# Official Transcript of Proceedings ACNWT-0186

# NUCLEAR REGULATORY COMMISSION

ORIGINAL

Title: Advisory Committee on Nuclear Waste
166th Meeting

PROCESS USING ADAMS
TEMPLATE: ACRS/ACNW-005

SISP - REVIEW COMPLETE

Docket Number: (not applicable)

Location: Rockville, Maryland

Date: Tuesday, December 13, 2005

Work Order No.: NRC-783 Pages 1-197

NEAL R. GROSS AND CO., INC.
Court Reporters and Transcribers
1323 Rhode Island Avenue, N.W.
Washington, D.C. 20005
(202) 234-4433

TR08

# DISCLAIMER

## UNITED STATES NUCLEAR REGULATORY COMMISSION'S

## ADVISORY COMMITTEE ON NUCLEAR WASTE

December 13, 2005

The contents of this transcript of the proceeding of the United States Nuclear Regulatory Commission Advisory Committee on Nuclear Waste, taken on December 13, 2005, as reported herein, is a record of the discussions recorded at the meeting held on the above date.

This transcript has not been reviewed, corrected and edited and it may contain inaccuracies.

UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

+ + + + +

ADVISORY COMMITTEE ON NUCLEAR WASTE (ACNW)

166TH MEETING

+ + + + +

TUESDAY,

DECEMBER 13, 2005

+ + + + +

ROCKVILLE, MARYLAND

+ + + + +

The Advisory Committee met at 8:30 a.m. in Room T-2B3 of the Nuclear Regulatory Commission, Two White Flint North, 11545 Rockville Pike, Rockville, Maryland, Dr. Michael T. Ryan, Chairman, presiding.

MEMBERS PRESENT:

MICHAEL T. RYAN, Chairman

ALLEN G. CROFF, Vice Chairman

JAMES H. CLARKE, Member

WILLIAM J. HINZE, Member

RUTH F. WEINER, Member

ACNW STAFF PRESENT:

NEIL M. COLEMAN
JOHN FLACK
LATIF HAMDAN
MICHAEL LEE
MICHAEL L. SCOTT

ALSO PRESENT:

SCOTT FLANDERS, NMSS
JOHN GREEVES
JANET KOTRA, NMSS
TIM MCCARTIN, NMSS
TOM NICHOLSON, RES
WARD SANFORD, USGS
CHEN ZHU, Indiana University

PRESENT VIA TELEPHONE:

KATHRYN HAYNES
RICK JACOBI
ALAN PASTERNAK
BUDHI SAGAR
STUART STOTHOFF
GORDON WITTMEYER, Southwest Research Institute

INDEX

P R O C E E D I N G S

8:32 A.M.

CHAIRMAN RYAN: The meeting will come to order. This is the first day of the 166th meeting of the Advisory Committee on Nuclear Waste.

My name is Michael Ryan, Chairman of the ACNW. The other members of the Committee present are Vice Chairman Allen Croff, Ruth Weiner, James Clarke, and William Hinze.

Today the Committee will discuss with representatives from the Office of Nuclear Materials Safety and Safeguards their plans for the implementation of a dose standard after 10,000 years at Yucca Mountain. We will hear presentations from and hold discussions with experts on the reasonableness of NRC infiltration assumption in the proposed 10 CFR Part 63. We will also have discussions on the Committee's white paper on low-level radioactive waste with NRC staff and stakeholders. Finally, we will discuss committee letters and reports.

Neil Coleman is the Designated Federal Official for today's session.

This meeting is being conducted in accordance with the provisions of the Federal Advisory

Committee Act.

We received requests from Mr. Alan Pasternak of the Cal Rad Forum and Mr. Rick Jacobi of the Jacobi Consulting who are participating by telephone during the discussion of the Low-Level Waste White Paper.

We've also received a written statement from the Southeast Compact Commission. Their comments will be made part of the official record for this meeting.

It is requested that speakers use one of the microphones, identify themselves and speak with sufficient clarity and volume so that they can be readily heard.

It is also requested that if you have cell phones or pagers, you kindly turn them off.

Thank you very much. I might add a scheduling note. Based on the anticipation of some bad weather on Thursday morning, we're going to try and work a little bit extra to conclude business tomorrow afternoon. So just if people want to make advance travel plans, we'll not likely have any session Thursday morning on letter writing or any other matters.

We'll try and conclude business so that

folks don't have to drive in the ice and bad weather coming in Thursday morning. I think all the Members can support that and the Staff certainly can help us out in that regard. So that's just a little scheduling item for those of you who have traveled from a distance to get here and want to make alternative plans home. Thanks very much.

Without further ado, we'll begin. And our first presenter is Tim McCartin from the NRC Staff.

Tim?

MR. McCARTIN: Good morning. Today, I'll be talking about the implementation of the dose standard after 10,000 years. And this really is part two of this topic. At your last meeting, Janet Kotra gave a very good explanation and background of the proposal. Today, I'm not going to repeat any of those points made, but what I'm going to attempt to do is provide a little more detail on a couple subjects and primarily --

CHAIRMAN RYAN: Tim, let me just recognize, if I may, while you get organized there, that we have members from the Center of Nuclear Policy Research in San Antonio who are on the video conference. Welcome, San Antonio.

You can hear us okay and the connection is okay?

Once again, we're in Ron Brown's capable hands.

Thank you.

MR. McCARTIN: Yes, and the presentation today is really both myself and Gordon Wittmeyer at the Center. For continuity, I will be doing the presentation here. When it comes to questions and things, I may rely on Gordon for some additional details. And today, I'll just give a brief statement on the purpose of the proposed Part 63 that provides for the discussions that will follow with respect to the inventory, some dosimetry perspectives and then I think of keen interest to the Committee is the representation of climate change and I'll end with the status of where we are with respect to Part 63.

In terms of the purpose of the proposed rule, pretty much what you heard last time was we're implementing a new standard for doses that could occur after 10,000 years. We're also specifying that the dosimetry for the worker and public would use the same current weighting factors that EPA specified for public doses in their standard, and lastly, specify the treatment of climate change for Yucca Mountain after 10,000 years.

Going right to the inventory perspective, in terms of how does the inventory change over this time period and just briefly, looking at 1,000 years over the next 100,000 years, you can see there's a fairly substantial reduction in the overall inventory in terms of curies over that time period. It's approximately 2 percent of what it was at a 1,000 years at 100,000 years.

If we went out to one million years over the next -- from the 100,000 years out to one million years, there's approximately an order, another order of magnitude decrease. So I'm not showing a curve beyond that, but at one million years, it would be approximately .2 percent, rather than the 2 percent it is at 100,000 years.

More importantly, I guess, is what kind of nuclides, what are the nuclides that are contributing to this inventory at those time periods? And not overly surprising at the 1,000 year time frame, americium-241 is the dominant radionuclide in terms of curies. There is some plutonium-240 and some plutonium-239. Go out to 10,000 years, you can see the americium-241 is gone. And really you're dominated, in terms of curies, by the two isotopes, plutonium-240 and -239.

You're starting to see some of the longer lived radionuclides like technicium start to show up as things die down. I mean each of these percentages are relative to the inventory at that time. Fifty-thousand years, you can see you're dominated by plutonium-239. Technicium is increasing in overall -- the relative percentage and you're starting to see neptunium.

At 100,000 years, once again plutonium-239 is still dominant; technicium is increasing further and so is neptunium. Continuing --

MEMBER WEINER: Excuse me, Tim?

MR. McCARTIN: Sure.

MEMBER WEINER: When I did this same sort of analysis, I don't think it's critical, but I think you should mention there are a couple -- there's also ingrowth of a couple of uranium isotopes and thorium-230.

MR. McCARTIN: Yes, thorium-230 will show up beyond 100,000 years. There is some -- uranium, it still is very small.

When we get beyond 100,000 years and 300,000 years, I've dropped off americium-241. At 10,000 years it was gone so there was really no reason -- but what you see is thorium-230 now appears as approximately 10 percent. And you can see uranium-234 and -238 is there around 10 percent. Plutonium-242 is decreased. Technicium is the dominant curie amount at 300,000 years and neptunium is there around 10 percent.

So you can see, other than technicium, you've got a cluster of things around -- contributing around 10 percent that continues approximately the same, out to 500,000. Around 700,000 years to one million years, you start to see the dominance of neptunium. And when you get out to one million years, it really is -- neptunium is the dominant radionuclide.

But as you can see, there really aren't as dramatic a change at this particular time frame just because the things that have lasted out at least to 100,000 years, a couple hundred thousand years are fairly long-lived radionuclides and they will persist for a fair amount of time. But it does end up at the end neptunium is the dominant curie amount in the repository.

Now, the question is with that kind of knowledge about the inventory, we are changing the dosimetry. We are updating the dosimetry to more recent values and suffice it to say previously the dose calculations were based really on FGR 11, Federal Guidance Report No. 11. EPA puts these out for the U.S. Government in terms of dose calculations. This was September 1988.

You can see the update to the newer values really reflects FGR, Federal Guidance Report 13 which is September 1999. So you can see a new -- a decade of information in terms of doing the dose calculations.

What does this mean in some of the -- for some of the nuclides that dominate the dose calculations and this is just the change factor in going from FGR 11 to FGR 13. You can see for technicium and iodine, there's almost a doubling in the dose. And this is for ingestion. The dose conversion factor, so you would get -- for the same amount of ingestion, you would calculate almost twice the dose that you would have previously.

For neptunium, it drops approximately an order of magnitude, so these two increased. This decreased. For thorium-230, it increases slightly also. And then for americium, plutonium and uranium, they decrease somewhere between, a factor of 2 and 4. So you can see there's a spectrum of changes. The largest for the nuclides that we typically see in dose calculations are neptunium for beyond 10,000 years. And for the first 10,000 years, we typically are dominated by iodine and technicium. Those values increased.

CHAIRMAN RYAN: Just a clarification question, Tim. Is it fair to say that most of the changes are based on updates to the metabolic model for that element?

MR. McCARTIN: That I really don't know. I'd have to get back to you on that one. I'm not that familiar with --

CHAIRMAN RYAN: It's a detail and the values are what they are, but I think it would be helpful to understand if it's really an improved knowledge of the metabolic model or some other issue that's come up and how the doses were previously calculated, risk factors to an organ.

There are several key things here that change it. That might help us understand the bases for the changes.

MR. McCARTIN: Right, yes. I'll have to get back to you on that. The one thing I know that I'm sure you're familiar with is as we get further and further away from the time of Hiroshima and Nagasaki, things get updated in that sense. I mean some changes are a result of that, but --

CHAIRMAN RYAN: And metabolic models.

MR. McCARTIN: Yes, right.

CHAIRMAN RYAN: Because it's a fairly limited number, there's really seven. It would be interesting, I think to just document that thorium is for this reason, neptunium is for that reason and so on. It would be interesting, I think and helpful to us to get a better picture of that.

MR. McCARTIN: Yes.

CHAIRMAN RYAN: Thanks.

MR. McCARTIN: In terms of just looking at those were relative changes, in terms of -- if I look at the previous calculations in terms of what and just making everything relative to the largest value, previously, the single largest dose conversion factor was neptunium for FGR 11. And you can see americium and plutonium were comparable. And iodine, thorium, uranium were quite a bit lower. Technicium was very small. It is the smallest dose conversion factor we had.

You'll remember that there was a fair amount of time where technicium is dominating the curie inventory amount, but it is of note that technicium is for the nuclides that we've looked at, I believe it is the single lowest dose conversion factor that we use.

Yes?

MEMBER WEINER: What exactly is this graph telling me? Is it if you simply -- is it that if you simply looked at the radionuclides and weight them in the sense of dose, ingestion dose conversion factor, this is what you get? Is that what I'm looking at?

MR. McCARTIN: Yes, the previous one was just what the changes were.

MEMBER WEINER: Right.

MR. McCARTIN: This tells you, in FGR 11, neptunium was by far the dominant dose conversion factor and you can see -- the change is one thing. It's another thing to know that actually technicium has a very lose dose conversion factor, regardless of its change. It did double, but the fact that it doubled when you have a very small value, doubling a very small value is not necessarily significant change, whereas you can look at your single largest dose conversion factor, dropping an order of magnitude, you can get a sense of what might happen to the dose calculation.

MEMBER WEINER: I was simply trying to clarify that this is a graph of dose conversion factors?

MR. McCARTIN: Yes.

MEMBER WEINER: And not of doses from --

MR. McCARTIN: Yes, correct, correct. Absolutely. And rather than using the units of dose conversion factors which have various meanings to various people, percent, I just made it all relative to the largest.

If we look at FGR 13, you can see somewhat as I said before, technicium doubling a very small number. Still, leaves you with a very small number. Technicium is still a very low dose conversion factor. But you can see neptunium was pulled back to some of the other radionuclides and actually plutonium-237 is the largest dose conversion factor for ingestion.

Next, is a curve that I went back and forth what the appropriate title for this curve should be and I decided with the word illustrative, and the reason, it's important for me to explain why I'm using that title.

We are in the process of modifying our TPA code to accommodate this long-term calculation. We are not done with those changes and I believe this gives a picture of how things might behave in a general sense, but changes are continuing. There are many important factors to account for in this calculation and we're not finished yet. And so it's really sort of an intermediate point.

And I think one part that was of interest to us that given the changes in the dosimetry, what nuclides would dominant. And interestingly enough, neptunium, despite its decrease is still the dominant radionuclide in our calculation.

These two down here, iodine and technicium, but you know, our doses right now track very well with neptunium. There are a number of things, I guess I'd like to mention with respect to this calculation that we continue to look at. Plutonium colloids need to be looked at. And we're continuing to do developments in our TPA code for plutonium colloids.

As you saw, plutonium is for FTR 13 is the largest dose contributor. It still didn't show up significantly here, but we are looking at plutonium colloids.

There are aspects of our calculation that we are thinking about, that -- and it would be nice if one could say, gee, I need to correct one, two and three, or modify one, two and three in our code and we're done. It really isn't that simple. And the reason we have a code is it is very difficult to integrate all the competing factors that will affect this peak dose and there are a lot of them that we're thinking through and doing analyses to date and I'll just -- I'll bring up a few that and I'll say the way the waste package fails, the release rate and the retardation are all very important that will affect what that peak dose is. And in that sense, I'll say the way the waste package fails, right now in our code we assume when it fails there's a single mode for water getting into the waste package and water exiting the waste package. We're not certain, in terms of if the waste package gradually degrades over a couple hundred thousand years, so that early on maybe there's a few pit holes, but very little water gets in. Later on, these pits grow. There's more pits. There's patches as the DOE model has and more water gets in.

Water has always been an important part to the release of radionuclides. How that package degrades over time, how important is that to estimating the peak? An that's something we have not looked at in great detail in our previous calculations. We need to understand that with respect to this one.

Release rate from the waste form. How

quickly does the material, the fuel degrade? Is it 100 years? A couple thousand years? A couple hundred thousand years? And where that's important -- now, when things get out of the waste package, there's different parts of the repository, different infiltration rates, different flow paths, different transport times to the accessible environment.

Generally, this peak is a result of the combination of a lot of leaky containers getting to the same point and overlapping. If I have a high release rate and I get stuff out of one part of the repository very quickly and then in another part of the repository at a later time, maybe they don't overlap. What are the conditions that cause this overlapping of releases?

And those are some of the issues in modifying the code, we want to think through and look at the uncertainties and clearly I would way, in general, this peak occurs because there's a lot of overlap of different areas of the repository at the same time.

And if you had a quicker release rate, does it actually get better? Things don't overlap as much? That would be an interesting result. Things to think about and so the beauty is we have a code and a capability to try to look at all these issues, to look at what seems to be a reasonable way to represent the behavior of the repository over this very long time period.

Like I say, trying to integrate this in your head is just too difficult. And the code is a way to help us think through these issues and those are some of the changes we're making with our code is to help us provide capability to look through these different issues, to understand where and when things overlap and what kinds of conditions are causing the peaks to occur or the peaks not to occur. And so, it's a problem that we haven't looked into as much detail beyond 10,000 years. And like I said, the calculation here, that's why it's illustrative. We have a lot more work to do.

We would expect to come back in and brief the Committee at some later time, as we progress in this work. The one fascinating thing -- I didn't know which way, what was going to happen with neptunium, with that fairly large substantial reduction in the dose conversion factor. It still was the dominant radionuclide.

CHAIRMAN RYAN: Tim, I was just going to say, it sounds like you reported previously, as you just mentioned on the before 10,000 years risk insights kind of approach and a vertical slice through the system, looking at the different components. It sounds like you're now on the high side of 10,000 and trying to develop that capability and those insights again.

Is that a fair --

MR. McCARTIN: Absolutely, and there's things that require more thought. Pre-10,000 years, we weren't as concerned about how the package degraded. We had some degradation and we had a model to represent the limitations on water entering a degraded package. But now, degradation over hundreds of thousands of years and how might this look? It's something that we want to think about more with our current approach and on the plus side, there is some capability in the code already that we can look at this to see does it make that much of a difference in estimating the peak.

But it is -- there's a lot of subtleties to doing the calculation much further that you certainly want to know the impact of -- and right now, I'll tell you. We have the capability for doing the time-dependent degradation of the waste package, allowing more water to come in at later times.

We have never utilized that capability. I think we'll take high marks for having that capability, if we needed it, but we in the first 10,000 years, we weren't as concerned about what's a credible model for that that variation. Now, over the longer time period we have the capability, but it's not an easy thing to come up with a basis for what seems to be a reasonable way to represent it.

But we can do the sensitivity analyses to get a sense of is there a -- is this a huge deal? And depending on how we vary that, those -- that parameter, does this peak change a lot?

And I'll say we're in the process of doing a lot of work and here and at the Center to just get a better sense of what seems to be an important aspect of the calculation.

Your first reaction is oh, a higher release rate, more water, get things out real quick. Will give you a higher dose. Maybe. But if you start to separate and you can see this little split here is a separation of where parts of the transport path have -- are slower than other parts.

As you separate these and have more detail on that, maybe the doses go down, if you have higher release rates. And they go up if you have slower release rates. You have more overlap. Or maybe it doesn't matter. And it just -- there's a lot of things. And that's why to get back to my original point, the word illustrative, that we're in the process of looking at this and as I said, I think we'll be happy to come back at some later time when we're further along.

For today, I thought it was important to show that with the dosimetric changes we were still seeing neptunium as the dominant radionuclide.

MEMBER HINZE: If I might, Tim, I realize this is illustrative, but I don't see the igneous activity peak in the first couple thousand years. And that just left off in this calculation?

MR. McCARTIN: Yes, I was just doing the ground water pathway. Sorry about that.

MEMBER HINZE: And are you looking here at the mean or are you looking at the median? Are you looking at the mean up to 10,000 years and then the median?

MR. McCARTIN: Well, this particular curve is based on the mean. This is a mean curve.

MEMBER HINZE: Oh. Do you have any feeling for how that's going to change as you move to median?

MR. McCARTIN: Not really. I thought I had a better idea a while back. As I've done more of the calculations and once again, we're at the early stages and the reason I did not show a median curve or any percentiles on this particular curve, it was purposeful.

And that is that because of what I talked about the way the waste package fails, the release rates, the overlap that may cause the peak, as we modify our model and do things differently, I don't know how it's going to affect that dose estimate. And I'm reluctant to put up any additional statistical measures for this calculation, but --

MEMBER HINZE: Load your guns first, sure. Let me ask you though, are you using the mean up to 10,000 years and then looking at the median when you do go to the median?

How is that handled?

MR. McCARTIN: Well, to date, I mean this is just the mean curve and it's from zero to one million years. There is no change. Just as easily one could plot a fifth percentile, 90th percentile, a median value of 50th percentile for zero to 10,000 years. My guess when we do the calculation, it's probably more trouble than it's worth to try to separate the two, that you would have a curve with this statistics on it.

MEMBER HINZE: Thank you.

MEMBER WEINER: Tim, at the risk of one more question, recognizing this is an illustrative curve, can you separate the factors that affect the time of the peak dose from the factors that affect the value of the peak dose? It's just -- can you in your model separate those two influences or do they conflate?

MR. McCARTIN: We can try and that's what we're in the process of doing. The trouble is, there's things that shift the time which can have an affect on changing the time of the peak also and I mean generally, the start, of course is and has always been failure of the waste package, as the first barrier. It always shows up as until the waste package fails, you don't get a dose. So that certainly has an effect.

But there are the transport path and for our particular model, we have eight subareas for the repository in the unsaturated zone; four subareas for the saturated zone. And so there is a split in the length of the alluvium and the overall transport path and time.

So the timing is affected by retardation and characteristics of each of those flow paths and so there's a fair amount of -- it's tricker to try to see that, but you raise a good point and as we're looking at this I think it would be trying to provide a measure of is this more significant to shifting things or raising it up or down and that's something to think about.

I'll say I have been doing a myriad of calculations and generally, at this early stage we try a lot of different combinations of sometimes just doing one subarea at a time, so I get one -- and vary things for it to see how it changes. And then look at each subarea by itself.

There's just a lot of things going on with that, especially release rates are important also and certainly the water.

CHAIRMAN RYAN: Tim, just to pick up on a point, I think you said something that's fairly profound, things that will affect the X axis are things that will affect the time axis.

And just sorting those things out would be a huge step toward insights of things, don't you?

MR. McCARTIN: Yes, no, I agree. I think that's what Dr. Weiner was referring to and it's a way to try to -- and there might be the third bin of things that affect both and you almost can't pull them apart and it's a good suggestion in terms of when we come back. I'll make a promise that we'll talk to those three bins, if you will, in some way, if possible. I won't say that we can pull it apart. It may be something that they're so horribly intertwined that is very difficult, with the exception, like you say, the waste package.

I mean as the first barrier, it's easy to get a handle on what that does, but everything past that, but it's -- it's part that when in our review of any potential license application, in terms of estimating that peak dose, what are the things that we want to review in more detail that are affecting it. And that's really ultimately what we're trying to get a better handle on. And I guess the bottom line is hopefully, we'll find out it's much simpler than we think, but to date, I can't give you any concrete evidence of that it will be that simple. It may be a little more complicated.

CHAIRMAN RYAN: Just from a conceptual point of view, you can think about failure mechanisms or modes that would increase the concentration, that's likely something that would increase does or failure modes that would make the duration of some concentration longer.

MR. McCARTIN: Yes.

CHAIRMAN RYAN: That's, to me, the kind of translation into the physical environment from the waste package environment. So it's -- there's lots of good things to think about. It sounds like you're on the right track.

MR. McCARTIN: Yes.

MEMBER CLARKE: Tim, before you go on past that slide, all is truly all, it's all the radionuclides, not just the three--

MR. McCARTIN: Yes. It's the --

MEMBER CLARKE: And it looks like up to, I don't know, it's before 100,000 years, neptunium and all are pretty much the same. And then you've got a delta 2 millirems down to less than 1 which is -- I just find that pretty interesting, what happens around that time.

You really use neptunium pretty much?

MR. McCARTIN: Yes, and part of this I would say, in general, are release rates for the spent fuel, is on the order of $10^4$ versus $10^{5th}$ years. So it's not too surprising that we're getting around 100,000 years spread, this pretty much mirrors the uncertainty in our release rates from the spent fuel, at least, when I saw this I saw okay, that makes sense, especially with neptunium being the dominant radionuclide.

Now once again, there are some suggestions with respect to schopite and other things in terms of neptunium release, so --

MEMBER CLARKE: Neptunium is a risk prior to --

MR. McCARTIN: Yes. Even more so, yeah. And I was -- I guess maybe I shouldn't have been surprised but I thought neptunium might decrease in significance.

Now I will say depending on how you approach plutonium colloids, they can add more to this dose. This particular curve does not have plutonium colloids. It has plutonium in solution. But it does not have plutonium colloids and I know previous analyses we have done have shown that plutonium colloids contribute. They did not dominate over neptunium, but we continue to refine our -- the model we have for plutonium colloids and that's something that will be in our code in the future. If you look at the DOE results, certainly, they have a contribution from plutonium colloids.

MEMBER WEINER: This means that one of your factors that you will probably be considering is changes in the redox environment because plutonium-4 is an intrinsic colloid and if you get a lot of that, then you get a major contribution.

MR. McCARTIN: There's a lot of work going into thinking about the environment within the waste package such causing plutonium colloids, etcetera. Yeah. That is an area where we certainly are putting some effort into.

DR. SANFORD: Tim, Ward Sanford, USGS. It sounds like one of the things you're talking about was looking at the different parameters and how they control the dose and the timing. Are you guys using or considering using automated parameter estimation routines that can help quantify parameter correlation?

MR. McCARTIN: Oh yes. We use Latin Hypercube sampling and we have a variety of statistical techniques for analyzing the results and -- yeah, yeah.

I knew the dose curve would bring out a lot of interesting questions and good ones.

With that and recognizing now, going back to the standard, and EPA proposed that the assessment could be limited to the effect of increased water flow through the repository as a result of climate changes beyond 10,000 year analysis. The nature and degree of climate change can be represented by constant conditions after 10,000 years. And they said that NRC should specify in regulation the values to be used to represent climate change, such as temperature, precipitation or the infiltration rate of water.

And that's the backdrop for what the standards said about climate change beyond 10,000 years. And in terms of what we have proposed, we looked at deep percolation, recognizing somewhat as I said before -- notwithstanding igneous activity, the thing that moves waste out of the repository is water. And so the deep percolation or the amount of water flowing to the repository horizon is what directly influences performance.

Certainly, recognize that deep percolation is affected by a variety of processes, the precipitation, the temperature, evaporation, plant transpiration, etcetera. But ultimately what are you interested in, what affects the performance of the repository? It really is the depercolation.

And so rather than looking to temperature and climate change that we think is certainly important and is the most -- given the weather we see today, climate change are things you recognize on a daily basis. People associate temperature and precipitation with climate, but it really is depercolation for the performance parameter that is most directly controls the dose estimate.

In estimating future depercolation, and we were looking for setting a reasonable test for the repository to meet, there were a couple of things that in terms of depercolation, there's really two aspects. One is what's the range for the mean annual precipitation. How much is it going to rain? And really, what fraction of that rain ends up as at depercolation?

And in looking at that, I will say in terms of rainfall, there's a recognition that when we look at the past record in the Pleistocene glacial transition and monsoon states dominate the long-term climate state. There tends to be more rainfall over the majority of the time in the past. That is the way we saw the record.

In terms of estimating this increase in rainfall, it was really -- we have tried to do a very straight forward simple approach. We looked for analog sites based on vegetation and generally there's packrat middens that suggest a certain vegetation that was growing in the late Pleistocene, in the Yucca Mountain region. We looked for that same kind of vegetation at modern sites and those are the analog sites or in the literature, I'd say. And in terms of at those analog sites, there was an estimate made for precipitation on the order of 266 to 321 millimeters per year. This is somewhat representative in that report that we referenced in our proposal of the last glacial maximum.

And so in terms of how much might it rain? We have that as our estimate.

MEMBER HINZE: Tim, would it be appropriate to ask you how you arrived at those numbers?

MR. McCARTIN: They were reported in a USGS document that we reference.

MEMBER HINZE: Yes, the open file report, right?

MR. McCARTIN: Yes.

MEMBER HINZE: But one of the things in looking at that open file report, there's a great deal of uncertainty in those numbers.

MR. McCARTIN: Absolutely.

MEMBER HINZE: And I think your use of things like 266 and 321, how many decimal points can one really use here?

(Laughter.)

MEMBER HINZE: Considering the uncertainty of the correlation factors that -- in the late, last glacial maximum, the correlation factors that were used to arrive at that are in the range of .75. Those don't give a -- don't really seem to suggest that one should use those precise a number. Is that correct?

MR. McCARTIN: Well, certainly three significant figures is impressive for that estimate. Those were the reported values. And I'll show in my next slide, I mean we -- for numbers that we calculated, we were not as precise, but we felt we did not want to change the numbers that were reported in that document. I don't believe the final number that we arrived at is significantly affected if say we made this 250 and 300.

DR. SANFORD: So are those numbers what was reported for the analog site based on modern precipitation at the analog site?

MR. McCARTIN: Yes.

DR. SANFORD: And what are the analog sites? Where are the analog sites?

MR. McCARTIN: That one, I don't remember. Gordon, do you remember what the analog sites were?

MR. WITTMEYER: I don't remember the exact locations that were used. I believe they were spread throughout the Great Basin area, but I don't recall. I'd have to go back to that report by Tom Senedal to identify those sites.

MEMBER HINZE: Well, I think Yucca Mountain, Gordon, I think Yucca Mountain falls right on a division between two different regions of NOAA's averages and as a result, you kind of can pick either the area 3 or area 4 and the open file report was just selected, the higher precipitation areas.

It was based upon a regional value, not specific sites.

But I wondered, Gordon, did you go back or did anyone go back and look at the original NOAA data that was used to develop those? Those are not given in that open file report.

MR. WITTMEYER: We did not go back to those data, Bill.

MEMBER HINZE: Do you think that might be worthwhile to look at? I mean there must be --

MR. WITTMEYER: Go ahead, Tim.

MR. McCARTIN: That's okay, Gordon, go on.

MR. WITTMEYER: It's probably something we should examine a little more closely.

MR. McCARTIN: So that's the basis for the precipitation that we used. The next step was well, what fraction of that precipitation ends up as depercolation? And for that, we used our TPA code. And the TPA code estimates depercolation, including -- but includes the consideration of the things we talked about before, precipitation, temperature, soil dep., evaporation and transpiration, all these things are in -- are considered within the TPA code. So we ran the TPA code. Quite simply for varying all those parameters.

And what we saw was that and here's where I'll get to -- maybe we could have made this 4.866 percent but it's approximately -- it was around 5 to 20 percent of the precipitation could reach the repository under conditions where the variation that we had for those conditions was approximately 250 to 420 millimeters per year precipitation. So what we saw was that, in general, 5 to 20 percent of the rainfall would end up as depercolation as based on our TPA code results.

MEMBER WEINER: Have you any plants to validate this part of the TPA code against measured results? I mean there are plenty of places in the United States with rainfall between 10 and 11 inches per year and you can measure the depercolation. Do you have any plans to look at such measurements or to do things like that?

MR. McCARTIN: Well, over the years, for the TPA code and its models, we have done a variety of things to try to get a sense that we're in the right area. And I don't know if Gordon, if you have with respect to the infiltration models over the years. I mean these codes have been developed for quite a while and continued to be improved.

Do you have a sense of any of any benchmarks we might have done?

MR. WITTMEYER: Tim, going back to the original development of the process level model that was used for the TPA construction that was the breath code developed back in the mid-90s. We did do some comparisons to other codes that were used to estimate infiltration or the water getting below the roots of and found that breath did a good job of estimating under similar conditions.

So that was the level of -- I think we're getting feedback. Can you hear me okay?

MR. McCARTIN: Yes, we hear you fine.

MR. WITTMEYER: Okay, so I think we felt pretty good about the process level model that we're using to estimate infiltration as a function of soil depth, temperature, etcetera.

I know Ruth referred to some sites where they had 10 to 11 inches per year and compare a model to the values of infiltration or depercolation, actually, she said that had been measured. We have not gone and looked at those data.

MEMBER HINZE: Speaking of looking at data, have you used any of the Apache Leap work, the results of Apache Leap in this analysis?

There was a great deal of work done in an area very analogous to Yucca Mountain by the Nuclear Regulatory Commission over a series of years, using the University of Arizona as a contractor. And I'm wondering how that information was folded into this.

MR. McCARTIN: Yes, certainly we have followed and used the Apache Leap work for years. I know, boy, going back many years, I've modeled some of the experiments with some of the models we have used as support for the TPA code to try to represent some of their field tests, etcetera.

In terms of infiltration, boy, in terms of pointing my finger on anything particular, I'm not aware of any one particular set of information, but we certainly have used the information.

I don't know, Gordon, are you aware of anything?

MR. WITTMEYER: Well, I don't believe we used the data from Apache Leap directly in attempting to assess the underpinnings of the breath code or the extraction that used in the TPA code and we're certainly aware of the research done at Apache Leap, NRC research over the years.

It is a little bit of a different site, the fracturing is quite a bit different. I think if I recall correctly, it actually has a fair amount more rainfall. It might be a reasonable analog for future sites, but we really are choosing for future climate, but we really have not evaluated the Apache Leap data.

MR. SAGAR: This is Budhi Sagar. Most of the major names at that site were for shallow infiltration of the operation. I'm not sure which sites you're referring to where one would have a depercolation say at 200 degrees meter depth?

MEMBER HINZE: Excuse me, Budhi, what was the depth of the tunnel in Apache Leap? It seems to me that was a couple hundred feet anyhow?

MR. SAGAR: Yes, the depth of the tunnel was a couple of hundred feet, but the direct correlation between what was happening at the surface and what they saw in the tunnel as I remember it was never established. I mean they got some signals, they did some statistical analysis and it was not -- and maybe even geochemistry, just to see what the signal was telling them.

The last I heard which was six or seven years ago, from Randy, was that it was difficult to conclude at the tunnel based on the precipitation at the surface, unless they had ephemeral streams, I don't know.

MR. McCARTIN: Yes. I mean with respect to the tunnel, as I recall, if they had a very significant precipitation event, and one of the ephemeral streams was running approximately six months later, they would see flow through some major fault zones in the tunnel.

MEMBER HINZE: It was a fracture.

MR. McCARTIN: yes.

MEMBER HINZE: It was the same thing that we have at Yucca Mountain.

MR. McCARTIN: Yes, but trying to get a -- say what fraction of the precipitation ended up in there is -- I mean it's --

MEMBER HINZE: I guess what I'm trying to get at is that the scientific basis and background and verification, validation of these results and I guess that brings me to another question, if I can, because it's of a similar nature and that is have the heater tests in the alcoves, and their recovery provided any information that has been useful to you at all in looking at depercolation?

MR. McCARTIN: That's a loaded question. I really am not prepared to talk to that one. I don't know if Gordon has anything with respect to the heater tests and depercolation, but --

MR. WITTMEYER: I followed the heater tests somewhat, but I never seen anyone really look at if there is any information from that test that could tell you anything about depercolation. It's mainly been looked at for the near repository thermal effects.

MR. SAGAR: Recirculation.

MR. WITTMEYER: Recirculation, etcetera. Driving the liquid water away from the heated area. But I haven't seen anyone examine the data from those experiments to see what it can say about depercolation.

MEMBER HINZE: Well, I think we also have the inverse and that is the movement of the water back in and that is of interest because it does duplicate in a very real sense depercolation.

MR. McCARTIN: Let me hit on one point that I think -- if there's something that we have seen in the modeling of trying to estimate depercolation from precipitation temperature, soil depth is incredibly important in this environment in terms of where you have enough soil that water -- precipitation goes into the soil, held there as a sponge and then there's a delay for it to evaporate out, is a very dominant role which is why we've chosen the modeling that -- and we've done a fair amount with respect to looking at the soil depths at Yucca Mountain which is why for the DOE model as well as our model, where you see the largest infiltration is where you have very little soil, near the peak. So water just goes into the fractures and goes away quickly.

And so there's -- it's a very complicated problem which is why we were trying to get a somewhat general approach that we think provides a reasonable test for Yucca Mountain. And once you start factoring in precipitation, temperature, soil, the amount of evaporation, it becomes complicated quickly. Like you said, the calculations, we believe the code correctly does a good job of estimating these processes, but there is uncertainty with respect to how much is the soil depth.

There's many factors there and like you said, we came with, we think, 5 to 20 percent, in terms of providing a proposal for people to comment on was not an unreasonable range for going out and seeking public comment.

MEMBER HINZE: I guess, Tim, that's one of my problems in this and the modeling because it's a question of how good that model does represent the actual earth conditions. And soil depth is important, but it is particularly important out in the basins.

On top of Yucca Mountain, my recollection is listening to the flints and back in those days and the primary recharge was coming through, jointing faults, cooling cracks, etcetera in the exposed bedrock which overlies the repository and therefore is the most important. And how to quantify in a model, appropriately, those cracks, fractures, etcetera, is a difficult process.

MR. McCARTIN: Yes, fortunately, there are a lot of fractures. It is a hard value to estimate. I will say and I don't know if Gordon can add more to this, but in terms of the soil depth in that area, the Center did a lot of work to try to get -- and I'm not exactly certain how, but in fairly pixels -- they did a very detailed map of the Yucca Mountain area and had soil depths that were estimated by -- and I think Gordon would have to help me out there, but there was a fair amount of work to ensure that there was a fairly extensive information base in terms of soil depth and slope, et cetera.

Now, can you add to that, Gordon?

MR. WITTMEYER: Yeah. I'm going to actually have Dr. Stuart Stothoff explain a little bit, maybe take three or four minutes here and explain how the modeling was done at Yucca Mountain using the breath code.

Stu, why don't you go ahead and explain that.

DR. STOTHOFF:What we have for the TPA code is a pre-processor that is designed to look at uncertainty and spacial variability and incorporate all of the uncertainties that we feel are out there.

So, for example, it accounts for uncertainties in soil depth by running multiple realizations of infiltration at different depths of soil. And it accounts for uncertainties in fracture densities by running the same realizations with different fracture densities, different apertures. And the bedrock properties similarly will have the different hydraulic properties will be sampled accounting for all of the uncertainties that we know of.

The code is based on the process level simulations in BRAC. We ran around 500 simulations to derive a response surface in terms of all the hydraulic parameters, in terms of all the climatic parameters, temperature, precipitation, soil depth. All of those factors are incorporated. And then plugged into the code to do all the realizations.

So we've, in fact, I think that the code explicitly accounts for most of the uncertainty in what's going on with infiltration. If there's more questions on that --

MR. SAGAR: You had a, these case resolutions, 30 meters, was it 30 meters?

MR. STOTHOFF: Correct.

MR. SAGAR: And the time resolution was?

DR. STOTHOFF: In the process level model, we ran hourly increments using National Weather Service data to generate the inputs for the simulations from desert rock. We account for changes in temperature over the elevation of the Yucca Mountain. We account for changes in precipitation due to elevation. We account for solar radiation being different on the north-facing and the south-facing. We account for different wind speeds on the ridge versus in the washes. So it accounts for I think most of the factors. It incorporates overland flow as a additional, effect of precipitation, lowering the slopes based on water shift scale modeling --

MEMBER HINZE:Can I ask a question, then? In those realizations to deal with the full glacial climate conditions, did you, and to reach the 20-percent percolation, did you assume that there was no evapo-transpiration, or no transpiration? How did you reach that 20 percent?

DR. STOTHOFF: The way we would do that in the breath simulations is to take the meteorologic record and multiply the precipitation, every precipitation value by a constant factor, say one-and -a half.

MEMBER HINZE: Let me interrupt you if I might. What we're really talking about here is the second bullet of Tim's overheads and this is the intermediate to full glacial climate, so it's not the present-day climate that we're dealing with?

DR. STOTHOFF: Correct.

MEMBER HINZE: So, how did you modify this in the TPA or the TSPA for the full climate conditions, to get that 20 percent?

DR. STOTHOFF: What we, in the breath simulations, what we did was change the precipitation to increase the precipitation by multiplying by a factor and dividing, or reducing temperature by a constant factor. Each hour. Once, and this is used to derive the response surface. So, once we had the response surface, then that response surface was plugged into the ITYM code to the pre-processor and then, a function of mean annual precipitation and mean annual temperature, we could simply multiply precipitation by one-and-a-half for whatever factor.

MR. McCARTIN: One thing to add would be that the, certainly the higher percent resulting in deep percolation is going to be due in part to cooler temperatures, where evaporation is less. So it is accounted for. But when you have the potential for more rainfall and cooler temperatures, actually, the cooler temperatures do a lot to allowing less evaporation and, thus, more deep percolation. And I know Janet has a comment to make.

MS. KOTRA: Yeah. I feel compelled to just note what we are trying to accomplish here. What the EPA in its proposed revisions to Part 197 is asking for here is more akin, less to a precise prediction of what the actual deep, what the actual climate is going to be in these long time frames as it is to the, it's more akin to the human intrusion scenario. A stylized approach in a sense that, you know, looks at, you know, we look at a reference biosphere, we're looking in a sense at a reference geosphere here.

In this range of five to 20 percent, is this a reasonable range within which we would expect that, knowing what we know about the past, is this a reasonable range to assume that how much wetter and colder could it be and what effect would that have on performance? But not, in any sense of the imagination, a precise prediction. And I think it's important to keep that in mind as we evaluate the reasonableness of what we've proposed here.

DR. SANFORD: Tim?

MR. McCARTIN: Yeah.

DR. SANFORD: One thing I didn't see addressed was the temporal variation in precipitation. I mean, these climates, you know, the extreme events can result in 90 percent of the recharge. Are these accounted for in the TPA simulations and is there any idea, in a change in climate, how that's going to change the frequency and intensity of the storms that might account for a lot of the recharge.

MR. McCARTIN: Well, as Stuart indicated, the breath code, the calculations were done on an hourly basis. So there is some evaluation, or you could have short-duration events.

In terms of, once again, I mean, I echo what Janet says. As I was saying, we're looking to what's a reasonable test to subject Yucca Mountain to? And I think we're looking at, you know, we aren't trying to say we have the Rosetta Stone for predicting climate for the next million years, but we think, based upon, we believe it's going to be wetter and cooler for a lot of the time. That we're proposing these values and, like I said, the comment period has recently ended and we'll be very interested in looking at the comments people provide us.

We'll be looking for feedback from the committee in terms of what do you think of this approach? And, you know, I personally believe we've put forward something that is reasonable to be considered. That's why we proposed it. Are we saying, hell no, we're not going to change anything of this? No. That's why we go out for comment.

And, you know, it, but I think it was a reasonable starting point for our proposal and the beauty is, as today, which is great, it elicits comments from people. And then we can go back and look at the comments we've received and see what seems to be a reasonable approach for the final rule.

MEMBER WEINER: Tim, does your five to 20 percent, do you believe that that encompasses the uncertainty and what kind of distribution, just generally speaking, is this the ninety-fifth percentile? Is it, what's the shape of your distribution? Is it flat?

MR. McCARTIN: Oh boy --

MEMBER WEINER: What have you thought, what are your thoughts?

MR. McCARTIN: Right. Well, the shape of the distribution, of that distribution, I didn't really, I couldn't even hazard a guess as to what it is other than saying it's log-normal, because most things are log-normal.

But, I think it is a reasonable range that, given precipitation is between 250 and 420. Now, 420 could be at the high end of the rainfall amount. This is definitely due to larger rainfall amounts and cooler temperatures. And, I'll say for the technical people here and at the Center, when we sat down and did this, the desire was no more than what I said. That, gee, here's a simple approach. I think, we think we're in the right ballpark. Let's go out for comment. Let's see what people tell us. I mean, there's no, it's very complex situation.

There's all kinds of uncertainties and debate about climate change over the next million years. It is just, I think that's not an unreasonable range. I mean, 20 percent sounds a bit large. It's hard for me to imagine a number any significantly larger than that. But that's my -- Gordon, I don't know if you want to -- he was one of my cohorts in crime if you want to just give a perspective on the values.

MR. WITTMEYER: Well, as an unindicted co-conspirator --

(Laughter)

MR. WITTMEYER: -- I'll just say, I don't think that we had a distribution for that five to 20. That was the lower end of what we were getting from the averaging of all the breath simulations, effectively for the Yucca Mountain area. The 20 percent was the upper end for the cooler, wetter climates we were simulating. And so we used those as an upper and lower value. And, I don't know what the distribution would be if we looked at all the intermediate values, or if we looked at something that pushed the ends, both the lower and then the upper end. That would require a bit more investigation on our part.

VICE CHAIRMAN CROFF: Tim --

MR. McCARTIN: Yes.

VICE CHAIRMAN CROFF: If I could ask you to go to your next slide. I think it may be in the interest not only of time but I think it would help me --

MR. McCARTIN: Sure.

VICE CHAIRMAN CROFF: -- I'll make my point. With the top part of it just being pretty much a multiplication.

Stepping away from the business of, needing to stylize this if your will, my, and I want to get to the reasonableness --

MR. McCARTIN: Yes.

VICE CHAIRMAN CROFF: -- part of it.

MR. McCARTIN: Sure.

VICE CHAIRMAN CROFF: If I understand what people seem to think reality will be very generally into the future, it is, we're sort of in a relatively dry period right now. The future, at least some believe, tendency towards some glaciation which would be warmer and, if I understand what's being said, more of the time, I'm sorry, I don't mean warmer, wetter, and more of the time wetter than dryer like we are now but cycling between the two --

MR. McCARTIN: Yes.

VICE CHAIRMAN CROFF: -- over a million years. And, when I look at that and then I look at this range of 13 to 64 with the lowest value being two-and-a-half times what we experience currently, it just doesn't seem reasonable to me the range into the future doesn't encompass the current situation. I'm not claiming this current situation should be the mean or median or something --

MR. McCARTIN: Sure.

-- like that, but it certainly seems that some of the time into the future, what we experience now should be there and some of the time it will be wetter. If we believe, you know, if we believe the glaciation people. There is, I, if I understand it, there's another camp that sort of tends to believe we may be dryer for a much longer period of time, but I'm not going to promote that view. But when I just stand back from the whole thing, it seems to me this range it's somehow it's reasonable that it should include the current situation.

MR. McCARTIN: Well, I --

VICE CHAIRMAN CROFF: So that's, let me leave that as a comment for a second. I think the second part of this is, when we go to the stylized thing, we're basically going to pick one value in a range and say this maintains for, basically forever, out to a million years. Has anybody looked at the comparative case where you assume a value, let's pick 50 from that range, and then looked at oscillation, you know, or cycling if you will, to see if you get about the same answer or whether the cycling makes a really big difference in a performance assessment? I mean --

MR. McCARTIN: Yes. Sure.

VICE CHAIRMAN CROFF: -- sort of a validation of the stylizing assumption if you will. So that's sort of my comment and thought.

MR. McCARTIN: Sure. Well, there's a couple things there. And I think we as a group, when we developed this approach, would disagree with keeping the current conditions throughout the next million years.

Currently, we tend to be at a very dry time. When we look at the information, and it's not, and once again, I'm not trying to say we're right, but

I do want to explain our thinking process and that's the reason we went out for comment. But we look at, it seemed like there was strong evidence for the majority of the time beyond 10,000 years, it is going to be wetter. So, to hold one of the more important parameters in calculating those, the amount of water getting to the repository, at a low value would seem not to be a fair test for, in our opinion, I mean for Yucca Mountain water --

VICE CHAIRMAN CROFF: No. That's not quite what I was --

MR. McCARTIN: Okay.

VICE CHAIRMAN CROFF: -- suggesting. It seems to me the current situation should be within the proposed range. Right now, it is well below the proposed range. I'm not saying that it should be that value.

MR. McCARTIN: Yes, yes. Certainly.

MR. WITTMEYER: This is Gordon at the Center. What the, the estimates that we're providing here are a long-term time average. You wouldn't expect to see the lowest lows, let's say what we're in right now, with the highest highs in a long-term time average. Think of averaging sine curves that are slightly different in amplitude or maybe have a slightly different root-mean-square value. You're not going to see the lowest values like the current value today. This is a long-term time average. It's a little bit different kind of a number here, we're talking about for this stylized climate scenario.

VICE CHAIRMAN CROFF: Okay. I hear you.

MR. WITTMEYER: Let me take a crack at it because I think --

MR. McCARTIN: Well, but, but let me continue with this. If this were some other things, I mean, and with respect to performance, generally in just about every repository calculation I've seen, more moving water is bad to performance. So, there's an understanding that indeed the more water will be bad. Higher release rates.

In terms of looking at this long-term average, recognizing that most of the time it's wetter, and with that as a backdrop. I think picking the, I personally I was actually kind of comforted by 13 at the low end, that it's not that dissimilar than what we see today and so, some people have estimated 10 millimeters per year as high. I mean, generally it's five, but, you know, people have gone up to almost 10 for Yucca Mountain. There's a lot of uncertainty in that. So, you know, as the low end I'm not terribly troubled by it.

The oscillation, I think would add a complexity that I don't know how anyone would deal with it in terms of what's the right kind of oscillation to do over time, in that, because now you would be dominant, well it wouldn't be dominant, you would be affected by when the waste package fails with respect to this oscillation --

MR. WITTMEYER: That's it.

MR. McCARTIN: -- and gee, what if I get a whole bunch of them failing when it's low, and so I'm dribbling out some release and then, there's some period where -- that's a complexity that I'm not convinced, understanding the behavior of a Yucca, of a potential depository at Yucca Mountain is enhanced by doing the oscillations rather than picking a range where we're, it's going to be wetter, and I know when it's wetter, when the waste packages fail, I will have the wet conditions.

And I'm not overly concerned about whether it's coming out of a dry, into a dry, out of a wet, into a wet, whatever. And, it just, once again, in terms of a reasonable test, I think the oscillations would be very problematic to try to describe how this oscillations occur --

VICE CHAIRMAN CROFF: I don't think you understand --

MR. McCARTIN: Okay.

VICE CHAIRMAN CROFF: -- all I'm suggesting on the oscillation is you, maybe, I mean, staff --

MR. McCARTIN: Yes.

VICE CHAIRMAN CROFF: -- needs to run a couple of cases, maybe failure at low, failure at high, just so you understand where, what the boundaries of this thing are. I'm not suggesting that it should be the stylized --

MR. McCARTIN: No. Okay.

VICE CHAIRMAN CROFF: -- proposal, if you will.

CHAIRMAN RYAN: Tim, at the end of the day we're trying to figure out what the concentration is that's going to enter some sort of transport scheme. And I think about infiltration and rainfall. And your earlier comment that sometimes the episodic events, the big rains, are, you know, controlling in some circumstances and some not.

If I have a dry period, that means I have very little water entering the system perhaps, so movement's minimized. Just accept that as a premise.

What happens if I now shift gears into a wetter system? I think you've got to at least explore this idea of oscillation because -- well, maybe that's not the right word for it, because can't you get higher concentration slugs coming out? And I don't mean a slug all in one day. I mean over some period of time?

I'd at least want to explore that somehow and make sure that when I'm operating within your range, that I don't have the possibility of what happens after a dry period and now it transitions into a wet period. Do I really get increases in release rate or am I off-base?

MR. McCARTIN: Well, certainly the -- as any natural system, the rainfall does not come out, or the depercolation does not enter as a uniform amount over time. And there will be sometimes large variations in that.

However, one aspect of slugs and these variations, the transport time is generally fairly long and dispersion and other hydrodynamic effects will tend to smear out these slugs. And might you see some oscillations? There could be some. I would argue that we do represent differences in transport paths and we do see some variation as a result of it, but there does come a point where I think the episodic nature, certainly of infiltration rainfall, I mean, you could have dry years and then wet years. But the hundreds of years, sometimes thousands of years of transport will tend to smear that out.

CHAIRMAN RYAN: And again, I don't disagree with your point, but I'm just saying that when you see a factor of say 5 or so of infiltration rate, I wouldn't want probably the wrong conclusion to say well, that translates to a factor of five and dose or concentration.

MR. McCARTIN: Right.

CHAIRMAN RYAN: And I think that's kind of what Allen, what you're getting at a bit. If you explore those ranges and how variations over time within the range, either at the low, the medium or the high, what effect that might have on concentration on an estimate of dose. That's helpful to get an insight.

MR. McCARTIN: Yes, and certainly most processes are not that linear with respect to performance, that doubling infiltration will double the release rate.

CHAIRMAN RYAN: And of course, certainly --

MR. McCARTIN: For solubility, lots of

radionuclides can do that, it depends on the release rate. There's many factors that come into play, but yes. It's not a one-to-one with that.

CHAIRMAN RYAN: Thanks.

MEMBER HINZE: Tim, to help clarify this, it's my recollection of the proposed EPA standard is that they have directed you to minimize the temporal variations going out to a million years, but to assume average conditions. Is that correct?

MR. McCARTIN: To minimize?

MEMBER HINZE: To minimize the oscillations, if you will.

MR. McCARTIN: They have suggested it could be represented as constant conditions.

MEMBER HINZE: Right. And so they should be represented as an average constant condition of what you are suggesting and that's what you are -- you're really taking some bounding conditions here, well, maybe not bounding, but some limiting conditions of the 5 to 20 percent and the precipitation.

MR. McCARTIN: Yes.

MEMBER HINZE: I think that's --

MR. McCARTIN: And people will have different views and comments have come in about the reasonableness of what these numbers represent, but yes, the desire is that we're doing a long-term average and -- Janet?

MS. KOTRA: I know the Committee understands this for the benefit of the broader audience, I think it's important to remember that while EPA suggested that a single constant level might be appropriate, we're not calling for that here. What we're calling for is in the multiple iterations that DOE will conduct, that each time they do an iteration, they sample over this range.

Now I know like I said, I know the Committee understands that, but I think sometimes in our shorthand, the way we speak, it gives a false impression that somehow we're only interested in a single value over all time and that's not what we're doing here.

VICE CHAIRMAN CROFF: This range of 266 to 321, that's your best stab at the average precipitation over very long times?

MR. McCARTIN: Yes, that was based on the site at USGS document on the analog sites that was representative of the last glacial maximum.

And so all we did was just take the --

VICE CHAIRMAN CROFF: Those are the words that are confusing me, "last glacial maximum."

MR. McCARTIN: That's out of the report. That's what they estimated the infiltration because they took --

VICE CHAIRMAN CROFF: I mean is a glacial maximum representative of the average climate over a million years?

MR. McCARTIN: And we expect to get comment on that. In general, there is this range that we think is not unreasonable for most of the time from the -- for the monsoon and interglacial. It's close enough that we are using it.

VICE CHAIRMAN CROFF: Forgetting whether it's reasonable or not, I'm just trying to establish fact. That range is representative of a glacial maximum?

MR. McCARTIN: Yes.

VICE CHAIRMAN CROFF: Thank you.

MEMBER WEINER: To get back to one of the comments that Dr. Sagar made, there are places in the United States which have this range of rainfall. I happen to live in one of them. And it seems to me that it ought to be possible to measure, to get some kind of field measurements of deep percolation over a period of years in places that today mimic this rainfall pattern. Because they certainly exist and you could look at a range of, you have different soil depths, different bedroom exposed. You could look at a range. And it seems to me that would anchor your estimates in some kind of valid reality.

MR. McCARTIN: Yes.

MR. WITTMEYER: Can I just say something before we proceed? We've actually looked at a lot of different studies conducted in similar air to semi-air climates where there has been some very good quantitative work done on many scales from using simple wing lysimeters run over time to I suppose different types of regional recharge estimates, such as using a tool like the Demecci-Ekin formula and this range of 5 to 20 percent of the annual precipitation becoming net infiltration is the term I'll use from those studies, isn't very reasonable range for similar climates.

MEMBER WEINER: Thank you. I think that's a very important statement.

MEMBER HINZE: I think one of the problems here, Ruth, is that we don't want to just duplicate the precipitation. What we have to duplicate, the other conditions that go along with the last glacial maximum. And that very much affects evaporate transpiration, in particular. And also, well, many other factors, but particularly evaporate transpiration. So you just can't go to your backyard where you have 11 inches of rainfall to do that. It's not going to be comparable to the last glacial maximum.

MEMBER WEINER: No, I understand that. But I think Gordon's statement was very cogent that there is a basis, a measured basis.

MR. McCARTIN: Just to finish this up, obviously, we took the too low values and multiplied them and two high values to get a range. We did use a log-uniform distribution. Why log-uniform? Well, depercolation is really a multiplicative process. This would suggest a logarithmic distribution.

We really have no basis for favoring either end of the distribution and so that would suggest a uniform distribution. We ended up with a log-uniform distribution.

In terms of that distribution, what happens? Really, when you sample this, you'll end up with a mean value of approximately 32 millimeters per year which is approximately 6 times greater than is currently estimated for Yucca Mountain under the current conditions.

And now to the status. The EPA comment

period ended on November 21st. Our comment period ended on December 7th. As I said, we put forward what we believe was reasonable basis for proposal. We'll consider the comments and we would expect to finalize our regulation shortly after EPA finalizes its standard. That's really where we're at, at this point.

A lot of good questions, suggestions. I'd be happy to answer further questions.

CHAIRMAN RYAN: Let's go around. Jim, do you have any questions?

MEMBER CLARKE: Going back to your illustrative-dose calculation, the neptunium really tracked well the dose for all the radionuclides. You did mention that you think it is important to look at other waste package degradation scenarios. I guess that reflects a particular set of assumptions.

Can you then use neptunium as a surrogate to look at a number of scenarios or would that be beneficial too?

MR. McCARTIN: Certainly, I think just before other purposes, we would continue to include iodine and technicium.

MEMBER CLARKE: The more mobile --

MR. McCARTIN: Yes, just because of their mobility and we are in the process of adding plutonium colloids. We're not aware of any significant change that will make, but certainly in looking at the DOE calculations, plutonium colloids do contribute, but it's certainly at present we have approximately 21 radionuclide -- 21 or 22 radionuclides that we simulate for the groundwater pathway.

And we are looking at ways to simplify that list of radionuclides just to make it more efficient, because it's a million year calculation. It just takes a little bit longer than 10,000 years.

MEMBER CLARKE: It just struck me that the area, to me would have a great deal of uncertainty as when they fail, how they fail and what happens after that. And limiting the number of radionuclide, I would think, would let you do a -- look at a lot of scenarios perhaps. I don't know the details about the model and the time required and all that.

MR. McCARTIN: Certainly what I'll say, the gedanken experiments that I do with the code, I often use neptunium and occasionally I'll throw in technicium or iodine, but you can learn a lot from neptunium. You obviously, whatever -- if you feel you've learned something significant, you go back and redo it for the full suite of radionuclides, but you're absolutely right that just running the code with neptunium, you can learn quite a bit.

MEMBER WEINER: Couple of things. Tim, if you go back to your slide 11, the infamous slide 11, I assume that from what you said that you were including mobility, some kind of mobility in this slide.

MR. McCARTIN: Oh yes.

MEMBER WEINER: My question is since your peak looks to be eyeballed at around a little more than 100,000 years, maybe 125,000, 150,000, why are we going out to a million years?

MR. McCARTIN: Well, you don't know the peak is there unless you go out longer. I mean it's easy to say where the peak is after the fact, but --

MEMBER WEINER: But now looking at this, you know, you can see that after 500,000 years, your dose is very greatly decreased and it even decreases markedly after 200,000. Would it make sense if this were not a regulatory world, but would it make sense to say okay, we only need to go out to 200,000 years?

MR. McCARTIN: Oh sure. And certainly in terms of when you're using the code, yeah, I've flipped it at 500,000 years, just because -- just to get the numbers out faster for no other reason. And once you know things, you'll still need to at some point go to a million to convince someone of what happens. And certainly -- I mean the reason this occurs at that location, in general, in our code, most of the waste packages have failed around 80,000 years, 60,000 to 80,000 years. And that's why it occurs there.

And we have a single non-time dependent degradation of that waste package. If we put in time dependent degradation of that waste package, it may move this around, do some other things, so there are other things that might occur.

MEMBER WEINER: I have two more quick ones. How does your estimate of the influence of climate change compare to the Department of Energy estimates? We had a presentation more than a year ago of their estimates of climate change and I just wondered, are they very far apart? Are they similar?

MR. McCARTIN: Well, certainly our proposal is looking to specify a long-term average value and neither prior to this current rulemaking, no one was estimating climate change in that manner and I can talk to our previous -- the code we currently have, the TPA-401 code has Milonkovitch cycle, 100,000 thousand year cycle of going up and going down with climate change, a relatively gradual up and down for climate change. That was our representation.

The Department had these steps, these very instantaneous steps to represent climate change, some of which were fairly large, so I think we're both -- the similarity is we were both estimating that that conditions would get wetter out in the future, but we had a smooth Milonkovitch 100,000-year cycle whereas they had a very rigid step function that was repeated for every realization it was exactly the same in terms of the timing of when climate changed, etcetera.

MEMBER WEINER: Thank you.

CHAIRMAN RYAN: Bill?

MEMBER HINZE: Couple of questions, please. Are the questions and comments of the public going to be made public?

MR. McCARTIN: Well, they are. They currently are on our website. If you go to either the internal NRC or the public NRB website, there's a -- I think on the home page, there's a tab that says rulemaking and you can get to proposed rules. There's a couple clicks and as comments are received, docketed and put into ADAMS, they are made available on that website. And I will say the last time I looked which was either late last week, yes, I think it was late last week, there were six comments, I believe, on the web site. Six.

More have been received, because they have come in under the -- you tend to get more right at the last minute and the State of Nevada's comments, I was told, I have not seen it, is approximately a thousand pages. And so reading that -- getting that scanned into ADAMS takes a while. So the State's comments have been received, putting that up on ADAMS will take a while. So there is some delay, but certainly additional comments have been received and as appropriate, SECY puts them on the website, yes.

MS. KOTRA: I just want to add that within that six that may have been up prior to the close of the comment period, there were many repetitions of some of those same ones that were received and have been treated, you know, we put discrete comments in, but we don't repeat multiple bulk mailing type of things.

MEMBER HINZE: And one final, more philosophical question. One of the things that we've seen during the past decade and the past two decades, we've seen a tremendous increase in our ability to predict recharge or what we think is recharge. The processes, we understand better, the input, etcetera.

And so we're doing a much better job. I'm wondering as you looked at the surrogate for climate change, if you considered the possibility of not specifying specific values for the recharge, but to make this in a more general sense so that based upon principles that would help us to -- would make it possible to incorporate new technologies, new information?

MR. McCARTIN: As I remember it, that particular approach did not come up in our discussions based on the language that was in the standard, that we felt we should provide a value and it would be no question in terms of what it is.

The Commission always has at its disposal, if at some later time, they learned something is either incorrect or not appropriate, we can modify anything in our regulations. So I appreciate the fact that yes, knowledge goes forward, but it just seems for the most direct way for us to provide the value is an explicit number.

MEMBER HINZE: It kind of smacks of the groundwater travel time show which we had in 60, of a very specific number. Thank you.

MR. McCARTIN: Although I tend to look on it more, as Janet indicated, this is a stylized approach for something that trying to get a handle on what the climate is going to be for the next million years is a daunting task. Likewise, for the reasonably maximally exposed individual in the rule, how much water is someone going to drink per day? We specify, the EPA specified two liters a day. Now people are going to drink less. People are going to drink more. That's a reasonable test. I believe that specifying this value, our desire was a similar kind of thing.

I can no more -- I can't tell you how much people are going to drink in the future, but two liters a day is reasonable. The approach, we tried to put forward something that we believe is a reasonable test for an average climate to use in the calculation.

So I prefer to look at it more like well two liters a day is something that the absolute number, here it is, use it, a similar kind of thing for climate change.

CHAIRMAN RYAN: We have for perhaps one or two more questions. John, you had your hand up, John Flack?

MR. FLACK: John Flack from ACNW Staff. I'm curious about the curve you have up there and the sensitivity of that curve to the integrity of the waste packages. And should the waste packages fail early or later, how sensitive is that curve?

And then given that, if it's wetter earlier, will that fail the packages sooner and is that all accounted to by the model?

MR. McCARTIN: Well, the model certainly accounts for the potential for different failure times of the waste package. We have approximately eight sub-areas and we calculate a representative package for a sub-area. So there's only eight, but within that sub-area, you have different infiltration rates. Most importantly different temperatures and so you have the potential for different corrosion rates and that impacts the time that the package fails.

It certainly is very sensitive to when the waste package fails. The peak, I would maintain, would not be sensitive, that neptunium has, I believe, a 2 million year half life and so if I move this out to say 400,000 years, and I'll do that test. I can artificially extend the lifetime of the waste package and see what happens, but the neptunium inventory is going to be pretty much the same. My guess it would be unaffected.

The only -- the biggest thing that I would say from a time standpoint that affects the calculations is extremely early waste package failure. Extremely early as in the first thousand years. When the source term is hot, the release rate tends to be higher and so if you had waste packages early on, you tend to get a higher release rate but that's --

MR. FLACK: That's what I mean. If you can show that the packages will survive for the first 10,000 years, then it really doesn't pay to go and pursue how they're going to degrade post-10,000 years or spend a large effort in there. I guess all the action is up front, right?

MR. McCARTIN: Right. But and I agree with that statement, but as a reviewer of the DOE, potential DOE license application, I want to review it from a position of understanding. And I want to understand, as I was talking before, does the way this waste package fails affect that dose estimate so I can understand better how DOE represents. They have a different model than we have. They have patches that grow with time and there's different release mechanisms, so they have a slightly different way of representing that waste package degradation.

My gut tells me it probably doesn't make a big difference, but it's something that we haven't really looked at much in the very long time frame and it's something to explore, but in general, the early on, during the thermal phase is when the waste package failure is of most concern.

CHAIRMAN RYAN: Just one last question and then we'll take our scheduled break so we stay on schedule for early speakers here and then we'll come back after break.

MR. SCOTT: Mike Scott, ACNW Staff. Tim, would you care to hazard a guess as to what that curve would look like if DOE goes back to the cold repository concept?

MR. McCARTIN: It might not look any different. It might not.

Assuming and this is assuming the -- and there continues to be updates in the parameters and models of our code. Assuming the waste package failure continues to be in the 60,000 to 80,000 year time frame, because a cold repository, if you're looking at eliminating bad chemistries early on that could potentially fail the waste package, at least in our code, we don't have those bad chemistries occurring early on.

So the failure of the waste package is not being caused by this bad chemistry early on during the thermal period and so I don't -- at least as a first assumption, I don't think it would change much.

However, I will say -- I am not -- we can get back to you with the corrosion experts. Corrosion is the long-term corrosion with a cool repository, would this be pushed out even further? I -- we don't have the people here to talk to the corrosion, but the bad chemistries early on aren't the issue. If it was cooler, does it change it dramatically? I don't now. In our models, so I draw the distinction. It's possible in the DOE models. Maybe that would make a much bigger difference.

CHAIRMAN RYAN: Tim, to finish up before our break, I think the idea of how the package interacts with these new views of infiltration might be a topic for our discussion down the line, same as developing your thinking a little bit more, but there are some good questions on those aspects.

So with that, we're scheduled for a break at 10:15 to 10:30. Let's come back at 10:35 and we'll start promptly, picking up with our other speakers and hopefully continuing the discussion through the end of our morning session. We'll start with some other questions after our presentations.

Thank you.

(Whereupon, the foregoing matter went off the record at 10:20 a.m. and went back on the record at 10:37 a.m.)

CHAIRMAN RYAN: Okay. We'll reconvene and begin with some additional presentations on the reasonableness of infiltration. The NRC infiltration assumption that proposed Part 63.

Leading us for the rest of the morning session will be Profession Hinze. Bill?

MEMBER HINZE: Thank you very much. We have two speakers in this unit on the reasonableness of NRC's infiltration assumptions and their proposed changes to Part 63.

The first presentation will be involved with the chloride mass balance which takes a prominent which takes a prominent role I this. And it will be given by Ward Sanford, Dr. Ward Sanford who is the research advisor on groundwater for the U.S. Geological Survey.

And as Senior Hydrogeologist for the Research Hydrologist for the Survey, he has written extensively on recharge and particularly the chloride mass balance method which is referred to in the discussion of the revised Part 63.

With that word, it's yours.

MEMBER HINZE: Thank you. Ward?

DR. SANFORD: So from what I understand now, in the Federal Register there was a reference to some work done using the chloride mass balance method at Yucca Mountain to also estimate recharge rates during the last glacial maximum. So this is sort of a two part presentation here.

I'm going to start with a broader context for those of you who aren't familiar with the chloride mass balance technique. And we'll give you some of the assumptions, the backgrounds, a couple of simple cases where it has been used successfully.

And then what are some of the issues involving estimating recharge at Yucca Mountain that it might involve understanding how the chloride mass balance assumptions might work there.

So as I was saying, first I'll give some background on the chloride mass balance methods, assumptions and examples. And talk about a little more general about transport water and chloride in the unsaturated zone in arid environments. I think there have been some very interesting things that have been learned just in the last few years.

And then how this might apply at Yucca Mountain. A very simple first presentation of how some numbers were calculated and then give it over to

Chen Zhu who will go into a lot more detail on how that approach was used at Yucca Mountain.

So here's the simplest form of the chloride mass balance approach. First of all, it really is just applying to any conservative solute that is in the precipitation then ends up in recharge. It's just the chloride happens to typically be the most conservative solute so that's what is most often used. And it has now been just called the chloride mass balance.

Essentially you are just balancing mass as you have precipitation fall on the land surface and evaporation then from the rue zone near the evaporation and transpiration. And then what gets below that down to recharge and deep percolation also has chloride in it.

So the key factor here is that evapo-transpiration does not -- it takes water but not chloride. So you can write a simple balance equation here that the precipitation times the chloride concentration in precipitation has to equal what comes out the bottom here, which is the recharge flux times the concentration of chloride in the deep percolation water or the groundwater.

Since these two terms are equal, you can rearrange and solve for recharge so that if you know the precipitation rate, the concentration in the precipitation, and the concentration in the groundwater, you simply can then estimate recharge.

So if the chloride in the concentration of groundwater, for example, is ten times that of precipitation, then that's telling you that only one-tenth of the precipitation ended up down here as recharge.

Now there are some important assumptions if you are going use this. One, if you're going to use that simple form I was just describing, you need to assume that there is steady state flow for your measurements. You also assume in that consideration that there is no runoff from the system. If there's runoff, you have to somehow account for that.

Also that somehow you've accounted for your anthropogenic sources or that you've measured the dry input on the land surface if there are any there. And that your measured samples have to be a good statistical average.

If you take one core at one place and get numbers, you have to ask yourself does that represent the whole area I'm interested in or do I need to take a whole range of samples?

Typically what you are sampling is in the matrix fine grain material. If it is a fractured rock, then you've got to worry well, is there a lot of bypass going on around what I've sampled for example, through fractures or macropores?

And if all of these assumptions are valid, then you might expect a chloride profile in the unsaturated zone to look like this where right at the surface, you've got concentrations of chloride represented precipitations. These are going to increase as you go below the land surface a meter or a few meters until you get below the root zone, there is no more transpiration.

Then if you are at steady state, those concentrations should be relatively constant down to the watertable.

So just a couple quick examples where this seems to have worked fairly well. I worked with Warren Wood when he was at the USGS in the High Plains, Southern High Plains in Texas. And we did a simple calculation looking at wet and dry chloride in precipitation all across the Southern High Plains.

We also looked at the published chloride values in groundwater from 3,000 wells across the High Plains, took and average. Turns out there is very little runoff across the High Plains. A lot of it focuses into very little small playas which then recharge the Ogallala Aquifer there.

And doing these very simple calculations, we came up with a calculation of 11 millimeters per year average recharge to the Ogallala. And it was interesting back in 1937, C. V. Theis made a very good estimate of recharge just looking at the slope and the water table and the known transmissivity of the aquifer and came up with a number that was very similar. So we -- very close to this, in fact, so we thought that was a good way to estimate recharge there on the Southern High Plains.

Another case I was recently sort of involved with was in the Albuquerque Basin where we were doing a lot of work collecting environmental tracers in the basin. We were creating a groundwater model for the Albuquerque Basin and using C-14 and doing paleo simulations in trying to estimate what the recharges were in the Albuquerque Basin.

And along there -- along the eastern side of the Albuquerque Basin there's the Sandia Mountains and other mountain ranges there. So a lot of the recharge in the basin falls in the mountains and then runs through these little streams and ephemeral streams in Arroyos. And then discharges out onto the flats here. And that's how a lot of the recharge curves right along the mountain front.

So Scott Anderholt at the USGS in Albuquerque did this study along the mountains there looking at these individual little watersheds that run off. So he calculated the area here and how much precipitation came in, what the concentration was. That all got focused out here onto the mountain fronts and into the streams.

He took concentrations of groundwater out here and made some comparisons. And so in this case, he wasn't looking at a flux versus flux but simply calculating total volume and mass of chloride and then putting it into the mountain front here and coming up with a volume metric rate of recharge. And that came up with about 11,000 acre feet per year along the entire mountain front.

We compared that with our model which we were calibrating using carbon-14 from these values here and we came up with quite a good similar number to what he got with the chloride mass balance. So we think the numbers are at least consistent with other methods there.

So now you might want to ask yourself --

and remember that profile has shown you what chloride should look like if you are assuming steady state in the unsaturated zone, does chloride tend to look like that in arid climates? And the answer is no.

If you look at steady state chloride profiles, for example, these were plotted and compiled here by Michelle Woolvard who is now at the USGS from some different sites around the west here. Typically this is what you see. You get a great big bulge in chloride her in the top few meters. And then it goes down relatively -- quite dilute for the rest of the way below that.

So it doesn't look at anything like the steady state model. You get this bulge in chloride. And what this high chloride then might be suggesting, of course, is that very little recharge has occurred in the last hundreds to thousands of years. It has been accumulating here in the top part of the soil profile.

So what does that mean? Is there anything we can do when we come to a situation like that? Well, one approach people have tried to use is something you might call a transient chloride mass balance approach.

Let's just assume that there's piston flow down through here. And that there has been a constant precipitation flux. You can do some calculations. If you assume the chloride constant precipitation is also constant and you can assume the recharge then varies with time, you can actually sort of calculate the accumulation time through past here for this vertical segment of the profile.

If you do that, then you -- the calculations reveal actually that this amount of chloride, for example, would take several thousand years to accumulate at very small infiltration rates. So it's sort of an adapted chloride mass balance approach.

What Michelle Woolvard also did recently, just in the past few years, is some very interesting simulations of the unsaturated zone here. And here she has looked at four different profiles out in southern Nevada here in an area not too far from interest to us.

And she did some detailed modeling of vertical profiles to match both the tensions they see in the unsaturated zone, the hydraulic tensions, and also the chloride bulges trying to get fits to chloride bulges.

So you'll see you get these little

chloride bulges here in a few meters below the land surface like I was showing before. A couple of these you get bulges a little bit deeper which suggest, perhaps, some older things going on there.

Let me see here. But what she found out was actually very interesting. How do I go back here? Can I go back? Previous? There we go.

She simulated not only water movement but also water vapor movement, heat transport, and solutransport. And discovered that under these dry, steady state conditions, there is a net -- in this deep section, contrary to what a lot of people have sort of assumed that there is some very small movement downward continuously of this water, there is a net movement actually upward in this system.

The plants up here, the desert plants are keeping the system very dry because they are very efficient at taking out water. There is actually a small network of movement of water upward in this system. And not downward over time.

MEMBER HINZE: Are any of these -- Ward, if I might, are any of these in fractured rocks where there is a matric flow but rather fracture flow?

DR. SANFORD: I don't so. If they are what they probably sampled here are the matrix materials. But what she was able to do is to try to fit those different curves of chloride -- as I was saying, she simulated water, heat, and vapor and chloride transport. She was using the FEHM model from Los Alamos Laboratory. And these are the four different profiles she was simulating.

She could adjust -- and this is time here along the X axis. So here is present and this is back in time. She could adjust between dry periods where she would set the tension in the top of the soil very dry approximately to what the plants are keeping it at.

And then you get these intervals of some type of net recharge event that would move the chloride downwards.

So they essentially build up in the dry periods and then get moved downward in these wet periods. So as you can see -- remember the profile, these two profiles 1 and 3 showed some lower bulges. Those were essentially -- had to be reproduced by having wet periods a log way back about 100,000 years.

And there was an interval of dry here until about the last glacial maximum or the end of the last glacial maximum where the precipitation occurred to help move the profiles down a bit. Then essentially in the last 10,000 years there has been zero recharge.

So what might all this add in terms of our discussion about recharge at Yucca Mountain -- and these issues have been brought up this morning already as well.

This was just something out of Fred Phillip's recent paper sort of summarizing a lot of what he knows about climate change in the desert and how it effects recharge, saying it is clear that a focus solely on changes in precipitation constitute a great oversimplification. Changes in other fluxes that redistribute precipitation after it hits the land surface must be considered.

So these are a generation of runoff, evaporation, and transpiration. And in talking in the discussions this morning, all of these are being considered.

MEMBER HINZE: Excuse me.

DR. SANFORD: Yes?

MEMBER HINZE: Let me ask you a question.

DR. SANFORD: Sure.

MEMBER HINZE: In terms of fracture flow rather than matrix flow, are any of these prominent in one or the other? Or are they prominent in all? Or how do you see that?

DR. SANFORD: How do I see --

MEMBER HINZE: See the --

DR. SANFORD: -- relation to the chloride mass balance?

MEMBER HINZE: -- for example, thermal gradients, matric potential?

DR. SANFORD: As far as I'm concerned -- as far as I am aware of -- from what I'm aware of, I have not seen those simulated. I mean it is a much more complicated system. So maybe somebody out there is trying to simulate these. But the simulations that Michelle did were the first I've seen, you know, the fully coupled simulation in the unsaturated zone period.

So the simplist thing to start with was this matrix material. So I have not seen it progress to look at what the effects are in a fractured rock. However, I'm sure the theory is out there. And perhaps the codes are there to do it. But it's complicated. I haven't seen any results yet. But people can correct me if they've seen something.

MEMBER HINZE: Thanks.

DR. SANFORD: So you're talking about vegetation changes. The Pleistocene-Holocene transition showed the widespread replacement of a pinon-juniper forest by desert scrub vegetation. Now I haven't read -- this morning we were talking about the analog sites.

And I haven't read that USGS report. I was actually glad to hear they were looking at analog sites. It's one of the first things I thought of, you know, I was thinking about why don't they look for some analog sites. So likely those sites were pinon-juniper forests which seem to be the type of vegetation around during the last glacial maximum.

And in know there has been one study at least by Woolvard and Phillips of these different vegetation types. I believe it was in West Texas where they looked at these different -- recharge under the different sites where they tried to see that all other factors being equal, essentially the forests allowed more recharge to infiltrate and come down as deep percolation.

Essentially the desert scrub are much more efficient at sucking up every last drop of water whereas the forests, for example in their study under the desert scrubs, there were thousands of years of chloride beneath the scrubs but under the pinon-juniper forests, there was only about 200 years of chloride built up under the forest, suggesting, of course, that the recharge is significantly higher under forest than under desert scrub.

So this leads to another point which I'm sure people are aware of here but if you're trying to estimate the percentage of precipitation that ends up in recharge, it's not a simple linear function where you can say in one area it is always going to be five percent but it is going to change as precipitation changes.

In arid areas, it could be very close to or equal to zero. But then at some point, you get this threshold, and it is possibly related to vegetation here, where suddenly you can get a much faster increase in this percentage of precipitation that is recharged. So that that percentage increases with increasing recharge. And it is nonlinear.

So as has been pointed out this morning, recharge in Basin and Range Province in Nevada, typically in Yucca Mountain, tends to be more aerially distributed at the high elevations. And in the fractured rock areas with low soil horizons.

But then it gets focused down into channels at the intermediate elevations. As you go from the ranges out onto the slopes into the basins you get channelized flow. And then typically out in the very broad areas of the basins, the recharge is nonexistent -- is very low or nonexistent.

Also another point I was just trying to make this morning and I think people are aware of, there is high temporal variability in this precipitation. And so it leads to greater recharge. When you've got focused events while less variability if you have very frequent but not intense storms, you'll actually get less recharge. There's more time for that water to evaporate and transpire than if you have single, you know, large events that are very infrequent.

MEMBER HINZE: Is that also true of snow on these higher elevations? That you get more recharge from snow than you would from precipitation -- from liquid precipitation?

DR. SANFORD: I'm not a snow -- I mean I'm not an expert there on snow. I'm sure there is a difference because the snow will stay there for a long time. Depending on your conditions, a lot of it can evaporate before it infiltrates. But I'd have to refer to someone who is --

MEMBER HINZE: But the chlorine stays in that. And if it is recharged, it will go into the subsurface, right?

DR. SANFORD: Yes.

Also, the fact that there is a lot of variability in recharge here, so it is a function of elevation, vegetation, and thickness of soil. A couple of Alan Flint's diagrams looking at statistically how the recharge might be distributed based on that. The Yucca Mountain Repository here.

Then it is also a function of the geologic framework under the system. In this case, it is quite complicated because as Bill is pointing out, there are a lot of fractures in the system. And we've got some geology in there with different permeabilities, different capillary conditions in the different layers. And, for example, we've got perch layers in there as well.

And as I was saying, the temporal variability, most of the recharge will occur often in the largest precipitation events -- things that should be considered and are being considered, I believe.

And if you just look at -- this was an interesting plot of some C-14 ages from groundwater in the Amargosa Desert and Yucca Mountain. And unfortunately, you can't see the difference here between the dark and the lighter ones as it comes out.

The dark areas are up here, here, here. Those are Yucca Mountain. But the overall picture here is if you just look at some raw C-14 data, you can see that most, if not virtually all of the recharge has occurred during the wetter period of the last glacial maximum.

I'm sure you are all familiar with these and more familiar with these sections than I am. Sections here through Yucca Mountain, potential repository watertable here. But what has come up now using the chloride mass balance is both in the watertable and in these perched horizons here.

There are values for chloride and some other isotopes that could be used to make some calculations using a balanced sort of approach, chloride balance -- or maybe extended chloride balance, if you will, calculations of how much of that water is Holocene water versus Pleistocene water. And what might the recharge rates have been to get those values in these perched water table and also in the saturated ground water.

I'll just show you quickly here and example of one that was done. Chen Zhu is going to go into more detail about these kinds of calculations.a of the numbers that was used was the 180 and the deuterium which shows similar things here. But the 180 of Holocene precipitation here is about minus 12. And from that in the Pleistocene, they're assuming it is about minus 14, about two per mil lighter.

They got these numbers looking at the long-term record from Devils Hole that Ike Winograd and others have collected. And during the shift, there was about a two per mil shift in O18 in the rainwater due largely to the fact of the cooler temperatures.

So if you sample the waters under there at Yucca Mountain in the perch zone, some of the unsaturated zones, and in the groundwater, you can see this variation between what looks like Holocene water and what looks like Pleistocene water. So this water, for example, in the perch zone is approximately right here. So this means this water recharged some time during the transition period between Pleistocene and Holocene or perhaps it is a mix between Pleistocene water and Holocene water.

And if you assume that, then you could simply do a fraction calculation here to say okay, what fraction of the water was Holocene water and what was Pleistocene water. So here are some tables of their calculations. Here are some fractions they came up with based on that -- based on these two different bore holes that were in the perch zone.

There are the 180 numbers. They've also got chloride precipitation they're using. The measure chloride in the perched water. And then from there, you can calculate and fraction out what is the Holocene and the Pleistocene water.

Then if you use another number, this chlorine 36 number, which there are data what it is today and what it might have been in the Pleistocene, you can come down to estimating actual fluxes here for Holocene and Pleistocene that must have occurred to give you the concentrations in the water you see today.

So you see the Holocene ones are lower than the Pleistocene. They range from about seven millimeters a year up to 40 millimeters per year in that case.

MEMBER HINZE: While you have that up there, can you speculate on the source of the variation in the Pleistocene of a fourfold nature between between UZ-14 and SD-7? Is that in the method? And is that in the geology? Is that in the surface topography?

DR. SANFORD: I think there's a lot of, you know, a lot of variability what can come into the number, the chlorine numbers, there is available.

I'm sure chloride in that perched zone there is probably variability. In chlorine 36, there is some variability in 18O. So given those variabilities and you run it through, this may be the variability you can see. Or the other possibility I think one of these is farther south. Maybe one is farther night. Maybe there was variability in the space.

But just given those single numbers, it's hard to, you know, tell which one of those is responsible for those variations.

Perhaps one of the other issues we have to think about is where did that perched water come from. Are we talking about direct infiltration from above into these pools of perched water? You know knowing the geology, that's probably not likely. There is some distorted path down through the system through which that perched water has been accumulating.

So maybe one of the questions is when you do this kind of calculation, are you assuming that recharge rate in an area directly above the perched water only in that area? And is there variability?

Or does that represent an average for the whole mountain? Or is that just fracture flow and so somehow those numbers might be a bit distorted? I think those are questions that you might want to discuss.

PARTICIPANT: It's interesting that Holocene gives pretty consistent value there. And yet the Pleistocene does not would suggest that its -- maybe in the variability of the assumptions rather than the geology. I don't know.

PARTICIPANT: I mean you are also assuming and I know in isotope hydrology, this is kind of assumed a lot. People find N members. And they like to mix N members. So this is what has been done here. Essentially you are assuming you got one water that's Holocene water. And the other is Pleistocene water. And somehow those exact N members mix. Where in reality that's not exactly what happened, you know, that potentially effect the number you get here.

Maybe I'll turn it over to Chen Zhu.

PARTICIPANT: Well, let's see if there are any questions. Jim, questions?

MEMBER CLARKE: Well, I was just wondering where those bore holes are in relation to the charts that you gave us.

DR. SANFORD: I'm not even sure I can answer that question. I'm sure somebody else here knows the answer to that. Let's see. I have a --

MR. HAMDAN: Okay, UZ-14 would be this right here.

PARTICIPANT: It's in the northern part, okay.

PARTICIPANT: Here is the repository. It's up here?

PARTICIPANT: Right.

PARTICIPANT: Okay.

MR. HAMDAN: And in the south, way south.

DR. SANFORD: Farther in the south. So one is up in the north. One is farther in the south.

PARTICIPANT: Yes. And that was your guess as I recall.

MR. HAMDAN: But according to Mr. Lee, both of these rings have perched water.

PARTICIPANT: Perched water.

MR. HAMDAN: So that's why the 14 versus 10 seems suspicious.

MEMBER HINZE: Any more questions? Ruth?

MEMBER WEINER: This may be an unfair question but could your comment on what we heard from Tim McCartin estimating from the rainfall the five to

20 percent deep percolation? Could you comment on that in the light of statements you made on some of your earlier slides?

DR. SANFORD: Some of the general statements --

MEMBER WEINER: Yes.

DR. SANFORD: -- about what should be considered?

MEMBER WEINER: About what should be --

DR. SANFORD: Well, I mean as I was listening to them, just the things that came to mind were this temporal variability. And they were -- it sounded to me like they were using the model and running it through some modern conditions.

And so since they had an hourly response, they must have been looking at some rainfall events for modern conditions. So I was just curious as to what extent of those they looked at, how big of rainfall events did they actually consider?

And is it possible or has anybody done a statistical look at the size of rainfall versus an event versus what -- I mean they could simulate, you know, a very large event with their model and say how much recharge does that get versus a lot of small events. That is something, you know, that could be looked at with the modeling and perhaps compared to, you know, a long-term rainfall statistics.

Then one of the questions, I think then if you go to a colder climate, not only does the temperature and the total rainfall amount change but does the frequency and the intensity of the storms change?

So, for example, if the intensity has got less, that could mean less recharge. But if for some reason they got more, that could mean more recharge than what simulations might suggest.

The other interesting thing I was thinking about in terms of the vegetation, they were using these numbers 266 and 321 which were to represent the vegetation at the last glacial maximum because they were taken from the similar vegetation areas of whether those were these -- a pinon-juniper forests, I'm not sure. I'd have to read the book.

But then the question might be raised, okay, assume those are those forests. And the estimated recharge in these areas today, they're essentially measured -- going there today and measuring what it is today.

But if those same forests were in a different climate in a different elevation, or something, are those going to give the same recharge events in the glacial maximum? And then you can assume that because the forests are these, they like a certain amount of rainfall.

And they probably allow a certain amount of recharge through but jut wondering you charge the climate dramatically and you put them in a different place, is that going to change how much those forests will allow it to pass through the recharge? So those are just some thoughts I had.

MEMBER WEINER: So you really couldn't make any guess. And again, I know this is asking you to speculate.

DR. SANFORD: No, I mean you were going to have Fred Phillips come talk. He would have given you a good guess probably maybe.

MEMBER WEINER: Thank you.

CHAIRMAN RYAN: Okay. If there are no more questions -- Neil?

MR. COLEMAN: Your slide on variable recharge notes the importance of temporal variability and that most recharge occurs in the largest praecipe events. So this is actually a question for the NRC staff.

The spring of 2005 was one of the wettest times on record for southern Nevada and Yucca Mountain. In Death Valley, in fact, the desert produced a veritable explosion of flowers that might be seen only a few times in a lifetime.

At Yucca Mountain there was a reported event. Water was found dripping into the tunnel, the exploratory studies facility near the south portal. Would the NRC model have predicted enhanced infiltration in that area based on the rainfall that had been occurring enough to cause dripping in the tunnel? Has this been looked at as a model calibration event? After all, that wet springtime was rather like a mini monsoon event.

PARTICIPANT: Who are you asking the question to?

MR. COLEMAN: NRC staff as I said.

MR. McCARTIN: Okay. I mean -- well approximately -- it depends on which model you are talking about. This is more of a process level question. And I'll just say that oh probably on the order of 15 to 20 years ago, we had work funded at Sandia National Laboratories where we developed a dual continual model, fracture matrix model. And it does predict certainly dripping in fractures with than saturated conditions which is what I think you are suggesting.

And so the models we have certainly supported that which is why 15 to 20 years ago, we certainly had estimates for infiltration at Yucca Mountain that were dependent on fractures and not on just matrix only flow.

And I don't know if that answers it. But I'm not -- we have always -- I mean you can go back to our iterative performance assessment Phase 1 approach. And we have, you know, certainly fractures drip in the unsaturated zone.

MEMBER HINZE: I would suggest that we follow this up with some personal conversations. We want to leave enough time for Chen Zhu to make his presentation. Thank you very much, Ward, it was very helpful.

The next presentation will be by Dr. Chen Zhu from the University of Indiana. He is a chemical modeler of wide repute. And is the lead author on a paper dealing with -- they recharged in both Holocene and Lake Pleistocene at the Yucca Mountain Region.

And Chen Zhu we welcome you. And we've got about 20 minutes or so. If that will be sufficient, that will be great.

DR. ZHU: Thank you.

I don't know whether you are aware of the Indiana --

PARTICIPANT: You'll have to stop and wait for the microphone.

DR. ZHU: Thank you. The work I'm going to talk about is what we published in 2003 in water resources research. So we heard this morning that when folks -- our discussion today is the amount of volume water that has percolated down to the repository level.

Okay. It turned out that to the accurate estimate of infiltration rates or recharge rates for an area and in some of our areas, it is extremely difficult. That is because the water fluxes and climate conditions are very low. And it is an especially and temporally variable.

So people have tried many, many different methods but not very successful.

So one method used and the water just talked about is the core item as a balance equation, what is a very low contender taught us about the background today and is also very organized in his papers, I'll just walk you through the equation more.

So if the typical equation were used here is this the recharge rates or infiltration rates in terms of milliliter per year. This is the precipitation, mean annual precipitation.

This term here is the effect of the chloride concentration deposition rate. That's including both in the wet and dry, wet in the rain and dry it is mostly dust. And here is the core concentration in the water.

So if we have an estimate of a precipitation, estimate of the deposition rates and we measure the chloride concentration which is very, very straightforward, we can estimate as a first approximation of the recharge concentration rates.

There are a number of assumptions and Ward has already gone over most of that. The assumption is chloride is the only source -- the only source of chloride is from atmosphere and it is conservative. And there are some hydrological assumptions like there's no run-on or run off. And one dimensional piston flow can represent the amount of the flow.

Very often ignored assumption in this equation is that in the state if precipitation and chloride flux.

And that lead to many misuses of this method by mixing parameters representing different time. Typically you see in the literature, including the literature on Yucca Mountain, that you see the present day precipitation used in the equation. You have the present day effective chloride concentration in the equation and then use the groundwater chloride concentration.

But groundwater, you know, mostly is from the later processing. So we are actually mixing parameters at different times.

And we know reasonably well that the chloride fluxes to the groundwater system probably are very different under different climate conditions. And this is an ice core, this ice core from Greenland. And you see the chloride concentration in the ice core in terms of parts per billion. And this in the last -- from 11,000 years ago to about 40,000 -- 35,000 years ago. You see about one order of magnitude in the Holocene.

So we see very different chloride fluxes. And also we can see in groundwater. This is in the Carrizo Aquifer in Texas. You see chloride concentrations change very differently. And in Aquia Aquifer. And this is the result of different chloride inputs and also from the distances from the coastline under different kinds of conditions.

So we cannot mix parameters. For

different time if we measure the water chloride concentration, which is very easy to measure, and we have used the precipitation of that time and the effect of chloride concentration time.

One way we can deal with that is to use a discreet state to state chloride model to separate into the last glacial time 11,000 years ago in late Pleistocene and Holocene. And we use the long-term average values of the effective chloride concentration precipitation. And the groundwater chloride condition to estimate the long-term average values of infiltration and recharge.

Now one question you may ask is whether we can get higher resolution data rather than just separate into two broad period. The question probably is not because we don't have a detailed time series on precipitation or chloride deposition over long time.

So this are the parameters we use for Holocene and for late Pleistocene for Yucca Mountain. This other chloride -- chlorine 36 chloride ratios found and this is the precipitation rates from the literature.

And then using the deposition rates of chlorine 36 and chloride to estimate the long-term average effective chloride concentration in precipitation. That included both wet precipitation and dry precipitation.

So that's the long-term average. It is well known that measured the dry deposition and chloride concentration in land, various changes over the period of time.

CHAIRMAN RYAN: Just a comment. I guess it's my own bias. I have a hard time thinking about 16 atoms per square meter per second.

(Laughter.)

CHAIRMAN RYAN: Help me understand that a little better.

DR. ZHU: Use accelerators, you can measure this now. And I'm not an analytical sort of expert. But I understand it can be measured.

CHAIRMAN RYAN: I challenge that because I, you know, 10, 20, 16, you know I don't know how you get to single atoms per square centimeter per second. That's pretty amazing to think about. I'll leave it until I ask you questions about your error analysis.

DR. ZHU: Okay. Very good.

DR. SANFORD: Maybe they measured that over one year and just divided by 12.

CHAIRMAN RYAN: Well, but by the same token, if it averages to such a small number, then I ask myself the question is that spatially accurate? Because there are lots of huge uncertainty questions when you are starting to predict single atom behavior of that kind of integral type in terms of how it correlates with other spatially discreet measurements and so on. And temporally discreet measures.

DR. ZHU: Yes. Okay. Mainly from the packrat midden data published by Plummer et al, 1996, we know that there is a Chlorine 36 and chloride initial change over time in late Pleistocene and Holocene. It's about one and a half to two times higher ration in the last glacial period.

All right. So use the estimated precipitation data in the literature. And using our estimate of the later processing effective chloride concentration with the estimate of recharge rates, using the groundwater that is underneath Yucca Mountain.

So the letter falls here our estimates. Now here we compare with some DOE estimates. You see two different bars, a black and a blue because DO used two different effective chloride concentrations. But in the DOE estimates, they use the present day precipitation and present day effective chloride concentrations and the mostly late-Pleistocene groundwater to do the estimates.

We have another problem that is a spacial problem. The water beneath Yucca Mountain in a saturated zone may not be recharged from the Yucca Mountain but probably from somewhere upstream of Yucca Mountain. So it does not represent the local recharge above the repository.

So that's why we look at it as perch water. That's probably more representative of local recharge in Yucca Mountain. And the perched water most widely believe it's a mixture of late Pleistocene and Holocene so we have the chloride measurement. The question is how we can now -- what's percentage of the water is Holocene, what percentage is later Pleistocene?

In this case, we used chlorine 36 chloride ratio. And the chloride concentration from all of the wells from WT-27 and UZ-14. And they turn out to fall along this mixing line. But now the chlorine 36 to chloride ratio, we are able to estimate as a member of the Holocene and Pleistocene chloride concentration.

And then we can plug this into the equations to estimate the concentration rates.

Of course each parameter has arrows. And it is very difficult to assign uncertainty to this parameters, So we did an error propagation analysis. I assumed six percent uncertainty for chloride analysis and uncertainties for the ratios and the precipitations.

So to see how much come up in the total estimated but the error propagation analysis cannot be construed as a reassurance because we really don't know much about the uncertainty assigned to it.

So the numbers come out from this calculation is about five millimeter per year, plus minus one for Holocene and this is a long-term average and it's 15 plus minus five millimeters per year so late Pleistocene.

And in terms of percentage, this is about a three percent and this is about a five percent.

MEMBER HINZE: Is that -- linked Pleistocene, is that comparable to the last glacial maximum that we've heard about previously this morning?

DR. ZHU: Yes.

MEMBER HINZE: Thank you.

DR. ZHU: In terms of comparison with other methods, in general it agrees with the numerical models of the watershed. In a way, the two methods are very different.

It's also comparable to -- we also apply the same method to Black Mesa, Arizona where we have very abundant hydrological data. And the agreement seemed to be good.

One problem for -- one uncertainty is that we only look at the perched water in the northern half of the repository and how that is representative of the whole Yucca Mountain area is unknown.

So in conclusion, we used the chloride mass balance method to estimate the long-term average value at Yucca Mountain and come up with two different values for the two different periods of time. And in the last glacial maximum, it was about three times more than today.

And the estimates seem to be agreed with the other methods. I think the methodology and the climate estimate are reasonable under the -- what circumstances are now but as we point out to you in the paper, this estimate will also carry considerable uncertainties because of the many assumptions and the uncertainty with the parameters.

CHAIRMAN RYAN: Have you attempted to do a propagation of error in a formal way to address this?

DR. ZHU: Yes. That's the formal error

for propagation assumed the errors are independent up on each other.

CHAIRMAN RYAN: So what's the error on -- you know what you've shown is 15 plus or minus five.

DR. ZHU: Yes.

CHAIRMAN RYAN: Is that a considerable error? I mean I'm trying to understand your comment in the highlighted portion of your last slide says that the myriad of assumptions and, you know, it implies order of magnitude or greater-type uncertainties. Yet you are showing that's a 30 percent error. I don't know if it is the standard deviation or what.

DR. ZHU: It's about 30 percent, yes. It's about -- it's from a formal error propagation analysis.

CHAIRMAN RYAN: Yes, the error propagation of what? You've got a whole list of assumptions that all carry errors, one through seven --

DR. ZHU: The parameters. The parameters.

CHAIRMAN RYAN: So that's a numerical propagation --

DR. ZHU: Yes.

CHAIRMAN RYAN: -- of just some small portions of what could be the smaller parts errors.

DR. ZHU: Right. We can get our hands on them. We have some local hydrological conditions. There is the fraction --

CHAIRMAN RYAN: Have you attempted to do any kind of a probabilistic analysis to estimate things where you don't know the estimate of error?

DR. ZHU: We did not do that.

CHAIRMAN RYAN: And I guess my view is that those kinds of more formal propagation of error, you know, this is like looking for your car keys under the streetlight. That's where the light is so that's where I look for my keys.

DR. ZHU: Yes.

CHAIRMAN RYAN: You know I think the bigger error picture is that you have a whole bunch of uncertainties and you can address those uncertainties by propagating, you know, some kind of an error in a probabilistic risk kind of way or probabilistic analysis kind of way.

And that's where you get a better understanding of the total system error. What we don't know is from this uncertainty analysis in this 15 plus or minus five is that plus or minus five a small portion of the total system error? Or is it a large portion of the total system error? That's what

I took away from your last comment on the last slide.

DR. ZHU: I agree with you. The biggest error may lie in assumptions, conceptual assumptions rather than numerical errors attached to each measurement.

CHAIRMAN RYAN: So I'm on pretty solid ground by saying you really don't have a grip on the whole total system error potential but you have a grip on these portions of it.

DR. ZHU: You are correct.

CHAIRMAN RYAN: Okay. Thanks.

MEMBER HINZE: Further questions?

MEMBER WEINER: On I think it is Slide 9, the table where you give the -- go back -- keep going -- keep going -- that one.

DR. ZHU: Okay.

PARTICIPANT: Please use your mike.

MEMBER WEINER: I'm sorry. On your Slide 9, on that last number, is there really any difference between those two numbers -- .35 and .18 given the errors that you have. And are those two numbers different?

DR. ZHU: I think so. It is a factor of two.

MEMBER WEINER: It's a factor of two and

your error is not great enough to overcome that factor of two? Okay.

The next question I have is if you go two more slides to the one where you have the Department of Energy, DOE slide -- keep going -- next one -- this one. What's the difference between DOE 1 and DOE 2?

DR. ZHU: The use of two different type effective chloride concentrations as a bracket.

MEMBER WEINER: As a bracket? Well, can you comment on the fact that your study was really not very different from DOE 1 and DOE 2 is very different. What conclusions can you draw from that?

DR. ZHU: The numerical values may not be that different but one is conceptually correct, one is conceptually wrong.

MEMBER WEINER: Ah ha. So you are saying that DOE 1 -- am I correct in inferring that DOE 1 is conceptually more correct than DOE 2?

DR. ZHU: No. This is the same approach but a use of two different effective chloride concentration to bracket the real calculation.

MEMBER WEINER: Oh, I see. Okay.

Finally, if we go to the slide where you have the linear extrapolation --

DR. ZHU: Okay.

MEMBER WEINER: -- from Holocene to Pleistocene --

DR. ZHU: Yes.

MEMBER WEINER: -- yes. Why did you draw the straight line where you did?

DR. ZHU: Okay.

MEMBER WEINER: When you have all those other points?

DR. ZHU: Yes. So first we have bailed samples and pumped samples. And the bailed samples now it turned out they may not be representative of the chemistry.

But we really had trouble to fit this SD-7 on this line. But SD-7 has very different points -- has different uranium isotope as well. Somehow it looks different. Whether this approach the body in the north, I don't know. I don't have the answer why it looks different.

MEMBER WEINER: But you just -- you've made the decision that it was different enough that you left it off your -- you didn't try to draw a straight line between all the pumped points? Just the --

DR. ZHU: No, I did not try to draw a line here like this.

MEMBER WEINER: Yes.

DR. ZHU: I have two wells and a series of samples if you --

MEMBER WEINER: Thank you.

MEMBER HINZE: James?

MEMBER CLARKE: While we're on that slide, what are the other symbols? The squares and --

DR. ZHU: All the open symbols are -- they are the samples.

MEMBER CLARKE: Okay.

DR. ZHU: And this is WT-24 and this is from UZ-14. And the other -- from the pumped samples of the SD-7.

MEMBER CLARKE: Okay.

MEMBER HINZE: Any other questions?

DR. SANFORD: One comment I'm just going to make here. The case I was showing, they did not, you know, apparently account for a different chlorine concentration in the Pleistocene versus the Holocene.

So if you actually use the chloride concentration, in the Pleistocene it was half as much as it is today. Their recharged numbers would have been half as much.

MEMBER HINZE: I'll try to ask a broad question if I can Chen. And that is that from the presentation of Dr. Sanford, we have the impression that the chloride mass balance has worked rather well on large basins, large regional aquifers.

We also understand the hydrologic, the geological sources of uncertainty as well as analytical, if you will, in the method. Are we pushing this method too far to go to a very localized region underneath a single mountain where there seemed to be so many violations of the assumptions?

DR. ZHU: I think I possibly can answer your question in combination with the earlier question by the Chairman. I always think that when you apply a method like this with big assumption is the assumption with geology and the local hydro geology.

MEMBER HINZE: And so the complexities of Yucca Mountain make it very difficult to apply this method? Is that what we're saying?

DR. ZHU: I would think so.

MEMBER HINZE: Yes. One last question. You used perched watertable. Did you use a perched table above or below the repository level? Do you recall?

DR. ZHU: Let's see, I have a cartoon where -- it's below. This is the cartoon. It's below.

MEMBER HINZE: It's the one below on the Calico Hills?

DR. ZHU: Yes. And that center showed a real geological cross section actually.

MEMBER HINZE: If there are further questions? Latif?

MR. HAMDAN: Yes. Dr. Zhu, just one question. The errors, how much of the error are generic and how much is it site specific?

DR. ZHU: How much? Okay.

MR. HAMDAN: Yes just something in the ballpark from your experience, from your application of this method --

DR. ZHU: Yes.

MR. HAMDAN: -- how much of the errors do you attribute to the side-specific conditions as opposed to the approach if you like.

DR. ZHU: The errors associated with chloride analysis is very small. Whether they are .36, I think an isotope specialist has to answer this question. When you have the big assumption about what's the precipitation in the later processing in a certain area, I think that's sort of major assumptions. And that can be error specific as an estimate of precipitation at Yucca Mountain is different for the estimate of precipitation in Arizona. Does that answer your question?

MR. HAMDAN: So you want to do it with number?

DR. ZHU: No, I cannot do the numbers.

MR. HAMDAN: Thank you.

MEMBER HINZE: If there are no further questions, I want to thank both of you for excellent presentations, well illustrated and giving us some insight into the pros and cons of the CMV. Thanks so much.

CHAIRMAN RYAN: And let's add our thanks to Tim McCartin for his excellent presentation as well this morning and our two speakers here in this second session. It's been a useful discussion of the topic of the Part 63 standard revision. So we appreciate everybody's input and good conversation and discussion.

And also, yes, our colleagues at the Center and your contributions from San Antonio. Thanks very much. We appreciate having you with us today.

With that, if there are no further question or comment, we will adjourn. And we're scheduled to reconvene promptly at one o'clock. Thank you very much.

(Whereupon, the foregoing matter went off the record at 11:39 a.m. to be reconvened in the afternoon.)

4) WHITE PAPER ON LOW-LEVEL RADIOACTIVE WASTE

CHAIRMAN RYAN: I am here this afternoon to welcome you to what I hope is a session where we have a good dialogue among participants and interested parties. We're talking this afternoon about the ACNW's low-level radioactive waste white paper that we have developed with a couple of goals in mind.

In my presentation, I will go through the development of this white paper and some points on what kinds of issues we reviewed, what kind of documentation we pulled together, and what sort of interesting opportunities that this analysis might provide for the theme of better risk-informing regulations regulated to radioactive waste management questions.

In our Commission briefing last year, 2005, -- next slide, please -- low-level radioactive waste was raised as an issue. I am sure that all of you in the room have heard that Barnwell's current schedule is that they won't be receiving waste from out of the compact after 2008. And Envirocare WCS recently announced they are not going to seek to expand their operation to higher classes of low-level radioactive waste and there is a development activity in Texas for a site there. But that's underway, and it's yet to be determined.

NMSS identified this as an emerging issue from their standpoint. And ACNW offered to identify opportunities of areas in part 61 that might be better risk-informed.

I want to quickly emphasize that the Committee and its staff have been in communication with NMSS management and their staff to understand their views. And we will continue to have a real productive open dialogue.

The goal of our identifying opportunities is not necessarily to tell NMSS what to do but to identify from our point of view from the science of risk-informing waste analysis that we might find some opportunities to provide guidance that may even be at a licensee level or it may be at the guidance level within the agency or other opportunities as well. So we look forward to our continued cooperation with the NMSS staff on these opportunities.

NRC's low-level waste regulation in part 61 is really deterministically based. If you study the preliminary environmental impact statement, the final environmental impact statement, and other documents used to prepare 61, the crux of 61 is in the intruder scenario, which is a deterministic and somewhat in my view extreme bounding case here.

Lots of things have to happen to the intruder. It's designed to estimate the highest doses that are envisionable for that kind of situation. The concentrations in the classification system fall from that.

By the way, I did not ask. Do we have anybody on the telephone we need to introduce at this point? Rick Jacobi from the State of Texas. Welcome, Rick. I apologize for not gathering you into the meeting earlier than this.

MS. HAYNES: Kathryn Haynes from the Southeast Compact Commission.

CHAIRMAN RYAN: Good afternoon, Kathryn. Anybody else?

(No response.)

CHAIRMAN RYAN: All right. Well, welcome, both of you. And we'll look forward to your participation as well.

MS. HAYNES: Thank you.

CHAIRMAN RYAN: As a follow-on to the part

61, agreement states developed regulations to comport with part 61, in spite of the fact that decided states all had low-level waste disposal regulations in place at the time 61 was promulgated.

Slide 3, please. The Committee agreed to develop the background paper to try to explain how the U.S. commercial low-level waste program evolved, the review processes by which 61 was developed evolved, past ACNW advice on low-level waste, and agreed to identify opportunities to improve part 61 to make it better risk-informed.

Very clearly, this paper is not intended to recommend how to implement any of these recommendations or opportunities identified. That's certainly not our role. As the Committee, we certainly stand ready to help NMSS as they first consider any or all of the opportunities we put forth to them and how they then work their regulatory development agenda as part of their overall program. So it's that kind of a relationship that we look forward to.

The paper was developed by ACNW members and staff. I would like to recognize two members of staff: Sharon Steele, who participated in some of the early drafting; and Mike Lee, who has really done quite a thorough job of pulling together lots of information and resources.

Let me go to slide 4 and comment that I think the ACNW has certainly exhausted, but it's not all-inclusive. We have not tried to be encyclopedic in nature. I think in one comment I heard, that we have condensed into a concise, small volume that could easily expand to five or six volumes if we wanted to cover every nuance and detail. So we tried to be exhaustive but not necessarily globally exclusive or encyclopedic in what we have covered.

Our literature is limited to perhaps 100 or so, Mike, key references, rather than the several hundred that you could easily amass if you chose to do so.

And we have had limited external review thus far. Our plan forward is to complete the paper and from today's meeting develop a letter to the Commission. And as it goes to the Commission, of course, that paper and letter will be made public.

The paper does not address some issues that are tangential or related to low-level waste. We did not try to cover mixed waste. Mixed waste is often considered to be in the same category because mixed waste can include low-level waste. Of course, it can include TRU or high-level waste, but we did not try and address any questions that pulled mixed waste in.

We did not address that study that is underway that the National Academy of Science of low-activity waste that's being prepared. We did not try and review extensively foreign low-level waste management experience. And, as yet, we have not included but will include stakeholder views as part of our writing that we provide in the document.

Next slide. Again, our goal for today's path forward is to introduce the white paper, which I will do in just a minute, to receive some preliminary feedback and input from NMSS on their views and what their activities are in these areas and where there's common thinking, which I think we will see a little bit of, and where there are other independent opportunities they have identified.

We want to identify areas for which part 61 could be better risk-informed. And that is the basis for our Committee letter for the opportunities we see. And we will approve within the Committee and transmit the Committee letter to any attached white paper to the Commission.

Our goal is, of course, to provide that by the end of the month, in December, and in our Commission briefing in January, which is scheduled, I believe, for January 11th, that we'll report on the activity at that time.

And we hope next year to pick up and conduct a working group meeting that takes up some of the higher-priority opportunities that NMSS may identify so we can pull together a technical working group meeting to address those two issues.

The white paper contents -- I'm on slide 6. It really has three main parts in it at the moment: the low-level waste program history. We start with ocean disposal under the AEC days and move all the way through the current state of affairs in low-level waste disposal in the United States. We track through that history the low-level waste regulatory framework. And we summarize past ACNW observations and recommendations.

Plus, there's an extensive list of references and four main appendices, which we have the structure and content of 10 CFR Part 61; the final Commission policy statement on the use of PRA methods; the regulatory evolution of the low-level waste definition, which is an interesting and somewhat convoluted definition. It's, as all of you probably know, a definition of exclusion, which makes it a challenge to explain to somebody new to that arena. And then NUREG 1753 is summarized.

Part 1 on slide 7, please. In the earlier approaches to management of low-level waste, there are really a couple of approaches. First, there's ocean disposal. I can't recall the exact year, but in 1969 -- is that right? Somebody will help me with the year ocean disposal was banned by international treaty.

And then in the mid '60s, things shifted to shell land burial and land disposal, in particular, for what was then the first six commercial low-level waste sites in the United States.

Congressional actions include the U.S. Nuclear Regulatory Commission and 10 CFR part 61 being promulgated. Later on we had the Low-Level Waste Policy Act of 1980 and the Low-Level Waste Policy Amendments Act of 1985 that took this from being a national activity to a regional contact activity.

Again, we go through quite a lot of the detail of these evolutions. I'm just trying to give you the higher bullets and subject areas that you'll see in the final report as it comes out.

We have summarized the efforts over the period from the time of three sites, South Carolina, Washington state, and Nevada, moving into the compact system, where we had 10 or 11 activities. And let's see. California I think formally issued a license, but it was never activated because the land transfer did not occur. Otherwise, the other sites were not successfully issuing new licenses.

And, of course, that's what's underway in developing and considering a license. And that's yet to be decided. I think the schedule there is 2007 or '8 time frame for the decision to come forth in that arena. And, of course, we talk a little bit about current program status with recent developments in stakeholder views.

In part two, we really go into quite a lot of detail on the regulatory framework, including all of the technical basis documents that we use to decide who should be protected, what should the level of protection be, what the 61 scoping activities were.

It was personally surprising to me to remember some of those activities and recognize that there were not many of my colleagues around who were participants. I think it's timely that we do get all of this documented in the place where we don't lose track of some of this institutional memory that we have created over those decades.

That includes NUREG 0456, the proposed low-level waste dose assessment model, NUREG/CR-1005, a proposed radioactive waste classification system; NUREG 0782, the low-level draft environmental impact statement describing the waste streams considered, the exposure pathways considered, approaches to developing a 61 continuing on slide 9. We looked at the assumed definition of safety, EPA's efforts to promulgate low-level waste standards, NRC's selection of a low-level waste default standard, and the proposed classification system that NRC put forth, including issues of the greater than classy low-level waste management in both the NRC and DOE activities that follow that arena.

We also included other NRC low-level waste program developments, including low-level waste regulatory guidance and policy, NRC's strategic planning in the area of low-level waste.

It's interesting that the Committee, the ACNW, was not in existence when part 61 was promulgated. Nonetheless, we have gone back and reviewed all the ACNWs that have touched on either low-level waste regulation or low-level waste generator regulation and guidance related to those issues. And that's an activity worth continuing, even as we speak.

We looked at in the letters the Committee has developed since 1988 some general low-level waste issues but specifically issues on groundwater monitoring; mixed low-level waste, which we included for completeness but we have not addressed in detail in the document; on-site storage issues; performance assessment issues; waste package and waste form issues; and so on.

In addition, the summary of our observations and conclusions really, again, covered some of these basic issues. For example, on waste packaging and waste form, we now have the branch technical position on waste form and waste plus spatial.

I see Mike Tokar in the room, who worked on the cement solidification process control programs and other activities in that area, where waste form is a critical issue to assessing performance. So there's lots of, again, intimation.

One thing we tried to do very rigorously is not interpret the history but report it so that folks that use this document will have a concise volume that the regulatory history without any embellishment or interpretation of what went where or why.

We need to very carefully lay it out on a timeline so that everybody can read it and see that it's as hopefully accurate and complete as we can make it and useful to folks as they think about what opportunities might lie ahead. So that's part three.

In the appendices, we again cover the structure of 10 CFR part 61, the final Commission policy statement, and use of PRA methods, the regulatory evolution of the definition.

Just a word there. A lot of folks -- I always ask my students, "Where do you find the definition of low-level waste?" And they tell me the Atomic Energy Act of 1946. I challenge you to go back and read it. It's called the McMann Act.

The word "safety" appears in the act four times: three with regard to dynamite and once with regard to sewer treatment systems for AEC facilities. It was very clearly focused on safeguards and security and our original definitions of source special nuclear and byproduct material are really centered on safeguards and security from that very first Atomic Energy Act. They exist almost with just a minor word change here or there as they existed in '46.

So our translation into safety, you know, safety considerations, has really come after those original definitions. So that's, in part, where low-level waste came from.

We all know it's a definition of exclusion. It doesn't include what, fuel, spent fuel. It doesn't include TRU. It doesn't include high-level waste. It's everything else. Well, it was the unimportant things from a security or a safeguards perspective that got it into the everything else category. So it's an interesting history to read, hopefully informative to all of you as you read it. Again, the performance assessment methodology for low-level waste disposal facilities is the more recent NUREG 1573 also covered.

Let me turn to page 13 and shift gears a bit. I think as the Committee has considered this mountain of information and thought about it, we thought about sort of one central idea. And that is that part 61 is really deterministically based.

I mentioned the intruder. The intruder has to spend 18 hours a day getting external exposure. It has to grow all of its food in class C waste. He has to drink all of his own water that he produces in a well that comes up through class C waste and so on to the primary and secondary pathways of exposure.

And if I read the draft environmental impact statement right, concentrations are based primarily on consideration in the dose at what was then the limit for members of the public, 500 millirem per year, with an additional caveat.

So you could take the view that it was a bounding case or even an extreme bounding case because the number of pathways and the opportunities for exposure were certainly maximized and not uncommon for the kinds of thinking of bounding analyses for the purpose of radiation protection at the time or even in use today for some ALARA situations or other workplace activities, it's still relatively common practice and useful.

Nonetheless, in the view today of risk-informing an exposure, you might think about a couple of additional points. For example, the probability of intrusion in 61 at year 100 was one, one. Now, I'm not sure if that is the best way to think about it in a risk-informed setting, but it certainly is what is in there. The probability of getting a class C waste is one.

Now, just taking any given low-level radioactive waste site that has probably a couple of hundred acres of which less than a fraction of an acre is actually class C waste if you just drill randomly from the top, that probability is probably $10^{-6}$ or $^{7}$, not one.

Again, I'm not saying those are right things to think about or not, but I think as we think about risk-informing kinds of opportunities, those are the kinds of questions that I think we should challenge ourselves to think a bit about. So just in that basic analysis, I think there are some opportunities.

All right. 10 CFR 20 has been updated, incorporating more recent ICRP recommendations from ICRP 26 and 30. What that means is the organ dose-specific limits in 61 somehow could be translated to a more modern view.

Sixty-one is the only place where organ doses still reside. And the basis for the 61 organ doses are ICRP 2, which is a 1959 method of calculating internal dose. It's interesting to think about what would change if we applied a more modern view of how to calculate or estimate doses, whether it's in a performance assessment circumstance or some other prospective analysis.

Interestingly enough, the reference in 6154, 5, or 6 -- I forget which one -- says use part

20 to protect workers. So workers at low-level waste sites are handled under the current part 40, as opposed to the prospective calculation for 200-year-old ICRP 2. There might be an opportunity there.

ICRP 2 calculations are dependent on the mix of radionuclides that you're assessing; whereas, the ICRP 20 methods are independent of that mix of radionuclides.

The subpart D siting criteria we observed are mostly qualitative. With the exception of the requirement for the flood plain mapping that must be done for a site, most of the other criteria are qualitative. For example, a site must be capable of being risk-analyzed and modeled. That's it.

And on down through the list, I think there are a number of them. A site must not be located so that it would impede the use of natural resources. Is that a mile, 10 miles, 100 miles? You know, what is the structure of that? I think there are opportunities in the siting criteria to think about how we would better risk-inform that with today's thinking.

So just, again, I don't pick these because they are my favorites or I think they're at the top of the list or they should be on NMSS' top list. I just point them out as examples of the kind of thinking that if we systematically go through, we might find some opportunities to provide better guidance or more detailed technical guidance that will make the process clearer and more capable.

Part 61 institutional controls and financial assurance measures do explicitly account incorporating environmental monitoring data for the institutional control period in the future requirements. I think we've got a typo here.

Let me break that into two: institutional controls and financial assurance. I thought about and the Committee also considered that we have heard a lot about those two issues in the decommissioning arena and how financial assurance and institutional control thinking is evolving in a risk-informed setting.

It's interesting to think about a low-level waste site in perpetuity. And maybe that thinking could be revised; again, just an opportunity to think about. It may not be something that bears fruit but one where there has been work done. In a different arena, it would be I think instructive and helpful to think about how it might fly in another.

Another interesting aspect of

institutional control is environmental monitoring. You know, we have heard in the decommissioning arena that environmental monitoring is being thought of as something integral to the decommissioning process over time and continued evaluation of data or information is helpful to decision-making and thinking about a decommissioning facility or site. So is that something that could happen to the low-level waste arena?

There are clearly requirements for long-term monitoring strategies, but what is the requirement to go beyond simply demonstrating compliance and perhaps gaining some insight into system behavior all the time? There may be some possibilities there.

One thing I think that is certainly becoming the rule, rather than the exception, is engineered barriers of all kinds are being incorporated into low-level waste management. At first, it's the waste form. You know, in the earlier days of low-level waste, there were cardboard boxes and adsorbed liquids and dry solids of all kinds and maybe even some not so dry solids and D1 and exchange resins and the like.

And now we're at a place where there's a lot more control of the waste form, certainly a lot more rigor in the waste packaging in a number of different arenas. And now even the incorporation of engineered vaults and other structures in the earthen part of disposal operations as well as multilayered caps and other let me call them geotechnical systems to help manage both surface water and infiltrate or preventing infiltration and so on.

So there's a lot of interesting developments that have occurred. And should a risk-informed view of these kinds of engineered barriers be taken into account? Some of them certainly offer confinement and containment in waste and others.

And we have frozen ponds on surface systems. For example, do caps last a long time? If they do, how long? What's the monitoring strategy to understand their either success or failure over time and so forth in the decommissioning arena? And, again, I think there's opportunity to take up those issues and see if there are some opportunities to better risk-inform low-level waste.

That is kind of my introduction to begin the discussion. I guess net I would like to call on Scott Flanders of the NMSS staff, who is going to offer some NMSS views. And then I hope to have members and others offer their comments and views and our participants on the telephone and others here in the auditorium.

Our gaol is to capture as rich of a range of views as we can. And this will help us develop our letter and guidance to the Commission on what the opportunities might be.

With that, Scott, let me turn it over to you.

MR. FLANDERS: Thanks, Dr. Ryan. Can everyone hear me okay?

CHAIRMAN RYAN: Let me introduce the co-presenter that's with Scott: Jim Kennedy. Jim, welcome, of course.

MR. KENNEDY: Thank you.

MR. FLANDERS: Thanks, Dr. Ryan.

Good afternoon. We're pleased to be here today to provide our views on ACNW paper on low-level waste.

Before I get started, I do want to introduce a few members of my staff that I have with me. First, I would like to introduce Ryan Whited, who is our section chief for our low-level waste section.

We recently reorganized and were able to form a low-level waste section, primarily as a result of the new responsibility that we have associated with the Department of Energy's or at least consulting with the Department of Energy on their non-high-level waste determinations. And, as such, we folded our low-level waste resources into that section. And Ryan is the section chief for that.

I also wanted to introduce Jim Kennedy, which I think most of you know. These are senior scientists and resident experts on low-level waste. So every time we come to talk about low-level waste, I make sure Jim is close by.

May I have the next slide, please? We appreciate the opportunity and the initiative that ACNW has taken to prepare the white paper. And we appreciate the opportunity, as I said earlier, to provide comments.

In the past, NRC has stated while the current low-level waste disposal system is safe, it is not reliable or cost-effective. We, therefore, welcome any insights that would help or ideas that would help to try to improve the system, especially from a group such as ACNW that has so much experience in the low-level waste area. So we look forward to interacting with you on this.

The topics that I want to cover today, briefly I want to provide a little bit of context, first looking at what is going on nationally and also what is going on internally to NRC that also shapes and provides some perspective for the work that we have on our plate.

I also then want to talk a little bit about some of the efforts that we currently have underway. And with that backdrop of discussing our activities in a current environment, we provide our views on the white paper. I think that background information will help provide some perspective on the views that we share on the white paper.

We also have a few recommendations for the Committee's consideration in their preparation of the white paper and then conclude with a few discussions of next steps.

To provide some context on the national low-level waste program where activities are going on external to NRC, I think it's important to give some context because it influences the work. And it has typically in the past influenced our work.

Some examples, NRC as a result of activities that are going on had to participate and provide input on issues associated with Ward Valley.

We have been recently involved in some of DOE's greater than class E disposal actions or activities in that area, certainly the role that we played in the Low-Level Waste Radioactive Policy Amendments Act and the activities that were assigned to us coming out of that act.

Another example is Utah's decision to provide an exemption for the Envirocare on private and ownership, is another example of external events that influence our work activities.

If you look at the current environment around low-level waste, the disposal of low-level waste continues to remain uncertain. I think, Dr. Ryan, you touched on a few of these points in terms of the potential closure with Barnwell as a key issue around the uncertainty around low-level waste disposal.

Certainly we don't see any change in the opportunity to dispose of waste at the Hanford facility beyond compact members of the Rocky Mountain and the Northwest, West compact.

We do see, as you mentioned earlier, some activity in the WCS application in the State of Texas as a possibility for a new disposal facility. And we do see DOE moving forward as it relates to greater than class C with the issuance of an advance notice of intent to prepare an environmental impact statement. And we expect soon that they would be issuing the notice of intent to prepare that impact statement. So there appears to be some activity by the department in the area for greater than class C disposal.

In addition to those activities that are going on, there are other external activities that are going on that also could influence our work. Currently GAO is working on a third report in recent years, I think the first being in 2004. And this third report focuses on best practices that are going on in the international community with the intent of identifying best practices that maybe could help facilitate or improve the U.S. national system. And there's likely to be information that comes out of that report that we may need to consider as well or potential actions for us as well that may come out of that effort.

The earlier report they issued in 2004 resulted in a congressional hearing in September of 2004. Certainly with the possibility of GAO working on this report, there is also another possibility for a hearing as well. So that's also another thing that we need to keep an eye on to stay abreast to be prepared to participate, if necessary and then certainly the National Academy of Science's study, which is expected to be completed soon, NRC was a sponsor to that study. And we would expect that there are recommendations that we would need to consider as well that come out of that.

A few other areas that I want to touch on briefly that influence the external environment are the low-activity waste. There's been a great deal of attention being received around disposal of low-activity waste. What I mean by low-activity waste, in this context, I'm talking about the lower end of class A-type waste. So it's a little bit different definition than what others have used, but in this context, I'm focusing on that lower end of class A waste. And there's been quite a bit of attention in terms of disposal activities on that. As a result, there have been some actions that I'll talk about a little bit later that NRC has undertaken.

You know, an example of the attention is an IAEA meeting that was held last December, an international symposium, where there were about 250 attendees and representing about 60 countries. Certainly the topic of low-activity waste was discussed in detail. Margaret Federline actually provided one of the principal papers describing the various U.S. programs for disposal of low-activity waste.

Another example of the interest around low-activity. It involves the NCRP's annual meeting, which focused heavily on this topic of low-activity waste, as well as work that EPA started a few years ago in terms of looking at or actually issuing an advance notice of proposed rulemaking on disposal of low-activity waste in RCRA facilities.

Whether they continue with that rulemaking, I think it's still uncertain. I think EPA is still making decisions around that, but certainly one of the things they are continuing to look at is the technical bases for disposal of low-activity waste.

Other external activities are going on. It's the recent call by various groups to change certain aspects of the low-level waste policy system. The Health Physics Society last September argued that for a complete overhaul of the regulatory framework for low-level waste as well as the limits to the Low-Level Waste Policy Amendments Act or new legislation that would allow access to DOE facilities for commercial generators, the ANS also last year argued for consideration of the use of DOE commercial facilities as well as the Council on Radionuclides and Radiopharmaceuticals argued for consolidation or improvements in the compacts and consolidation of low-level waste compacts.

Now, I mention those just to provide context as to the external environment. Currently NRC has not taken any positions on any of those statements, but I point them out in an effort to provide some context for the current environment.

For completeness, it's important for me to mention that the Low-Level Waste Forum has also taken a position. And its position has been one that's urged caution in making any changes to the current system.

So these are all different perspectives that are being voiced and certainly could get the attention of Congress as well. So it provides some context as to what is going on externally.

If I could have the next slide? Internally, just to provide some context, our statutory responsibility under AEA is for safety, security, and protection of the environment as it relates to low-level waste.

But one of the points I wanted to make on this slide, emphasize a point on this slide, is in the most recent strategic plan that was issued by the Commission for fiscal years 2004 to 2009, one of the means to satisfying our safety goal was to include a strategy to assess the key issues affecting safe management of civilian low-level waste disposal to ensure that potential disruptions in access to the three disposal sites does not adversely affect licensees' ability to operate safely and decommission safely.

So it is certainly an important issue to the Commission and is included as one of the strategies that we continue to assess, key factors that could have an impact on licensees' ability to dispose of their waste.

One point also to provide some context about our low-level waste program is that there was a strategic assessment that was done about ten years ago. At that time, in its formal strategic assessment for key direction setting, the Commission decided to reduce the low-level waste program.

At that time, we had an effort as high as 20 FTE in the late '80s, early '90s. As a result of us completing much of the work under the Low-Level Waste Policy Act as well as not expecting to see any particular siting programs, the fact that they had ended in most states, we reduced the level significantly, where we have about a three FTE, three to four FTE, program now. So that's also important as we go forward in talking about some of the activities and how we are going to intend to work some of the opportunities.

Next slide. I just want to just briefly touch on some of the current activities that we have underway. The first one that I want to mention is an effort to update our low-level waste stores guidance. At this point, we're in the process of assessing as a part of direction from the Commission the need to update our extended storage guidance. At this point, we are expected to provide a Commission paper in March which would make a recommendation as to whether we believe it's necessary to update extended storage guidance.

Much of the extended storage guidance is over 20 years old. The last time we looked at the need to update it was at least ten years ago, in 1995. There's certainly a consideration in terms of trying to consolidate it in various places. So that's one of the activities that we're working on right now.

We're also looking at improving the

transparency in the 20.2002 alternate disposal process, which is actually also directed by the Commission for us to take a look at ways to improve the transparency in their 20.2002 process. And we're looking at how best to do that and provide recommendations to the Commission.

We're also working to develop guidance for our 20.2002 reviews, internal guidance for our staff. And also we would share that guidance with external stakeholders as well so that they understand what we're looking for as it relates to 20.2002 type of disposal requests.

Another issue that we recently is responding to a Commission order regarding disposal of large quantities of depleted uranium. This is something that came out of the LES hearing, the Commission's review of issues associated with the hearing. That's another activity that we're starting to engage on.

And then, of course, there are a number of other activities that we currently also do associated with technical assistance to states and PET reviews, work to support international import/export of waste issues. There's a whole list of other activities. This just gives you a flavor of some of the activities that we have on our plate and what we try to do with the resources that we have.

Next slide, please. One of the things that we're also embarking on that we think is very important and I think fits nicely with what you're proposing to do with the white paper is that one of the things that we want to do is complete a strategic planning effort to try to figure out how best to utilize our resources in an effort to most effectively focus on the expectations of the Commission, our statutory responsibilities given the limited amount of resources that we have, how best to focus on those responsibilities given the current environment.

So what we would like to do is assess what is going on in the current environment, receive stakeholder input as to whether a key issue is one of our important issues associated with low-level waste and, from that, assess what are the key things, work that needs to be done in the area of low-level waste and then how best to prioritize and use our resources.

So we see this strategic assessment as really an important effort to effectively prioritize and utilize the resources that we do have in an effort to try to focus and facilitate improvements in the low-level waste system.

Next slide, please. With that background in terms of the work that we have on our plate and the current summary of the current environment around low-level waste, we provide that to you to give some focus and background on some of the comments that we're going to have on your white paper and some of the recommendations that we provide.

In general, we think that the white paper provided a very good summary, particularly of the development of part 61. We think it was very factual. It was well-written.

We agree with you. We do view it as a tool that is important for management and knowledge transfer. As you said, many of the folks who worked on the rule are now gone. We are fortunate to have a few folks that we were able to obtain, such as Jim Kennedy, Jim Shaffner, Mike Tokar, who were around in the days when we had a program of 20 FTE for low-level waste. And they bring a lot of experience to bear, which is very important to us. But we think that the paper was well-written and provided a good summary.

We think that, you know, as you mentioned, the paper focuses heavily on part 61. Others may have taken maybe a different tack in terms of focusing in on the history of low-level waste, but we recognize that in trying to focus in on the history of low-level waste, you could write volumes, as you said earlier.

So, you know, this was just an observation that we made, not necessarily any particular criticism in terms of how you focus the paper, but it's just a recognition that it focuses heavily on part 61, which lends itself to a focus on opportunities, primarily borne out of modifications associated with part 61 rule and guidance.

The next comment that I want to make is on the importance of stakeholder views. We saw that you had a placeholder in section 4 of part two of the paper to receive stakeholder views. We assume that that is going to be stakeholder views on the current environment as well as maybe the part 61 and the implementation of it. We think that is important to seek that stakeholder input as it helps. It would be beneficial in helping to formulate opportunities and to help focus on what opportunities may be most beneficial.

CHAIRMAN RYAN: Just for everybody's benefit, Scott, we certainly are going to put something in that place on the two points you've mentioned. So that's kind of what we're working on right at the minute to finish up. So there is material that is going to be in there.

MR. FLANDERS: Okay. If I could have the next slide, please? Just in the way of some recommendations for your consideration on the white paper, one of the things I mentioned earlier is the interest on low-activity waste.

Right now a lot of the rule focuses on part 61 in terms of low-level waste. There might be some benefit in continuing to look at other ways to focus on disposal of low-activity waste. That's an area that there seems to be some diversity in interests, and there might be some opportunities to even further enhance disposal of low-activity waste.

When identifying the opportunities, we think it may be important to consider certainly the views of other key stakeholders Also positively -- I know in your presentation, you said that you focus, you didn't look internationally, but we think it might be some benefit from looking at other countries similar to what G.E. does in terms of managing risk and how their programs are structured and some insights possibly from DOE in terms of how they manage their low-level waste program, possibly EPA. Just in terms of what they're doing and how they may manage risk may provide some good information for us to consider.

One of the other important points that we think is important when considering opportunities is consequences that may result. Certainly because of the low-level waste regulations or so it's a patchwork of regulations and they're so intertwined, when you change one, there may be an unintended consequence on another aspect of it. So that's something always to keep in mind. Even in the space of guidance, we think it's important to keep that in mind as well.

Our last recommendation really goes to a recommendation in terms of how you proceed forward and write your letter to the Commission. We would recommend that the Committee consider identifying the staff's strategic planning effort and consider recommending the opportunities identified by ACNW be folded into that effort, where we can take this more integrated look so that we can come out with a suite of activities that we think we need to focus on for low-level waste and be able to prioritize them and try to take on those things that give us the most return on investment. And with limited resources, both ACNW and the staff, we have to figure out ways to try to focus on those activities that give us the most return on investment and things that we think can improve their system the most.

If I can have the next slide? With that, I just want to conclude with the few next steps that we see. We are available to assist in finalizing the white paper. We have some editorial and minor comments to prove. And we'll provide those to Mike, Mike Lee. We have pulled those together and we'll provide those to Mike. And certainly we'll respond to any direction provided by the Commission as a result of the white paper.

So that's a high-level review. Again, until just a few minutes ago, we hadn't seen the opportunity. So we really haven't had an opportunity to react to those. But we certainly think that some of the things you identified are things that we want to consider as we look, take this strategic look, at how to prioritize our activities.

So, with that, I will conclude and welcome any comments.

CHAIRMAN RYAN: Well, Scott, thanks very much for a real informative presentation on the NMSS views. I think if you'd just maybe back up one slide, please, Michelle? I think we're in complete agreement on all of your recommendations. Certainly you've added some key insights for us to think about, evidenced by the fact that you have been working hard. That's a good idea. Let's think about that.

Clearly -- and the one I wanted to point to is the last one, really, in the mode of trying to identify from our perspective as an outside technical committee to the Commission to talk about things from that perspective.

And, again, our focus is if you use our risk-informed thinking that works in other areas, here what are the benefits and what could they be and certainly not to come up with an independent agenda for NMSS but, in fact, to give you the insights that may help you create a better agenda for the whole NMSS team, particularly the low-level waste part. So we clearly recognize that cooperative aspect of what we want to accomplish here.

I might at this time before we take questions invite our two speakers who are on the phone.

Let me start with Kathryn Haynes from the Southeast compact. Kathryn, we do have your letter that you provided, signed by Mike Mulwood, you faxed to us, the Southeast Compact Commission policy statement. And we will enter that into our record for this meeting.

Hello? Kathryn? Rick?

MR. JACOBI: Yes, I'm here.

CHAIRMAN RYAN: Kathryn, are you on the phone? Well, she's not there. So, Rick, do you have any comments you would like to offer?

MR. JACOBI: No. I'm impressed with the analysis that I heard today. And I appreciate the opportunity to listen in like this because it's not easy for all of us to make a trip to D.C. to attend these meetings.

CHAIRMAN RYAN: Indeed. Just for our record and for completeness, Rick, if you wouldn't mind identifying who you are and your organizational affiliation, that would help our record.

MR. JACOBI: Yes. I'm Rick Jacobi. I'm a consultant in Austin, Texas. And part of my consulting practice is radioactive waste disposal.

CHAIRMAN RYAN: Great. Thank you very much.

Has Kathryn Haynes joined us on the call?

MS. HAYNES: I'm here.

CHAIRMAN RYAN: Oh, there you are. We thought we lost you for a minute. Kathryn, we do have the letter, I guess it is, that you sent in to us by fax. And we'll enter that into our written record of the meeting.

But I wanted to give you this opportunity to make any comments or observations for us at this point.

MS. HAYNES: I have nothing to add. I would just ask that the Committee carefully read the letter and the policy statement. That was developed by our commission over the course of several months.

As I know that you know, Dr. Ryan, there are many individuals on our commission with a long history of work in low-level waste management. And I think they put a lot of careful thought into that policy statement.

So we're hoping that the Committee will consider it.

CHAIRMAN RYAN: Well, we appreciate you giving us a copy of that. And we will certainly make it a part of our record and our consideration. So thanks for being with us today.

MS. HAYNES: Thanks very much.

CHAIRMAN RYAN: And we welcome your continued participation on the phone.

MS. HAYNES: Thank you.

CHAIRMAN RYAN: Let's see. Any initial comments from Committee members? Dr. Clarke?

MEMBER CLARKE: Just a question for Scott. On that slide, on your second bullet, could you tell us a little more? And you did speak to it briefly, but I just wonder if you could give us a little more of your concerns about number 3, "Consequences that may result." And I assume you mean unintended consequences, adverse consequences.

MR. FLANDERS: Yes. I guess the point there is just if you look at the way the low-level waste regulations are put together; for example, the Low-Level Waste Policy Amendments Act defines or uses the classification scheme, class A, class B, greater than class C classification scheme, that was put into part 61. You make changes to classification scheme. You know, are there some unintended consequences in terms of the law itself?

So it's just the way the things are so integrated. And it's important to always be thinking about potential unintended consequences because we hadn't seen the opportunities that you identified. So not there are any concerns with any specific opportunity that you have identified or that Dr. Ryan mentioned earlier but just as a way of thinking about these, always to keep that in the back of your mind.

CHAIRMAN RYAN: And I think, Scott, that

is absolutely one of the key reasons to think very carefully and, frankly, the reason we wanted to document as detailed a legislative and regulatory history as we did so that we at least have all of them.

Okay. Where does that string lead? And it leads to waste determinations. It leads to other issues. And clearly that caution is one that I think we'll all have to help each other make sure we don't miss some connection that has a difference.

And even TRU comes in the definition some places along the way. So it's something we'll have to be mindful of.

MEMBER CLARKE: And just as a follow-up to that, the opportunities that Dr. Ryan presented in his overview of the white paper, any comment on those opportunities? Is that a good list as far as you go?

MR. FLANDERS: In the amount of time we had to react to it, I don't see anything that jumps out at me as particularly alarming, but, as I said, what I think is important is that we take those opportunities that are identified and run through a kind of a structured process where we can have an overall strategy in terms of identifying what things are the most important, which things can give us the most return on investment, how do these things affect stakeholder concerns and issues, and then come out with the right suite of activities to focus on.

So I think I see that as kind of a feeding into that process. I wouldn't necessarily say that I saw anything that we wouldn't want to at least start into that process.

CHAIRMAN RYAN: And, to be fair to Scott, I hope I identify at least three or four times that these are ideas that if they fall off the table for all good reasons, that's great. The process of creating the list, modifying the list, and then developing the list according to the protocol that Scott mentioned is really our goal as well, so no pride of authorship in any of those get the ball rolling suggestions.

Any other questions, Jim?

MEMBER CLARKE: No, no thanks.

CHAIRMAN RYAN: Ruth?

MEMBER WEINER: I have a couple of comments, really. First of all, I think this has been a tremendous job, and I thank you very much. Scott, I judge from what you say that you didn't have a whole lot of time to come up with comments.

One of the things you put up really caught my eye. And that is the question of depleted uranium. Now, depleted uranium is not, strictly speaking, waste in the sense that it has a use. And I'm not proposing here to argue whether DU is a waste or not a waste but to draw your attention to the fact that this is an example of something that is classified as a waste but has uses other than simply being disposed of in some kind of shallow, or burial shallow, land or otherwise. I think that's an area that has not been considered. And even if DU is the only thing that falls into that category, I think it's an area that does need to be considered.

The classification of depleted uranium as a waste was done in a particular socioeconomic context, if you will. And it's a substance that we use a lot in a lot of different ways.

I would like to have your comments on that, if I could.

MR. FLANDERS: That was quite a bit, and I'll try to react to your comments. One issue there still continues to be the debate around whether or not depleted uranium is a waste. Certainly I am not aware of any position where the Department of Energy has actually said that DU is a waste. So there are certainly some stakeholder who hold that view that depleted uranium is not a waste.

The issue that we have before us goes to if the depleted uranium is converted for disposal, which is one of the things that the department is looking at, that whether the impacts associated with disposal of depleted uranium is converted to an oxide. And under the current part 61, 61.55 classification scheme, is there a need to modify it if, in fact, you're going to dispose of it in the commercial low-level waste facility?

So that's the issue we're looking at. So it's more of a question on the actual how would you categorize it and how is it considered in the context of 61.55 for disposal?

MEMBER WEINER: I would like to point out that I was trying to suggest that perhaps you looked not just at DU but at the large number of things that are classified as low-level waste. There may be others that actually have a use.

I mean, DU does, whether, you know, it's recognized by NRC or not. There may be other things that are very low specific activity, very low total activity that still have a use. And there is presently in 61, to the best of my knowledge -- I don't claim the kind of familiarity with 61 that others here, especially the Chairman, have. But, to the best of my knowledge, the question of dual use, if you will, is not addressed.

And I would encourage you to look at it because I think just to take this one example, just to look at it and say, "Okay. How are we going to dispose of it?" not only sends a message to the public that I think you have to think very carefully about sending. It really does confuse the issue a bit.

CHAIRMAN RYAN: Well, I think it's even more complicated than that, Ruth. I think your focus on DOE's DU or enrichment processes DU is -- and that is what I am getting from your comment -- one area, but there has been, perhaps not on a volume basis, this kind of DU that we're talking about because a lot of DU is exposed as commercial low-level waste, DU metal, stuff that's being used in armaments, stuff that is being used as DU shielding, even things like trimmers that used to be used in X-ray machines narrow beams and so forth, lots of little parts and pieces. So there is a commercial aspect of it that's completely independent of the enrichment system.

MR. FLANDERS: And I guess --

MEMBER WEINER: I recognize that. That's why I brought the whole thing up. The enrichment thing was just something that brought it to mind.

MR. FLANDERS: Part 61 establishes regulations associated with the disposal of low-level waste. And certainly if there's material that could be used for other purposes but also could be exposed I think from the standpoint of establishing regulations, which ensure that safe disposal, I think you would want to make sure that that regulation considers those things, not necessarily making the assumptions that it necessarily has to be if there are alternate uses for it certainly, but from the standpoint of considering disposal impacts, I think that's the angle on which we would look at it.

MEMBER WEINER: The only other comment I have is I want to hark back to something that Dr. Clarke said. And I want to congratulate you for the third sub-bullet under your second bullet, "The Consequences."

One of the stakeholders you mentioned as making a statement, the American Nuclear Society, says specifically -- I have their position paper here -- "10 CFR part 61 is a good regulation and should be left in place as it is."

I think you're all aware that to change the rule is something that if that is found to be needed or desirable is something where you want a great deal of stakeholder input from, in particular, the people who use 10 CFR part 61.

MR. FLANDERS: Actually, we agree. And that's why we think it's so important. In addition to looking at the unintended consequences, also to take just above that in terms of getting stakeholder views and input as well is very important to look at these issues in a strategic, holistic way because there are several factors you have to consider before deciding to move forward on changes, whether it be the part 61 or the guidance, et cetera. So I appreciate that comment.

MEMBER WEINER: Thank you.

CHAIRMAN RYAN: Just a follow-up, Scott. I think, too, there I tend not to jump to the regulation step, I think there are lots of opportunities before that. And let's don't leave those out of the discussion.

I think that sometimes, for example, simple things on packaging for a specific case-by-case sort of analysis -- and, again, 61 has that case-by-case opportunity built into it for individual waste determinations and special case kinds of considerations. So a licensee or an individual permittee, whatever you want to think about, could consider -- I call to mind some wastes that have been disposed at the U.S. ecology hazardous waste facility in North Dakota. Is that right?

MR. FLANDERS: U.S. ecology?

CHAIRMAN RYAN: U.S. ecology. I'm sorry. Not North Dakota. I'm one state over. In Idaho because they have been cleared through the regulatory process on the NRC side. But, yet, again, they're permitted carefully on the other side of the equation.

So there's kind of a very formal and very clear hand-off of what went for that kind of disposal. So that's a permit license kind of change. And then up the life in that, we're all familiar with low-level waste guidance documents, like the branch technical position on waste form and waste classification, certainly the guidance on averaging, for example, irradiated hardware and what's the range of hot and cold pieces you can average together to make a class determination and things of that sort. So I think perhaps there are lots of opportunities before you get to that question in the regulations that some of these may fall into.

And, again, I'm assuming that when you talk about your prioritization and strategic planning, it's all those levels will come into your thinking.

MR. FLANDERS: Right. And that's an important point that you make as we run these things through this structured process. One of the things you need to look at is, do you really need to change a regulation to address an issue? Can you do it in guidance? And then you have to prioritize, well, what's the benefit of making that particular change in general?

So yes. We agree that it's important to look at that guidance --

CHAIRMAN RYAN: Sure.

MR. FLANDERS: -- and other ways of doing it other than just the regulations.

CHAIRMAN RYAN: Thank you.

Allen?

DR. PASTERNAK: Dr. Ryan?

CHAIRMAN RYAN: Yes?

DR. PASTERNAK: Alan Pasternak here, Cal Rad Forum.

CHAIRMAN RYAN: Welcome, Alan.

DR. PASTERNAK: Thank you. Should I add a word or two here?

CHAIRMAN RYAN: Well, how about I finish going around the Committee members, and then we'll catch up with you if that's okay.

DR. PASTERNAK: Okay. Fine.

CHAIRMAN RYAN: Great. Thanks. Allen? I know that's Allen Croff I'm speaking to. Maybe that's why you chimed in. But welcome on the call, Alan.

VICE CHAIRMAN CROFF: A couple of thoughts. First, I'll reiterate what others have already said. Bringing up the unintended consequences is a good thing to do.

I think all of us could rattle off a number of things that interface with part 61 or would be affected, but I'm not sure that any of us could rattle off all of them. And it's I think a very long list and a very intricate list.

I'm wondering if something that may be an opportunity that's been implicit here that should be made explicit is to simply try to figure out all of the things that part 61 touches, other regulations, activities. It might be a useful screening tool or a useful tool to examine other opportunities, but to make that explicit, I'm assuming it doesn't exist anyplace except maybe in a couple of people's minds in part.

But it might be a good thing to know

because it has become a very pivotal regulation. And maybe better understanding that would help everybody figure out what can be done and how to go about it.

The second issue I would bring up goes back to the law passed I guess it's been about a year that gave the Commission jurisdiction over some NARM waste, I think not the diffuse but the accelerator-produced and concentrated radium sources, as I remember it.

I'm not sure whether those are technically low-level waste or they're a waste that's sort of managed as low-level waste or what they are, but it would seem another opportunity in this context might be to figure out how do those get integrated into the system, does something else have to be done, is something like a part 61 okay, but to work through that issue and that new responsibility. That's all I have.

CHAIRMAN RYAN: That's great. Those are a couple of good additions from the list.

Let me just pick up and maybe ask you guys, should we think about either an appendix or another chapter that address Allen's first point of what are the connections?

MR. FLANDERS: Actually, I think it's

actually kind of an intriguing thought. And to the extent that you have time to do something like that, that certainly would be useful.

CHAIRMAN RYAN: Either that or given that we owe the Commission something by the end of the month, maybe we'll tell them we'll go work on that chapter for volume 2.

I don't want to lose that idea. I think that is something that really gets at maybe even two of your bullets there, Scott. And that's something that I think we could help and do a lot of homework on and offer the same kind of factual sort of document to at least try and get us all started on the same page.

VICE CHAIRMAN CROFF: My initial view is it's more than a couple of days of work. I think it's --

CHAIRMAN RYAN: Yes. We're smiling over that one. It is a couple of days of work. Thanks. I think we might take that into consideration.

Bill Hinze?

MEMBER HINZE: Well, an observation that may be helpful, it seems to me that it's very important that there is some kind of consensus on what the problems and what the problems may be in the future. And it seems to me that if you're going to not only develop opportunities but also to prioritize, that there has to be some consensus on those.

As I look at the document, it seems as though the current program status could well be beefed up in terms of that. What are some of the consequences of the problems that we are facing in the low-level waste arena? And how will that develop in the future?

CHAIRMAN RYAN: Yes. And, again, I think that's a much broader question than one we can take up as a committee. Certainly NMSS staff, as they have articulated and I think as we agree, have a strategic planning effort to address those very questions. And I think our input would give them some additional food for thought and things is really the right first step.

Now, as they consider their process, we certainly might be asked questions or hear presentations and can offer further comment, but I guess what I'm trying to say is I think that it would be hard to have a ship with two steering wheels in it.

I think ultimately the NMSS staff will have the responsibility to execute the Commission's direction on any guidance or regulatory activities. In our role as advisers to the Commission, we certainly can participate and offer technical comment and comment to the staff on their strategic planning efforts and all the rest.

At the end of the day, it's something where I ultimately see the NMSS staff having to deal with it in their framework and their strategic plan, much like we do our own work.

MR. FLANDERS: We would certainly need to deal with that as part of our framework. And we see the importance of stakeholder input to assist in doing that.

We also see the benefit of interacting with the Committee to get your insights and knowledge on those issues as well. So it is a good point.

CHAIRMAN RYAN: And I think at this point we're at the point where we're thinking about how to best cooperate and take advantage of what we can contribute. That's certainly an open question where I think one is ultimately one --

MEMBER HINZE: But if you are going to prioritize, you also have to know the implications of some of these problems.

CHAIRMAN RYAN: Clearly that's right up there.

MR. FLANDERS: Absolutely.

CHAIRMAN RYAN: Other questions or

comments? Mike Lee?

MR. LEE: In reference to the stakeholder comments, last night and this morning I finished a little paragraph accompanied by a table that summarizes what published policy statements I found based on low-level waste.

So I think I've gotten the statement that was just distributed about Cal rads. I found about seven. The only new one that I'm aware of is the one that Scott made reference to, which is the Council on Radionuclides and Pharmaceuticals. I'll see if I can't find that.

CHAIRMAN RYAN: That's a good start.

MR. LEE: We've got that information

CHAIRMAN RYAN: If I could turn to Alan Pasternak? Alan, would you help our record and just tell us who you are and who you represent, please?

DR. PASTERNAK: Yes. I'm the Technical Director of the California Radioactive Materials Management Forum, which is an association of organizations that use radioactive materials in the four states of the Southwestern contact region: California, the host state; Arizona; North Dakota; and South Dakota. We also have some members in some of the other states.

My comments on what I have heard about the white paper to date are fairly similar to what I had to say at your last meeting. The overriding issue, I think, is not the adequacy of 10 CFR 61, which is a good set of regulations. The overriding issue is the inadequacy of disposal capacity.

As has been mentioned, the Barnwell facility, which now accepts waste from not only the Atlantic compact but 36 other states, is scheduled to restrict access from July 1, 2008. And at that point, we'll accept waste only from Connecticut, New Jersey, and South Carolina, the three states of the Atlantic compact.

That means that organizations that use radioactive materials in some 34 or 36 states depending on whether or not Texas is successful will have no place at that time to dispose of their class B and C waste.

And as to class A waste, there will be only one facility. That's the Envirocare facility in Utah, which operates outside of the compact system, only one place to which they can send their class A waste.

When you look back at the 25-year history, 26-year history of the Low-Level Waste Policy Act, this is clearly a failure. We have made some suggestions. I think your staff is familiar with them. They were put on the record in testimony before the Senate Energy and Natural Resources last year. We have made some suggestions for alternative approaches, which would probably require amendment of the Low-Level Waste Policy Act.

Use these facilities for commercial waste, at least on a near-term basis, and then the development of one or two facilities under the aegis of the federal government, new facilities.

You know, we have ten compact commissions around the country. We don't need 10 or 12 disposal facilities. Maybe at one time it was thought we might, but we certainly don't today.

And so I think the foundations of the Policy Act are no longer operative. And, in any event, it has not worked. It has no produced the needed new disposal capacity.

A second comment I would like to make is that we all use the phrase "commercial low-level waste" to talk about what we're talking about, to describe what we're talking about. It's a bit misleading because the wastes that are subject to the Low-Level Waste Policy Act, the wastes that we're talking about, are produced not only by commercial users of radioactive materials but also users in the public sector: universities, medical facilities, and so on.

In addition, there is another very important category. And that is the government: state and federal governments. The only organization, private, public, government, whatever, that uses radioactive materials that today has assured access is the Department of Energy. Other federal agencies, state agencies rely on the same commercial disposal facilities that utilities, medical facilities, universities. And I think that's an important point to keep in mind.

Those are my comments, at least for today.

CHAIRMAN RYAN: Alan, thanks very much. I do believe we have your previous comments and the materials to which you referred in hand. We appreciate you being with us today for the discussion and offering us your views.

Are there any other comments, questions, observations? Members of the audience? Yes?

MR. FLACK: John Flack, ACNW staff.

You know, I heard the discussion on the deterministically based regulations. And just thinking back at the reactor side of thins, those regulations were deterministically based and still are today.

What has happened, what has evolved around those is a probablistic framework for implementing and showing that you meet these regulations. So it's not so much the regulations themselves but how you implement the regulations.

Now, with the reactor side, of course, you know, we have things like safety goals, 1.174 and so on, reg guide 1.174, that established that framework. And I guess next month we're going to be hearing from Dennis Damon about NMSS activities with regards to those, you know, using a risk-informed framework for the nuclear waste and materials arena.

And I think that's where a lot of this can come to bear. I mean, the thinking, how one goes about, I mean, we could talk about a dose that needs to be met. But what you're really trying to understand is what is the likelihood that those will not be seated. And it's a different way of thinking than just saying, "Well, this is the regulations. Meet the regulations."

So it's in that capacity that I think you'll find the biggest benefit of risk-informing the regulations, establishing a framework using the current regulations that you have now. And then later on you can go back and say, "Well, this regulation doesn't really make sense in this context because we've been spending a lot of resources trying to implement this. And it's very low likelihoods and very low consequences." Then eventually you go back to change the regulation.

As you move ahead, I think the focus really should be within developing a kind of probablistic framework to do this work.

CHAIRMAN RYAN: And I see a theme in some of the things you're saying, John, with some of the things we've heard from commenters about likelihood and consequences. And that in my mind anyway kind of ties to these very low activity wastes and other opportunities. So having that framework at least at something to think about I think is helpful as well.

MR. FLANDERS: That is true. And it will be interesting to hear some of the views that Dennis shares on what we're doing in the NMSS.

One other point I also want to point out is we do have guidance I think that was actually referenced in your white paper, NUREG 1573, which looks at how we do performance assessment. And we do the performance assessment in a probablistic way from low-level waste as well as for decommissioning activities.

So, to that end, there is that risk-informed thinking, but certainly we should look to consider opportunities to continue that type of thinking.

CHAIRMAN RYAN: And, again, when I think ahead to strategic planning and then action planning thereafter, where is the low-hanging fruit to be the first or second or third application of that process in thinking?

I think that's what you were referring to earlier. It's where do we get the most return on our early investments in this arena. And that is going to take some thought and consideration and shuffling in the list and all the rest of the usual things that happen and that kind of exercise.

Any other comments or questions? John Greeves, please? Tell us who you are.

MR. GREEVES: Good afternoon. I'm John Greeves. It's good to be back. I'm former Director, Division of Waste Management, Environmental Protection.

Like a lot of people on the phone, I've

touched this issue for 20-plus years. I, I think like the others with the public, haven't gotten a copy of this document. You're talking about a document that we haven't seen yet, which we will presumably after the first of the year.

Dr. Ryan, a couple of comments. There's already a lot of information out there about part 61. There's volumes of material out there. I look forward to scanning what you're producing. But from my perspective, the key is you're going to have to focus on what the priorities are in moving forward, not reviewing old material.

I think there's a mismatch here. You've got the staff sitting over there with three FTE. Based on experience, I can tell you that that FTE is applied to a lot of licensing casework.

And if the staff is going to do a strategic plan with three FTE on a project this significant, I don't understand how you do that. So I would suggest that there needs to be a focus.

It's the issues that the people on the phone mentioned, as Al Pasternak mentioned. They have already been mentioned, but, for emphasis, I'll tick them off.

I wrote down a list of five, the key of

which is the B&C waste issue. You're going to have 30-plus states without access in 2008. That's a focus here. That's something that if you can provide a solution to that, you'll be doing some good.

So that's one of them. The second one on my list is greater than class C waste. There are responsibilities out there now. Scott mentioned them. The department has to do something when greater than class C waste. There are lots of stakeholders who would like to see that problem resolved. So that's a second one.

The third one is the DU issue. The Commission just issued an order that tangentially laid it back in the staff's lap. Yes, it is a dual-use material, but the volumes of this are so large. And can they be used in near-surface disposal?

That issue has been handed over to the NRC staff. That one issue could gobble up the three FTE that Scott and Larry Camper have to address these issues.

My emphasis is it needs to sharpen up the scope of what you really are going to work on because the resources are terribly limited here. Finishing off my list, internationally there is more and more use of what's called a very low-level waste disposal facility. It's very successful. It's not taken root in this country. That's a solution that just hasn't come here yet. Again, the international community has taken leadership on things like this.

The last item is one that has been mentioned by a number of parties. Call it what the IAEA has done on clearance. It's a loose end. It's a big loose end. And the rest of the world has moved on. Lots of countries I actually do some consulting for invoke that IAEA standard and making use of it. It works. And it just is not here.

So that's a list of five. But without focusing and deciding what are you going to do with those three FTE, frankly, I don't see how you get it done. So I just wanted to offer those comments from some experience. And I would urge, you know, in a small way, I'll help over time to try and focus what you really can do with few resources because the Commission doesn't have a lot invested in this particular arena.

I just wanted to offer some candid comments. And I'll be happy to --

CHAIRMAN RYAN: Any time you want to go up to the 19th floor and, you know, share those views, John, please feel free.

MR. GREEVES: You're going to be doing that yourself.

CHAIRMAN RYAN: No. I think everybody is aware of -- first of all, thanks for the list of issues. I think a couple that we haven't explicitly talked about but a couple that are on the list of the very low-activity waste question, which I think Scott touched on a bit, but the other is the disposition of solid materials, which in EU is safety directive 6 or 29- something or other. I can't recall the numbers, but you're right. There are some examples from the international environment or some of the things we might be thinking about we ought to have models to follow or at least be informed by. So we appreciate your insights.

MR. GREEVES: Good. Thanks.

CHAIRMAN RYAN: Thank you.

MR. GREEVES: Thanks for listening.

CHAIRMAN RYAN: You bet. Any other comments, questions, observations? Yes? Dr. Nicholson, welcome.

DR. NICHOLSON: Tom Nicholson, Research.

One thing that struck me, I think back of the tremendous effort put in by the States of Illinois, North Carolina, and California in trying to cite a low-level waste site.

CHAIRMAN RYAN: Pennsylvania.

DR. NICHOLSON: Yes, Pennsylvania and Texas. Have you thought about incorporating some of the lessons learned from those examples of how they tried, what worked, what didn't work, and the examples that they bring to the table?

CHAIRMAN RYAN: I would say implicitly yes. You know, a lot of those documents that aren't necessarily readily available, but having participated in three of the last that we ticked off together, I would say implicitly yes.

Some of the questions surrounded interpretation, for example, of siting criteria and looking at new sites. That was always the issue. How do I decide when I'm modelable and some of those things?

So I think there are things in that arena when you look at the siting criteria that would probably be from those experiences perhaps some of the questions, certainly not all but some.

So the other aspect was the engineered barriers. How do you credit them in some way? You know, we would kind of get in the situation of having lots of barriers and then immediately assuming they aren't there. Not only did they fail in some mode, but they're not there. That's radioactive material mixed with soil, and water hits it.

So I think there was some sort of discontinuities, for lack of a better term, coming out of those examples. And I hope we've at least identified a few to think about.

Now, whether they would float to the top of the list after the staff considers the entire list, I don't know. My guess is they might not be exactly on the top of the hit parade. Some of the other ones that John Greeves mentioned, the B and C question and the greater than class C question, might have a higher priority.

Again, I'm not trying to prejudge or offer a comment, but I think the answer to your basic question is yes but perhaps not explicitly from stuff that's been published or those kinds of things. And I don't think there's much literature out there on it.

Thanks.

MR. FLANDERS: If I could just --

CHAIRMAN RYAN: Yes?

MR. FLANDERS: -- take a minute? I just wanted to respond to some of the comments that John made because he made some very good comments. I think, John, your point is well-taken on the challenge to do the strategic planning with the limited resources that we have. But the fact that we have such limited resources makes it all the more important why we really feel it's important to do the strategic look to make sure that we focus on those things.

Many of the activities you identified are key things that certainly one would expect would be key things that the staff would want to focus on. So that's why we think it's such a valuable effort, but it will be challenging for us to do it with the resources that we have. You know that better than anybody.

CHAIRMAN RYAN: And I think, frankly, too, Scott, the idea that the Committee has got a keen interest in this area and we can certainly, you know, be involved in a way that is helpful to the staff in their thinking or take up issues or other issues is a way to take advantage of our shared resources or how to combine our resources to a better effect.

MR. FLANDERS: And, again, that's why I think it is also important for us to leverage the insights and information and experience from stakeholders. It's very critical to do that as well. And to get that stakeholder input is very important.

CHAIRMAN RYAN: Other questions, comments, observations?

(No response.)

CHAIRMAN RYAN: Okay. Why don't we do this? We'll take perhaps a 15-minute break, come back about 10 minutes after 3:00, then have a brief wrap-up session with everybody. And then we'll go on from there. Fair enough? Thank you. Ten minutes to 3:00.

(Whereupon, the foregoing matter went off the record at 2:35 p.m. and went back on the record at 2:56 p.m.)

CHAIRMAN RYAN: We're going to go ahead and reconvene and finish up our close-out discussion. I think what we have had is a good discussion on the elements of the white paper and on both the Committee's views and staff's views on some opportunities and some patch forward kinds of things.

I guess what I would like to do is maybe kill two birds with one stone. I think we can clearly bring the paper itself closure and bring that to the Commission as a report or work product of the Committee on the low-level waste arena. And then I think what we have got to really focus our attention on is what detail we want to carry in the letter that transmits it to them.

Clearly it's the Committee's effort to review low-level waste as a topic and consider risk-informed approaches to various issues in the low-level waste area.

I think we should recognize that after consultation with staff in this meeting, that we have identified some further opportunities to recognize their activities in their strategic planning in similar areas that overlap ways that are complementary to what we're doing. And that dialogue should continue. And we plan to continue that dialogue with staff.

The part I am thinking out loud here a little bit about and we appreciate views on is how much of the kind of straw man, if you will, for the opportunities list do we want to put forward? My view is less, rather than more, because I think that is something that will evolve with staff over time. And then we talk about the commitment to do that, rather than trying to say this is an opportunity.

You know, if you said, well, what direction are you looking for the Commission to tell staff and us to continue working together to identify a more complete list of opportunities and, you know, move forward with your analysis and bring what you think are a list of opportunities and strategies to better risk-inform this area of regulation.

Jim?

MEMBER CLARKE: I just want to support that. I think we should not attempt to include an inclusive list of opportunities. That's a work in progress. And there might be merit to just giving a couple of examples or potential examples.

CHAIRMAN RYAN: Yes, either that or we could also give the categories of examples. I mean, we talked about risk-informing the siting criteria, risk-informing the basic scenarios from which the concentration tables were developed, and then risk-informing other related activities, which are some of the ones that Scott mentioned and we're going to continue: one, to build the list; and, two, to support NMSS's strategic planning activities to develop priorities for this list with their more comprehensive view of the regulatory agenda in this area. And that's kind of getting to closing the letter up.

I don't see it as being very long, but I see it as at least giving them something that will allow them to see what we have been working on and give us their feedback and insights and perhaps ideas for future directions.

MEMBER CLARKE: You know, there may be merit to linking, at least referencing, the decommissioning proposed decommissioning, guidance revisions because they speak to some of these same areas. And I continue to think that we can truly do things that are more risk-informed way if we recognize that engineered barriers and institutional controls are part of an integrated system.

CHAIRMAN RYAN: We're kind of getting down into the specific examples, but that may be something we develop later on. I think the idea that there's overlap on this instruction that could be taken from the decommissioning arena and others that we mentioned and talked about is something we want to study and analyze more fully now that we would be taking this first step. What do you think?

MR. FLANDERS: Yes. I think that's a good approach to take. Really, it sounds like what you want is agreement from the Commission in terms of the effort in terms of trying to identify opportunities. And I think if you'd keep it at a high level and say that is what you want to do, it gives you time to think more fully through what those opportunities are and address some of the issues that we're thinking.

So I think that's --

CHAIRMAN RYAN: And I think we'll tell them the reason is some of the cautions, Scott, that you actually provided us with today, which is what unintended consequences could there be, what are stakeholder views. And we heard several of those in the telephone.

Are our telephone participants still on line? Hello? Anybody on telephone?

MR. COLEMAN: The light is on on the phone.

CHAIRMAN RYAN: Well, it's on, yes. I know. It's green. So it's on.

But, you know, those are used as well, and we can point to the reasons why we're continuing to study. And we don't have this complete, comprehensive list, but we'll press ahead.

MEMBER CLARKE: I don't think this will be comprehensive until you've got some idea of priorities.

CHAIRMAN RYAN: Exactly, yes. Anybody have a different view?

(No response.)

CHAIRMAN RYAN: So I guess, with that said, Mike Lee, maybe you can and I can noodle before we break for the day and divvy that up. And we'll put together a straw man.

I guess I'm going to suggest, even though it's relatively brisk scheduling, Mike, maybe you and I can draft this letter tonight and we can review it in the open session tomorrow in our letter-writing period and get some concurrence from the Committee on the short transmittal letter. That will give staff time to have input in the public session. Off we go. Fair enough?

(No response.)

CHAIRMAN RYAN: All right. With that, we'll conclude our low-level waste discussion. I appreciate everybody's -- oh, I did forget to mention one thing for the record, which I will mention. Thank you very much, Michelle.

Ralph Anderson from NEI was not able to be with us. He had a family activity that he had to take care of today and was at the late hour not able to join us. So we do have his slides, which we will enter into the record, and his views, which he was going to give us verbally from NEI. So those will be available to one and all as part of our record of the meeting. And I appreciate you reminding me to mention that for the record. Thanks.

Okay. Any other comments or corrections, items?

(No response.)

CHAIRMAN RYAN: Thank you all very much. We appreciate your participation, and we will press on from here. We'll conclude our formal record here. Thank you.

(Whereupon, the foregoing matter was concluded at 3:03 p.m.)

**CERTIFICATE**

This is to certify that the attached proceedings before the United States Nuclear Regulatory Commission in the matter of:

Name of Proceeding: Advisory Committee on Nuclear Waste 166th Meeting

Docket Number: n/a

Location: Rockville, MD

were held as herein appears, and that this is the original transcript thereof for the file of the United States Nuclear Regulatory Commission taken by me and, thereafter reduced to typewriting by me or under the direction of the court reporting company, and that the transcript is a true and accurate record of the foregoing proceedings.

Lindsay Barnes

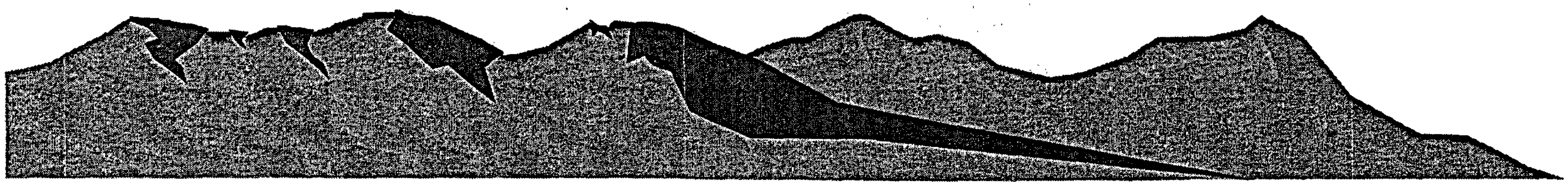
Lindsay Barnes
Official Reporter
Neal R. Gross & Co., Inc.

# Implementation of a Dose Standard after 10,000 Years

166th Meeting of
Advisory Committee on Nuclear Waste
December 13, 2005

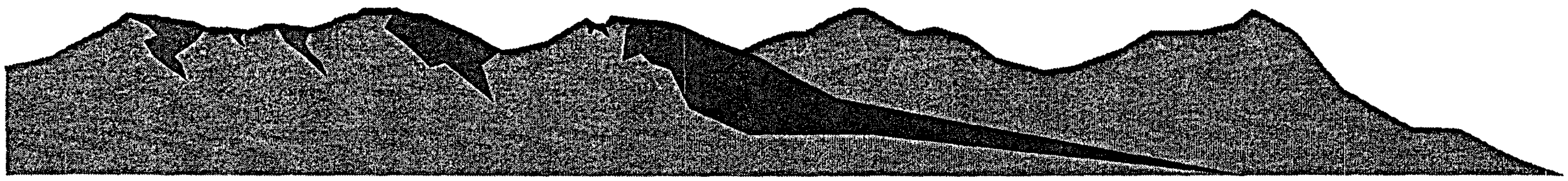
Tim McCartin
Division of High Level Waste Repository Safety
U.S. Nuclear Regulatory Commission

Gordon Wittmeyer
Center for Nuclear Waste Regulatory Analyses
Southwest Research Institute



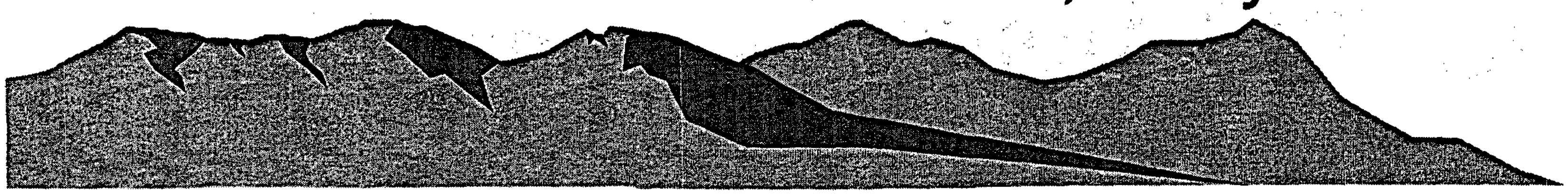
# Outline

- Purpose of Proposed Part 63
- Inventory Perspective
- Dosimetry Perspective
- Representation of Climate Change
- Status of Part 63



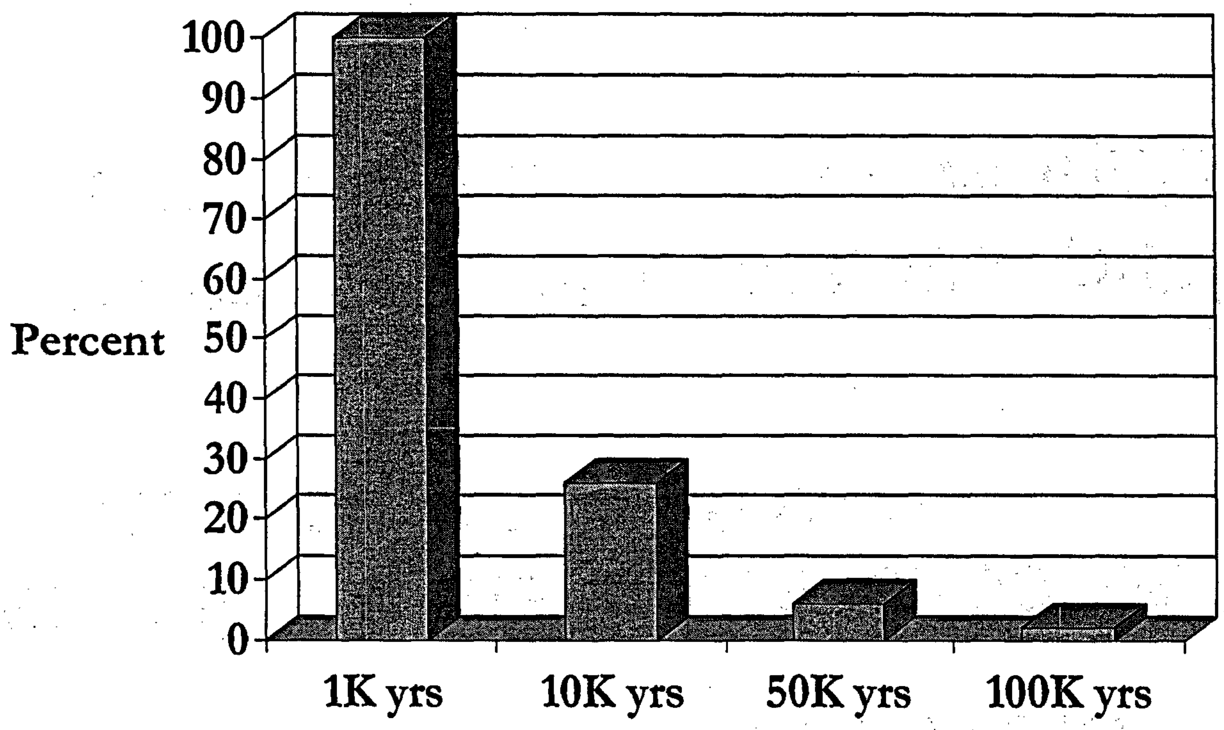
# Purpose of NRC's Proposed Rule

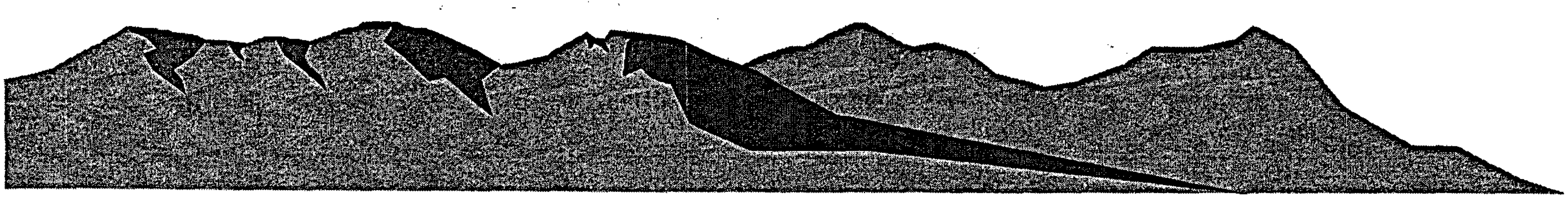
- Implement new standards for doses that could occur after 10,000 years
- Specify estimates of worker and public doses use the same, current weighting factors
- Specify treatment of climate change at Yucca Mountain after 10,000 years



# Variation in Inventory over Time

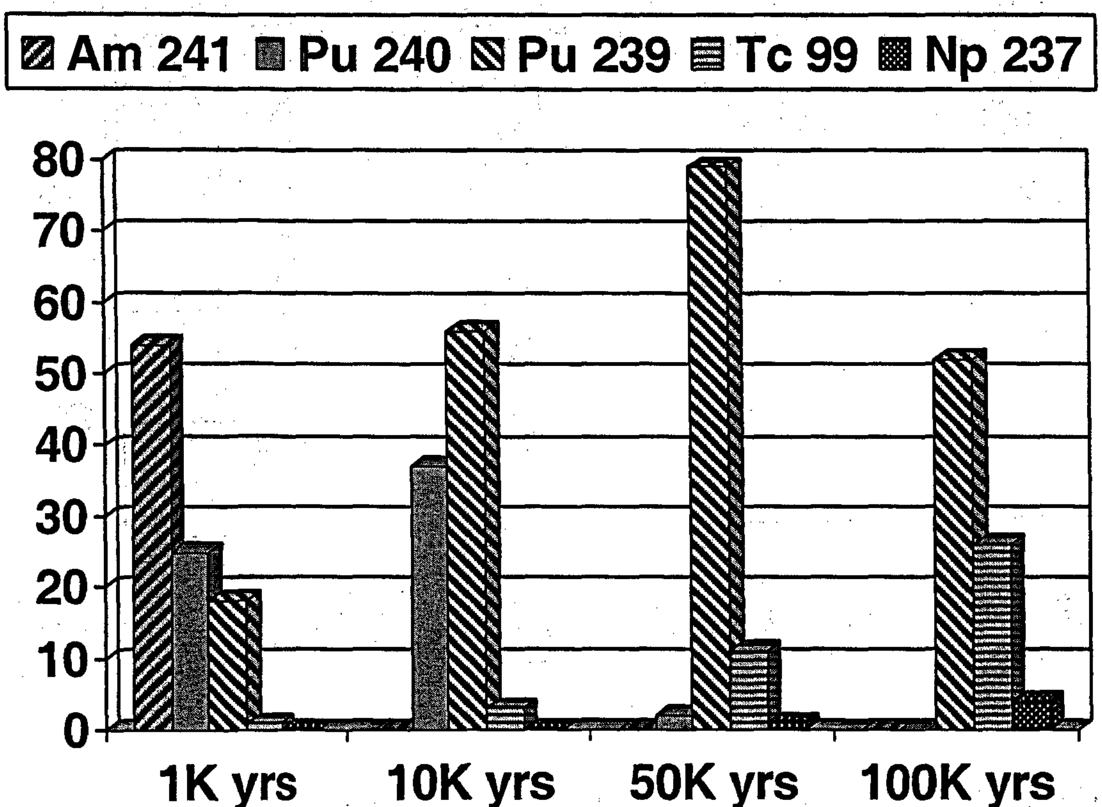
## (relative to inventory in curies at 1,000 years)



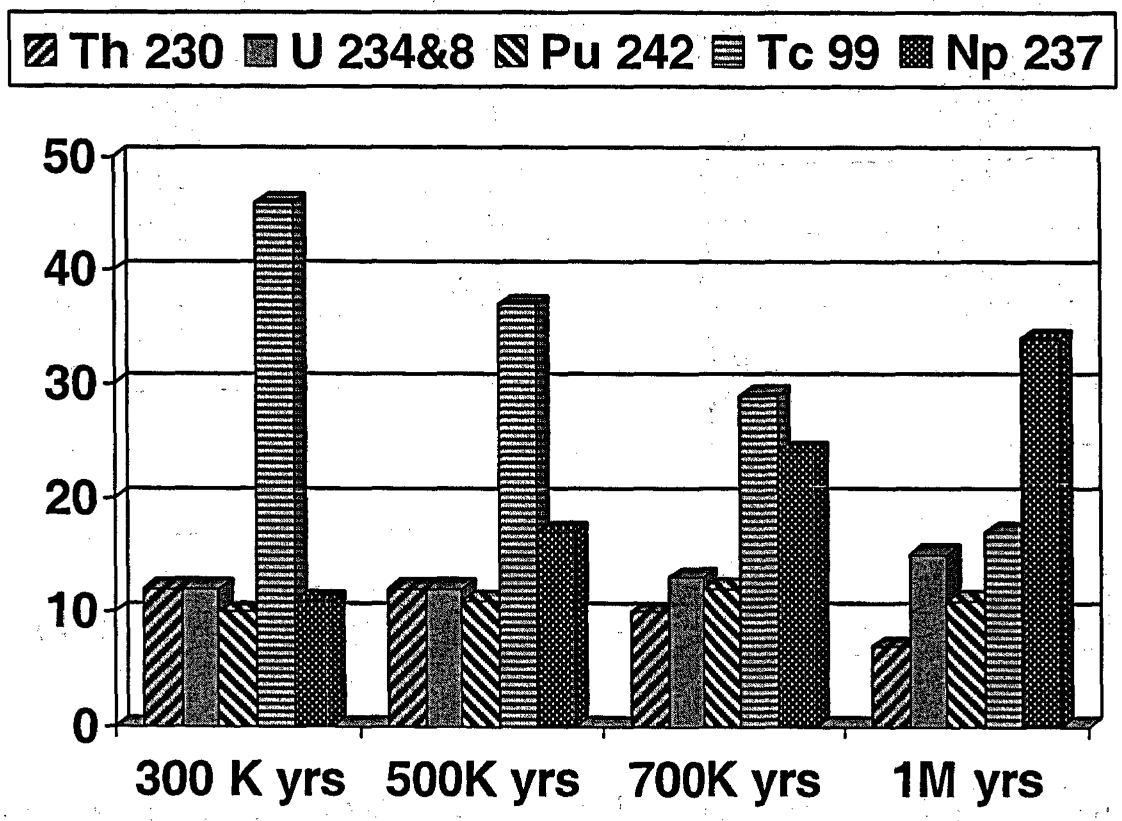
# Radionuclide Inventory

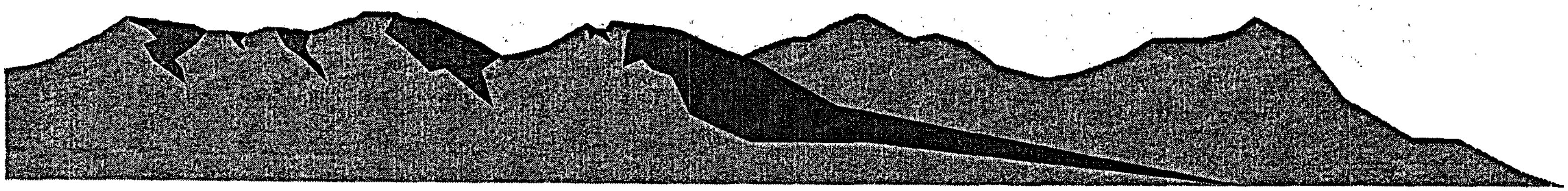
(Percent of total inventory, in curies, at specific times)



# Radionuclide Inventory

## (Percent of total inventory, in curies, at specific times)



# EPA Guidance Documents

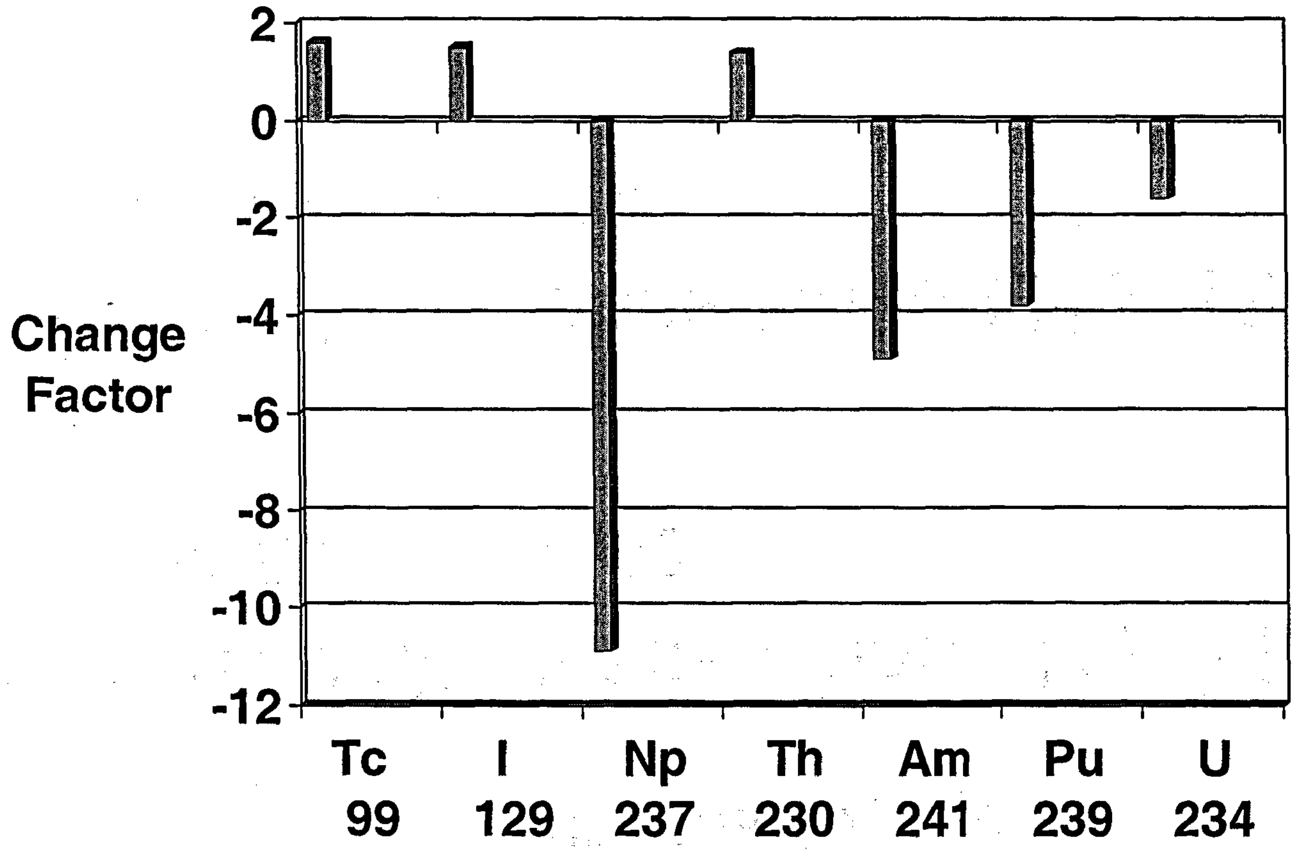
(Internal Exposures)

- Federal Guidance Report No. 11 (FGR 11)
  - September 1988

- Federal Guidance Report No. 13 (FGR 13)
  - September 1999

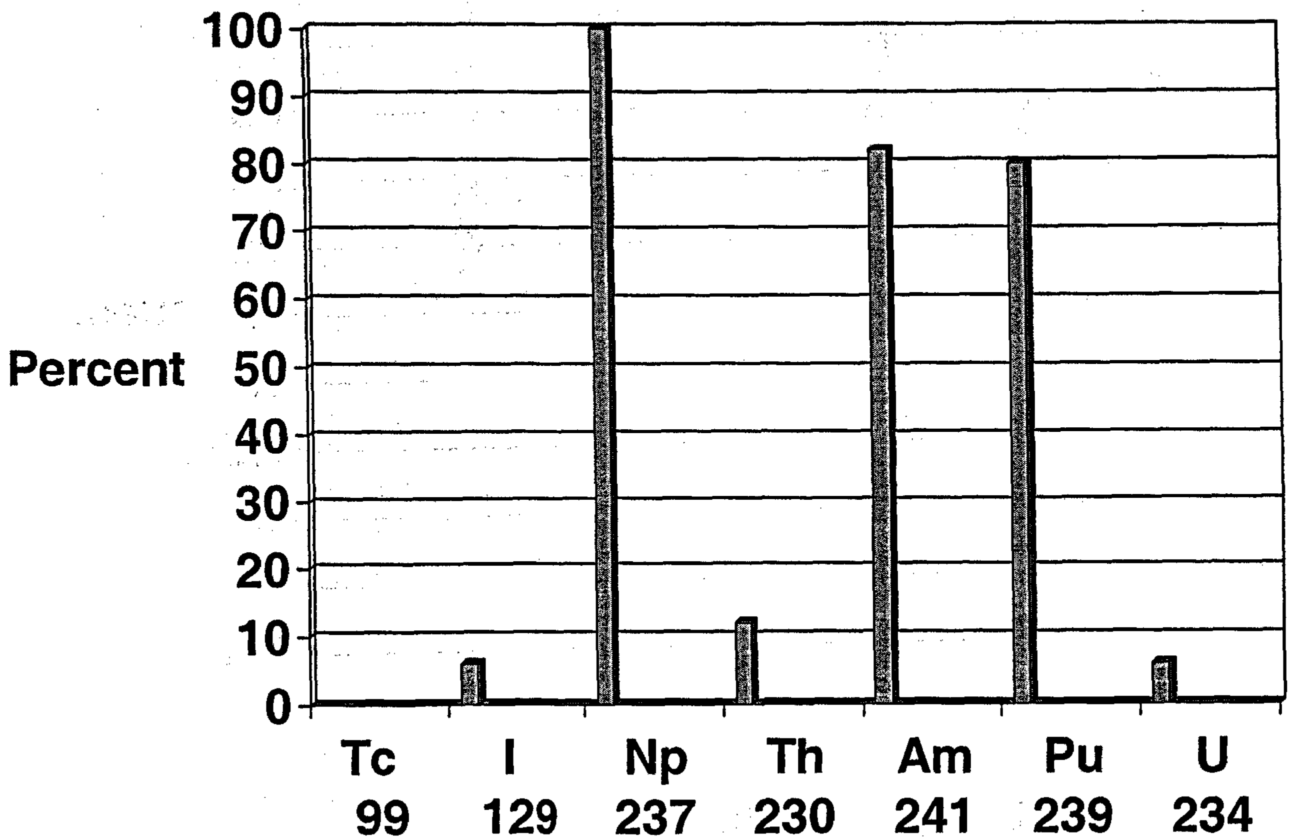
# Change in Dose Conversion Factor

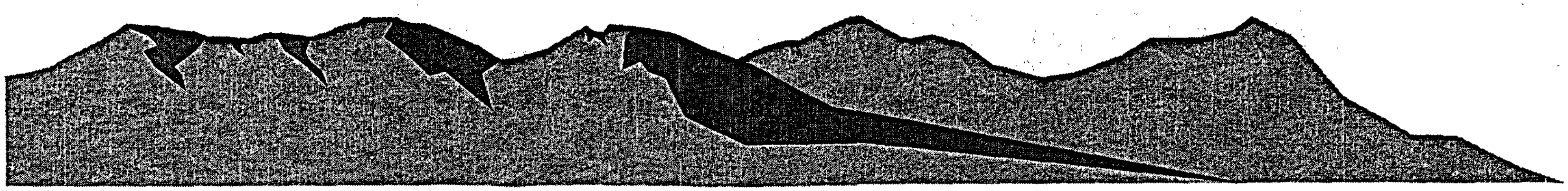
(Ingestion – change from FGR 11 to FGR 13)



# Relative Dose Conversion Factor

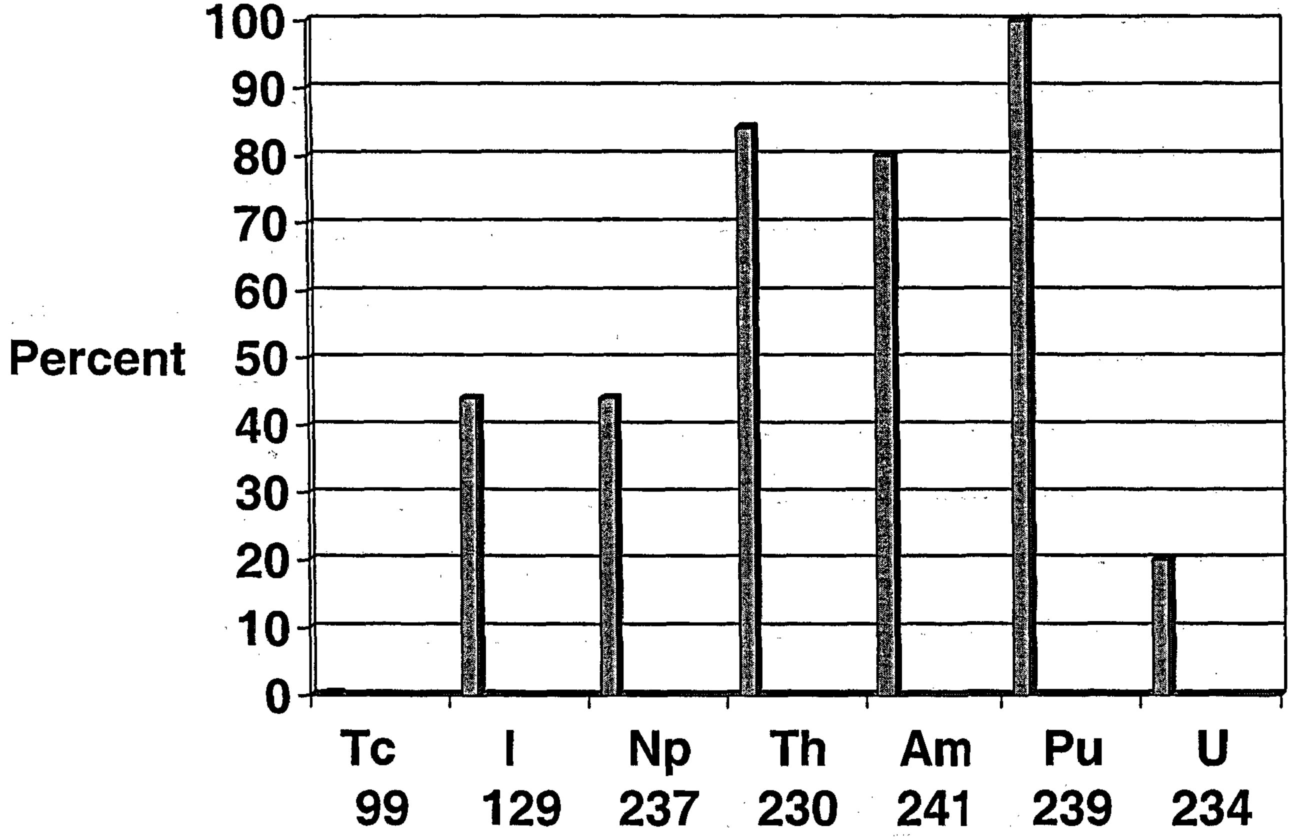
(Ingestion – FGR 11)



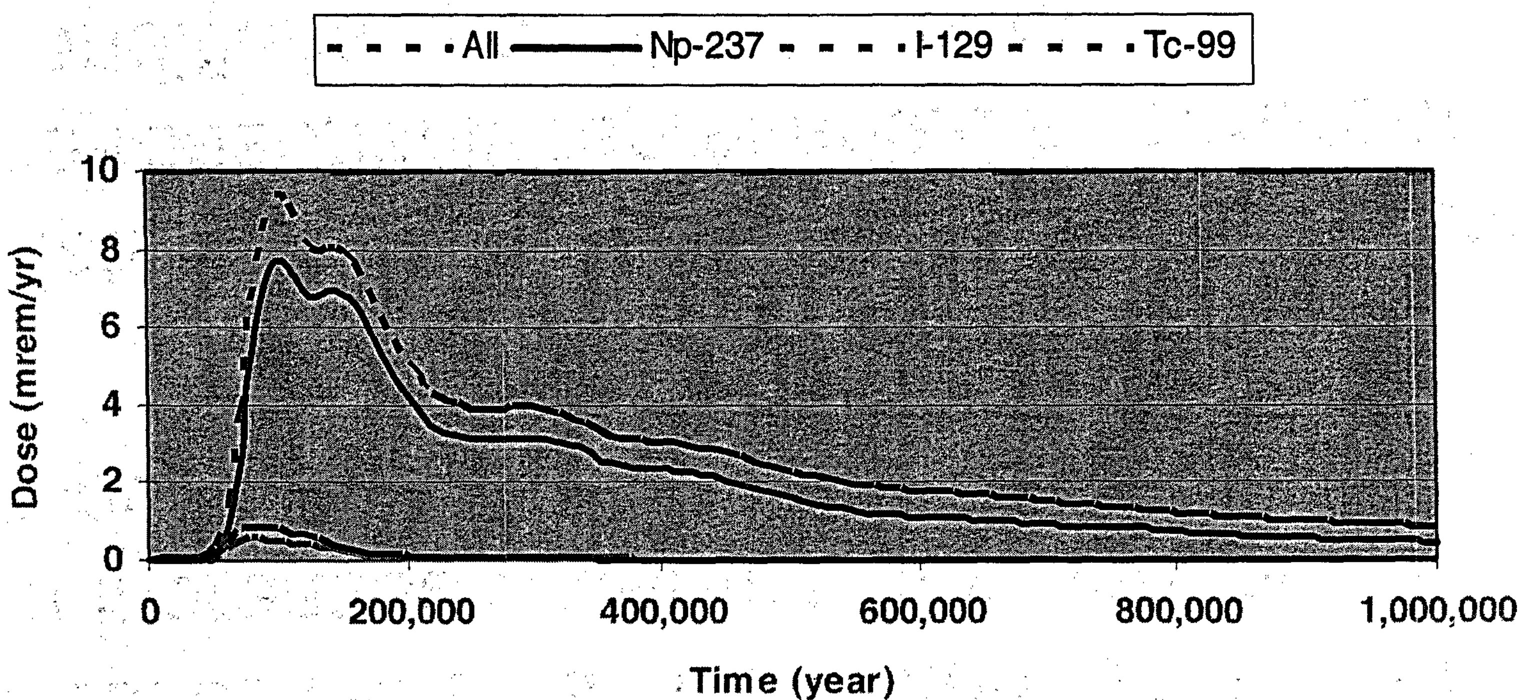
# Relative Dose Conversion Factor

(Ingestion – FGR 13)



# Illustrative Dose Estimate

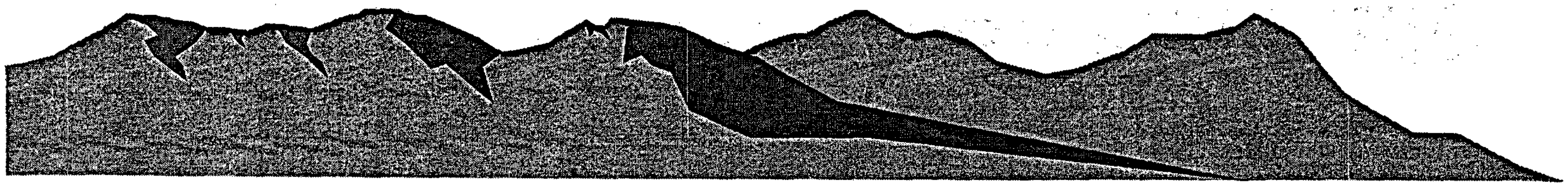
## (FGR 13 Dosimetry – Ground Water Pathway)



# Representation of Climate Change: 40 CFR 197

- Assessment may be limited to the effects of increased water flow through the repository as a result of climate change

- Nature and degree of climate change can be reasonably represented by constant conditions after 10,000 years



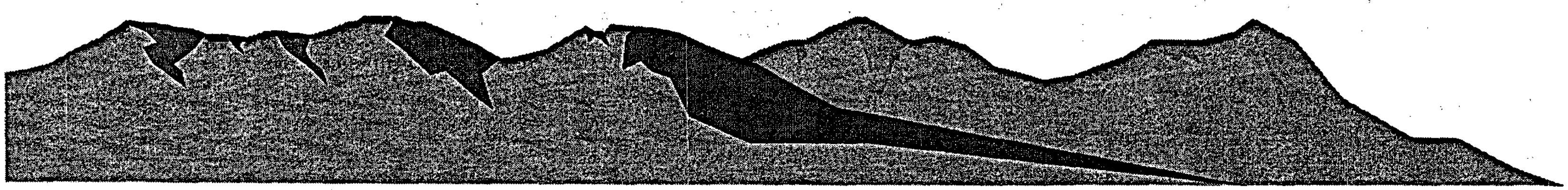
# Representation of Climate Change: 40 CFR 197 (cont.)

- NRC shall specify in regulation the values to be used to represent climate change such as temperature, precipitation, or infiltration rate of water

# Deep Percolation

- Deep percolation, or the amount of water flowing to the repository horizon, directly influences repository performance

- Deep percolation is controlled by a variety of processes such as precipitation, temperature, evaporation, and plant transpiration



# Estimating Future Deep Percolation

- Representative range for mean annual precipitation
  - glacial-transition/monsoon states dominate long-term climate state

- Representative range for fraction of precipitation that ends up as deep percolation

# Future Precipitation

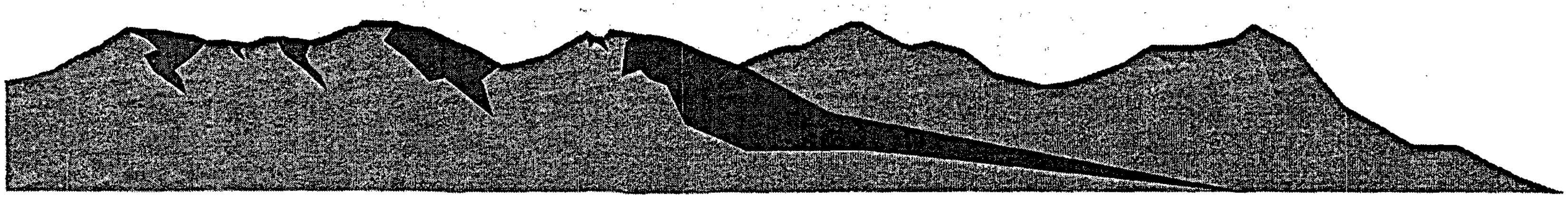
- Analog sites based on vegetation
  - modern sites that have vegetation similar to late Pleistocene vegetation found in packrat middens

- Precipitation at Yucca Mountain analog sites estimated as 266 to 321 mm per year
  - last glacial maximum

# Fraction of Precipitation Resulting in Deep Percolation

- TPA code estimates of deep percolation include consideration of precipitation, temperature, soil depth, evaporation and transpiration

- 5 to 20 Percent of Precipitation Could Reach the Repository Under Intermediate/Monsoon to Full Glacial Climate Conditions
  - precipitation 250 to 420 mm/year



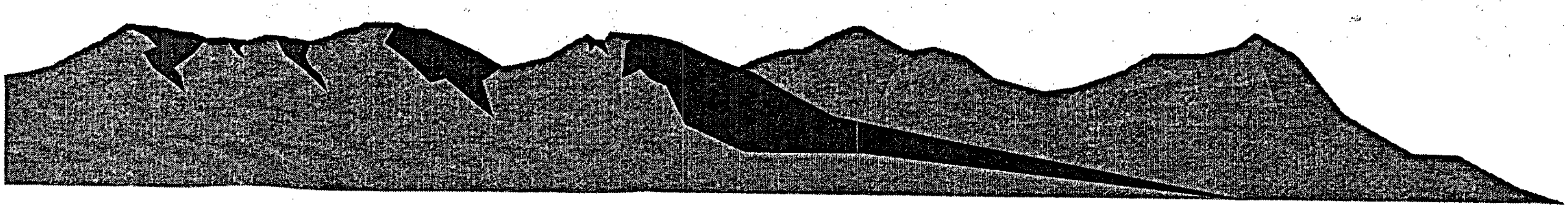
# Future Deep Percolation

- Future Deep Percolation Range:
  - 13 mm/year (5% of 266 mm/year)
  - 64 mm/year (20% of 321 mm/year)

- Log-uniform Distribution
  - deep percolation is a multiplicative process suggesting logarithmic distribution
  - no basis for favoring either end of the distribution suggesting a uniform distribution

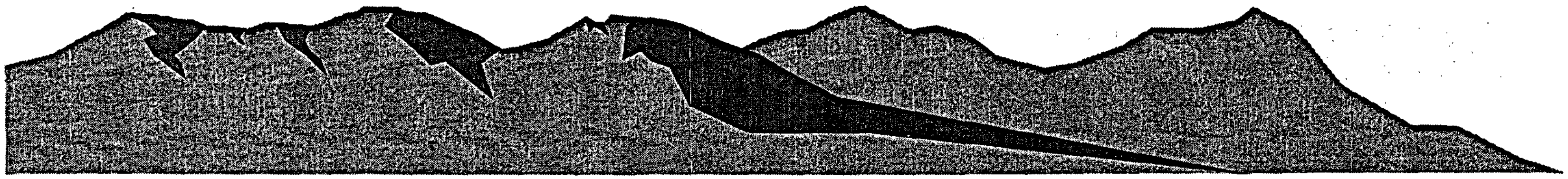
# Future Deep Percolation (cont.)

- Mean value of 32 mm/year
  - approximately 6 times greater than current rate for deep percolation



# Status of Proposed Part 63

- EPA comment period ended November 21
- NRC comment period ended December 7
- NRC will consider the comments and expects to finalize its regulation shortly after the EPA finalizes its standard



# Recharge at Yucca Mountain, Nevada: Estimates from the Chloride Mass Balance Method and Chlorine-36 Data

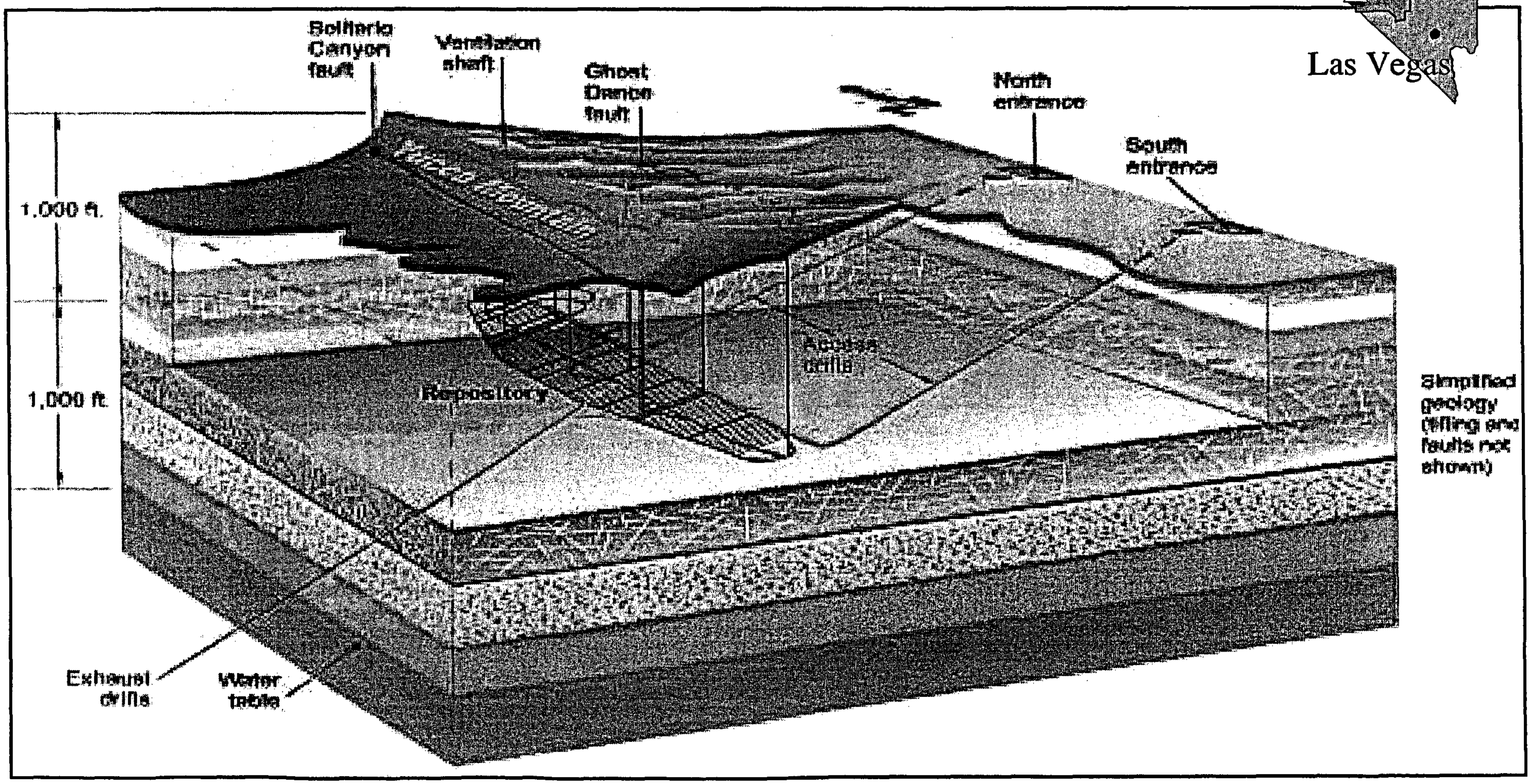

Chen Zhu, Ph.D.

Associate Professor

INDIANA UNIVERSITY
BLOOMINGTON

# High-level Nuclear Waste Disposal

## Yucca Mountain

## Infiltration & Recharge (Freeze and Cherry, 1979)

- **Infiltration:** the entry into the soil of water made available at the ground surface, together with associated flow away from the ground surface within the unsaturated zone

**Accurate estimate of infiltration rates for arid and semi-arid areas is extremely difficult because the water fluxes under these climate conditions are low and spatially and temporarily variable.**

# Chloride Mass Balance Method (CMB)

$$R = P\frac{Cl_{eff}}{Cl_{GW}}$$

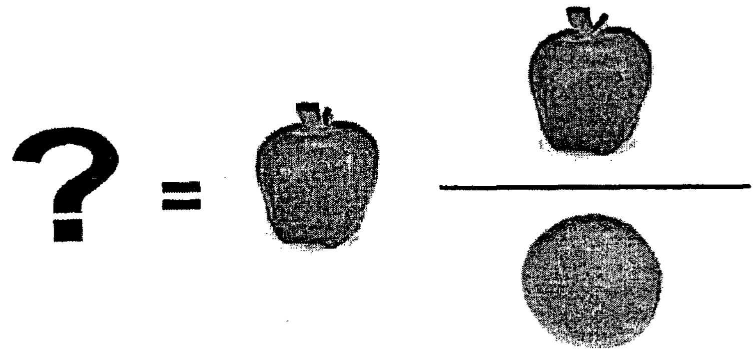
- *R* – infiltration or recharge rate (mm/yr)
- *P* – mean annual precipitation (mm/yr)
- $Cl_{eff}$ – "effective" Cl concentration including both wet and dry deposition
- $Cl_{GW}$ – Cl concentration in groundwater samples from the saturated zone

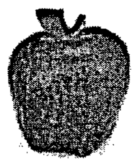
# Common Assumptions

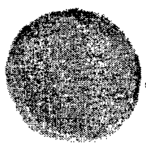
1. Atmospheric deposition is the only source of $Cl^-$ in groundwater;
2. $Cl^-$ behaves as a conservative tracer along its path;
3. $Cl^-$ uptake by roots and anions exclusions are negligible;
4. Leaching of $Cl^-$ deposit at ground surface and in the soil zone is complete;
5. Groundwater movement in both UZ and SZ can be approximated as a one-dimensional piston flow;
6. Surface run off and run-on can be neglected; and
7. Steady state precipitation and $Cl^-$ fluxes.

# Problems in some applications

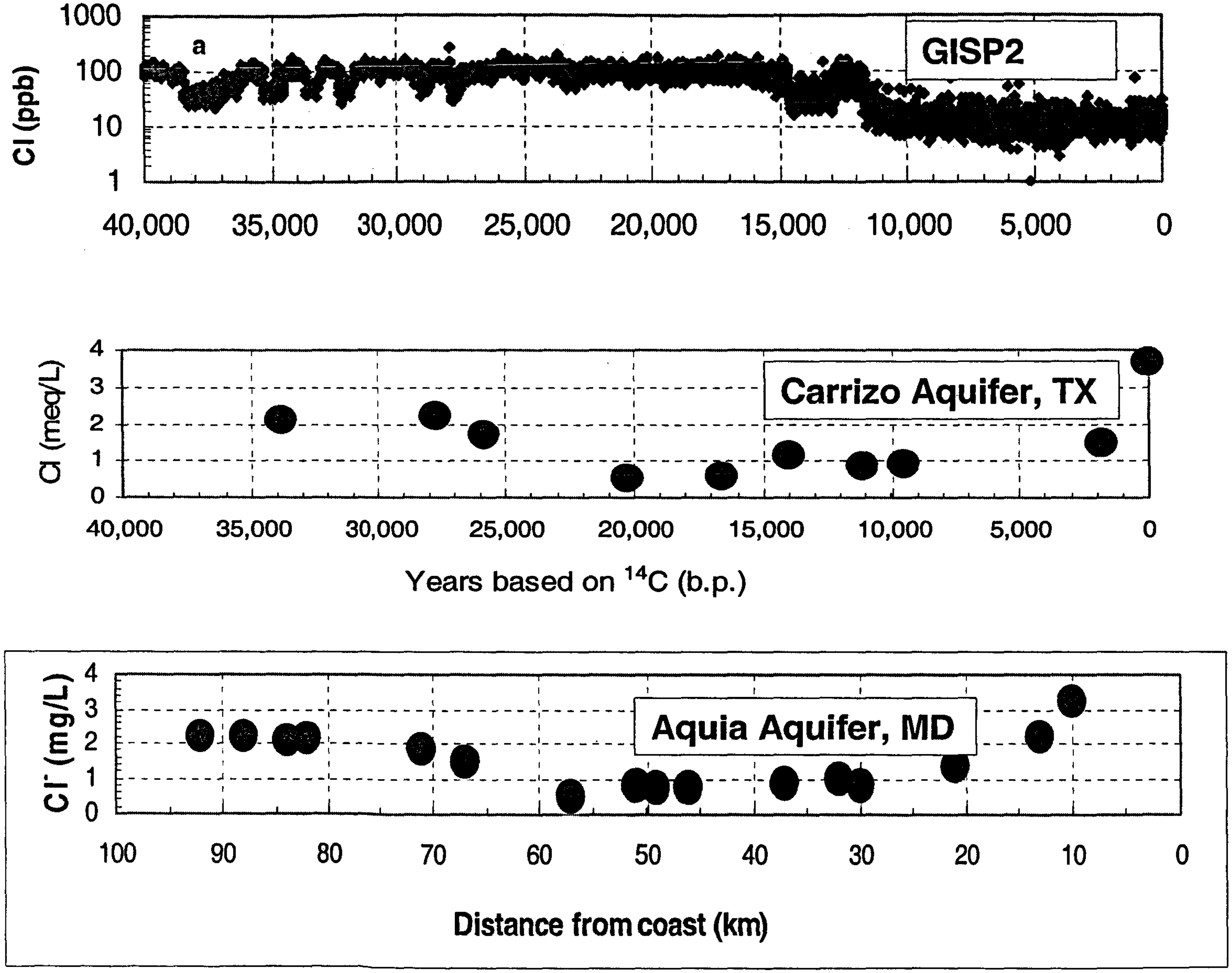
$$R^{\Delta t} = P^{\Delta t} \frac{Cl_{eff}^{\Delta t}}{Cl_{gw}^{\Delta t}}$$




 Holocene data

 Late Pleistocene data

# Change in $Cl^-$ with Time



# Discrete steady state CMB model

$$\bar{R}^{H} = \bar{P}^{H}\,\frac{\overline{Cl}_{eff}^{H}}{\overline{Cl}_{GW}}$$

$$\bar{R}^{P} = \bar{P}^{P}\,\frac{\overline{Cl}_{eff}^{P}}{Cl_{GW}}$$

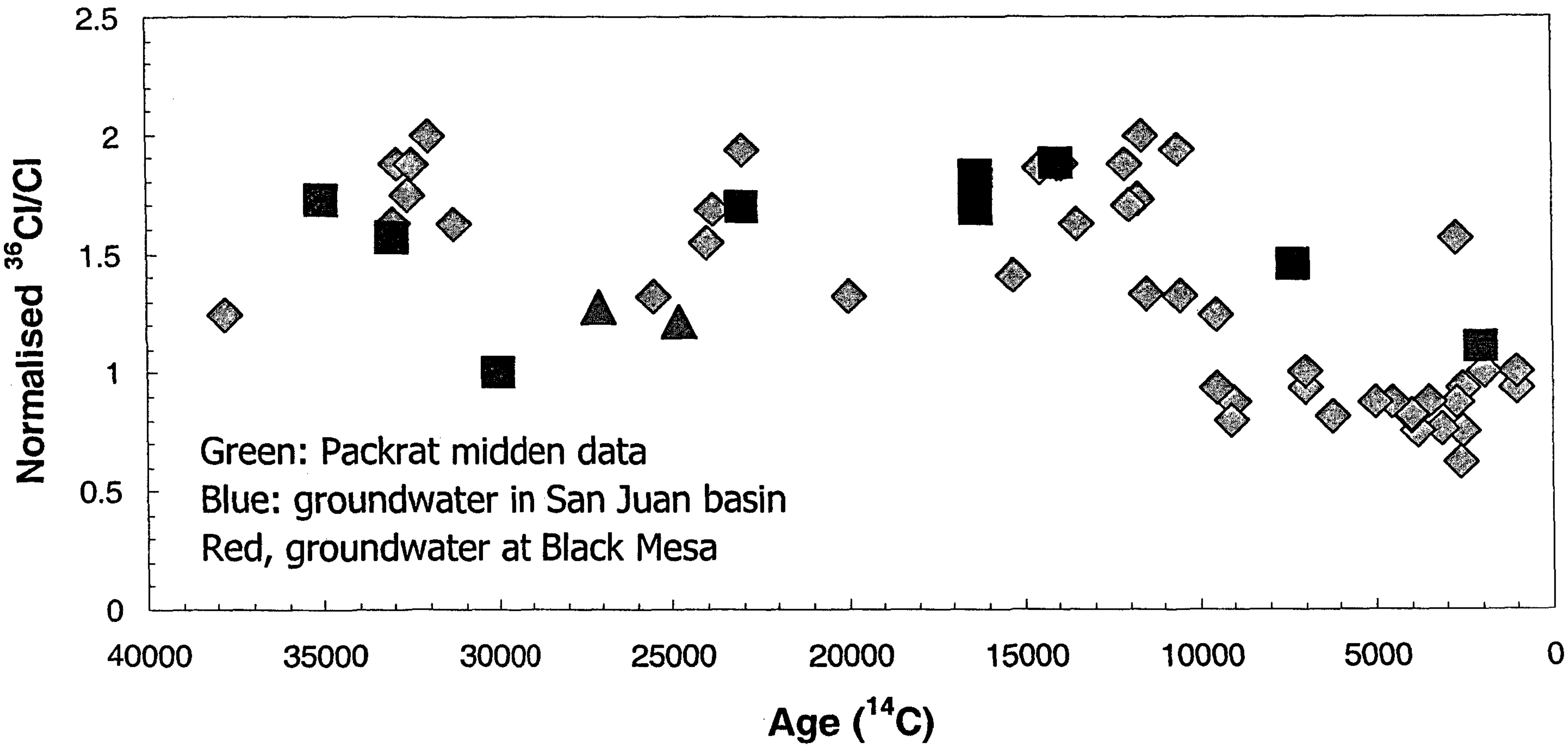
**<u>Long-term average</u> values of infiltration rates in Holocene and late Pleistocene. High-resolution inversion is not possible because of lack of detailed data.**

# CMB Parameters at Yucca Mountain

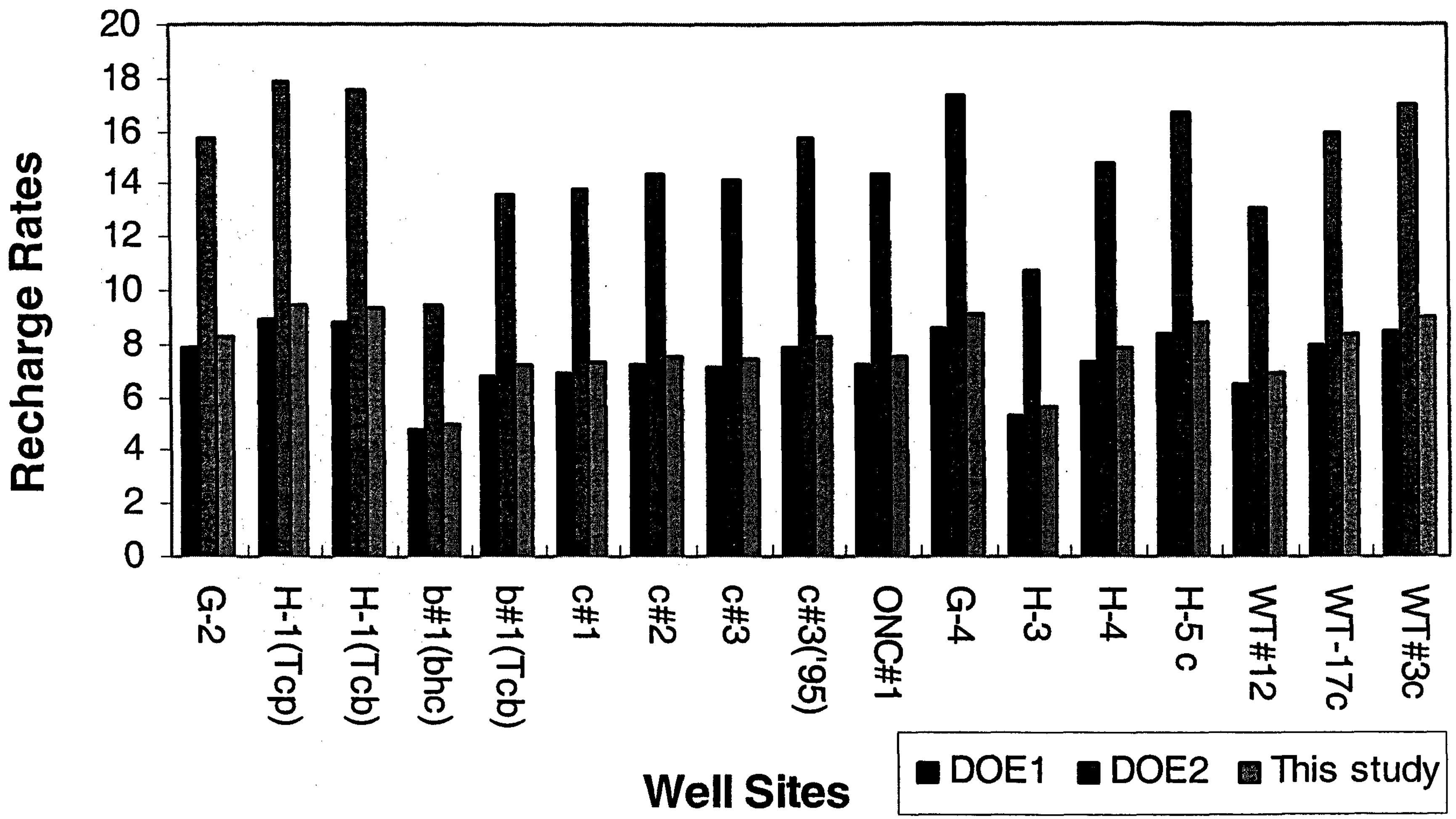
| | $^{36}Cl/Cl$ (x $10^{15}$) | P (mm / yr) | $D_{36}$ (atoms / $m^2$ s) | $D_{Cl}$ (mg / $m^2$ yr) | $Cl_{eff}$ (mg / L) |
|---|---|---|---|---|---|
| Holocene | 500 | 172 | 16 | 60 | 0.35 |
| Late Pleistocene | 1000 | 300 | 30 | 55 | 0.18 |

**$Cl_{eff}$ and $Cl_{eff}$ for Holocene (Fabryka-Martin et al., 2000) and late Pleistocene estimated from $^{36}Cl/Cl$ data and $^{36}Cl$ deposition rate at appropriate latitude (Phillips, 2000)**

# $^{36}Cl/Cl$ Ratios

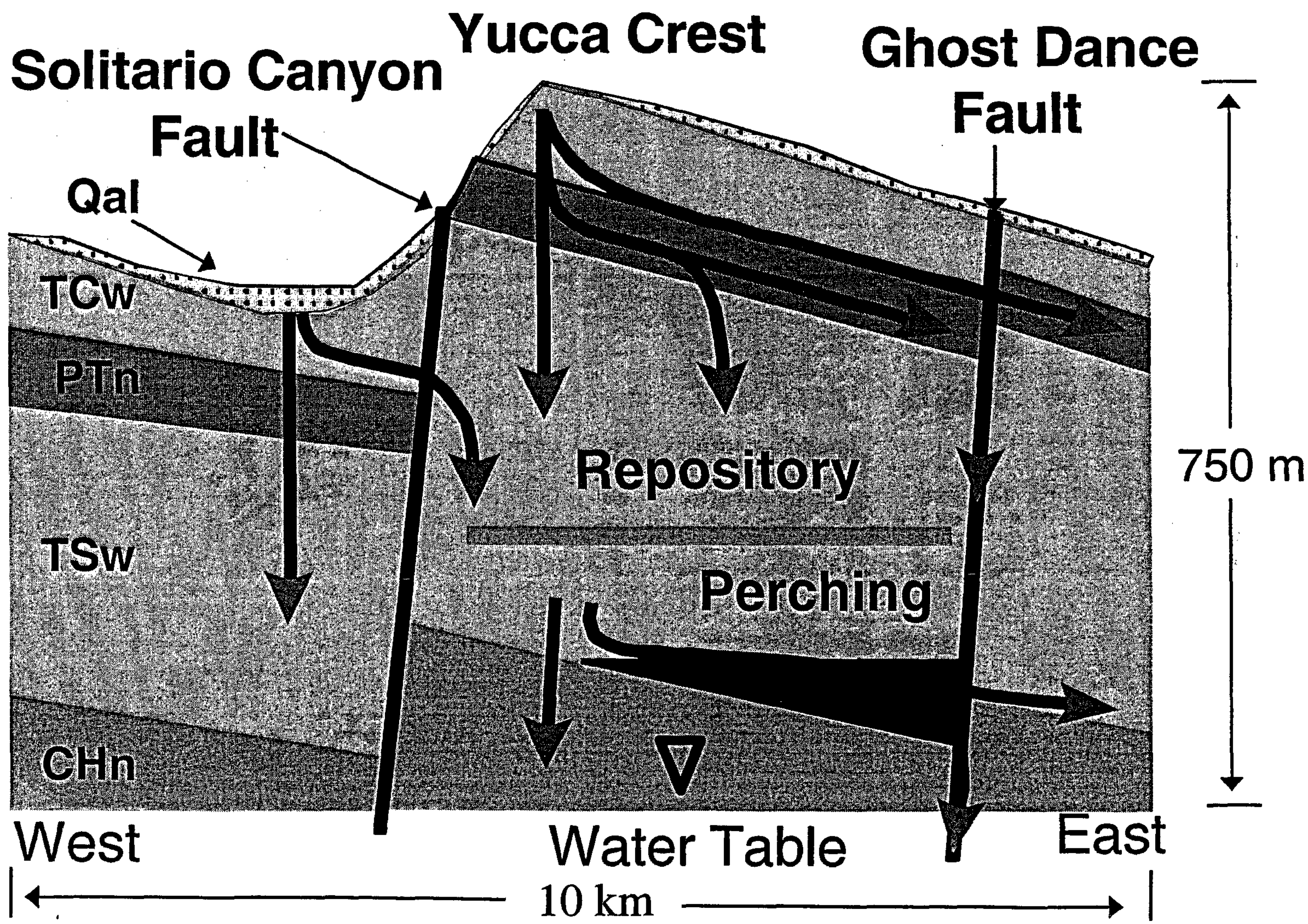


# Recharge Estimates from Saturated Zone Samples

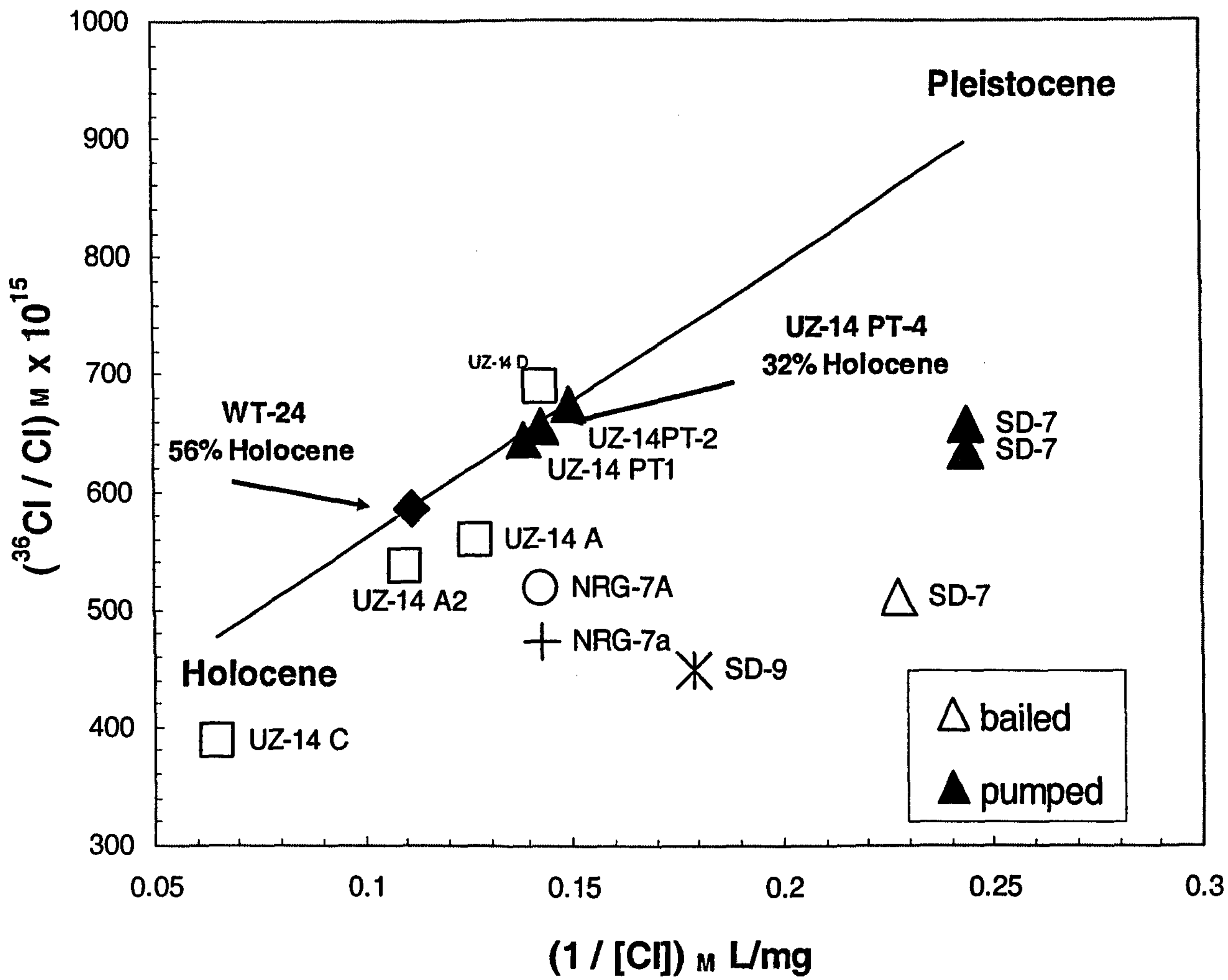



**Spatial problem: *SZ* water probably recharged north of the repository, not above the repository.**

# Schematic cross-section of Yucca Mountain



# Mixing of Holocene and Late Pleistocene Waters in Perched Water Bodies




$$Cl_{gw}^{H} = 13.5(mg/L)$$

$$Cl_{gw}^{P} = 3.5(mg/L)$$

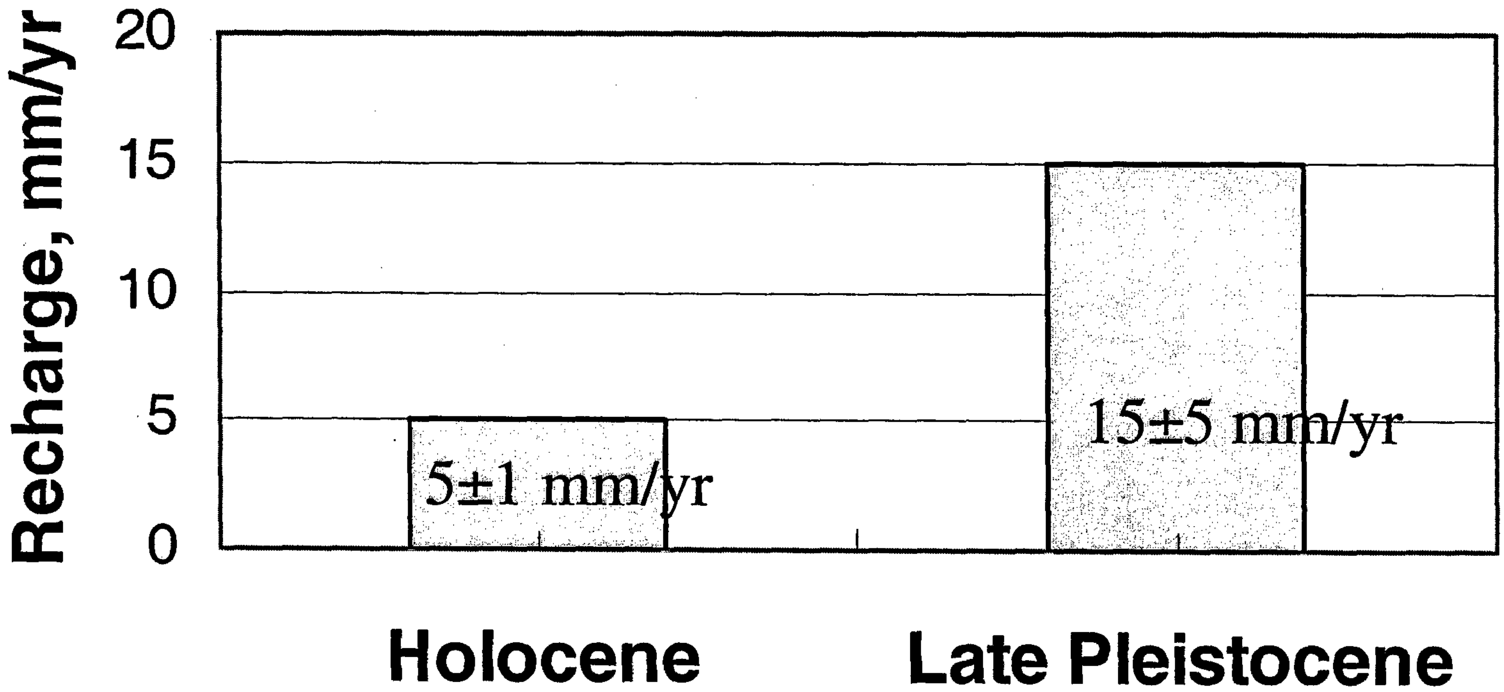
$$\bar{R}^{H} = \bar{P}^{H}\frac{\overline{Cl}_{eff}^{H}}{\overline{Cl}_{GW}}$$

$$\bar{R}^{P} = \bar{P}^{P}\frac{\overline{Cl}_{eff}^{P}}{Cl_{GW}}$$

# Error propagation analysis

- 6% for $Cl^-$ analytical precision;
- 30% for $^{36}Cl/Cl$ ratios;
- 20% for precipitation in Holocene and 50% for late Pleistocene.

# Estimated Recharge for Yucca Mountain



# Comparison with other methods

- Agree with watershed modeling (Flint et al., 1996, 4.5 mm/yr area averaged)
- Agree with watershed modeling (DOE, 2000, 4.7 mm/yr for H and 19.8 mm/yr for P);
- Rates estimated for Black Mesa are in good agreement with independent numerical method at Black Mesa, Arizona;
- CMB: Spatial uncertainty, perched water, northern half of the repository.

# Conclusions

- Used Chloride Mass Balance method to estimate long-term average infiltration rates at Yucca Mountain, Nevada

  Late Pleistocene infiltration rate – 15 ± 5 mm/yr

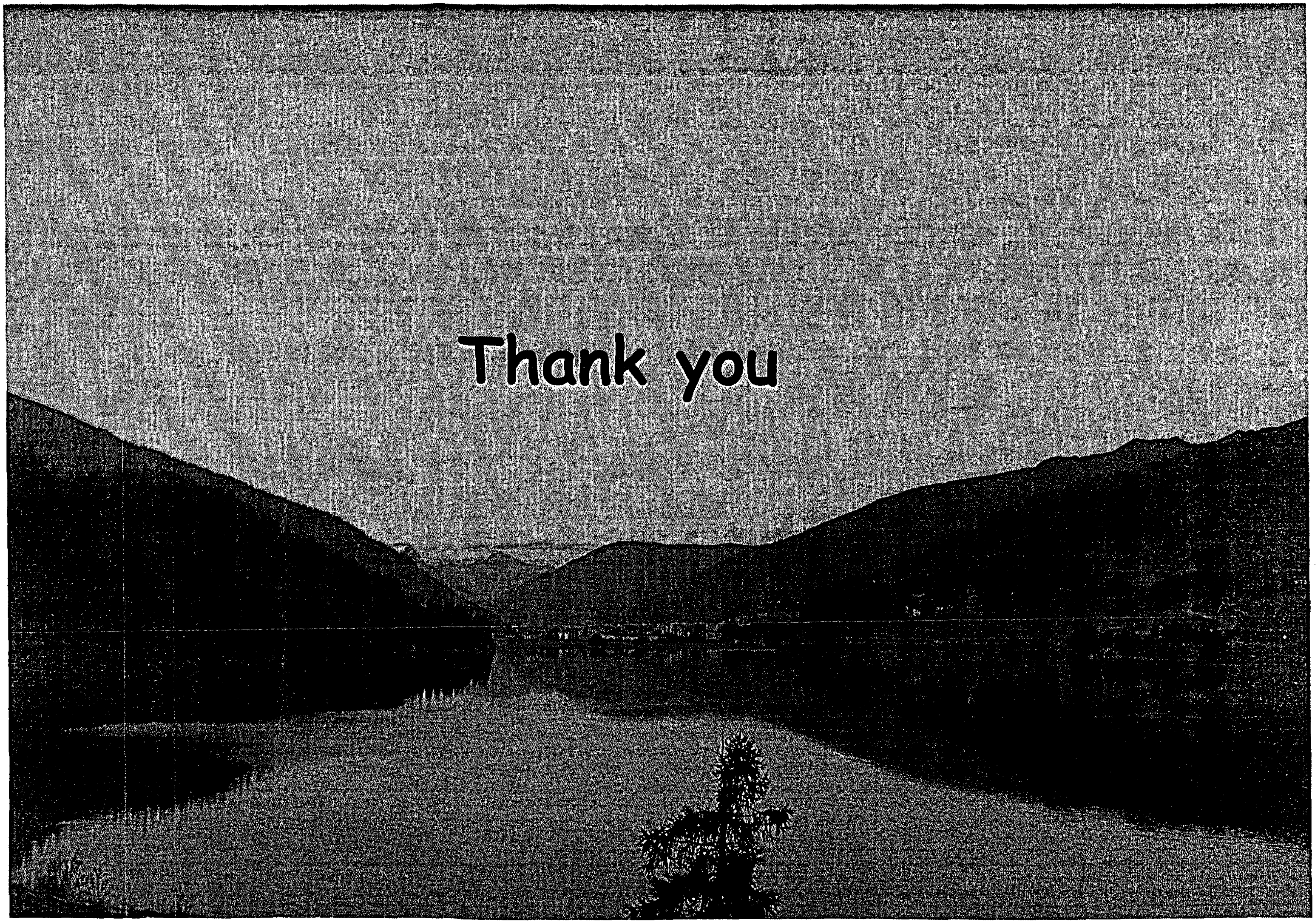
  Holocene infiltration rate – 5 ± 1 mm/yr

- Estimated infiltration rates agree with infiltration models at Yucca Mountain that are independent in terms of methods
- Methodology and parameter estimates are reasonable and represent best practice, but inherent uncertainties are large

estimate of paleorecharge from the CMB method.

[59] Considerable uncertainties are associated with estimated recharge values from the CMB method because of the myriad of assumptions, some of which are certainly violated when applying the CMB method to saturated aquifers (e.g., one-dimensional piston flow). The value of the CMB method may lie in its economics and the general lack of other reliable methods for estimating the very important recharge rates in arid and semiarid regions. Like all other field methods, it can be improved with a good

**Zhu et al. (2003), *Water Resources Research***


Thank you

science for a changing world

# The Chloride Mass-Balance Method and Estimating Recharge at Yucca Mountain

Ward Sanford
USGS, Reston, VA

ACRW meeting, December 13, 2005

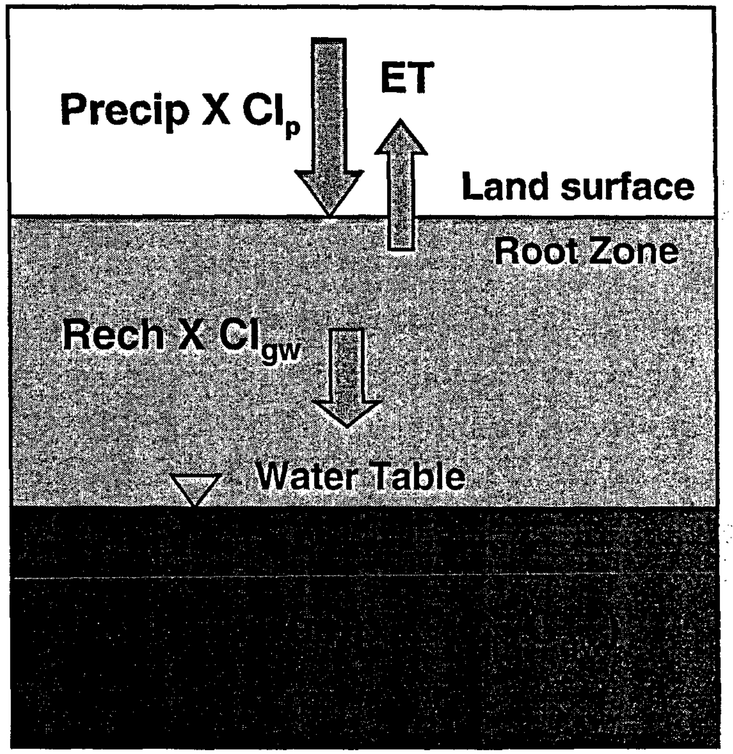
U.S. Department of the Interior
U.S. Geological Survey

# Overview of Presentation

- Using the Chloride Mass-Balance Method: Assumptions and examples
- Transport of Water and Chloride in the Unsaturated Zone in Arid Environments
- Recharge at Yucca Mountain

# The Classic CMB approach:

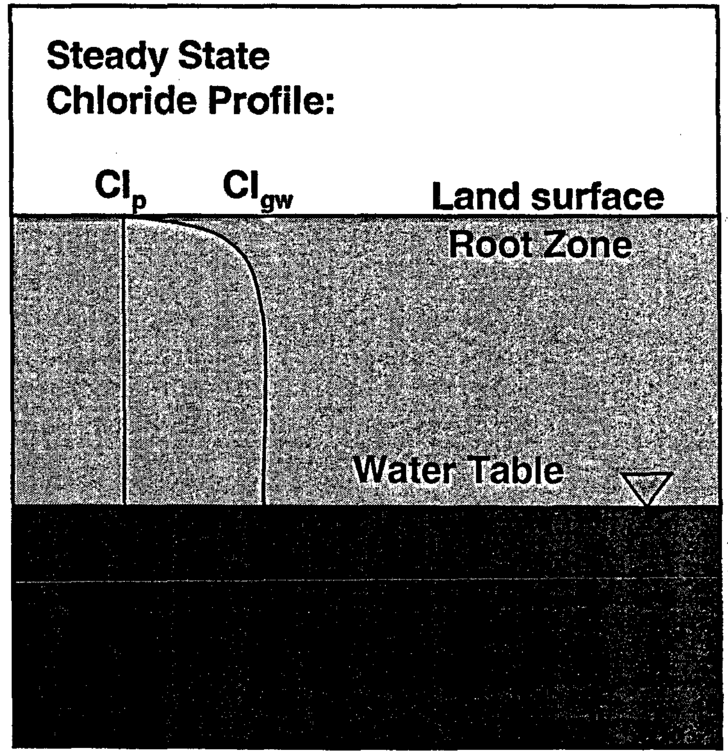
- Simplest form is a mass balance of a conservative solute
- Chloride is the most conservative and easily measured
- Three measurements give you the fourth unknown: recharge




USGS

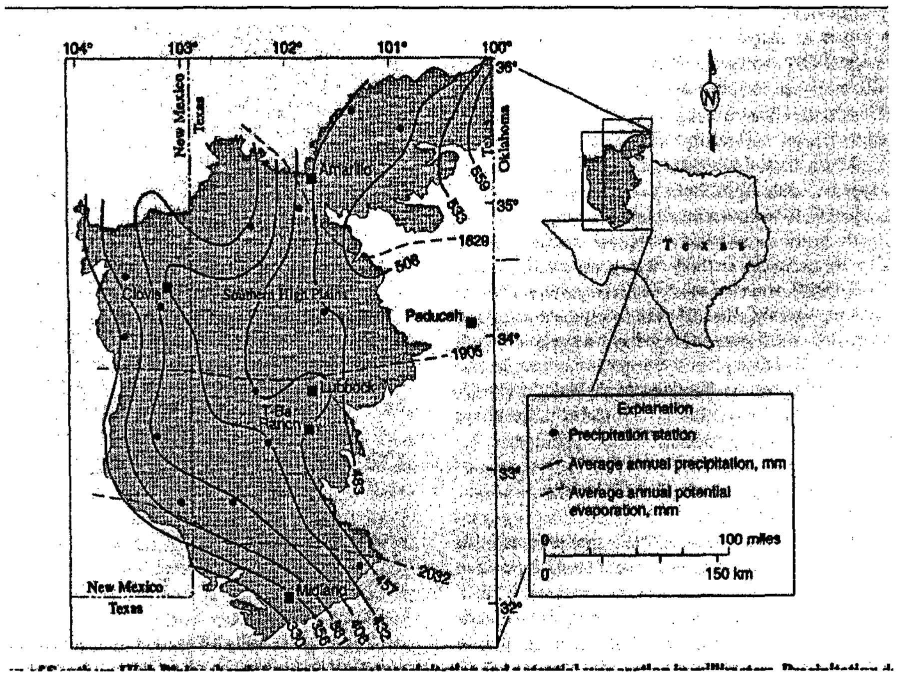
# Assumptions in the CMB method:

- Steady State flow and chloride concentrations
- Runoff is zero
- Anthropogenic sources are small or can be accounted for
- Measured samples are a good statistical average



# Example 1: The Southern High Plains

- Wet and dry chloride in precip was collected at numerous sites
- Chloride in GW was averaged from 3000 wells
- 11 mm/year average recharge calculated
- Good agreement with Theis (1937) estimate from slope of water table

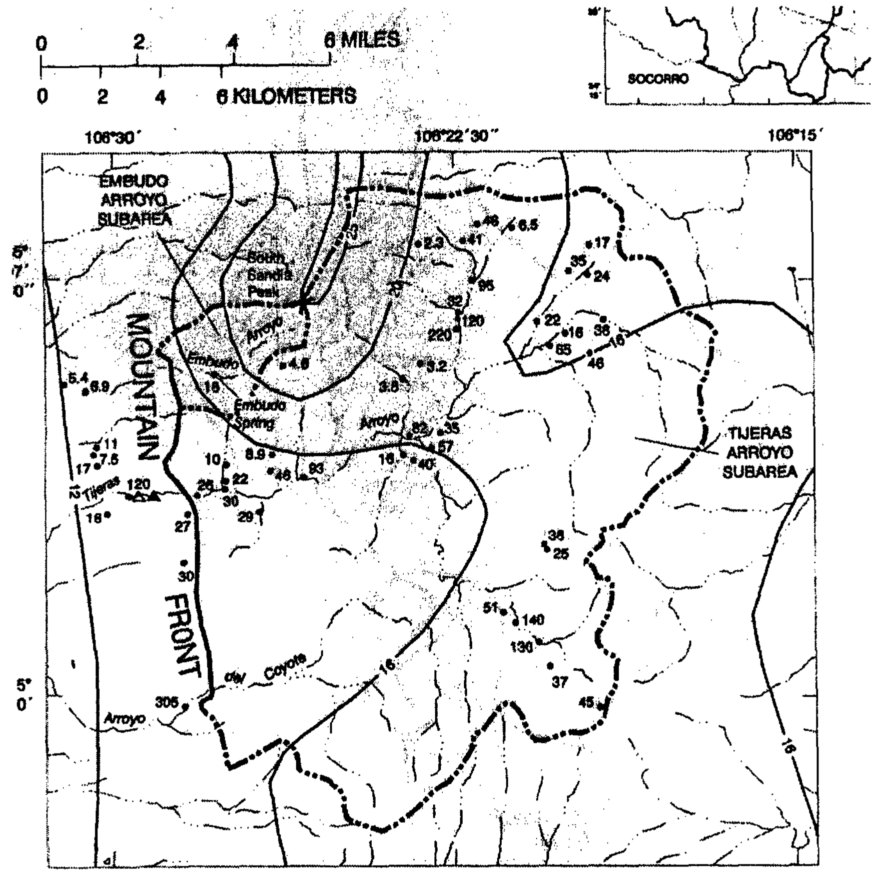



From Wood and Sanford (1995) Ground Water, p. 458-468.

USGS

# Example 2: The Albuquerque Basin

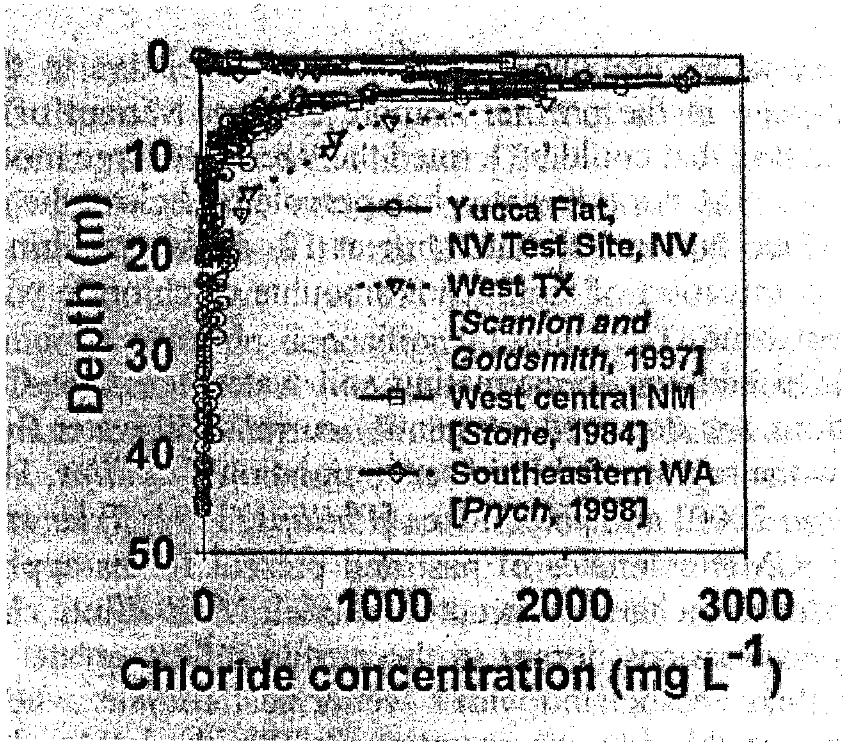
- Multiple watershed study of Eastern Mountain Front (EMF)
- Total recharge for EMF was 11,000 acre-ft/year
- Estimate was in good agreement with C-14 & flow model results




USGS

# Chloride Profiles in Arid Environments

- The "steady state" Cl profile is not observed
- A bulge in chloride usually is present 5-10 meters below land surface
- Very high values of chloride infer very little recharge has occurred

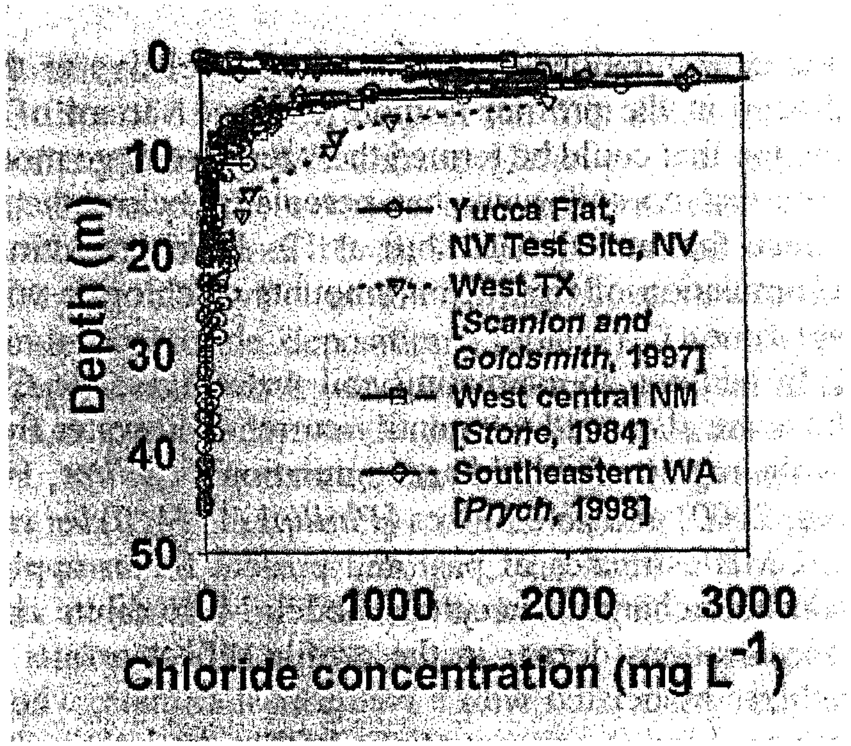



From Woolvard et al. (2002)

USGS

# Using a "Transient" CMB approach

- Assume piston flow and constant precipitation flux
- Assume Cl concentration in precipitation is constant
- Recharge varies with time
- "Accumulation time" can then be calculated for each vertical segment of profile
- Such calculations reveal that several thousand years are required to accumulate typical amounts of chloride




From Woolvard et al. (2002)

USGS

# Simulations of Chloride Profiles

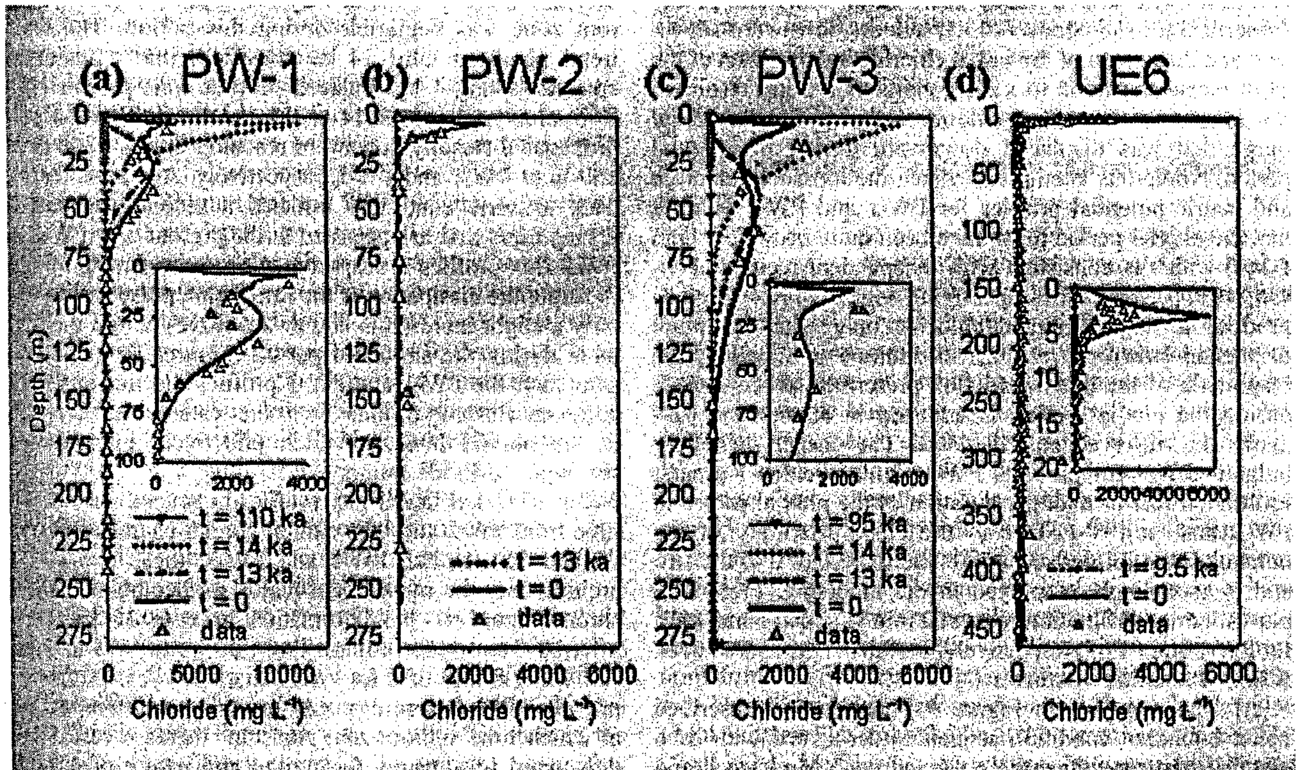


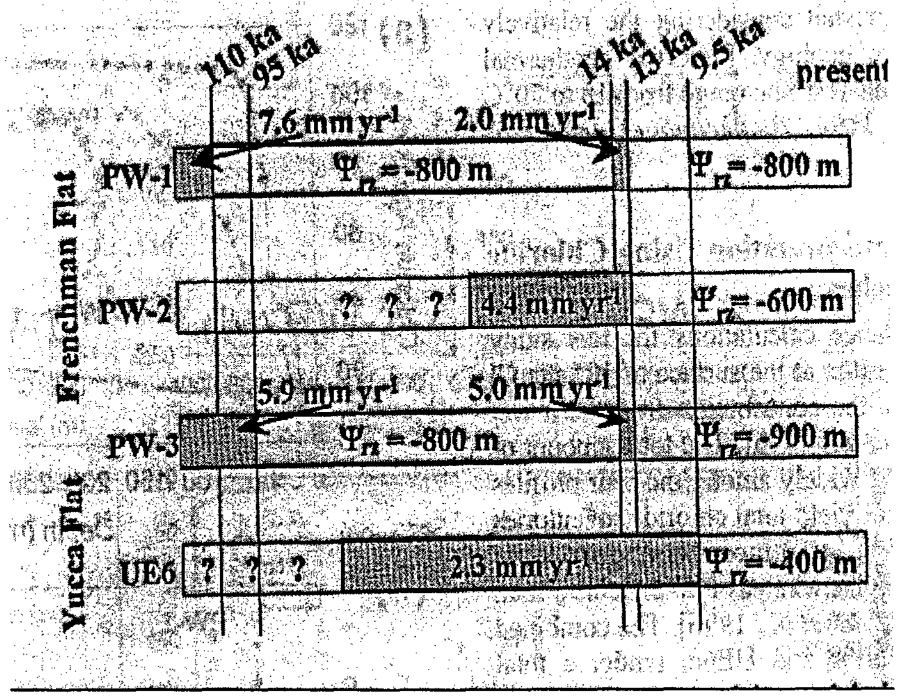

Figure 6. Modeled chloride profiles developed over time in response to climate/vegetation transitions for the (a–c) Frenchman Flat and (d) Yucca Flat sites. The t = 0 profile represents present-day. Chloride values are pore water concentrations.

USGS

From Woolvard et al. (2002)

# Details of Chloride Simulations

- Water, Heat, Vapor, and Chloride transport
- FEHM model used from Los Alamos Lab
- Steady-State Upward Net Moisture Flux
- Multiple Wet and Dry periods for PV1 & PV3




USGS

# Estimating Recharge at Yucca Mountain

- "It is clear that a focus solely on changes in precipitation constitutes a great oversimplification of the actual recharge mechanisms. Changes in other fluxes that redistribute precipitation after it hits the land surface must be considered. These include the generation of runoff, evaporation and transpiration."

Fred Phillips et al. (2004)

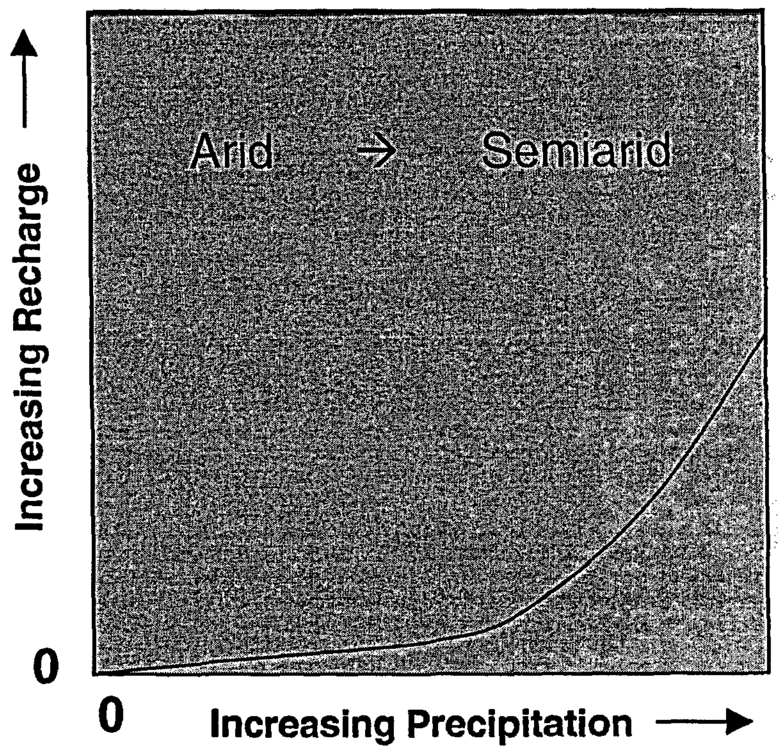
# Recharge and Transpiration by Vegetation

- In the American West, the Pleistocene-Holocene transition saw the widespread replacement of a piñon-juniper forest by desert scrub vegetation.

- Walvoord and Phillips (2004) study of these vegetation shows much higher recharge rates beneath the forests, all other factors being equal—the desert scrub are more efficient.

# Recharge = f (Precipitation) is Nonlinear

- The percentage is very small and often zero in arid regions
- A "threshold" exists that may be vegetation related
- The Percentage increases with increasing precipitation




USGS

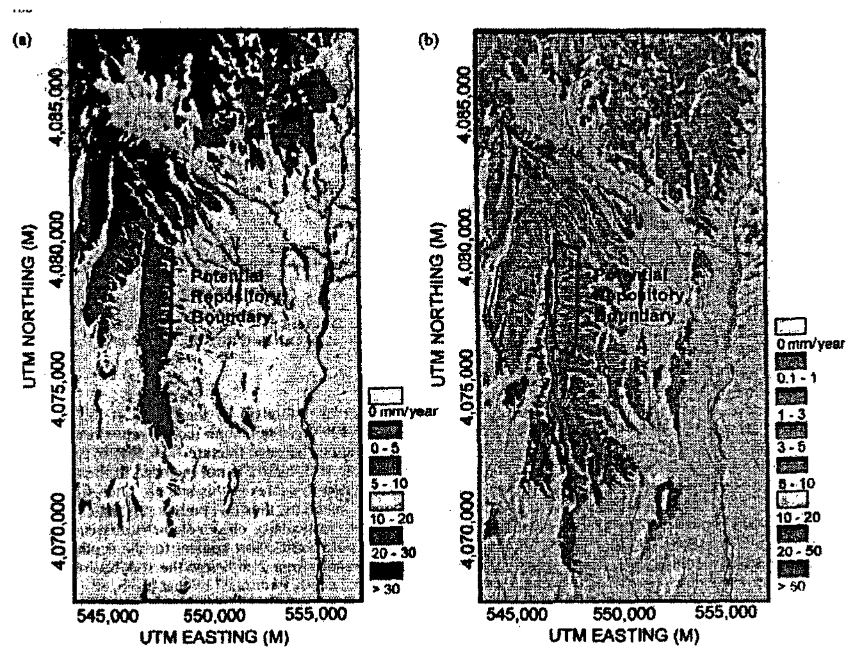
# Recharge and Runoff

- Recharge in the Basin and Range Province tends to be (1) areally distributed at high elevations, (2) focused by runoff into channels at intermediate elevations, and (3) nonexistent at lower elevations.

- High temporal variability in precipitation leads to greater recharge in focused events, while less variability leads to less recharge.

# Variable Recharge

- Recharge is a function of elevation, vegetation and thickness of soil
- Deep recharge is a function of geologic framework
- Temporal variability-- most recharge occurs in the largest precipitation events




From Flint et al. (2002)

USGS

# Ground-water recharge in southern Nevada has been primarily from the end of the last glacial maximum

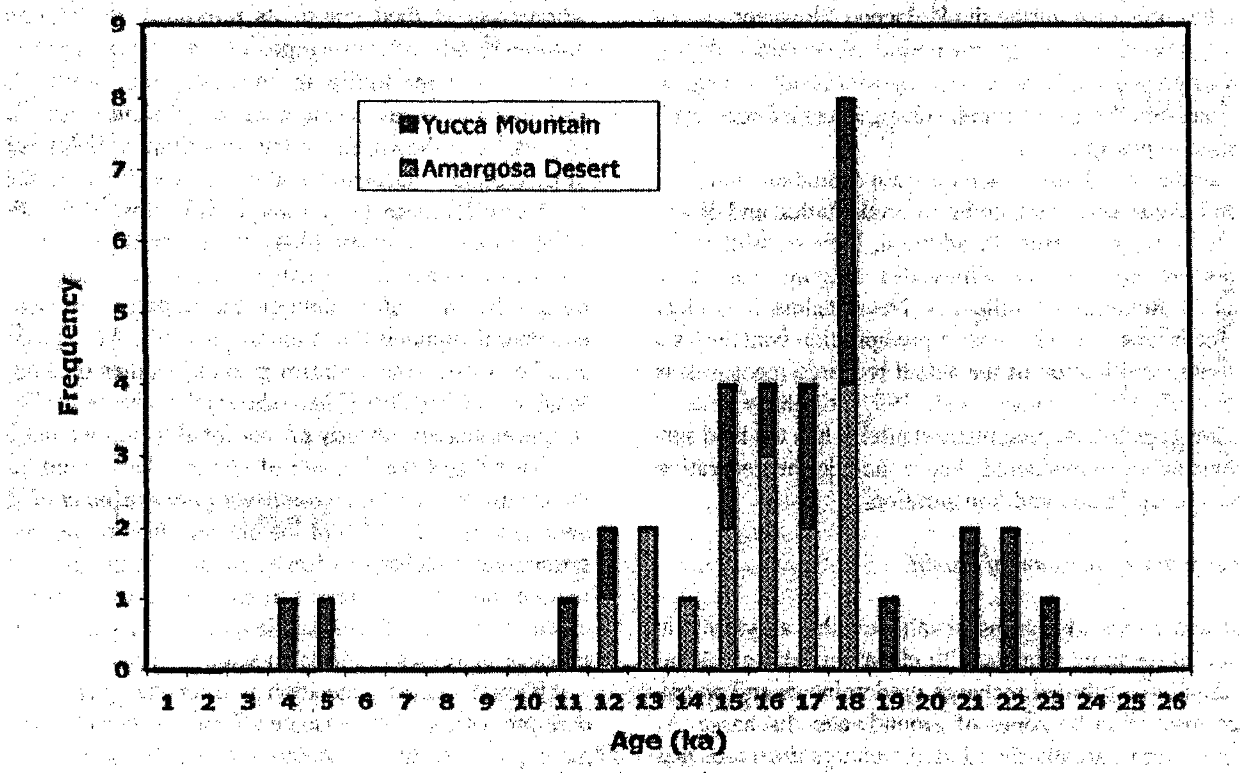


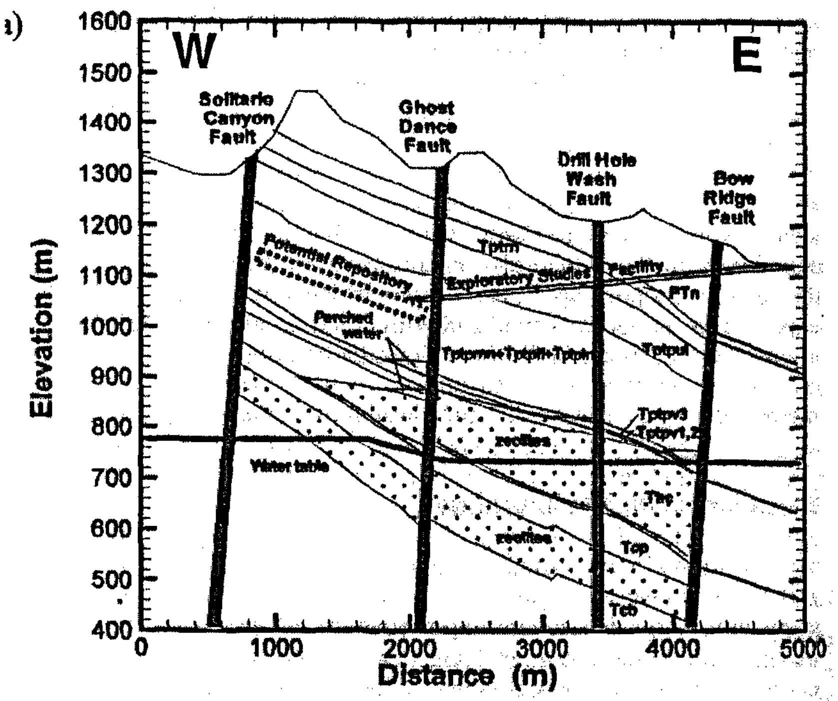

**Figure 4.** Histogram of $^{14}C$ ages of groundwater in the Amargosa Desert and Yucca Mountain areas of southern Nevada. The ages have been corrected for atmospheric radiocarbon activity variations, but not for any subsurface geochemical processes. The figure is based on data from *Benson and Klieforth* [1989] and *Claassen* [1986].

USGS

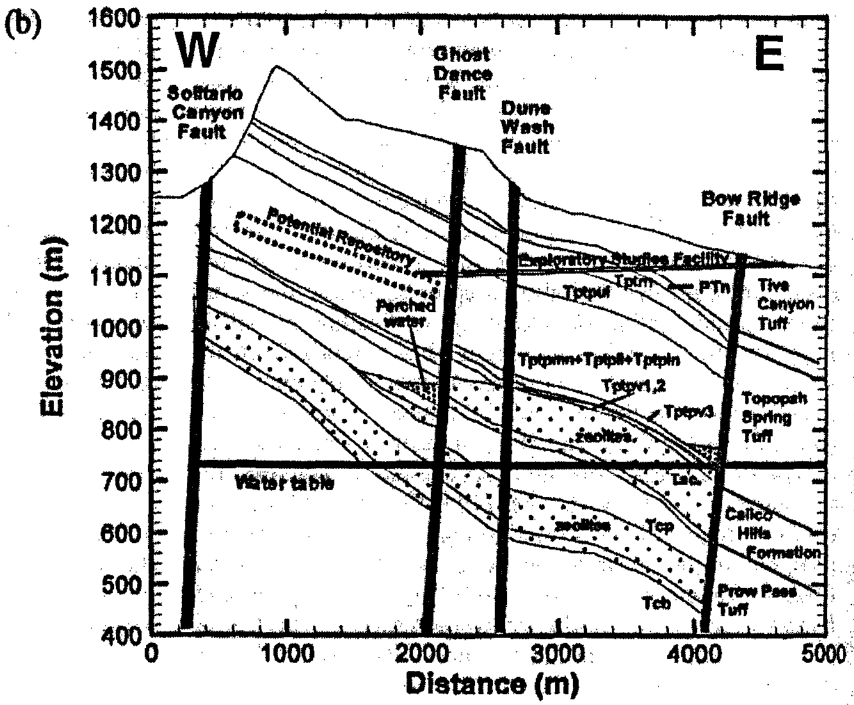
After Phillips et al. (2004)

# Cross Sections Through Yucca Mountain

### Northern Section




### Southern Section




From Flint et al. (2002)

USGS

# Applying CMB to Perched Yucca Mountain Water

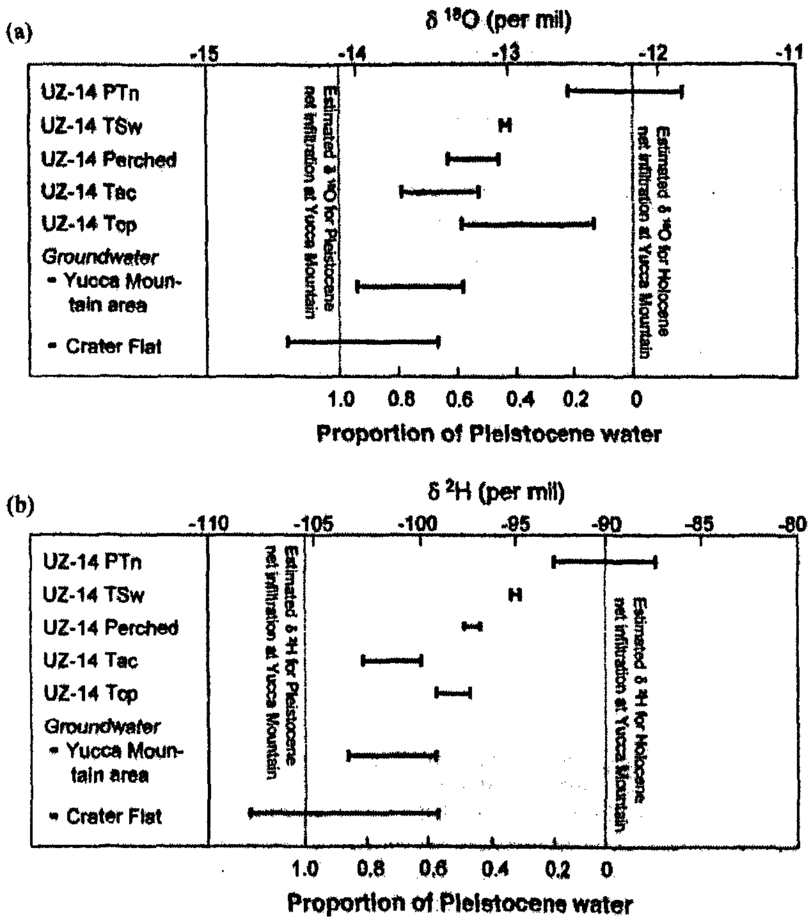



**Table 2** Measured chloride concentrations and estimated Holocene and Pleistocene chloride concentrations and recharge rates for perched water at boreholes SD-7 and UZ-14

| Parameter | Value | |
|---|---|---|
| | Borehole SD-7 | Borehole UZ-14 |
| *Measured values*[a] | | |
| $\delta^{18}O$ (per mil) | −13.3 | −13.1 |
| Cl (mg/L) | 3.95 | 6.8 |
| $^{36}Cl/Cl \times 10^{15}$ | 612 | 690 |
| *Calculated values* | | |
| Pleistocene fraction[b] | 0.58 | 0.47 |
| Cl concentration (mg/L) | | |
| Holocene[c] | 7.3 | 8.0 |
| Pleistocene[d] | 1.5 | 5.5 |
| Flux[e] (mm/year) | | |
| Overall average[f] | 15 | 8.5 |
| Holocene | 8.2 | 7.4 |
| Pleistocene | 40.0 | 10.8 |

[a] Data source: CRWMS M&O (2000a)
[b] Calculated based on $\delta^{18}O$ by the approach described in the text
[c] Calculated using Eq. (2b)
[d] Calculated using Eq. (2a)
[e] Calculated using Eq. (1)
[f] Calculated using the measured Cl concentration

USGS

From Flint et al. (2002)

# References


- Flint and others (2002). Estimating recharge at Yucca Mountain, Nevada, USA: comparison of methods: *Hydrogeology Journal*, vol. 10, no. 1, p. 180-204. (a special volume on groundwater recharge).

- Walvoord and Phillips (2002). Deep arid system hydrodynamics, parts 1 & 2. *Water Resources Research*, vol. 38., no 12, articles 27 and 44.

- Phillips, Walvoord and Small (2004). Effects of Environmental Change on Groundwater Recharge in the Desert Southwest: In *Groundwater Recharge in a Desert Environment—The Southwestern United States*, AGU Water Science and Application Series Vol. 9, p. 273-294.

- Zhu and others (2003) Late Pleistocene and Holocene groundwater recharge from the chloride mass balance method and Cl-36 data: *Water Resources Research*, vol. 39, no. 7, article SBH-4.


USGS

# ACNW WHITE PAPER: LOW-LEVEL RADIOACTIVE WASTE MANAGEMENT ISSUES

Michael T. Ryan
December 13, 2005

1

## BACKGROUND

- **2005 COMMISSION BRIEFINGS: COMMERCIAL LLW RAISED AS AN ISSUE**
  - Recent GAO Study
  - NMSS Identified as an Emerging Issue
  - ACNW Offered to Identify Opportunities (Areas) Part 61 Might be Better Risk-Informed
- **NRC's LLW REGULATION AT PART 61**
  - Deterministically-Based
  - Developed Prior to Development of Commission's 1995 PRA Policy Statement
  - Agreement-States Developed Regulations to Comport with Part 61

2

## ACNW WHITE PAPER

- o **COMMITTEE AGREED TO DEVELOP BACKGROUND PAPER**
  - Explaining How US Commercial LLW Program Evolved
  - Review Process by Which Part 61 was Developed
  - Review Past ACNW Advice on LLW
  - Identify Opportunities to Improve Part 61 to Make it Better Risk-Informed
  - Paper Does Not Make Recommendations on How to Implement Recommendations

- o **PAPER DEVELOPED BY ACNW MEMBERS AND STAFF**
  - Reflects Informal Comments from NMSS and RES
  - Will be Made Available for Public/Stakeholder Comment/Review

3

## ACNW WHITE PAPER: LIMITATIONS

- o **NRC LLW PROGRAM SCALED-BACK ABOUT 1995**
- o **LITERATURE LIMITED TO KEY REFERENCES**
- o **LIMITED EXTERNAL ACNW REVIEW THUS FAR**
- o **PAPER DOES NOT ADDRESS**
  - Mixed Waste/RCRA Issue
  - NAS Low-Activity Study
  - Foreign LLW Management Experience
  - Stakeholder Views

4

## GOALS FOR TODAY/PATH FORWARD

- INTRODUCE WHITE PAPER
- RECEIVE SOME PRELIMINARY FEED-BACK FROM NMSS
- IDENTIFY AREAS FOR WHICH PART 61 COULD BE BETTER RISK-INFORMED (BASIS FOR COMMITTEE LETTER)
- APPROVE AND TRANSMIT COMMITTEE LETTER (WITH ATTACHED WHITE PAPER) TO COMMISSION
- BRIEF COMMISSION IN JANUARY
- CONDUCT WORKING GROUP MEETING LATER IN YEAR

5

## WHITE PAPER CONTENTS

- 3 PARTS:
  - LLW Program History
  - NRC LLW Regulatory Framework
  - Past ACNW Observations and Recommendations
- REFERENCES
- 4 APPENDICES
  - Structure of 10 CFR Part 61
  - Final Commission *Policy Statement* on the Use of PRA Methods
  - Regulatory Evolution of the LLW Definition
  - NUREG-1573 Summary

6

## PART I: LLW PROGRAM HISTORY



7

## PART II: NRC LLW REGULATORY FRAMEWORK



8

## PART II (continued)

**6 Approach to Developing Part 61 (con't.)**

- 6.4 Assumed Definition of Safety
  - 6.4.1 EPA Efforts to Promulgate LLW Standards
  - 6.4.2 NRC's Selection of a Default LLW Standard
  - 6.4.3 NRC's Proposed LLW Classification System
  - 6.4.4 Summary
- 6.5 GTCC LLW Management
  - 6.5.1 NRC Activities
  - 6.5.2 DOE Activities

**7 Other NRC LLW Program Developments**

- 7.1 LLW Regulatory Guidance and Policy
- 7.2 NRC Strategic Planning

9

## PART III: PAST ACNW ADVICE AND RECOMMENDATIONS

- **COMMITTEE NOT IN EXISTANCE WHEN PART 61 PROMULGATED**
- **PREVIOUS ACNW REVIEWS**
  - Limited to Period 1988-2000
  - Not All Staff LLW Activities Examined
- **21 LETTER REPORTS DEVELOPED SINCE 1988**
  - General LLW Issues
  - Groundwater Monitoring Issues
  - Mixed LLW Issues
  - Onsite Storage Issues
  - Performance Assessment Issues
  - Waste Package and Waste Form Issues

10

## PART III (continued)



11

## WHITE PAPER APPENDICIES



12

## WHITE PAPER OPPORTUNITIES

- Part 61 is a **deterministically-based** regulation.
- Part 61 intruder scenarios are not risked informed and include bounding or extreme bounding conditions.
- 10 CFR Part 20 has been updated incorporating ICRP recommendations (Publications ICRP-26 and 30).
- Subpart D Siting Criteria are mostly qualitative.
- Part 61 institutional controls and financial assurance measures do explicitly account incorporate environmental monitoring data from the institutional control period into future requirements.

13

## OPPORTUNITIES (continued)

- Credit for engineered barriers related to waste form; waste packaging; disposal site design including; and cover technology design were not explicitly included in Part 61
- Others ?

14

# Staff LLW Activities and ACNW White Paper

Scott Flanders, Deputy Director

Division of Waste Management and Environmental Protection

Office of Nuclear Material Safety and Safeguards, USNRC

December 13, 2005

# Topics

- Context –External and Internal
- Staff LLW Efforts
- Views on White Paper
- Recommendations and Next Steps

# Context--National LLW Program

- Future disposal of LLW remains uncertain
  - Barnwell closure to out-of-compact generators in 2008
  - Limited use of Hanford commercial disposal facility
  - License application for WCS facility
  - GTCC disposal developments

- Potential near-term developments may affect our work
  - GAO report on other countries' programs
  - Congressional interest
  - National Academies' Study

# Context--National LLW Program

- Low-Activity Waste is receiving increased attention
- Various groups have called for change
  - Health Physics Society
  - American Nuclear Society
- Public acceptance and political concerns remain prominent factors

# LLW Context—Internal to NRC

- Statutory responsibility under AEA for safety, security and protection of the environment

- Strategic Plan—one means to support safety strategy is to:

    - "Assess the key issues affecting safe management of civilian LLW disposal to ensure that potential disruption in access to the three licensed disposal sites does not adversely affect licensee's ability to operate safely and decommission their plants safely"

- As a result of mid-1990's Strategic Assessment, Commission affirmed reduced level of LLW activities. LLW resources have declined significantly since late 80's and early 90's, currently about 3 FTE

# Staff LLW Activities

- Assess need for updating LLW storage guidance per Commission SRM
- Improve Transparency in 10 CFR 20.2002 alternate disposals, per Commission SRM
- Developing 20.2002 review guidance
- Responding to Commission Order, regarding disposal of large quantities of depleted uranium
- Other

# Staff LLW Activities

- Continue with required activities

- Complete strategic planning effort to guide future staff activities
  - statutory responsibilities and Commission direction in Strategic Plan
  - considers external and internal factors
  - identify and prioritize LLW activities

- Limited staff LLW resources are a challenge

# Staff Views on White Paper

- Good summary of LLW program and Part 61
- Focus is on Part 61. Other stakeholders might emphasize different aspects of national program in identifying opportunities for improvement
- Certain aspects of external and internal context for LLW program not addressed in detail, but are important in evaluating opportunities

# Recommendations

- Consider more explicitly adding low activity waste disposal

- When identifying opportunities, ACNW might consider:
  - other approaches to managing risks (DOE, EPA, other countries)
  - views of key stakeholders
  - consequences that may result

- Staff recommends that ACNW recognize in its letter to the Commission the staff's strategic planning effort and consider recommending that opportunities identified by ACNW be evaluated as part of the staff's effort

# Next Steps

- Staff available to assist in finalizing the White Paper

- Staff will provide editorial and minor comments separately

- Staff will respond to Commission direction on White Paper

**Southeast Compact Commission**
*for Low-Level Radioactive Waste Management*

*States Working for Responsible Waste Management*

Richard G. Hunter, Ph.D.
Chairman

Debra G. Shults
Vice-Chairman

Michael H. Mobley
Secretary-Treasurer

Kathryn V. Haynes, M.P.H
Executive Director

December 12, 2005

Michael T. Ryan, Ph.D., Chairman
Advisory Council on Nuclear Waste
U.S. Nuclear Regulatory Commission
Mail Stop T-2E26
Washington DC 20555

Dear ~~Dr Ryan~~: Mike

On November 30, 2005, the Southeast Compact Commission adopted the attached policy statement on the management of commercial low-level radioactive waste (LLRW). The Commission developed this document partly in response to policy statements by other organizations and partly to aid the Commission's officers and liaisons in accurately and concisely conveying the Commission's position in this matter.

In its statement, the Commission indicates its preference for permanent disposal of low-level radioactive waste, while recognizing that loss of access to the Barnwell disposal facility in 2008 may result in storage of some wastes for an undetermined period. The Commission expresses its agreement with the U.S. Government Accountability Office (GAO) that "there is no health or safety crisis posed in the near term by the lack of access to disposal for Class B & C waste."

The Commission cautions proponents of Congressional action to allow disposal of commercial LLRW at the U.S. Department of Energy sites or to allow construction of a commercial disposal facility on federal land that federal involvement in the siting of a waste facility does not guarantee success. The Commission urges all concerned parties to closely examine the politics and economics of low-level radioactive waste disposal and insists that any proposed solution must support and uphold the rights of all interstate compacts to control the flow of waste into waste processing or disposal facilities within their borders. The Commission explains that "Threats to these controls, such as the suggestion that the LLW Policy Act should be amended or replaced, run the risk of impeding the continued operation of the existing processing and disposal facilities or leading to the actual closure of the facilities."

The Commission maintains that "adequate mechanisms exist for compacts with facilities to voluntarily accept waste from additional states/compacts and that voluntary acceptance has been and will continue to be critical to a lasting solution to this issue." The Commission affirms its plans to continue efforts in voluntary cooperation with other states and compacts to facilitate access to all low-level radioactive waste management services and to minimize the cost of these services. However, the Commission is not averse to pursuing other alternatives as long as those alternatives

AL
FL
GA
MS
TN
VA

21 Glenwood Avenue, Suite 207
Raleigh, North Carolina 27603

(919) 821-0500 fax (919) 821-1090
seco@secompact.org
www.secompact.org

are well thought out and do not jeopardize the tenuous balance we have achieved to this point. In fact the Commission has expressed its desire to solve the waste disposal problem for all low-level radioactive waste (NORM, NARM, as well as AEA LLW).

Please consider the views expressed in the attached policy statement in the development of the ACNW white paper on LLRW. I am available to discuss the Commission's views at 931-801-7540.

Sincerely,

Michael H. Mobley

Michael H. Mobley
Chair

Attachment: Southeast Compact Commission Policy Statement, November 30, 2005

SOUTHEAST COMPACT COMMISSION
21 GLENWOOD AVENUE, SUITE 207
RALEIGH, NC 27603
919/821-0500 919/821-1090 FAX
secc@secompact.org

*STATES WORKING FOR RESPONSIBLE WASTE MANAGEMENT*

# facsimile transmittal

To: Sharon Steele Fax:

From: Kathryn Haynes Date: 12/12/05

Re: Attachment to Letter Pages: 4

CC:

☒ Urgent ☐ For Review ☐ Please Comment ☐ Please Reply ☐ As Requested

Notes:

Here is the attachment mentioned in the letter to Dr. Ryan.

# SOUTHEAST COMPACT COMMISSION POLICY STATEMENT

## Management of Low-Level Radioactive Waste
## Adopted November 30, 2005

The Southeast Interstate Low-Level Radioactive Waste Management Compact was enacted by its party states in 1983 and ratified by Congress in 1985. Party states currently include Alabama, Florida, Georgia, Mississippi, Tennessee, and Virginia.

The mission of the Southeast Interstate Low-Level Radioactive Waste Management Commission (Southeast Compact Commission) is to ensure that adequate, reliable, and appropriate services are available, now and in the foreseeable future, such that low-level radioactive waste generated in the Southeast Region can be safely managed in an efficient, equitable, economical, and environmentally responsible manner in order that each party state may meet its responsibility for providing for the availability of capacity either within or outside the State for disposal of low-level radioactive waste generated within its borders (Article 1, PL 99-240).

The Commission believes that it has successfully fulfilled its mission since 1983. Its efforts to site a new disposal facility in North Carolina were thwarted in 1997 when North Carolina refused to honor its commitment to build a regional disposal facility. Nonetheless, through inter-regional cooperation, the Commission has provided for access to licensed waste management services for waste generators in the Southeast on an almost continuous basis for twenty-two years, while balancing issues of political equity and cost.

Generators in the Southeast Compact states currently ship waste to processing and disposal facilities without export restrictions. The majority of the region's waste by volume is Class A waste, most of which is disposed at a facility in Clive, Utah. A much smaller portion of the region's waste is Class B and Class C waste, which is disposed in Barnwell, South Carolina. Unless the South Carolina legislature amends existing law, this waste will not be accepted in South Carolina beginning July 1, 2008.

The Southeast Compact Commission believes that permanent disposal of low-level radioactive waste is preferable. However, the Commission agrees with the United States General Accountability Office that there is no health or safety crisis posed in the near term by the lack of access to disposal for Class B & C waste.[1] This waste is regulated and has been and can be safely stored temporarily at the site of generation, pending the availability of permanent disposal. To date, the Commission has seen no evidence that lack of disposal capacity will impede research, medical, industrial, or other beneficial uses of radioactive materials in the region. However, some generators have altered the use of radioactive materials because of potential disposal problems. There is no crisis now, but states, compacts, and the federal government should closely monitor the situation to avoid a crisis in the future.

---

[1] GAO-04-604, a report to the Chairman, Committee on Energy and Natural Resources, U.S. Senate, June 2004.

The Commission cautions that decisions should be made in the light of full understanding of all the factors, including political and economic realties.

The Commission firmly maintains that any effort to improve access to low-level radioactive waste management facilities must support and uphold the rights of the Northwest Compact, the Rocky Mountain Compact, the Atlantic Compact, the Texas Compact, and all other interstate compacts to control the flow of waste into waste processing or disposal facilities within their borders. Threats to these controls, such as the suggestion that the LLW Policy Act should be amended or replaced, run the risk of impeding the continued operation of the existing processing and disposal facilities or leading to the actual closure of the facilities.[2] Such a threat is what led to the development of the current compact system.

Adequate mechanisms exist for compacts with facilities to voluntarily accept waste from additional states/compacts. We maintain that voluntary acceptance has been, and will continue to be critical to a lasting solution to this issue. Just as it has done successfully in the past, this Commission will continue its efforts in voluntary cooperation with other states and compacts to facilitate access to all low-level radioactive waste management services and to minimize the cost of these services.

Proponents of Congressional action to make Department of Energy disposal sites available for the disposal of commercial waste or to allow commercial entities to site disposal capacity on federal land must consider that all DOE sites are located in states. Such an effort should therefore be expected to meet the same local and statewide political opposition faced by states and compacts that attempted to site facilities in the1980's and 1990's. One could actually expect that opposition to be compounded by the existing public opposition and conflicts associated with the existing DOE sites.[3] Further, one could argue that the federal government is no better equipped to deal with public opposition than are state governments. In the case of the siting efforts in the Southwestern compact, it was the Federal government -- not the state of California or the public of California -- that ended the siting of a disposal facility on federal land.

Acceptance of commercial waste at DOE disposal sites would also require a new regulatory framework. The DOE facilities were not sited under 10 CFR Part 61[4] and did not go through the

[2] The State of Washington serves as the host state of the Northwest Compact and, by contract, accepts low-level waste from the three member states of the Rocky Mountain Compact. Washington has always been willing to do its fair share but does not want to be put in the position of again having to accept waste from states throughout the nation. To ensure that this does not occur, the new sublease with the site operator contains a clause allowing the state to terminate the sublease should compacts lose the exclusionary authority provided by federal law (statement by Mike Garner, Executive Director, Northwest Compact Committee, March 25, 2005).

[3] In Washington State, a law was enacted by public referendum in 2004 that prohibits disposal of more Department of Energy waste at radioactive mixed waste sites until all on-site waste is treated, stored or disposed in compliance with all state and federal environmental laws.

[4] 10 CFR Part 61 is that part of the NRC regulations that sets forth the standards for issuing a license for a commercial LLW disposal facility. Agreement States generally have compatible regulations for licensing a LLW disposal facility.

stringent siting requirements required by 10 CFR Part 61. These sites were not licensed and are not regulated by the NRC nor the states.

Moreover, we suggest that proponents of establishing new facilities for low-level radioactive waste disposal should more closely examine the economic factors. It is economics--not the existence of interstate compacts--that makes development of new disposal sites unattractive to commercial companies. In actuality, siting new facilities could drastically increase the cost of disposal. The cost of licensing and construction of a new disposal site is estimated to be at least $100 million. At today's disposal volumes, even if all the Class A, B and C wastes from the 36 non-sited states were disposed at the new facility, it would not be possible to recover the development costs unless fees were considerably higher and/or the federal government subsidized the cost. Without the prospect of cost recovery in the near term and significant profit in the foreseeable future, no commercial company will be interested in siting a facility.

It is noted that the current trend in declining disposal volumes and continued efforts in waste minimization will further impact the economics of disposal for Class B and Class C waste. In addition, if the efforts of the NRC, EPA, and others are successful to allow exemption of waste streams from disposal requirements and to allow disposal of certain waste streams at facilities for hazardous or solid waste, this will further impact the economic viability of facilities managing low-level radioactive waste. We urge decision makers to thoroughly study the potential impacts to waste brokers, waste processors, and low-level radioactive waste disposal facilities before proceeding with regulatory changes.

The Commission applauds individuals and organizations in the United States who are bringing the issue of low-level radioactive waste management into the light of public debate. Certainty in waste management is needed and desirable. Whereas the current national policy provides the greatest certainty at the present time, the Commission is open to any option, including options that would disband compacts, if such options hold a better promise for providing a reliable, permanent solution for managing the waste of our region and the nation in a safe and cost-effective manner.