing data bases. It has a report about to go out to the community, particularly Pahrump and Amargosa Valley, as to what it anticipates would be available water. Plus, what needs to happen to more effectively characterize the site or the region surrounding the site.

It has put together a program, a long return program, for putting wells in and monitoring off-site the water supply and water characteristics. And with that I'll just be happy to participate in the discussion.

DR. WONG: Thank you, Phil. Next we have Engelbrecht von Thiesenhausen, who represents Clark County, that's the county that Las Vegas is located in. And as the largest population center near Yucca Mountain, Clark County has an obvious interest in the Yucca Mountain project and it's impact on the region. So Mr. von Thiesenhausen would you like to make some comments, please?

DR. VON TIESENHAUSEN: Thank you for allowing me to participate in this discussion. When I first moved to Clark County in 1965, it had a population of about 250,000, and today we're looking at well over a million. So this will give you some idea of the growth rates in the area. Whether those same rates will be reflected in Nye County also, is difficult to say, as Phil mentioned, because of the water situation.

But it is certainly not unreasonable to assume that there will be major changes in population, in demographics, in the economic base of Nye County in time. And I guess the reason I bring this up is with the question of the critical group it is probably, I hate to say, shortsighted almost, but just to look at today and say that this is going to be what it's like 5,000 years from now or 200 years from now, even.

Otherwise DOE's interim post closure performance measure I think is fairly reasonable. I would like to see the goal of 25 mr past 10,000 made into a performance measure actually. The difficulty I have is with the whole concept because so far TSPA has been basically intransparent to me.

I have not gotten any documents that have given me detailed assumptions that were made, issues that were decided on, what data was used, and how it was put into the calculations. And I would strongly recommend DOE to come out with a decisions document, or something on that basis, that goes through all those steps for TSPA.

In other issues, I guess, a lot of comment has been made that work on Yucca Mountain should stop and there should be no interim storage. I don't advocate Nevada as the place to have either a repository or an interim storage facility, but I think from a standpoint of generational equity, it is probably unjust to drop the ball and wait 200 years to see what will happen.

And I think we owe it to our children and their children to address an issue that has benefitted this society. And to address it in a manner that is safe and still leaves them the option of doing whatever they might decide to do in the future. And, otherwise, I'll be happy to throw in my two cents worth whenever I get the chance.

DR. WONG: Thank you. Let's open this up to a general discussion. We've heard a number of calls for increased transparency, reconsideration of what the exposure scenario should be, consideration of change in population and land use. And, I guess, that's all implied criticism of the current DOE approach. So with that, I'd like to ask Steve or Abe Van Luik to maybe make a few comments about that.

DR. BROCOUM: Let me just make one general comment here. Sitting around the table looking at people around the table, and I'd say two of the three parties are not at the table. In other words we are talking about our performance measure which will probably be in place a year, maybe two years, maybe three years depending on how long it takes EPA their standard.

The fact is that we don't decide that is, EPA does. So EPA is not at the table. I do see them in the audience. And, of course, the other part, how to implement it is very important to the NRC. They are not at the table either. So it's a kind of interesting discussion that the two key players who will decide what the standard is and how it's implemented are not at the table.

That's my general comment. Now is there anything else, did you want me to comment on something else? You've mentioned a few things.

DR. WONG: There is the issue of transparency.

DR. BROCOUM: We talked a second about the issue of transparency, and Abe can talk a lot more about this. Of the key areas, scientific investigations, the design, and the TSPA, the first two have been Quality program for quite some time. TSPA has not. And we are in the process of putting the TSPA under the QA program which should help in our traceability.

In other words, tracing through what kind of data, what data was used. Making sure there is traceability from one document to another, and so on. We recently visited WIPP, where they've gone through this process in applying for the certification from the EPA. And they told us it was a much bigger job and challenge than they thought it was when they started it four years ago.

Actually getting all this stuff, getting it traceable, getting a system in place that they know exactly, you know, control the codes, control the parameters, we have a big job to do that for a license application.

We are on our way doing that now, but we don't know if we can cover all of that in time for the VA. But we have started the process and we've put it under a Q process, and we'll do the best we can over the next year.

But looking at WIPP, it took them four years to get that whole process, and I'm not even sure it's completed yet, at the place they think they should be. So that's my comment on transparency. Did you want say something, Abe?

DR. VAN LUIK: Well, I can say something to the effect that Engelbrecht has read our documents and couldn't make heads nor tails out of our value judgements, I think it was the term Kjell used. In fact, we're very acutely aware of that, because even internally, with the NRC reading our products and asking us questions that should have been obvious had they done the work that we did and thought what we thought, we're acutely aware of this need.

And we are trying very hard to address this by having the people doing the modeling write down their assumptions as they do the work. What this is going to do is create a very large document which in itself is very daunting to the average reader. Even though it may be more transparent, there is also a price to pay on whether or not anybody is going to open it and tackle it. So we're very aware of it.

We are also looking at doing deterministic analyses as illustrations. And the issue was brought up this morning, are you going to do just random sampling? Also, to illustrate certain sensitivities, we will also do what we have called "stratified random sampling" where we push it out to the boundaries to see what the importance of an analysis actually is. And all of that will also be described.

We're looking at well over 1,000 pages this time, and it may be more than that in order to fold all of that into the document. So that no matter who the reader is, if they really want to know what the assumptions were, what the underlying importance of something is, they will be able to find it in this document.

It's a daunting task but this is what we're trying to do in practice for this year. And then in a couple of years for the license application, of course, it'll be for real because the societal decision will be based on that latter document.

DR. WONG: Engelbrecht, do you have any specific suggestions for the DOE on increasing transparency? I guess I would ask that also of Kjell.

DR. VON TIESENHAUSEN: I guess I could just comment that traceability and transparency are not necessarily synonymous. And putting something under a QA program doesn't make it more understandable. It may mean that with a lot of time and effort you can finally find out where you got to and why you did it, but that isn't going to help me and it isn't going to help the other participants in the program.

It is an immense undertaking at TSPA. And I have to agree it is going to be a very difficult task to go through and say, We made this assumption here, and We made this assumption here, and Here we had a data point, and Here we had two data points, and Here we made another assumption, but this is the kind of thing that we're looking for.

And we're also looking for the degree of uncertainty in the data points. We're looking for the total degree of uncertainty in the final answer. And just something that I can go to my commission and say, "This is where they are, this is what they've done, and this is how much faith I can put in that number."

DR. WONG: Phil?

DR. NIEDZIELSKI-EICHNER: I've raised the point about inadequate data. And no matter what kind of machinations one puts into the TSPA, in the assumptions that go into it, with the limited data points that we understand exist, if you don't have some more informed data or more data that can inform the model, than we would question the value of that, you know, that the models are inadequate in their data. It's as simple as that.

So our greatest concern, Nye County's greatest concern, is the way in which the water supply is characterized and the flow patterns are identified. And if the model is inadequate in its base data, while expert judgement is to help compensate for that, we're concerned that that may not be sufficient.

DR. WONG: Dr. Makhijani?

DR. MAKHIJANI: I'd like to make a relatively simple suggestion for making transparent the numbers that have been generated so far. In my talk I cited a variety of dose estimates that have been made by official bodies the last 15 years, contractors, the National Research Council, DOE. They have been ranging from a few milli-rem to 20 sieverts.

It would be interesting to write down these doses, who has made the calculation, what were the basic assumptions in the calculation, starting with the 1983 National Research Council Report, and what were the changes in the assumptions that were made that resulted in the different dose numbers, and how that relates to exactly how the scientific work was done that resulted in the change of numbers.

One would hope that changing calculations were not just tweaking models but actually reflected some progress in the scientific investigation of the site. So I'm presuming that you are able to show that there is some scientific investigation that is going on and that it is somehow related to these dose numbers. That, I think, would be an extremely meaningful exercise.

And if you can make the documentation available to folks like us that might want to check up on it, that would also be interesting, because in the example that I cited earlier about the science applications and the depleted uranium doses, they cited some swedish literature, KBS study, for certain values of groundwater parameters. And when we looked at the study, actually the original reference didn't reflect what was cited.

So things like that. Relatively straight forward stuff that you might submit to an english major that loves how to write, some published story teller that can understand numbers. There are people like that. I have a couple of them in my office that do our editing. And a set of references that are for more egghead folks like me.

DR. CARTER: Excuse me, Mr. Chairman. Might I? I'd like to suggest something that's related to what Dr. Makhijani is saying. I don't know what he'd call that list to begin with unless it's Walk the Plank List, Go overboard If You've Made a Mistake, or something. I'd like to add not a facetious thing, but related to this morning.

I thought if I had an opportunity that I would ask Dr. Brocoum if he would comment on changes in the dose versus time curves that have been mentioned by several people. As far as I know, the changes on those, namely the lowering or flattening of the peak risk or the peak dose, the shortening of the period in which that will occur in terms of the time into the future.

I think that's extremely significant, and there obviously has to be reasons for this rather than, you know, errors in the calculation, and what not. So I wonder if they would address that, what engineering enhancements or fixes, if you will, explains the changes, the significant changes in the dose time relationships? And they relate very significantly to at least part of Dr. Makhijani's --

DR. MAKHIJANI: If I've actually helped them catch errors, I think it would be a great accomplishment. Because this is the time to do it, not 40 years from now, because right now you can fix the mistakes.

And I think there is absolutely no shame or anything negative in catching an error in science. I mean, we all make mistakes. Certainly I have, I don't claim to be and don't -- I try to be as error-free as possible, but I know that's not possible. And so a process that makes you actually check your work and catch the mistakes, I think should be a good one.

DR. CARTER: Well, I think we're both on the same side of that, you know.

DR. MAKHIJANI: Yes, I agree.

DR. CARTER: I'm not for errors and you're against errors. Otherwise, I'd like to reframe the question.

DR. WONG: Go ahead, Steve.

DR. BROCOUM: Let me just answer the first question about making the material more available. What we're looking at doing for the license application is actually write the document or documents in the format that they would be on line on the Internet, so when you see a reference you can click to it and it can take you right to the reference.

We have experimental development in house. We've done it for a couple of small documents, the seismic topicals one and two, and so forth. The license application, our vision is, you know, we'll have a license application with a TSPA outlay, it'll be online. All the links will be in blue so if you want to check a swedish reference, you click it and it'll take you into our database, that reference. You can even go through data from that, if we can pull this all off.

That's a big job to implement. In a sense it requires a different way of working than we've been working up to today. We won't have that for the VA but we are working on it. Okay. So I think by the time we get to L.A., much of our information will be available on the Internet, many of the references, you can click to. In a sense, the license application will be on an electronic documents.

We've broached this idea with the NRC. They like it. It goes a long ways to addressing their concerns about the LSS, and so on. So I think that's coming and in the next few years that'll come very fast.

I just wanted to make a comment here on some of the changes, and then I'm going to let Abe go into a little more detail. But, basically, the big change we've had in the last few years at the mountain is the percolation flux, the amount of water flowing through the unsaturated zone.

And based on a higher percolation fluxes, we've had more water, you know, and the waste packages and the waste packages corrode faster. And that's led to the earlier releases and to the big doses that occur in the 20 or 30,000 year time frame.

Also, I understand we are using a more up-to-date solubility for neptunium, several orders of magnitude lower, and so you don't get that peak from neptunium that occurred several hundred thousand years in the future.

The latest work we are doing on PA suggests that two key things that are driving performance right now is the corrosion waste packages, and the models you use, and how many of them get wet in all of this, that's the first thing.

And the second thing that's related is the amount of infiltration in the drift. That's more important, in a sense, than the percolation flux.

So understanding infiltration to the drift is key. And understanding how wet or what percentage, however you want to characterize it, waste packages get wet, is also key. Those two things affect performance more than just about anything else right now, based on our state of knowledge at this point. If Abe wants to amplify anything I said --

DR. VAN LUIK: Well, at the risk of taking time away from other issues, I don't detract from anything that

Steve said. The change in the solubility of neptunium is interesting because it was hotly suggested to us by a member of the Board. And so we did an internal inquiry into all the data available and decided, yes, we can lower, that's defensibly, for a couple of orders of magnitude.

And so that brought the previous, you know, second peak into first place. And that second peak has always been a lot sooner than the hundreds of thousands of years. And then multiplying the infiltration an order of magnitude from the modeling updates from a year and a half ago, basically got us off our butts. Because the low infiltration rates that we were assuming before made it very easy to ignore a lot of things in the near-field environment that now stand out as very important.

So a lot of these changes that you've seen over the last year basically in the dose curves have been due to our progressively changing understanding. I wouldn't say improving, but changing understanding of the way that things work. And I believe that in the VA you will see yet more changes coming up because of the greater emphasis we're putting on understanding the processes in the near field.

About your other suggestion about doing a little history of dose curves, I actually advocated that at one point and compromised with the people doing the work. My favorite thing is to always go back to the 1983 WISP report because I think in a way it was prophetic. Because, you know, the calculation was done for the saturated zone with the warning that, Hey, this may not work out too good, and then, Oh, if you're going to go to the unsaturated zone, add 4 orders of magnitude to the time but everything else stays the same. That's very interesting because you know, there is something to that, although we're seeing a lot of non-linearity in the way that we're approaching things now.

But to get to the point, for the TSPA-VA, we are going to compare the calculations since TSPA-1991, maybe throw in the P&L calculations that were done in 1988. But we're still not sure of that, because the point is to start at a point where we had a conceptual model and then to walk through the changes that happened over time in that conceptual model which drives these changes.

We don't particularly want to get into what everybody else has assumed for a conceptual model except the NRC. We want to look at their calculations and throw them into the comparison. So we're thinking along the same wave length that you are, except in a more truncated fashion, to make it more manageable and to make it more meaningful for us.

DR. WONG: Kjell?

DR. ANDERSSON: I think there are ways for one to make the criteria the performance assessment more transparent. Certainly, traceability is one part of it but certainly it's not the key problem. And I hope Abe didn't mean that it would only mean that the reports would be even more extensive just on the extra that you put into it.

I think two areas, first, the TSPA itself and then the procedures around it. And for the performance assessment, itself, I mean we've just got illustrated from DOE that certainly there are alternately key factors that really drive the results from the performance assessment, waste package degradation, radionuclide solubilities, dilution, whatever. A few of these things are really important ones when you look on the results.

Hopefully, that could be explained maybe even not within 1,000 pages but with 5 or 10 pages. That's about how to present the results from the performance assessment itself.

And then something could probably be done about the procedures around the performance assessment and somehow try to establish fuller or more dialogue between those who do the performance assessment and non-experts with the aim to make it clear what are the facts, why do the experts disagree, or why do we have uncertainties, what are the values judgements behind, a much more interactive approach.

Of course, this is easy to say coming from a small country like Sweden and probably much more difficult to do in a big country like the U.S. But in Sweden at least there is now really a strong trend in this direction in establishing more open meetings and public inquiries, and so on.

One of the ways, and this is what I think Abe or what Steve said here, is that you don't have the regulators here. And what we've seen in Sweden with site selection program, which really then involves also the local communities, that they ask for the opinions of the regulators, they ask, "What criteria are you setting for the performance of the repository?" From our perspective at least, they should be participating.

DR. VAN LUIK: Can I make a quick reply to that?

DR. WONG: Sure, go ahead.

DR. VAN LUIK: I think you'll find this interesting and I hate to keep doing this, saying, "Yeah, we're doing that, it's in there," but I have just reviewed from the M&O, in fact, an overview chapter that walks you through what's important in the chapters that follow and why it's important in the context of the whole system. Also, it's not an easy chapter to write, but I think we've done a credible job. I think it was 11 pages, so it fits your criterion almost.

MR. FRISHMAN: I want to go back and take a look again at what's driving the changes and estimated doses through time. And my take is in a way similar to what was described, but I think it also points up something really fundamental that's going on in the program right now that needs to be recognized.

First, I think that for having watched it all these years, the big changes have been coming from two things that are interrelated. One is changing understandings of the conceptual model of the site. And that was said a slightly different way earlier, that that's a really key factor and primarily having to do with the percolation flux.

The second is changes in the conceptual design of the repository in response to the changes that data have brought in the conceptual models. And what's happened is we're now looking at a site that is conceptually, in terms of operating as a repository, very, very different from the site that was named in 1987. What we're looking at now is a site that relies on engineered barriers, a site including thermal loading. We're looking at a site that relies very heavily on dilution at the water table.

Both of these are entirely contrary to our concept of geologic isolation beginning back in the late 50's. We're doing things now trying to show that this site performs in ways that we never thought were valid in terms of why we talked about geologic isolation in the first place, because we were looking for a stable geologic and hydrologic system.

So it has gotten to the point now -- I just want to read a couple of paragraphs from a statement that John Garrick, chairman of the NRC's ACMW made, back in their July meeting, because I think it's really telling and I think he sees what's going on just as some of the rest of us do.

"It's clear to me that we're never going to be able to characterize a geologic site with sufficient confidence to say that we can depend upon that 100 percent for containment for all time. We haven't been able to do that, we're not even close to it."

So unlike maybe we were thinking a few years ago, we were sort of content with the concept of geologic isolation and it's ability to dispose of waste, I think now we're seeing that, at least for high level waste, we're going to have to depend on some form of engineered system probably regardless of the site.

This tells me that at least some people, in positions of understanding and probably influence, understand what's happening to the concept of geologic isolation. And it's happening because of Yucca Mountain. And it's happening because of what little sort of continuing data come in keep changing the conceptual model of the undisturbed system, and lead to reliance on engineering, and lead to something that is essentially anathema to all pollution control thinking today, and that's that you don't rely on dilution in order to mitigate pollution. So we're really going backwards and away from what we originally thought of as geologic isolation.

And let me show you the extent in the current dose estimates, the extent of reliance just on dilution and engineered barriers. I'm just looking at the same two charts and I'll give you some numbers. These are the 20 kilometer dose estimate and the 5 kilometer dose estimate.

At 20 kilometers you don't even see any doses at 10,000 years. And you see 1 milli-rem at approximately 20,000 years. At 5 kilometers you begin to see doses at about 7,000 years. You see 1 milli-rem at about 10,000 years, as opposed to 20,000 at 20 kilometers. And your peak dose shows up at about 17 or 18,000 years for 5 kilometers, and it shows up way out at 24,000 for 20 kilometers.

That is, first of all, evidence of a remarkable reliance on dilution based on distance between 5 and 20 kilometers. The period of time when the doses appear and when the peaks appear show a remarkable reliance on what nominally is going to become probably a 10,000 year waste container. So the big question I think, the fundamental one that this points out is that, yes, we do understand, or at least I think I understand why the dose estimates have changed so much.

And it's because the entire concept of geologic isolation is gone and we have a new concept which is engineering isolation in a geologic system and reliance on dilution. I think that's fundamental to what's going on here now. And it shouldn't surprise us that we see doses through time jumping all over the place because we're not even talking about the same systems.

DR. NIEDZIELSKI-EICHNER: I'd like to speak to that as well. Steve points up a concern that Nye County has had and that's been evolving over the past year, to the point where the county has put forward the proposition that, at a minimum, if there is going to be a shift to an engineered system that the alternative must be considered that includes ventilation in some type of fashion.

Because if dilution is to be relied upon, if we're moving in the direction of dilution, then the County is very, very concerned about that and believes, based on its own modeling, that the closed but ventilated system is going to provide the better alternative. At least we believe that the Department, the regulators, ought to take a look at that alternative.

MR. FRISHMAN: Can I just follow up with one additional point that's right on top of this, very quickly?

DR. WONG: Sure, go ahead, Steve.

MR. FRISHMAN: If you look at the 20 kilometer versus the 5 kilometers of 40 CFR 191, as I tried to point out and illustrate, that's your dilution field. But at the same time from a policy standpoint and especially from a policy standpoint relative to the State of Nevada, what that is saying is, if this is accomplished, the DOE is doing something that no one else is allowed to do and that's pollute the ground waters of the State.

These are public waters. And this distance out there for 20 kilometers, that is water that's under the jurisdiction of the State. And the State doesn't allow anyone else, under not only State law but Federal law which we have adopted and we administer -- what's that doing is injecting pollutants into the ground water of the state.

So I don't quite understand why it's so cavalierly stated that this 20 kilometers is such a good thing when you are using up permanently somebody else's resource. It's not even a resource that's yours to burn. What you are doing is you are relying on the dilution capability of the resource of the State of Nevada to try to solve your problem, and doing it in a way that would be illegal for anyone else to do.

DR. WONG: Kjell?

DR. ANDERSSON: Comments to what Steve said here. One is about dilution. I mean, as soon as you have individual dose as a performance measure, inevitably dilution will be an important factor in the PA because the dose will be inversely proportional to the dilution. And we have a very good example of that also in Sweden when we discuss for instance whether to have an inland repository or a coast repository.

The inland repository there will be lakes and wells as the primary recipients. A repository close to the sea, we would have the sea as a recipient, a much higher dilution and probably much lower doses, although this is not really discussed in Sweden so far. But when we come to these valuations behind performance assessment and criteria, we will certainly get that issue on the table.

The other comment is about the role of the geosphere. I think it's not just something for Yucca Mountain it's also in other countries and other programs, also in crystalline, where we have repositories in crystalline rock that the role of the geosphere is decreasing as a barrier for radiation transport has been decreased. We are now talking about things like fast transport pathways also in crystalline repositories, and so on.

DR. WONG: Arjun.

DR. MAKHIJANI: I think that dilution is not the inevitable solution. I think that this is frowned upon by a lot of people, it's not inevitable. The first approach to that is to select a place such as the one I mentioned, where the question of the consumption of the resource doesn't arise. So if you are talking about, say, the east, in which there are plenty of surface water resources and you are talking about a repository in which there is brackish water, so far as human intelligence is going to allow us to project, these resources are really uninteresting.

And no one is going to go down into brackish water in this area because it would be much cheaper, even if you wanted salty water, to desalinate the ocean. And so I think the idea that an individual dose -- dilution is the solution or that it is inevitable is really not correct.

I'd really like to hear a response to Steve's remark because I'd like to know whether it's correct or not that the two things that he said, that you have moved from the concept of geologic isolation as the primary barrier to relying much more on engineered barriers, and that you are really looking to dilution as the solution.

Before I finish, I'd like to say one more thing. The other way to solve the problem of individual dose and dilution is to adopt population dose limits and concentration limits. And if you have a population dose limit, then the temptation to dilution disappears because it is no longer a solution. And this is why I mention that individual dose limit, while it has been endorsed by a lot of people and official bodies.

I do think that the EPA, in its original standard in limiting the total number of cancer deaths and therefore total dose was quite right. There are calculational ways in which this can be done reasonably without having to do diet surveys.

DR. WONG: Engelbrecht.

DR. VON TIESENHAUSEN: I don't want to get into policy issues because that's not my area of expertise. But in the issue of dilution, I would just like to know again, what data was used to come up with the dilution factor? To my knowledge, and as I said I don't understand the whole document, there is really insufficient data available to make that kind of conclusion.

Another issue I'd like to address is the engineered barrier system. And yes, it does seem to be a propensity to go more and more toward engineered barriers as a solution. But that doesn't relieve DOE from the necessity to thoroughly characterize in your field and get a good understanding of the environment that they are putting these engineered barriers in. Without that understanding they cannot make anything but bad assumptions about how long those barriers will last.

DR. BROCOUM: Let me talk about dilution for one second here. It's a little history now. In 1992, the EPA was told to develop a health-based standard. We heard Mel Carter this morning say there were three ways you could measure, health effects, risk, doses. To do that you cannot get away from the dilution, which I think is the point you made.

Once we went away from a release-based standard, we had to go then look at the pathway from the repository to the population center. You just can't get away from that, it's just inherent in that system. The other thing to keep in mind though when we talk about population doses at Yucca Mountain, it feeds a closed basin. So from the water pathway you'll never get a world wide population dose, you will get a population dose in that region to south Yucca Mountain towards Death Valley.

With regard to engineering versus site, I've always felt that that's a little bit of a red herring. On the one hand, for example, the doses get lower as you get further away because you are diluting, you are dispersing, you are retarding, whatever. And that's using the natural environment.

On the other hand, we're trying to design a repository that'll function well in Yucca Mountain. It's the combination of the site and the engineering. You ask what we're trying to do with our TSPA, look at that whole combination. So I think separating one in isolation from the other really detracts from the discussion as to how the thing will perform overall. So I've always felt that when you try to break those apart and talk about one in isolation to the other, you could be misleading.

Third, on the date that we used, I'd have to turn to somebody in the audience. Is there anybody here? Larry Hayes, is he here? Can you answer that for Engelbrecht here?

MR. HAYES: Larry Hayes, M&O. What was the specific question on data, Steve?

DR. BROCOUM: The basis for the dilution and the information we used to --

MR. HAYES: We've been doing considerable work at what we call our C wells complex. And based on what we've learned there through some aquifer hydraulic testing through some tracer injection testing we feel there is valid reason for taking credit for dilution. Now, I think that's all put into your PA models and that's partly why we see a decreased dose with travel time and distance. Did that answer your question?

DR. VON TIESENHAUSEN: Well, I'm aware of the testing being done at the C well complex. I guess the word "scaling" comes to my mind.

MR. HAYES: Sure.

DR. VON TIESENHAUSEN: It's still basically a fairly limited data set.

MR. HAYES: That's true.

DR. VON TIESENHAUSEN: And I wouldn't want to hang my hat on dilution based, on that data set. Now other people may feel differently but I wouldn't.

MR. HAYES: Everything you said is correct and of course, we are aware of that. And what we are planning this year is a large scale test out in the future down flow from the repository, what we're calling our southern tracer complex. And in that test, we're trying to come up with some ways we could deal with the scaling problem.

DR. VON TIESENHAUSEN: How many orders of magnitude of dilution have you got?

MR. HAYES: Abe, what are you using in your model for the dilution?

DR. VAN LUIK: Actually, this is the subject of a lively internal debate at this point. We've had an Expert Elicitation on the saturated zone model. They found some fault with the model and made suggestions for corrections that lower the degree of dilution to some extent.

We've also had a lot of interaction with the NRC who feel that we should take a more stratified approach to modeling the saturated zone which gives us less dilution, but then they also say in that case you need to be realistic about the mixing at the well head. And when we do that, they come about equivalent to the mixing zone without the wellhead mixing that we assumed before. So this is work in progress.

Your people are working on it, the model itself, so the next version of it is going to be out, I forget just when, but it's actively being worked.

And it's not something for which right now we could put our finger down and say, "Say, this is the answer, this is the final approach," because, like Steve said, we've only been working the saturated zone seriously, with the need for licensing, that is. We were fooled by the old standard into not meeting it. Because it was a release-based standard, we could meet at the interface between the unsaturated and saturated zones.

MR. HAYES: I think the question for the experts is perhaps not so much the dilution at the C wells area but as we travel out in time, does the plume spread out and do we get additional dilution? And is it true that the experts are not all in agreement?

DR. VAN LUIK: The experts, being true experts, are not in agreement. However, we were able to take their results and quantify them using standard techniques to give us a broad distribution of uncertainties which we will use until these larger tests come in and better inform us. But we realize that this is an issue which is ripe for both controversy and constructive discussion.

DR. MAKHIJANI: There is a concentration at the repository that you are assuming. You've got a number for dose. There is an implicit dilution there between what dose you would get if you use the water from the repository and the water that you are using. What's that factor? There has got to be a factor.

DR. VAN LUIK: I don't remember exactly what the factor was in the last -- I think it was 2 orders of magnitude perhaps, going from the repository boundary to the 20 kilometers. It might be 1 order of magnitude or 1-1/2 from the 5 to the 20. It's when it gets out of the tough aquifer into the alluvial aquifer that we were assuming most of our dilution. And this is the subject of controversy at this point.

DR. MAKHIJANI: Okay, thank you.

DR. WONG: It's my job to manage time here. So I would like to ask the panel if they have any last comments, short comments. If you talk too long, I'm going to warn you with this and you only get two chances.

DR. NIEDZIELSKI-EICHNER: I just have what I think is a quick question for DOE. And that's with regard to if the movement is toward a greater emphasis on engineered system, has the Department explored the ventilated alternative design? And if not, why not? And if so, what's your consideration at this point?

DR. BROCOUM: The Department is looking at a series of potential enhancements. And a ventilated or keeping it open longer, if you like, not closing it, is one of the things under active consideration. So that has not been rejected and is being looked at very actively.

DR. WONG: Steve?

MR. FRISHMAN: I think it's important for the Board to spend some time thinking about how this fundamental change is coming about and whether it's one that should go forward just through its own evolution or whether it's serious enough to reopen in some form the question of the national policy of geologic waste isolation.

I think it is that serious. And I think it is primarily because of the recognition that I think we have not only in this country but we hear in Sweden as well. And that's that the public was led to some pretty profound expectations about geologic isolation. And those came to a peak in 1982 when the Waste Policy Act was passed. And that act was passed to do something that the current system isn't doing.

And the public understood geologic isolation to be essentially zero release. And because the concept was at that time probably overblown any way. But now the concept is an entirely different one and it's one where I think the public is owed an airing of the issue. Here we've gone, as I said earlier this morning, we've gone 15 years. The public and the utilities certainly are still expecting something to happen. Well, what their expectations were are never going to be realized. Something else might be but it's going to be a compromise on what the original expectations were.

So I think just from that standpoint, it's important that the Board take their charge to look at the technical validity of what's going on to include the technical issue that is at hand, and that's are we going to have a system that relies on engineering for not only containment but isolation and a system that is contrary to what the EPA said when they adopted 191, which is that individual dose is not a good standard because it encourages the reliance on dilution. And that is something that national policy has been trying to get away from in all other areas.

So I think it's worth some consideration by the Board and some public discussion that has to do with a national policy that by fiat is getting changed steps at a time.

DR. WONG: Any other comments? Kjell?

DR. ANDERSSON: Individual dose, I think it has also a positive side to it because it really addressed the risk that the individual at the site takes. So that as a person I think that's a question you will ask in any risk evaluation, how dangerous is it for me? And here it is, I mean, individual dose as risk standard. For me, it feels good but, of course, dilution is something that comes with it.

DR. CARTER: Mr. Chairman, I wonder if I could interrupt your order? I have to leave and I apologize.

DR. WONG: Sure.

DR. CARTER: I've got to dash out in a moment to catch a cab. But I appreciate very much being invited to be here. I've enjoyed it. I think, as I recall, one of the responsibilities or goals, at least, of the NWTRB is to foster and improve scientific technical communication and other things, so I commend you for doing that.

And I would say "Go to it," in addition to more of these sorts of things because we can already hear, "Oh, I didn't know that," or "I didn't see that," or "Why are these numbers different?", and so forth. So I think, fundamentally, communication is extremely vital in the process. And no matter what view you have, I think we can all benefit from this sort of exchange interested parties. Thank you very much.

DR. WONG: Thank you, Dr. Carter. Arjun?

DR. MAKHIJANI: Yes, I'll say it stronger than Steve. I really do think that we need both an individual dose limit and a population dose limit, given the fact that DOE is operating without a standard, and you are doing a viability assessment which you call a total system viability assessment.

I don't think you can call it a total system viability assessment unless you do population dose calculations as well as individual dose calculations, especially as the only standard in effect still has a population dose component or a stand-in for a population dose component in it.

I think that the point that Dr. Carter made about the uniqueness of groundwater resources, he made it very eloquently and in response to a question Craig put to him. And I think that this factor does have to be considered in a viability assessment. And I would very strongly urge that, at least, if we have abandoned a real investigation of other repository sites, that some kind of comparative analysis be done of Yucca Mountain with potential other repository sites. I mean there is literature on this subject.

And, finally, I think this charge or observation that Steve Frishman has made is partly disturbing and partly heartening. If it were in a different context, it would be heartening. In this context, it's very disturbing that we're going to engineered barriers because the repository performance is not expected to be good. That's sort of the bottom line that I understand from what is happening.

And I think that the NRC standards would need to be revisited in that case because the NRC standards, in effect, do not reflect a primary reliance on engineered barriers. The NRC standards, in effect, reflect a primary reliance on geologic isolation. And if the project is in a situation where that is no longer true, a very, very fundamental reassessment of where we're at is really needed.

And I think perhaps the NWTRB is the only body that could provide that. So it made me sit up. I had not thought of it that way, what Steve said. And I can't make a judgement about it because of that, but I think if it's anywhere near true, it does require very fundamental reassessment.

DR. WONG: Thank you. Engelbrecht?

DR. VON TIESENHAUSEN: I have very few additional comments to make on top of the ones I made already. I'd just like to thank you for allowing me to participate and I hope DOE gets that document together.

DR. WONG: Thank you. Steve or Abe?

DR. BROCOUM: Let me make one final comment here. There has been several suggestions around the table that, you know, we air the issue, it's time for the country to air the issue. Part of the viability assessment is to present the information to the Congress so it can air the issue. They are our representatives, they are the right body, in my view, to air the issue.

I think though, in airing the issue, there is one thing we need to consider and we always say, should it be Yucca Mountain or should it not be Yucca Mountain?

But if it's not Yucca Mountain, we still have the problem, we still have the waste. And so I think in entering the issue, we ought to be talking about the risks at Yucca Mountain, whatever they are, versus the risks of not doing anything. That's the other extreme. I think that's called the "no action alternative" in the EIS.

But anyway, I think that's an important issue that hasn't come up yet, I just wanted to raise it, raise people's awareness. If, for example, the country decides not to go forward with Yucca Mountain, it hasn't solved the problem. The problem still exists. And that's the main point I'm trying to make.

DR. VAN LUIK: Okay. By default I get the last word. I think the primary concern is public health. If this repository is not particularly for public health, it should not be built, should not go forward. Everything else, including the issue of whether or not we've shifted reliance from the site to the engineered system, is to me, secondary.

The other thing is that there has been kind of a hint that there is a better site out there somewhere. Well, the best site is always the one you haven't studied yet. I'll never forget big arguments during the time of the environmental assessments when they did the comparative study between the sites to recommend which ones to characterize.

One of the Hanford spokespeople at that meeting, and they always brought more than anybody else did, he blurted out, he said, "If you guys had characterized your sites, we wouldn't be last, we'd be first." He said, "The minute you start characterizing you find out that all the things you assumed weren't quite the way you thought they were."

And I think that's true, basically. And that's, you know, for salt, Texas, and you were probably in charge of this. Texas was very smart, worked on the contract to DOE and figured out that. No problem, the dissolution front wasn't going to reach the repository for 10,000 years. You know, it's been around for millions of years.

But the point is that every time you start characterizing, you start finding out things that you didn't think were the way they were. And we mentioned granite as being an ideal site, especially granite underlain by brackish water.

But if you look at the granite countries, the Swiss have had a real comeuppance bringing experts in that said, "Whoa, you guys, there is going to be new glaciation. When that glaciation lifts, you get decompression and you get fracture zones where you didn't know -- you have no way of predicting where they are going.

So the Swiss thought they'd be real smart and send them to Sweden, these experts. And what did they come back with from Sweden? "Those people are reckless." So you know, until you start studying something, you don't know what the uncertainties really are. And to me, the best U.S. granite sites are the Wolf River batholith in Wisconsin and the White Mountains of New England. Those are absolutely the best, least fractured pieces of rock in the United States.

However, there you have the question, the same question that the Swiss bring up, once you start studying these sites you will come up with some uncertainties you didn't know about, and you are going to spread your doses to sizeable populations in those areas. So to me the best site is a moot point. It's a non-issue.

The issue is, will this site with this system be protective of public health? That's the real issue, that's the question we have to answer to the NRC. And we will answer it honestly, and the NRC and the country can make up their mind.

DR. WONG: Thank you, Abe. Okay, at this time I'd like to end the round table. I'd like to thank all of you for your comments and energetic contributions. It makes my job a lot easier.

At this time the agenda calls for the Board to listen to questions and comments from the audience. And our sign-up list indicates that, again, Ms. Judy Treichel would like to make a contribution.

MS. TREICHEL: I'm not sure I ever make much of a contribution, I want to take a little of the time. And you said that part of this was for questions and I have a question.

After listening to Kjell talk about, in your very opening statement, you talked about how if the public doesn't accept the idea of the repository, that it's not going to happen. And that, as well as scientific issues, you've got to discuss ethical issues. And this question has come up in public meetings before.

And at one point one of the DOE spokespeople was nailed by a member of the audience to say, "Do you have ethicists on your staff? Do you do any work on ethics?" And I already know that the two of you can answer that by saying, "No." Right? And so I'm just wondering if that's even a possibility in this whole issue?

DR. BROCOUM: I guess anything is possible. I'm not aware that we have a philosopher and ethicist on our staff.

MS. TREICHEL: Okay. And it would be a tremendous leap to try and get to that. And as was mentioned here by a couple of the panelists, it's about time to go back and take a lot -- I don't think you could infuse an ethicist into the system at this point. That would have to be a part of going back to relook and reask all of these questions when it came up.

And it would seem to me that when we get into any sort of public discussion, you wind up with incredible frustration because all that's left for the public is to say, "Yes." They have absolutely no avenue for saying, "No." And some of that is very evident in the EIS process where we are now. There is no need to consider the need. That makes this thing unEIS-able. It's a game that people are being asked to play.

And many, many, many of these things wind up being games when you don't have to consider the need. And particularly when you've got something that's involuntary and that you've got a whole lot of people out there who don't want, they do not want this project. Just to throw in, you know, everybody is doing statistics here.

There is somewhere between 20 and 30,000 little postcards that have just gone off to the President as a result of the two concert tours. They came together in Los Vegas, so they were both there together. But the Honor the Earth tour was off in one direction in the east and the No Nukes tour was off in another direction.

And they both had these little postcards that people were filling out there. And there were 20,000 and more of those. And one of the things that happened, I know in Los Vegas there was a friend of mine who attended the concert. She happens to be a bartender, and she picked up a handful of cards, and in one night got 40 additional ones signed. And so she threw those in an envelope and sent them off.

So I don't think that the numbers are in on where people come down on this. And I don't think they've been asked. And I don't think there is any way that they can be asked. And even if they are not asked there is no way that they can actually let anybody know. And we are continually trying to set up public meetings, and we argue a lot about whether we can do that.

And the person now working with the project, to who that falls, is generally scared to death of having DOE get bashed. Well, I would say that DOE-bashing has been a minor league sport compared with what you may see if this thing just keeps rolling along, if the thing goes through that's sitting in Congress right now, if Yucca Mountain goes through.

We just recently had, I think, what I could report to you as the first Yucca Mountain court case in Los Vegas. And it was a public meeting by the way, Steve. You could have come to that. It was really very interesting. It was supposed to last one morning because the D.A. had other things to do.

Well, as it turned out, the thing went on for a day and a half. And the protestors who had chained themselves to Highway 95 and stopped a couple of trucks and disrupted Nevada Test Site operations, they let the regular traffic go through but they were out to get the Nevada Test Site and make a statement on Yucca Mountain.

The three of them acted as their own attorney, and the judge gave them tremendous leeway. And the judge became more lenient as time went on. And the second day he brought to Court his mother, his wife, and his infant child, because he thought this was incredibly important. And he wanted them to be able to see what was going on. I'm not sure what the baby got out of it, but, you know, he couldn't leave it parked outside, as the danish woman learned.

But, any way, it all came down and there were very interesting questions asked of everybody, particularly the police that had been involved in the action. And when it all came down and all was said and done, they were sentenced. The whole group was sentenced to 40 hours of community service and that was to be served working for their own organization. So, you know, we may have a very interesting precedent here.

And one of things you better never try to put into a model and do assumptions, predictions, calculations on, is public behavior. Because once they get forced -- you know, if you've got an airplane full of people and you throw a few out because you said you had to lighten the load so that everybody didn't crash, and then they find out later that it was because somebody wanted more leg room, then you are going to have a situation where people decide they've got nothing to lose.

And I've played this game for a long time. I've been in a lot of public interest, public representation things, and when people think they've got nothing to lose, they get real dangerous. It gets real fun. But I'm not sure that you want to do a project like this that has to do that not only without public confidence but without even public tolerance. So I guess that's the only rant that I have to put on today.

But, you know, just for those from the nuke industry who are here, I think we learn a lot more each time after they've run all of those ads that say that it's totally arid, completely unpopulated, and oppressively hot. I'll go with hot. But, you know, the assumptions aren't holding up. Thanks.

DR. WONG: Thank you, Judy. Are there any further comments from any member of the audience?

[No response.]

DR. WONG: Okay. If not, I'd like to offer the panel members or any of the other Board members the opportunity to express any conclusions they've reached during the closing remarks that they wish to offer.

DR. MAKHIJANI: After the speech about future generations, I did want to offer an environmental response about alternatives. And the technical challenge of Judy's, of how to put all those things into a model, I think it can be done, public response, I mean.

MS. TREICHEL: You would try and model those responses?

DR. MAKHIJANI: Yes.

MS. TREICHEL: Yeah, I want to work on that.

DR. MAKHIJANI: There is a real life model as to what happened, it's in Gorleben. They can fit that into a model and try to figure out the cost. I think it can be done. They drove the public bananas, the bananas public responded. They showed you what it's going to cost you per canister. You can put it in a model, I think it can be done.

DR. WONG: Okay.

MR. FRISHMAN: One more comment, and that's that I've completed my back-of-the-napkin calculation for the homework assignment I was given earlier this morning. And that's approximately what size population would the current 22,000 acre feet of appropriated water and Amargosa Valley support? The answer is, on the order of 110,000 people.

DR. WONG: Thank you Steve. Again, trying to stick to our schedule, is there any other comments from the Board members?

[No response.]

DR. WONG: As there is no further discussion then we have reached the end of our meeting. I'd like to thank all of you who have participated, either with formal presentation, round table discussion, and comments again from the audience. You've given the Board, I think, a lot of things to think about. It's been very educational for us and I've enjoyed the discussion this afternoon. Thank you all for coming.

[Whereupon, at 4:10 p.m., the meeting was recessed, to reconvene at 9:30 a.m., Thursday, October 22, 1997.]