WORKSHOP ON ENGINEERED BARRIER PERFORMANCE RELATED TO LOW-LEVEL RADIOACTIVE WASTE, DECOMISSIONING, AND URANIUM MILL TAILINGS FACILITIES

U.S. NUCLEAR REGULATORY COMMISSION

- - - TRANSCRIPT - - -

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U.S. NRC HEADQUARTERS AUDITORIUM

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P R O C E E D I N G S

>> CHAIR: This is a formal technical workshop with participants sitting at the table with NRC staff along with federal and state regulators and engineers and the public are welcome to attend and observe.

A public comment period has been scheduled today to begin at 3:30 p.m. and during that time, please use the microphones -- they are not in the aisles today so we have a hand mic moving around for any one in the auditorium who has a comment or question at 3:30 p.m.

For those viewing the workshop remotely, a special call-in number is provided in the workshop program on the NRC public website. The number is 1-888-566-6344, pass code 15103. I'll repeat it. Telephone number is 1-888-566-6344, pass code 15103.

Restrooms are located in the back of the auditorium. We will break today at approximately, 12:30 for lunch. You will be guided up the stair to the security portal and then up those stairs to the cafeteria.

No taking of pictures. Please turn off your cell phones. No food or beverage of water permitted in the auditorium and finally, a public feedback has been provided to you. If you don't have them, we can get more for you, but they were on the registration desk. And we have more of them.

Please fill in the form, leave it on the registration table or mail it, postage free back to the NRC.

This morning's session is Hans Arlt and George Alexander. Hans, would you like to introduce the topic?

>> MR. ARLT: This is Session 5. I want to say a few words about the workshop. I know when we put it together, there were a couple of people saying we were trying to do too much and I kind of agreed with them, but they all told me Monday and Friday is impossible, four days is impossible so we tried to cram a lot within these 3 days and that goes from 8:30 to 12:30 and 1:30 to 5:30. You have to go through security, you don't have anywhere to go, no food and drink, so this is a hard workshop.

And I really appreciate you all coming here and sitting the third day. The room is still full. I think that is really great. We have had some really excellent presentations. It's just amazing. My wife logged in once or twice and she said wasn't really fascinated with the subject but could feel the brain power. So anyways, I just wanted to thank you for participating and hanging out here because it is not an easy workshop.

I want to thank, especially, Craig Benson, Jody Waugh, Bill Albright, Susan Jablonski, and Brian Andraski for helping out with being co-chairs. And with that, oh, the other thing I wanted to say is with the recommendations, don't feel bashful making some because I know there has been some kind of reluctance to recommend things.

If you think you want to recommend something, this is not a place where we are making any kind of decisions. And Steve Rock had an excellent point yesterday and had a good example with BP drilling that hole and that another thing is intersecting them, 7 inches or. So anything is possible.

If it's super expensive options, just put it up there because you're not going to make the decision anyway. Somebody else will be making the decision. So if it is some kind of ultra deluxe Cadillac version of the monitoring system and somebody says no, that's way too expensive, but at least let's put it up as an option.

If you have something you think should be considered, please give it a try.

Okay, let's see.

The other thing, also with web streaming, I know on Monday, there were 928 log-ins. I don't know what it was yesterday but we didn't have anybody ask any questions between 5:30 and 6:00. If you want to call in, I recommend that you do.

Today's workshop is on model support or lines of evidence, performance confirmation, all of those kind of tie in. It is a difficult topic. So David Esh will be explaining and kind of going through what it consists of and so forth. So David?

>> I would like to thank Hans and Tom for all their work they did putting this workshop together. It's been really good. The follow through I think is

the most important thing for something like that.

So I'm going to give you an overview of model support and four engineered barriers but its' a little more general than that.

Model support applies to -- I work on performance assessment and it applies to all parts of the performance assessment we do.

I've probably seen all different types of model support ranging from very good to not so good.

I'm going to try to give you a flavor of what we look for that we would consider more in the good direction.

So, I guess I promised you a joke about scientists and engineers so I'm going to go ahead and give you that now.

Hans is more of a scientist and knows that will not offend anybody. I will offend myself.

There is group of scientists and engineers heading to a technical conference in a neighboring city. The engineers go up to the ticket window, purchase a ticket and the scientists go up to the window and they each purchase a ticket and get on the train. And the engineer sees the conductor coming through the train and they all pile into the restroom.

The scientists each hand over the ticket. And the conductor knocks on the restroom door and the engineer reaches out and hand their one ticket out and the conductor goes on his way.

Well, the scientists not wanting to be out done, on the return trip, purchased a ticket to return. The engineers don't purchase any tickets. So the scientists and engineers get on the train, and the scientists see the conductor coming into the train and pile into the restroom. And the engineers walk up and knock on the scientist's door and say, ticket please. Get in the other restroom.

So and the geologists didn't go to the conference because they didn't have funding.

A little bit of overview. We have some background about what we think about model support and then, maybe some principles and practices that we would look for. Some examples are not necessarily examples of model support but maybe what you see sometimes when you look for model support.

We heard about that early on. Sometimes you see things that you don't expect and that's natural and I think maybe Roger Sykes from Savannah River expressed that reservation that how do you balance collecting g information but they been causing some uncertainty or at least aggravation about your decision if that information does not directly align? And from my standpoint, that's natural and it has to be part of a communication process.

So when you try to make these decisions and you talk about your monitoring systems or your performance confirmation plan, you need to do an extra strong job of communicating that may be an expected outcome.

But it doesn't necessarily mean failure. We talked a lot about barriers in terms of failure but it's really more decreased performance. The barrier does not serve its function at all. But I think that's probably going to be pretty rare.

It's going to be more likely that you under-perform or over-perform. So if you have a cover system on a large facility and you have some areas that's not performing its function, in all likelihood the majority of its covers may still be performing its function.

That is not a failure necessarily only if that translates into not meeting your regulatory criteria.

If your regulatory criteria are zero waste release, all facilities for some period of time and you fail a portion of the cover and that results in a release, well, then obviously, you failed but our regulations at least as we move forward are not written that way, generally.

We are trying to meet some sort of integrated performance metric at the end which allows for some under-performance. So a little bit of background.

We've talked about this, models are used to project the future performance engineer covers. Why? Primarily because the time frames are long and we can't observe.

So in many engineered applications, you can build things, test them, observe them, quantify them and validate in the true sense of the word. But in these waste disposal problems especially over a long period, you can't achieve true validation.

That's why we like to use the terminology model support. We actually went through this a number of years ago. I worked on the high level waste project. We were starting to write our review plan for it and we got to this point of our main elements of review, what we wanted to look at. So we had things like data and data uncertainty and model uncertainty and we got to this model area. And we had this pretty detailed discussion about validation and how it's used and we thought that might communicate the wrong expectations regarding models for waste disposal problems because you can't truly achieve the same type of validation you do for other problems.

I'd say model support is arguably, the most essential element of confidence building process. It's where you are forced to realize all the work that you have put in, whether it comports with reality. And it's in many cases I think under-vested in the process. You spend an awful lot of effort making some complicated numerical model and very little effort in verifying or providing support for the calculations of that model when you get into the decisionmaking process.

The desired performance can be much longer than the experience base. That's one of the main reasons for using model support and using models.

One of the challenges though is spacial and temporal variabilities can really cause some problems because if you only have limited information and we talked -- some people talked about this up front, data can be pretty sparse and it is easy to misinterpret it.

One of the areas that I try to focus some attention on and pay attention to is biases and all the things humans do and we don't intend to do. I think engineers are probably one of the worst groups having biases.

They -- they are especially good at interpreting information but they are not necessarily good at thinking outside the box sometimes, myself included.

So engineers know what they know and don't know what they don't know.

Scientists don't know what they know and they absolutely know what they don't know. So if you caught all that or think about it, it will make sense. A variety of types of information can be used to support models and I will talk about those.

So the context, performance assessment, what are we looking at? We have some sort of real system that we represent with a mathematical model and then, on top of that, we usually need to abstract it due to scaling on spacial and temporal scales or the level of knowledge or limitations on computational power.

All that goes into some sort of representation of estimated future performance. And you might get something like on the bottom corner there or even a lot more complicated than that and that's showing say some mean results for individual radionuclides of some hypothetical calculation where you get these horse tail plots with the distributions and curves and all looks nice and complicated and confusing. But the reality is you need something to say whether it's right or not. And I think you can follow some principles to get you to this point.

These principles are that you want to use multiple lines of evidence or multiple lines of information and that helps you avoid making type one and type two errors and helps you ensure because this information is kind of variable in your data sparse, the greater likelihood that you will make a good decision.

We talked about the direct and indirect information. And one could argue that for these sorts of model projections, all the information is indirect especially for the long term. But the more direct types of observation are obviously preferred because then you don't have the challenges of the translation of the information to your output metric that you're looking at.

The level of model support should be based on the risk significant.

So I will show that in a curve here to try to communicate the point.

It depends on what you're doing with that model and the risks and your problem, how much support you need for it.

We as regulators do not have aversion to people using conservative approaches to make regulatory decisions. That is a good way to make regulatory decisions, avoid a lot of the problems you get into if you have much less conservatism or I would call it much less pessimism in your representations.

Longer experience generally, if you have longer experience with your barriers or materials, then maybe you can get away with somewhat less support and because of the experience base.

Natural analogs, things are very important to consider for very long-term performance and the support should encompass the full range of expected future conditions.

This is a hard one because generally, we bias what we think the conditions are by where we are today and what we observe but that may not be much of a subset of expected future conditions. So when you're developing support for your models, you have to consider expected future conditions and ensure your support is consistent with that so you try as best you can to avoid these extrapolations and avoid extrapolations where you don't have much information.

At a minimum, the model support should have elements of verification and validation.

These are traditional type terms and described generally as solving equations right and solving the right equations. The verification part is much more standard and there are lots of documentation how to go about that.

You still see things and didn't I ask everybody to raise their hand who's ever made a unit conversion error? I would hope everybody raises their hand -- except for Jake maybe.

But everybody makes mistakes of various types and that is an easy one to do.

The harder part of this problem and model support is solving the right equation.

So do you have your model structure right? Is it complete? That's the harder part and that's the part whereas you do develop your support, you may find that you missed something or that something was somewhat incomplete.

So a variety of elements can be part of the model support process including internal review, QA, quality assurance. That's essential. You want to look carefully that you truly achieve that independent part because bias can play a big role in interpretation in this technical information and documentation of the verification efforts is really important if you're going to convince stakeholders and regulators. So the multi-faceted validation effort which I kind of talked about in principles and practices that would maybe include things like comparison, field experience, analogs, et cetera. I will show you these.

On this curve, let's see -- this curve -- or this chart we're trying to demonstrate model support for engineered barriers.

What I have shown here is what we may see from an analyst or regulator or what actual is. These are all hypothetical.

We may have somebody that wants to have a high level performance for their engineered barrier for an extended period of time and analysts interpret the information and may end up with something like you have up here with this dash line.

The regulator looks at the information and they say, no, I don't think so.

We are going to have lower performance here to start and I'm uncomfortable with what's happening at the long-term.

We are going to say at step function here at some time, we don't have any more performance and we are going to run a curve like the red one in our calculation.

It is pretty common. The reality is that actual performance is probably somewhere in between like the purple dotted line. And what you really want to see is that if the performance is in between and you have this difference between say an analyst, licensee or regulator, that information is provided to help define where exactly you are.

So what you may do for these early times, you may do things like laboratory experiments, field experiments, observations, working systems, monitoring. Those are all things you can do to try to decrease this difference that you may have at early times. And then, at much longer times, you might be looking at things like analogs or if you can accelerate some experiments some way, we saw that with the geomembrane and accelerated based on temperature. That's common. A lot of waste and degradation processes. Expert elicitation even though it's an indirect method, sometimes humans and their brain power is a good source of information to use. In comparison to other models, it is kind of more soft but at least it gives you an idea. We saw that inner model comparison that Bridget Scanland had done for some calculations. It gives you an idea of the uncertainty and the calculations themselves or at least whether you didn't make a gross error or you did make a gross error in one of the calculations.

But the model support should be fluid or should combine components-- should have components to address each of these parts of the curve.

So you want to get the initial part of your expected performance. You want to get the part where your slope changes or your performance is expected to decrease. And then, you want support for out at the long end if in fact you need performance out at those longer terms. So multiple lines of evidence, you will want those especially when the performance is complex.

When you have variable initial conditions and boundary conditions and we heard that some of these problems have pretty complicated boundary conditions and they change pretty quickly and you need that information to do your simulation.

A couple of processes, increase the need for more multiple lines of evidence and these would hopefully reduce errors and increase confidence.

And there might be direct measurement such as field experiments and monitoring data using performance indicators. That's what that PI is, and then, a variety of form of indirect measurements that could all be used to support your calculations.

Experience base, this is not definitive, it's conceptual to show you generally what we are talking about.

The experience base is generally short, so ten, maybe many tens of years. It could vary for different materials.

For some materials though, there are some natural components that have some pretty long-term performance so nature's made the equivalent of ET covers and they have been persisting in the environment for some time and same thing with clay.

I worked on a problem where an individual had cited a data source where there is some clays I believe in a eastern U.S. site that were dated at many millions years old and they are basically at the land surface and they seem to have pretty low permeability, et cetera.

So natural materials, clays, ET covers, drainage materials may have some natural analogs or components have a longer experience base. The engineered composite or geomembranes may not necessarily have natural analogs and the experience base is evolving rapidly. So natural analogs, they are dated for very long-term. You do have this issue of confirmation bias.

So the problem with analogs is the things that you see persisting are the things that persisted. And you don't observe the things that are not persisting which is the other part of the problem that you want to see. So it can provide some confidence, and it's one of the few methods you can do for very long-term performance. And you have to be careful that you're unbiased in interpreting the information and you are normally searching out sources that support your case. They do suffer sometimes from unknown exposure conditions and that really determines performance.

So what we have here are a few photographs. This is one of the Native American burrow mounds, photos from Terry Johnson of NRC.

This is a big rock slide that's persisted in the environment for a long period of time. Nature basically built this armor and it stayed there.

There is a couple of pictures here. I believe it's called devil's den, there's an unfortunate individual in the top picture there, but it's used to demonstrate the stability of some of these large rock features and this is over Mantuka multiple hundreds of years. And they have changed relatively little. The rocks were restacked in the picture, they are different but the big rocks are essentially the same and unchanged. And there are some examples where he did some work trying to look at these Native American mounds and dated them.

They don't have enormous riprap covers over them and they are in relatively humid sites and at least some have persisted for a pretty long time.

So it may be indirect and it may suffer from confirmation bias but at least provide you some information that if you can understand why these persisted, then hopefully, you can engineer other things to persist like them if you want them to.

Expected future conditions: Exposure conditions can be highly dynamic.

This picture on the right is from some data inside a buried vault. And the only thing I want you to really understand by it is the precipitation is dynamic. And even inside a buried vault, you see a response of the vault system where you see the fluctuations in the water level in the vault.

It's dynamic. These systems especially with preferential pathways can respond very dynamically and that needs to be considered, and it can be a challenge for developing model support.

You need to ensure that your support has the appropriate temporal and spacial resolutions for the engineered system that you are trying to use.

Over long time frames, the consideration of natural climate cycles should be done and as I indicated, the support needs to be for your full range of performance. The Sanford Barrier controlled fire, I think I need to give them kudos for doing that.

You usually don't see that sort of thought going into engineered processes. I think about some sort of event or process that might be infrequent and they study how that may affect their design.

That is a really good thing to do. Okay.

Model support erosion: One of my caveats here is that you don't want to get into a situation where your complexity of your model is much, much greater than your support.

You aren't advancing your decision then. You might make great figures and you might be able to impress some stakeholders, but the reality is whether you've made a good decision or not is not going to be determined by how complex your model is.

You want to ensure your model support is consistent with the level of complexity you have in your model.

I just have some examples of erosion that I done for another project, of increasing complexity and effort. Well, I don't think if your model support was as simple as you had some measurements of maybe a discharge area, some sediment loading in response to storms, that you would want to be necessarily using probabilistic Siberia calculation in that case.

Those two things don't seem to match up. And so anyway, make sure your complexity and your model support are somewhat consistent. And it may be that as you collect your model support,you realize you need more complexity.

A couple of examples or caveats.

This is one for uranium mill tailings. And once again, I have to give somebody kudos, Jody Waugh who did a lot of this work and then the people that funded his work for continuing to look at their problem and trying to understand it.

Because if you're a decision-maker, I think we heard this from maybe Steve Rock yesterday, if you've made the decision, there is an apprehension to learning more about your problem because you got the decision through the process.

So why do you want to learn more about it? You have a lot of risk to the downside and really, no risk to the upside.

So humans don't want to learn more in that situation. The decisionmakers that do that, I think they are more the exception and not the rule. But we need to make it more the rule and not the exception.

So in this case, they had an original conceptual model, used resistant covers, limited infiltration rate release, radon gas transport.

The low hydraulic conductivity will limit water contact, the covers will change slowly with time. And what they found it is difficult to achieve maybe in the field scale, those hydraulic properties when encouragement occurred more rapidly and the work by Craig and some other people found that resistive -- pedogenesis and other properties can alter hydraulic properties and it doesn't matter or not.

We heard comments about maybe the tailings themselves are fairly low permeability when they dewater. The NRC definitely agrees with looking at these problems as a systems approach and you can't necessarily jump to conclusions because one aspect of your problem did not perform as intended. You need to investigate it and understand it.

In this case, I'd say DOE did for the plan encouragement part, they did a risk assessment and said okay, even though we got all these plans, what does it mean, does it matter? And the result of that risk assessment, their interpretation was no, it does not matter.

And I think that is a good example of the process working. It's not a won and done, you're dealing with iteration on information.

And then, I showed a couple of these pictures with low-level waste. I won't go through the ones on the left again. But it basically shows the process is working. And in this case, it was early in the process and a variety of the low-level waste sites, they identified this problem. In this case, effective mitigation efforts were taken.

In other cases, NRC changed the regulations because we basically identified characteristics of sites that we didn't really want to have and we realized stability was a really big issue, stability of the waste and management of water. And so 10 CFR 61 was developed and has a lot of in it to try to mitigate the early problems that we're seeing. And if you think about what was done with waste 50 years ago, we've come a long way in 50 years and I think we will go an awful long way in another 50 years.

Interesting thing here on the right, observations of arid sites in Hanford seem to be doing pretty well. At Beatte, they had some rapid transport tritium and we heard some talk about maybe there is some paper transport tritium.

And then all these similar tritium were reported to be transported because they put liquid waste in there and they were not supposed to.

But the interesting thing for me is this fissure you see in the cap here. This is the synergistic effect from processing resulting in the fissure of the closure cap. So I was asking about off diagonals yesterday. Basically, a small seismic event by itself, you would not expect to do anything to the cover. Erosion and subsidence by itself based on the design was not expected to do anything to the cover.

You put them together and you got this fissure in it. In this case, it was repaired and fixed but if you didn't combine those processes, you would not have seen the effect. But the combined processes resulted in impacted and may have propagated forward in time.

So the following principles will increase acceptance of modeling and cover performance hopefully.

What we hope to get out of this, one of the goals we had indicated was the collaboration and synthesis of experiences would be very beneficial. I think from our standpoint and from those of you out there doing it, you can learn from what's happened at other sites, both the good things and the bad and people need to be open to talk about the things they see that they didn't expect and maybe why they seen them because they can't apply to other sites, and model support is essential for this decisionmaking.

Thank you.

>> HANS: Thank you Dave. I have two introductions to make. One is my co-chair. I want to thank him for helping me out with that. His name is George Alexander, sitting next to me here, systems performance analyst at NRC, Division of Waste Management and Environmental Protection; received his MS from the Pennsylvania State University.

Our next speaker is Abe Van Luik. Abraham Van Luik was with the Yucca Mountain project. He was a senior policy advisor for performance assessment for the last decade.

He's moving to join DOE's Carlsbad field office in New Mexico. He has a Ph.D. His Ph.D was a model of physical chemistry of North Great Salt Lake Ita, so working in Salt Lake is a great way for him to return to his doctorate in chemistry.

I want to thank him for being here. Abe has not worked directly with engineered barriers but he has a lot of experience with performance confirmation which is directly tied to model support. So I think this is like a great opportunity to find out what performance confirmation can do. All right, thanks.

MR. VAN LUIK: And speaking of brain power, I mentioned here that I have based a lot of this presentation on work by David (inaudible) and Cliff Hanson at Sandeia. And you might know that DOE basically hires the good work that was done by contractors. And being a former contractor, I feel pretty good about that.

This is an invaluable reference for us in the high level waste program and you might want to look at it yourself. But it basically says what David just said is that validation in the normative sense in the financial community, you count back and see if you actually have the numbers that are on your piece of paper.

It's not possible and this document is very good.

It was done by some really smart people. Basically the regulator from Sweden and the regulator from the U.S. got together and said let's say something about this together. And they concluded that validation is the aggregate of all activities used to support the modeling and therefore, it is confidence building.

You don't want to do what we did for the Yucca Mountain Project. I must say that the Yucca Mountain Project was so successful technically that it took a President to stop it. And as a consequence, I'm moving to Carlsbad, New Mexico.

Volume II of this very large document is completely dedicated to demonstrating the basis for confidence in the modeling.

This is 10 CFR 63 requirements and I'll read the bottom one. You have to provide the technical basis for models used to represent 10,000 years after disposal and make comparison without the process level model and empirical observation, laboratory testing field investigation, natural analogs. And this is what that large volume is trying to do is to provide all of the information that supports the modeling.

Now, the reason that I bring up Yucca mountain as kind of an outlier is because it was very elaborate.

And I think that you should reflect in the amount of work that you do. You should reflect the potential disposal facility risks.

In other words, the amount of effort you go to should somehow be at least related to the risk you're posing to the public and to your workers.

But you want to do similar activities. You just don't want to go as hard as was done for the high level waste program.

Now, suggestions as to what to compare yourselves to for support. You already have past, present, future domestic, international radioactive waste facilities. And you also for that matter have hazardous waste facilities. And they all have safety assessments and they can serve as analogs for each other.

And the point here is there is no need for you to reinvent what already exist.

But I think David was hinting at this: In a nuclear safety culture, there is a need to continually question and seek to improve what exists.

Even if you have your license in hand and you're operating, you want to make sure that you're continually questioning and trying to improve your system.

International cooperation can and does save domestic resources and is a confidence building activity in and of itself.

If the French have covers that you're imitating, then by all means cooperate with them and whatever ancillary information that they have created, use it.

The model validation approach in that volume I showed you a minute ago has two stages. During development of the code, confidence building activities and post confidence building activities. And of course during development, you do the verification, you do the stability testing and a lot of uncertainty characterization reviews. Post development is where I want to spend my time. And that's -- we used abstraction models to run probabilistic calculations because to string together all of our scientific detailed models would have been very difficult.

And so we needed to show that the abstracted models mimicked the outcomes of the scientific models. that's one thing that we did.

We also did auxillary analysis, that single realization deterministic which were easier to explain to people but not as meaningful as the full probabilistic ones.

We had the benefits of having an independent model result to work with from the Electric Power Research Institute. They did their own modeling always showing us to be worse than we needed to be.

I didn't mention it in here because it is not appropriate to mention it but also we benefited much from the NRC's independent modeling effort and we studied the differences between our different models. And we also did a performance margin analysis because the accusation was that in our probabilistic model, we did a lot of things that were conservative and to some people, being conservative means you hide the possibilities that you are missing something.

So we did a model where we removed key conservatisms. We didn't quite go all the way to removing all conservatisms but it gave us an indication of whether we were diluting risk or not by being conservative.

We looked at natural analogs. We had independent technical reviews both external and international. And we also did planned performance monitoring and testing.

I don't want to spend a lot of time on this but when you look at the barriers, features and components of Yucca Mountain, and there you have some comparison at least with the kind of things that you're looking at for low-level waste and other near service facilities.

All these other things we don't really care about.

The TSBA information flow, you can see this was a real whale of a model and this is why it took thousands of pages to describe the model and thousands of pages to show what was done scientifically to support each one of these components of the model, but we don't want do go into that right now.

The post model development validation activities, I have already listed them a minute ago, single realization, independent analysis, performance margin analysis.

The reason you do a single realization analysis, if your main goal is to do a probabilistic analysis because the regulator is giving you a probabilistic safety standard. You want to do single realization analysis to provide sub-model coupling insights. Do these make sense? It was a very powerful thing also with the public. If I was a able to explain,this is the mean output from here.

This is the mean output from there and therefore, this is the mean output from here.

It all made logical sense to people who did not understand in their minds probabilistic modeling.

And I must say as an aside since David Esh was making fun of engineers and scientists, the biggest problem that we had to face is not the engineers and scientists in their different cultures. It is dragging deterministic scientists into the probabilistic world.

I mean, we had many scientists say the universe is deterministic. If we just had all of the answers at the right scale, we would know everything.

And from the performance and analyst point of view, we said, we don't care. We want a probabilistic assessment because you will never know everything.

So anyway, dragging people from science into probabilistic calculations that project into the future was a huge culture change for those scientists.

The engineers had the same problem but you know, we coped with that in a slightly different matter.

Error checking and model verification: We found a lot of tiny little errors by doing these single realization analyses where you talk -- we didn't have unit conversion problems; we were very well aware of the problems there but we did have some translation problems form one model to the next. And the example I show next is somewhat analogous to an evaluation of an engineered disposal site cover over time.

That was clear to me at one point but I got to staring at this last night and I thought what the heck does this have the do with the engineer's cover? But basically, the problem is that we divided uncertainty into epistemic uncertainty and alterity uncertainty and then, analyzed both of them as much as we could separately and then, looked at disturbing events like a seismic event.

This is where you would also look at a disturbing event for a low-level waste site.

And basically, we had a lot of detail in this model that you probably would not have for a similar system.

EPRI did us a great favor by doing completely separate performance assessment and it was like making a comparison with independent safety evaluation of an analogous disposal system.

They used a logisty; we used a Monticello sampling approach. We used the same model components and featured events and processes and I will talk a little bit about features events and processes or FEPs. And the difference in results is explained by determining the differences between the two models.

This was very helpful to us because we saw that where they just didn't agree with our assumptions and we saw that if we made their assumptions, we would need a lot more corroborating information. And I think that they understood this, that they were looking at it from the industry side how much money are we spending to do this thing and that's not really necessary because that it is a lot safer than we thought it was. And I will never forget the chairman of the Technical Review Board at one time when he was looking at our modeling results saying this mountain could not possibly be as made as your model makes it look.

But the point is that we were trying to go for a license. We were trying to convince the regulator and so we did do conservative things and we did make assumptions that were defensible from the information on hand.

If you look at the features of events and processes, and this is where you basically go and find out what it is that you need to analyze. For the high-level waste program, we were helped by the Nuclear Energy Agency in Paris providing a list of generic features, events and processes potentially relevant. And then, we looked at that from Yucca Mountain and tsunamis are not a problem in Yucca Mountain so there were irrelevant FEPs and we combined redundant FEPs.

And then we come up with a list of FEPs specific to Yucca Mountain. For example, once we got the engineered system defined, those were a lot of features that would link to events and processes like seismic shaking.

So we expanded the generic list that we got internationally to create a list specific for Yucca Mountain. And then we screened them versus regulations and I don't know enough about 10 CFR 61 to know if there are screening criteria in 61 but there is in 63. And there were probabilistic and also consequence screens. And so we put it through those screens and those who passed through those screens were saved and put into the models. And every FEP that is identified in a very large document that is identified as being credible and likely to have a -- make a difference in performance is then addressed in the models.

IF you look at the EPRI versus the DOE analysis, you see that DOE was about are an order of magnitude worse at the million year time frame, 10 CFR 63 for us defined that we needed to provide corroboration for everything in the models up to 10,000 years and we had to run permits out to a million years. And when we did that, we came in with slightly different outcomes because we were more pessimistic. And in a million years, the dose results are really quite comparable and the most significant dose contributors are iodine and technician because they are very mobile in the environment. But this is strictly to illustrate the value of comparing against an independent analyses.

There is no sense sitting here studying these things. The performance margin analysis was suggested by several outside review groups who said we would sure like to know how conservative you are in the aggregate.

And so we took the same model, and basically said okay, what conservatisms can we narrow and still be somewhat defensible even though we are not quite as defensible as the main model? And when we did, we got another order of magnitude type of change in the final outcome and we also saw that the conservatisms we had introduced in order to make the model more defensible really did not dilute the risk.

This is something that the Nuclear Regulatory

Commission was worried about because in some instances when you are multiplying factors together, if two factors are very conservatively chosen, you can basically dilute the risk and this is a complicated topic to think about but it's one that you need to look into.

I'm going to move a lot faster though but the point about risk dilution, this is something that the international community is keen on also.

We had an international peer review that said watch out because all these conservatisms compounded need to be evaluated. So the PMA analysis also answered that question for them.

When we looked at each distribution that went into the probabilistic model and the basis for it, we did find 3 or 4 places where the analyst had said, well, it's probably in this range right here but to be conservative, let's go there and we cut those off for the license application and went with what we could actually support from the data rather than let's add an extra margin of safety because we realizes that when you have you had a margin of safety in one area, it may in the complex modeling, it may actually introduce non conservatisms in another area and we found a couple of places where it could be true.

Natural analogs for the high level waste program and DOE, we looked at volcanic eruptions in Nicaragua and in fact this was brought to our attention and the work was done by the NRC.

We looked at the uranium deposits in Tuallo, New Mexico and in fact, that was also brought to our attention by the NRC. They were on the ball so-to-speak when it came to this project.

Pena Blanco, this probably has very little to do with anything that you're interested in but the point is that we learned from this analog that things moved at certain rates. In fact, with the NRC's aid and with our own analysis, we determined what the KDs basically are for some of the radio elements in that deposit, and that they are not FEP or different from the ones we got from the laboratory. So that was a very good collaboration.

Here's a conceptual model for Pena Blanca but very similar to what Yucca Mountain was looking at.

So what would be an example of analog for engineered cover? I think rock openings in caves have been actually studied to look at annual rainfall and infiltration through a cover that's really not that deep for many caves. And then, also, anthro, chinese burial sites, earth and dams effective because of layering condition of different velocity and nothing should really grow there except that you got fine material deposited by wind sitting on top of the fractured rock. And that fine material holds enough water that if you plant it at the right time, you can grow a complete wheat crop without irrigating.

So that's interesting analogs that you can use in explaining why your cover over your low-level waste site is effective.

Seepage into a cave, Altamira in Spain, 14 thousand year old painting, I suggest you all go visit the place because you should be able to put it in your budget that this is scientific support for your modeling. But they have done a 22 month study of measuring rainfall and infiltration and it's only a hundred meters or so, and less than one percent even in this somewhat wet area but not completely wet and infiltration became seepage into the cave and involved one percent is what you see in most caves.

Independent technical review, we had standard reviews from the Nuclear Waste Technical Review Board. We had IEA NEA international review team. We had a independent validation review team completed their work in 2006.

And anyway, the peer review by the international program, at the bottom, it says, "well presenting room for improvement" and they gave us 25 pages of suggested improvement.

The model was soundly based and has been implemented in a competent manner.

And when it says conforms to international best practice, that was actually language used by the Secretary of Energy's recommendation to the President recommending Yucca Mountain in 2002.

So these things also not only do they give you good insight into technical issues but also they can be useful in communicating to your stakeholders. Performance confirmation monitoring testing, we put together a performance confirmation program. It was required by the regulator to look at test experiments and analysis to be conducted to evaluate the adequacy of the information used to demonstrate safety.

In other words, we would continue and promise to continue to monitor key aspects of the system that we were putting together even after we started using it and licensing it.

David Esh would have been proud. Actually, David Esh required it. Performance confirmation program should demonstrate that the system and the subsistence component, the barriers are operating as anticipated by the monitoring.

This is so easy to say. It is so hard to do. I don't want to go through these all because it would bore you to tears but you might if you are looking at this, you might want to read what we did.

In fact, I'll step through some of them. We use the decision analysis approach to look at all the different options and select from them what we could afford to do and what would be most beneficial.

We had to make tradeoffs because there were competing objectives and goals. So we used a formal utility analyses to develop portfolios of testing and then, we went to a second phase to bring in management concerns and regulatory concerns.

And then, the continuing phase would have been periodic evaluating of this plan because as you go forward, we are talking about a hundred years of operations at least.

So you probably learned things during that time that make you want to change the plan. And also, you're looking at a post-closure period of monitoring which needs to be defined yet.

Evaluating candidate activities: And one of the biggest bugaboos here, we all knew what the key parameters were and what the sensitive parameters were. We all had a good feeling for what he confidence was for the current representation.

The real bugaboo was what is the accuracy with which proposed activities measured or estimated that parameter? And we had some beautiful candidate parameters but how to take a working system and without violating that system, keeping measurements of those parameters going in a meaningful way was a real problem and some things got tossed by the wayside because there was no good way to get data.

Management provided waiting functions to the dry criteria that the scientists and the engineers put together and then, we combined all of that. This is a lot of detail right here.

But basically, you need to estimate the utility of the specific activity and this is all in the presentation available on the web, the Internet.

Anyway, if you want more detail on this, contact me directly. Hans has my new e-mail address. Okay, we may have a problem.

I'm actually physically between jobs so if the one does not work yet, it will, but the old one does not work either. So I'm actually free and clear. Nobody can touch me.

In fact, while I'm telling jokes, what's left of management, Yucca Mountain says I would never have been allowed to give this talk if we were still a licensee because the lawyers would have never allowed it. Basically, I'm telling you that there was trade options made in selecting what to do for this portfolio that we finally submitted with the license application for performance confirmation.

So these are the kinds of steps we went through and I suggest that no matter what the size of your operation, you are going to go through similar steps, selecting the portfolio finally and then documenting the performance confirmation program.

We selected 20 activities out of hundreds that were possible for the initial performance confirmation program which was proposed with the license application. The NRC I'm sure would come back and say what about this and what about that? And this seems like a self serving thing to put in.

You know, the NRC was actually very open and honest with us in their evaluations of things as we went along. And I appreciated the fact that they did their own analyses and therefore developed a little empathy for our problem. That's the end of my presentation and I think I still have a few seconds left.

So, but I don't know if you want to take questions or not? No. That's later.

MR. ARLT: George Koerner is our next speaker. We have a ten minute break coming up after our next presentation. George Koerner is our next speaker. DR. Koerner is director designate of the Geosynthetic Institute from Folsom, Pennsylvania. George's doctorate is from Drexel University in geotechnical engineering. He is a registered professional engineer in Pennsylvania and New Jersey and CQA certified.

>> MR. KOERNER: Thanks. It is a pleasure to be here. I have to break it down for model support two-fold.

I will talk to you about laboratory and then, we will go into field testing. This topic has to be bracket education. What I would like to do is give you a little boundary condition for it in the presentation.

I'm only going to talk about polyethylene for the geomembrane barrier. The surface areas is going to work against you in the geo-textile as well as the geo net and concentrate on deposits work as well.

So a geomembrane backed up by natural soil barrier or clay barrier will be quite helpful for you. Also, gradiant helped you out which is unfortunate, gradient at least, 2 percent would be quite fortuitous to use and for 7, 8 years and asphalt will get much more if it's on a sharper incline.

Mark Phifer, are you here? You are a gentleman. We had a very productive conference call and you sent out references to us where the bracket the dosage and not only one or two but eight of them. I'm embarrassed to say one them was from the conference so thank you so much.

It was very productive but in the order of magnitude of -- so in the order of magnitude of 10 to the 6, 10 to the 7, rad we are looking at and once you get beyond this, really, a geomembrane would be suspect as your barrier system.

Let's look at this geosynthetic lifetime performance. I'll talk to you about UV a little bit later. Radiation was very nicely defined by those references. I could not do better work, but these later four oxidation chemical elevated temperatures and various stress conditions, can we create an experiment, a laboratory experiment that would model those? And that's what was undertaken at GSI. Here's the test chamber.

This is a large diameter cylinder. It has the geomembrane in the cylinder, soil above and below it. There is a temperature thermal couple in the center of the cylinder. We are now going to expose the geomembrane to a large compressive normal stress simulating somewhere around 150 feet of waste.

We are going to have it in a acquiesce solution and we are also going to have this at elevated temperatures.

Showing you the setup of the experiment here in the upper corner, you will see the geomembrane going in with bracket soil above and below of course played upon normal pressure, acquiesces solution always wet.

Heat tapes around it as well as a heat pad, large compressive normal pressure and then, 16 to 22 years wait.

We are setting this up in quadruplet, four different temperatures every six months on going there and sample the material and rotate them out to double for this analysis. Would love to generate curves like this.

It's a series of time sensitive super position and there is a couple of things, there is a measured property.

What would that be, a physical mechanical property possibly but most often, OIT. There's two OIT tests, one standard, the other high pressure.

You need to know the additive package that was placed into your geomembrane. This is changed over the 20, 30 years that we've been at this.

Okay. Temperature will degrade the material. The higher the temperature, the more degradation you can expect.

Also, there is three different stages through this degradation. One, the antioxidant completion, two, the time of just the raw resin. And third is that half life. That half life stage; why 50 percent for the half life? Convention.

First presenter, it's not all over. David presented it's not all over at that time but this decay is very representative of your sample.

You then would like to plot up this reaction rate. The slope of that curve will allow you to make a lifetime prediction.

Yeah, this is 22 years worth of work I showed you in one slide. But antioxidant depletions breaks it from 50 to 150 years; induction time, 20 to 30. Professor Rowe presented his work but these are the different predictions that are out there. For the Gas Pipe Institute, they are 200 years, different conditions that they test for.

GSI is somewhere in the neighborhood of 500 years. Cable shielding business, they are getting their half lives in the neighborhood of 700 years.

Okay, total estimates anywhere from 270 to a thousand. The time frames we see are comfortable and they are corroborated by several other studies around the world.

That's the good news. That is the best that you can do.

How about you're exposing this at elevated temperatures out in if time.

If it was 20-degrees C sort of like this room. It would be a very nice place to store the geomembrane.

You would get those long lives but if you have elevated temperatures at your site, these life time predictions come down significantly.

Here, you can see the different stages all modeled A,B,C, and the totals, let's say was at 55-degrees or 50 degrees.

Those times would be cut underneath a hundred years.

On this conference call that I really enjoy, I'm listening more than I talked and learned as well. There was an expressed interest of geomembranes in the exposed condition.

What I have given to you there is in a covered condition, okay. So these are geomembranes.

Do we have a study for exposed geomembrane? And there is quite a bit of work in this regard. There is 3 ways to model this or predict it.

You can actually go through a correlation with energy maps and again do time temperatures, super position which I just described and subsequently could correlate to field realms of time.

As far as the correlation is concerned, you would incubate a sample until its half life, report the UV energy that went to that sample, obtain the UV energy from a site field map, make a ratio and then, back out a life time prediction. Are those energy maps available? Certainly. We have it so quite durable.

The second one is time temperature super position but not in the device that I showed you before. These are the two most common. There are many out there.

Xenon Art or UV florescent devices, again expose your samples in these conditions and then do an arrangement plot from them.

This is hot off the press. We just printed this a week ago. So these are three different polyethylenes. One HD, the second linear low and the third, a very thin extremely reinforcement material used for temporary cover applications. But here you have percent strength and percent elongation retained with respect to time. And please realize these times are out to 35,000 hours, the time frame.

You can see the one crashed in there, that is a very thin term used as a temporary cover.

From these sequence of data, we can again do time temperature super position and formulate life time projections.

The last which we don't have for the buried applications, but in covered applications we do have some field failures.

Geomembrane, the life of geomembranes is in the realm of 20, 25 years.

So we do have materials that have been exposed that long and some performed poorly and from that, we can back out materials, properties. So this is our best estimate.

This is the take home message for exposed geomembrane samples. Again, if the high density polyethylene meets GN 13 specification, we have it currently going for 22 years or better in the weather only. Linear low density, about 36 years if it is well formulated material.

EPDN, this is a rubber material, 24 plus, close to its realm.

This polyethylene reinforced, you saw that crash in the curve, that equates to around 17 years in field Texas application. And as far as the flexible polyethylene material well formulated material in the neighborhood of 33 years. Okay, that's the laboratory study.

What do you see in front of you here? If you are a cynic, you see a failure of the core. You see a gas system that's no longer functioning. The geomembrane has come up through two feet of soil, cover soil. A geomembrane happens to be HDPE.

It is accommodating strains in the hundred percent range. I'm an advocate of geosynthetics. That is a thing of beauty.

That is unbelievable. That is really gorgeous, the power of these membranes really will give you a definitive barrier system. What I would like to talk is field related studies.

Professor Rowe was talking a little bit coming home -- thanks for doing this, so nice to -- we were just talking about field dig up. Usually, Craig and I are in the hole somewhere digging things up but these are from the most recent ones. One is 16 years, the other is 22 years exposed geomembranes.

Sixty mill, HDPE both on cover systems at hazardous -- one is on a hazardous waste facility, the other is in a lagoon system.

Did the entire suite of GM 13 specification, the only thing we could see is a little increase in density and what I mean by that is hundreds of grams per cc increases. This might indicate some embrittlement of material with respect to time but those papers are available through the IGS.

I wish I could give you double line leakage from a cover. But I don't know of one of those.

I don't know of a double line geomembrane cover.

Mr. Robert Paneuf yesterday gave you a bunch of data on double line liner facilities and this is the bevy of information that I have from them. It's a pretty involved graph. You have the leakage rate versus different stages of a landfill.

Okay. After the initial filling, the

operation time and then after the final cover. The one that works the best seems to be this composite geomembrane GCL and we have leakage rates, single digits.

This is a composite of a lot of work that was done at the risk reduction lab, University USC PA. Bob (inaudible) sponsored this work.

A different point of interest, Bob's data from New York. Very nice, all 34. I love this slide.

I use it all the time but all 34 of the facilities in New York are tracked.

And they give primary leakage and these things are operating efficiencies in the neighborhood of 99 percent. You would do better on a cover system. Okay.

You don't have the heads there. You could make use of gradient, higher gradient and I would be very surprised if your performance was not better than these systems. Okay.

This is a pretty involved summary but the geomembrane has to be a good geomembrane. (Low audio) from the study that I showed you, the resin manufacturer does not exist who made this geomembrane. The manufacturer who fabricated this does not exist, its national seal out of Illinois are no longer there.

Disheartened, I shake about this.

We are making that out titanium dioxide, stabilized material, again, HDPE, put texture in these and all different -- I can't -- my experiment didn't do that.

I'm sorry, I'm a little rattled by that but -- okay, it has to be a good geomembrane.

Buried life time, a hundred years on the conference call, it is a slam dunk if you use the right -- dunk, Dr. Rowe corroborated this. That's a huge take home bullet in number 3, okay.

Have to have a nice design. We really like longitudinal cells, makes our work a lot easier, raw material has to be good. These terms are formulation.

It is a lie about the label. You are really losing medium density polyethylene. It is only the compounded resin that moves it up. You need a good specification.

You need quality control in the factory. And you need quality assurance out in the field.

This leak integrity survey, it's in Part 360, my hat's off to New Work but you have to performance test the facility right before it goes online.

It is a bunch of different techniques for that.

Maintenance: I'm sorry, these are fragile terms especially if you do exposed maintenance, has to be on your list.

Answers are out there. They asked me to make a recommendation. This is a big one if you do a double composite cap. What I'd suggest, they cut costs, go right over top of the existing cap, the Corp of Engineers in the back of the room, a couple of them to do that. Pure middle configuration will give you four test plots. I see Kevin smiling, so thank you.

It is a pleasure to be with you.

MR. ARLT: Thank you George.

We will take a ten minute break and we are going to move from geomembrane that provide early performance in the model support, to provide confidence in those geomembranes into model support for long-term performance.

(Short break taken)

If everybody could return to their seats.

We will get started again.

>> All right, we would like to continue with the fourth presentation and it's Jody Waugh.

He probably doesn't need an introduction but I will go through it anyway.

Jody Waugh is a lead ecologist for SM Stoller Corporation in Grand Junction, Colorado.

He has over 25 years of research and operations experience designing and monitoring lab filled covers for hazardous and radioactive waste for the DOE facilities. He is currently working on long-term stewardship issues for DOE Office Of Legacy Management.

Jody?

>> MR. WAUGH: Thanks. I guess the first thing is in Colorado, we use a different spelling of analog than they do in Nevada.

We are talking about the same sort of thing, natural analog. Craig Benson likes to talk about putting together an analog catalog, some sort of extensive catalog with all the information for earthen covers and we're talking about earthen covers now. Specifically for uranium mill tailings but part of the applications at other sites.

This presentation is not the analog catalog that Craig talks about. It's more like the going out of business flier that you see on your windshield sometimes in the parking lot.

Most of this stuff is 10, 15, 20 years old. We really have not done a whole lot with analogs recently. There is some renewed interest on applications and analogs. Also I'm just going to be just going through and hitting on a few examples here and there and as I go through these examples, I'm not really getting into the meat of any one of these but just to give you an idea of different ways from a kind of a broad interpretation of what an analog might be of value and an additional line of evidence for model support as we are defining it today.

I think Terry said something earlier or yesterday about this fight between the engineering and mother nature. Eventually, mother nature is going to win, ecology happens. We got to deal with it.

This is a kind of engineering perspective, kind of an ex-rated graphic of what might happen to your disposal cell in the long-term.

I got this from Tom Hawkinson years who was doing this kind of work at Los Alamos National Lab and over the years I've been kind of pulling information together for what I call ecosystem engineering paradigm information together what I called a echo system paradigm combining ecology and engineering aspects of this. And there are different components of this but what might be applicable is that earthen covers really are engineered ecosystems but putting this into a near surface environment. So if we think of it that way, it is manipulations of soils and ecology of that ecosystem.

The initial state of this cover is quite dissimilar too but is going to be greatly influenced by the surrounding echosystem.

So, climate change, soil development, ecological succession can alter -- we've been talking about the degradation processes for the last couple of days can alter these engineered soil properties and can alter cover performance. May be a relatively short period of time.

The analogs may provided evidence -- maybe even evidence is too strong of a word, -- clues might provide evidence for understanding these changes in climate soils and ecology and hopefully provide evidence to increase confidence in long-term performance evaluation. You saw a similar graphic earlier from Andy Ward, who's kind of like professional genealogy. Andy and I go way back 20 years ago. We came from the same place and I guess we still have some of the same graphics from that time period. But you look at long-term performance evaluation tools, we've been talking a lot about miracle models and monitoring and now the third part of this tirade analogs and how that fits in as a line of evidence.

So first, just very generally, this line of evidence, what might natural analogs do for us? Well, it's kind of more tangible evidence for understanding long-term cover degradation.

I think it was mentioned earlier, this can go a long way not just for non-modelers like myself but also for the stakeholders. Take them out to a site and say we think this is what it might look like in 200, 10,000 years from now, tangible evidence. Evidence for designing covers that maybe can accommodate these changes or imitate a favorable natural setting that we been able to characterize. Evidence for designing fuel experiments, better tests what might change over a long period of time; evidence perhaps for monitoring precursors of change. If the analog gives us an understanding of how that change might progress, what might we might be monitoring to see what is happening before it's damaging?

And then, maybe evidence for developing some scenarios for performance monitoring.

We talked a little bit about that yesterday at the end of the modeling panel discussion. Let's define some scenarios and try to model those conditions.

And so that's kind of where I'm going to start with kind of a follow on from that discussion yesterday.

A few years ago, Cliff Holt from Sandier was working with us, kind of put together this report of generalized long-term performance evaluation process.

I won't say this is performance assessment in the formal sense necessarily but performance evaluation and the first component of that is development and screen these scenarios for possible future environmental siting.

What might this earthen cover look like in 200 years from now? How might the climate change over that period of time? How might the soil develop over that period of time? How might ecological succession progress over that period of time? So let's develop, screen three scenarios and model climates. ET, we talked a little about that. Estimating parameter ranges and uncertainty, what are these key performance parameters? We talked about saturated conductivity. We talked about leaf area, performed the calculations, pretty simple stuff, iteration.

My main point is that natural analogs can help in a couple of different ways here, helping to develop and screen those scenarios, future conditions but then, it should go beyond that, not just waving our arm and saying here's something that may look similar to what it might look like but actually go out and measure some of those parameters, measure saturated conductivity for soil that you say it's going to look like in 200 years. Measure leaf area for that drier warmer climate that you think might be there in the future time period. So it's quantitative in measuring the analog.

Now, most of the rest of presentation, I will be giving examples with natural analogs, most of these. I get the red dot.

I'm just going to be touching on some examples of how analogs might be used or how we looked at from these different sites. As I go through these, I don't know if I will get through all of them, if I don't, Hans will give me the hook in two minutes so I can summarize.

And I actually have some examples dating back to the Hanford years working with Steven Link, a lot of the work at these sites. We worked with -- there is a

Research Institute, Todd Caldwell worked on some of these sites and a whole lot of folks involved in looking at some of these.

First, let's go back to Monticello, Utah. Remember, this is the ET cover, kind of the Cadillac for uranium mill tailings.

And so when you have an ET cover, you are looking at these processes that can lead to degradation so the long-term is really what we are looking at here. So natural analogs, long-term climate change, ecological change and soil development. So we will focus on with these examples.

So the issue for climate change is long-term shifts in climate states but also variability of the climate and that might be a little bit hard to get at with analogs.

Different tools that you can use. And again, kind of a broader interpretation perhaps in analog; paleoecological records can help you reconstruct climate in the past to give you, yeah, this is a reasonable range of climate that you may see in the future. This is what we saw in the past over a thousand, 10,000 and there are different types of evidence from tree rings to pack rat mittens to paleontology to lake pollen and so on.

There's climate change models. I'm not going to really talk about climate change models today but climate analog site, present day location. This is analogous to perhaps a future climate state on your engineer cover.

Let me give you an example here with uranium mill tailings. Monticello, here are the four corner states; Monticello is here and actually, these little red plus signs are uranium mill tailings sites throughout the four corners area. The blue dots are paleoecological reconstruction sites in that same area. The problem with climate models is that they are very regional. The paleoclimate data gets a lot more localized in understanding how that might affect soil and ecology and to here are just some examples.

And really, when you do these types of reconstructions, you are looking at an elevational gradience, at least in the southwest, and how vegetation, reconstructing how vegetation has shifted along that elevational gradient in response to climate change so you had to reconstruct what temperature of precipritation would have been to create the environment for the vegetation that you find for that period of time.

So it is different types from pack rat mittens to pollens and sediment bars and lake sediments, to shifts, reconstructing shifts and timberline. A lot of different clues that you can get from the paleoecological data.

This is just trying to give you an illustration of a transfer function, looking on an elevational gradient and how vegetation abundance changes along that elevational gradient. How temperature and precipitation changes along that elevational gradient and from the paleoclimate sites, how you can reconstruct how the plant abundance shifted and therefore, how temperature and precipitation vary.

So if you go to Monticello here with the shifts and vegetation along an elevational gradient, you can get an idea of how temperature and precipitation change at that particular elevation. And this is just a representation again, generalized boundary shift looking at the whole vegetation sequence and how it might change, upper and lower forest boundaries and what the temperature precipitation would have been to produce the vegetation of these time periods, from (inaudible) of 15,000 years ago all the way up to today.

Okay, well, you can use this type of paleoclimate data and couple that with climate change models to develop scenarios for future climate models and then from those, get present day soil and vegetation analogs for those scenarios. And you go out and the landscape and your soil maps, use climate maps, vegetation maps and say, okay, where is the location today with the soils, or like the soils that were used, the same soil series or mapping that was used to build that cover but the climate is like some future scenario that we defined based on the paleoclimate.

So we went through this exercise and if you looked at temperature and precipitation, here is where Monticello falls in. Well, let's look at the warm dry -- reasonable, warm/ dry change based on paleoclimate data and the cold/wet at Fort Lewis, Colorado. And this is just a map showing here, Monticello, the four corner states landing over a thousand feet drop in elevations even though it's fairly close to Monticello there, and cooler near the mountains over here in Colorado.

So at those sites, cell development is an issue, next to soil development, hydraulic properties primarily. But also, adaptive properties we talked about before. Let's go out and measure these hydraulic and adaptive properties act natural and in the case of landing, I'll show you archaeological soils.

Here is Fort Lewis, this is work that Todd and others did with us.

Essentially, the soil mapping, the soil series for his site is very similar to the soil that we used to build at water storage layer for the cover. But here's a site where it's in a cooler weather climate and characterize the morphology hydraulic properties of those soils. And Todd used tension infiltrometers. So here this one is a early Holocene soil fine sandy like sponge layer at Monticello; over that period of time developed a blocking structure and based on these tension infiltrometers, you got 4 to the minus 7 saturated conductivity for that condition.

Let's go the opposite direction, warm/dry. This is a kind of a unique analog site as you're actually familiar with the native people of the southwest. Sometimes when Pueblo people or (inaudible) people, early structures, they built these kevas (pn) and before that, these pit houses, these subterranean structures that the climate change in the past rapidly filled with sediment when they left. So it kind of gives you a starting point for soil development. And you can go back and say this soil was laid down at this point, a thousand years ago. Let's look and see how it is developed and the hydraulic properties we have now.

So we worked with some archeologists who were excavating the keva and we were looking at the hydraulic properties of those. And looked at the morphology of those soils, getting fairly well developed soils, blocking charismatic structures, plains of weakness of these heads. By observation that had gone on, you can see where burrows that had gone into it and refilled with different sediment. Even saw some curious horizons, calcium, carbonated with those calcium horizons in the southwest were beginning to form which is basically -- by carbonated equilibrium in the soil related to temperature and precipitation. And in general, kind of a depth that water has moved over long, long periods of time. You can see those. Saturated conductivity there 10 to the minus 6-meters per second.

Let's look at ecological change: What's the issue here? Well, the effects of climate change, soil development of disturbances like fire, drought, grazing plant animal and soil ecology.

Analogs, well in general, we're looking at structural and functional ecology of successional chronosequences.

I should have said earlier, I'm going to step back a little bit; in all of these examples, the big question that you have to have is how good is the analog? We like to say this is what it's going to look like but at some point, we need to have some sort of metric on really how good the analog is for the condition that you're looking at.

So let me go ahead with the ecology aspect here. Just an example. Current potential vegetation at Monticello where the cover was built, this is just off the site which is kind of the wrong season here but it is a sagebrush steppe, sagebrush, western wheatgrass with leaf area index of about 1.4. If you go back to that dry site, different plant community, still sagebrush, different species of sagebrush, and it's a warm season grass and lower leaf index. And we looked at burrow land management exposures to try to get an idea of when the lake successional vegetation would be under those conditions.

Let me go back to Fort Lewis, Colorado and for that soil and those climate conditions, you know, we got scrub ponderous pine coming in, a very different structure of the vegetation that might come on to your Monticello cover should that scenario occur.

Going in a little bit different direction; Monticello, you can use or call it analogs or reference areas if you will, to develop our revegetation criteria. So analogs can help you actually with the design. If you're trying to mimic the natural system that works as we talked about earlier, let's go characterize that system, what's important and how can we mimic it.

In this case, you go out and you find on the soil that you're using to engineer your cover, what's the potential vegetation there, how might it change over time? Old field succession, sagebrush steppe. You go imitate the ecology and IET of this diverse native and naturalized vegetation. So you characterize the soil and vegetation of the site and develop your revegetation targets and your acceptance criteria if you're a regulator for that revegetation based on those analogs. And this is what we did to build the Monticello coverage. We ended up transplanting and a little bit of irrigation, getting sagebrush growing and other shrubs. Revegetation can take some time.

This is a year after the revegetation. And if you're kind of antsy to see something come in, well, especially in the southwest, you're just going to have to wait a few years. First, we got a lot of cheatgrass and yellow sweet clover and the odds of failure. But by 2008, we got sagebrush steppe vegetation growing in the Monticello cover.

Now, I'll go through some other examples.

Where am I on time? Okay. Let's go to an eastern site, Burrough, Pennsylvania is one of our uranium mill tailings sites.

If you were here on Tuesday, we talked about how we measured, actually measured conductivity and parameters on the cover, but we also found a natural analog.

Again, we found out what kind of soil was used to build that cover. We got NRC's survey maps, found that soil series in a location where it -- actually, we lucked out at this site because it was a historical site, had not be disturbed for a long period of time. On that soil, it's sugar maple coming in eventually. Essentially, the same soil series but with a late soral vegetation growing on it. The development that's occurred there -- we took some measurements, just kind of a comparison. And on the cover, remember the Japanese knotweed. Where the plants were growing rooting through that cover, 3.8 to the minus 2 years per second, measuring the sugar maple area, 1.6 minus 6 per second, maybe it will move that direction if we let mother nature take its course at the site.

Wheat thinner index comparison, the knotweed is just kind of getting started on that rock cover at Burrell. You go into that sugar maple with the different layers and the canopy and you got a leaf area greater than five. Let's go to another example, a cooler weather site that we have in the LM program.

You recall from Tuesday in the cover, we measured saturated conductivity of that radon barrier or that compacted soil layer there, looked to Burrell source for that soil and did some measurements there. This is right next door, same soil series, very, very close, a lot of material and of course we did a lot of measurements here but still, in a short period of time, we don't know exactly what saturated conductivity was to begin with, but in a short period of time since this has been constructed, it was pretty much matching what the original soil was, native soil was in predisturbance condition.

Here, Lakeview again, looking at climate change, looked at kind of wet and dry analogs, ecology analogs.

You have a wetter climate that could occur, a weather scenario for a lake view site. Here is a site where long soil, about the same type of soil used to build a cover. We got mixed copper growing on it with a wet climate analog, leaf area, 1.6.

We go to a dry warmer analog for lake view climate, the suspend (inaudible) sagebrush, not nearly as much grass, LAM 1.43.

Another way of using analogs, we talked about fire in the past. Maybe you can look at a fire chronosequence, in this case what's the LAI since that seems to be an important parameter, what's the LAI? The vegetation might change recovering from fire.

Initially you might have grasses, and these are actually sites that had been burned in past.

Here is area that had been burned apparently, about 30 years ago or so, came in with primarily, sagebrush.

You can see some old stems from bitterbrush which is more of the lake successional species, dominant species in that area. So you can get an idea of how the species composition changes and the leaf area might change following a fire on a lake view cover sometime in the future.

This lake view again, another example is slope stability. Here in the background is the slide slope of the cover. Here is the top slope. Here is the side slope and there is some question about vegetation comes in here and the rock starts to break down a little bit. How stable might this be in the future?

Well, right next door, there is a hill, Foder Hill and the reason it is a hill is because there is rock mixed in with the soil that's kept that slope stable for a long period of time.

These are all plexitis delta cobbles overlying lake sediment, which is a pull out like the cover, soil and rock mixed together, radon barrier at that site really made up of these same types of lake sediment.

This evidence suggests that this particular slope has been stable for a long period of time.

Let's go to Grand Junction for another example: Here is the Grand Junction disposal cell. If you're here Tuesday, there's the earthen cover on the Grand Junction site. Not too far we have this greater debri flow, similar slope. Soil and rock are mixed together in this case. This might be a analog for design renovation or might be an analog if we just let the cover go, let mother nature take its course, the blow in-fill will fill with rock. What might be there in the future?

Will it still work, will it last? Here is some evidence.

That glacial debris flow is greater than 10,000 years old. You look at things like the rock varnish. You look at the geometry liken it to ground over time. You look at the slope geometry. You look at how developed, how well developed the soils are, getting these algesic suggesting soil has been stable for a long territory.

Again, the calcic horizon may be a pedogenic indicator. Measure the plant community to limit percolation. There are clues that suggest yes, you got the rock fill, disposal cell, you actually renovate it to encourage that. You probably create something based on the analog that's going to persist and will perform as a water balance type cover.

Durango is another example. You probably saw this earlier. Here is -- Durango was kind of a hybrid when it was built. The top slope was a vegetative cover, the side slope was the rock cover.

The question is, on this rock cover, what sort of vegetation might come into the rock over long periods of time and how might that affect the performance of that rock cover? Is it a degradation or isn't it? How might it change over time? Well, we found an analog site similar to something that David presented earlier.

Here is a slide rock area, similar slope, different type of rock, similar slope and the succession, the plant succession that occurs in this slide rock that is similar to our side slope at the Durango site. First you see vegetation encroaching from the side, then you begin to get soil developing within the rock, organic swells from litter within those soils developing the rock.

You start to see oak growing and eventually probably quaking aspen which is a wetter condition than surrounding that slide rock because the rock actually is holding some moisture in the soil and creates a little bit wetter environment that you can expect otherwise.

Now I'm going way back to some stuff I did with Steve years ago at Hanford a couple of examples of analog.

This one was kind of unique in that some of these earthen covers, ET covers, you have a fine soil of coarse layer that perform as a capillary barrier, capillary break. And so at Hanford, we looked and we found kind of an analog aspen for a natural capillary break in these soils.

The fine soils looks good, silky soil that Abe was talking about over this coarse materials acting as a capillary break. And right in here, you see this really white layer in here, this is the caseic horizon is forming right at the contact between the fines and the courts which, a couple of things going on here.

The rock remained open.

That's a concern with capillary barriers fill with fine over time. This is a open-work brock layer with fines over the top of it, about 10,000 years old, dates back to the cataclysmic floods that came down that this somebody talked about a couple of days ago in the northwest, flooded out these areas and you have this pedogenic indicator.

It's interesting if we look at this and looked at how that soil layer varied in thickness over the top of the natural capillary break, we had a really thick fine layer with loose type soil as Abe was talking about earlier, kind of distributed over a wide area up in that fine.

You have a really thin layer and this is actually approaching that and exceeding a thin layer. You start to see the carbonate is actually down precipitating on some of the cobble, that water breaking through and gives you an idea how thick does that layer have to be with the storage layer under those conditions. Here is one that Steve and I had worked on.

It was actually the burrow soil and a couple of days ago, we talked partial spacial patterns that may develop over time here on this soil, that you could put that out on the cover and perhaps over time, you might get these coppice dunes pluming. That's what naturally occurring on this soil. Well, Steve and I went out and looked and said how does the vegetation vary where these coppice dunes have formed, and how does it relate to moisture profiles in the soil? The vegetation swells. We get thick sagebrush.

The dunes themselves, the plant is a kind of stabilizer, is spinny (inaudible), you have some swales that are very sparse. And you punch some neutron probe ports, put in its hydroprobe ports.

And we look at over a period of time how moisture storage, and water storage varies for these different conditions. One thing this is telling us is that we can't assume uniformly when you got a patch work of vegetation, a patch work of topography on these surfaces, they will behave differently in different conditions where the dune is between dunes and swales.

I will skip that one, running out of time, will go straight to the summary.

So all this all these examples of analogs what is this telling us? Analogs may provide evidence for developing and screening long-term change scenarios that you might use for your modeling for performance modeling, to get more local, paleoclimate changes, get an idea of how the climate may have changed in your specific area. Evidence for salt pedogenesis for these covered soils and how changes in soil morphology over time have affected some properties. Plant succession, the species may change, how important parameters have changed in response to disturbances and response to climate change.

Soil water balance response to plant succession and spacial patterns, the coppice dune example.

Perhaps even pedogenic tracers where water has moved in these soils over long periods of time with calcium occurring.

Long-term erosion protection, glacier debris flow. Even in our designs, targets for our re-vegetation design and successful criteria for judging how good that re-vegetation is. Targets for actually what the properties should be in our engineered soil layers especially if you're trying to design a storage layer.

Targets for cover renovation designs, we talked about that a couple of days ago; long-term integrity of engineered soil layers such as capillary barriers. And that concludes the presentation.

>> CHAIR: Our next speaker is Todd Caldwell. Mr. Caldwell is a hydrologist and soil physicist specializing in field investigations and numerical modeling associated with near surface beta hydrology, characterization of scaling of soils and hydraulic properties, and soil evolution in response to past climate change. He is currently enrolled at the University of Nevada, Reno seeking his P.hD while continuing his professional career at PRF. Thank you.

>> MR. CALDWELL: I want to thank Jody for that good sagway. That was a good entry. I was a little worried with the HPDE liners and how that was going to sag way into soil development. But Jody kind of brought it out. And I also wanted to apology, I'm a

little embarrassed that I think Jody has more slides of soil in his talk than I do in mine but I will make up for it in graphs of vegetation.

I wanted to acknowledge some of my co-authors, Erica Donavon and Mike Young have both been working on this with me on this for a very long time. We have really been concentrating on pedogenic processes and arid environments. Why arid environments? Mainly because the soils can lock everything up in place. We don't have to worry about deep drainage.

We're pretty sure that when we look at salt profiles and the carbonated FEPs that we can determine that a lot of drainage has not occurred. And therefore we can look at these soils, infer pedogenic processes and rates and really have some confidence in these numbers. And things happen so slowly in the desert that we will be looking back to the 150,000 to almost 400,000 year time frame. So, what do we mean by soil development? There is a lot of equations and pedogenesis has been one of the oldest fact functions in soil science since the early 1900s.

And it's really related to climate. The parent material that you're dealing with, the topography biology and most importantly, time.

And what we mean when we talk about morphological changes is that we start with depositional sediment. So a package of sediment will come out of the headwaters, deposit itself across the landscape. You work microbial processes and these are or more or less high energy microbial processes than desert; leave behind a pile of sand we'll call it or gravel. And then the hydraulic drainage patterns will change, leave that sediment isolated and that will then become time zero beyond which these soils will evolve.

And as these soils' evolve, a whole bunch of things will change. They are going to change hydraulic hydraulic property. They are going to change plant continuity and I'll kind of illustrate that in the next few slides. And how these relates to engineered surface barriers is really -- we can use these as a natural analogs sort of confer pedogenic rates that may evolve on cover or engineered soil. And one thing I want to state in the beginning so I don't forget, when we have these initial deposits, these are more or less, equilibrium with the environment. When you have an engineered surface, you are kind of sending a dis-equalibrum soil into a new status and processes are going to operate at a much different rate and a much different time frame than a lot of the stuff I'll be showing you.

And what we are going to try to do in the near future is take what we know on natural rates and really evolve that with what we can infer on these anthroprogenic soils and how they are going to change with time.

So I was asked to give kind of a general overview of pedogenic processes across multiple climates. And a lot is known in other climates. You develop soil structure, you develop crump blockey (phn) structure. This is your parent material here. You go through various -- this is your parent material here and you will go through various arrays of bar charts to determine your final end point which is generally oxisoil and altrasoil when you have moisture.

When you don't have moisture, not a lot goes on. You sort of end up here in the aridisol and the aridisol stays in aridisol as it ages. Not too exciting but there's other things that happen that are real exciting and that's this accumalatory nature of desert soils. Most -- more humid soils are more like a bleaching.

So they can start off as a material, water flows through it, removes material preferentially dissolves minerals, leaches them out and you end up with a different soil horizon. In the desert, it is an accumulator soil. The two is blown in, infiltrates with water, deposits behind but with it generally, salt soluble material that can precipitate off in the lower horizon. This all sort of leaves a record of what happened in the past.

So there is two different processes we like to think about to operate on alluvial surfaces or even desert environments or even engineered surface barriers. And they consist of biotic processes and abiotic processes. We have seen a lot of this, a lot of plant mound development. Burrowing, those are all biotic processes. Abiotic processes that we have barely just kind of barely touched on here is this accumulation of dust, particularly when you have like a riprap service. There is a very good efficient trapped of dust in the desert, the blowing around all the time. It can fall into these cracks and infiltrate slowly, develop with time into a soil and that's really the main pedogenic driver that you see in arid environments. Accumulation of dust, that therefore results in increased water holding capacity, more evaporation. Less water is going to infiltrate, change plant community structure, change plant rooting patterns.

That's going to eventually form horizons -- there's not a lot in situ weather happening in a dry environment. When you get below 150 millimeters of rain per year, there is not a lot of chemical processes that can really take a piece of felt bar and weather it into silts and clays.

So these sort of abiotic processes operate over a much wider scale, tens of square kilometers regional scales really related to pulses in climate change related to alluvial periods when you had applied fill with material with water and fine-grained material that will desecrate. That material is then transported hundreds of miles away and laid down over top of most of the rock and gravel and soil.

So these also operated over much longer time period.

This is a little schematic we like to show of alluvial lakes there in Majove terminal to the Majove River just outside of Ziax, California. And you can see it is a roily polly surface that suffers from desiccation when it drys. And when it drys, it blows by wind transport a lot of this material up into the Oluvian slopes, probably on the order of 2 to 3 grams per hundred year.

So it's not a small process when you're talking about 10,000 year stimulations. That material is then infiltrated into this and this slide comes from sinks and sources. One of the things, I do a lot of work for the Military and one of the biggest problems they had is driving over this material. And once you have moved the dust from the ply into the soils, you disturb these soils, they become huge dust problems when they are trying to move across the landscape.

So here is another cartoon of this. We start with a sort of coarse grain, almost gravel supported matrix. Through time and inputs of dust, you can actually raise the surface soil if you go from a sort of humincay -barn and swale, a ludeposit to a smooth almost table top like deposit with a single area of gravel -- here's one soil slide -- a single layer of gravel across the top which is a desert pavement.

Beneath that you have a vicercular horizon, AV horizon. This is completely 100 percent dust that's been collected from time. And you can see it has structure to it. It's almost like a biscut shaped structure that allows the water to flow in between what we call pegs. Below that, you generally have a platy soil which forms a horizontal structure and beneath that, you have these zones of accumulation salts and carbonates. And this happens through a pretty well-known period of time.

You can date these services with some pretty high competence and we have several different par materials we work on. There's a really nice -- I'll show you the idea of a chronosequence in a slide next. There is a chronosequence in the southern Majove Desert that has a series of granite, limestones, mixed volcanic rocks all beside each other and they have all come down through a series of episodic events and the paleoclimate.

And we can look at how pedogenesis is a function of parent material across this chronosequence. And we get information like this lower graph that shows you time and thickness of this AV horizon or thickness of this accumulation of dust. And then here is a little outline of some of those biscuits. This is what's basically underneath that monolayer of gravel. So we will be doing a lot of -- later at the top, I'll show you a lot of hydraulic properties related to how this AV horizon forms and how it changes hydraulic properties of the surface with time.

And here's one slide just of that. We use a lot of these terms QF 6. These are the geomorphologists that I work with and a QF 6 is a younger than QF 2. So the numbers kind of go backwards in time.

This is your young soil up here on the left and this is kind of going around like that from young to old.

And we run a lot of infiltration tests on these soils and this is a study of dye and how the influence of microporosity develops with time. And you can see when you started the QF6, there is not a lot of blue. It's kind of spread out. Now, as you age the soil, you go from matrix dominated flow system to more of a micropore dominated flow system.

And what does that really do? That changes the depth of the water. It changes the availability of that water, to get the plant roots. And a lot of our work we looked at is how we can look at this change in time to use it to start calculating changes in properties with time.

So that's the graph on the right. But first, let me show you the left one. That is the same soil series. Here, we have a QF3 which is your oldest soil going to the youngest soil. And this is the same graphs of AV horizon thickness and you are basically increasing the horizon of thickness and increasing the amount of inter-pack 12 but you are also packing a lot more silt and clay into the surface.

So what you see with time is a general decrease in hydraulic conductivity. That's these red bars from the surface oil. And you're going from 10 to the minus 4, 10 to the minus 2 in centimeters per second. I've seen a lot of different units on KS but I'll throw another one at you. And what you have here on these other bars is that region right below the AV horizon.

That's basically your unaltered original parent material staying more or less constant with time. But as you develop this upper horizon, you're really decrease in conductivity. This is opposite of a lot of what Craig's work would show starting with a compacted clay and you're actually developing structure. Here, we are starting with a loose high conductivity matrix and decreasing it by adding silt and clay to it.

It has a rather predictable decrease with time that we can use to apply to numerical models which

I'll show you later.

And then here is a little graph of how the water retention curves sort of changes as a function of this AV horizon. You go from a young soil down here, these triangles up to a old thick AV horizon. What you are really doing is retaining a lot more water at the surface. And the more water you are going to retain at the surface, the more you are going to loose to natural evaporation and less to transpiration.

And that really sort of dictates how the plants will respond. And that will be directly related to some sort of engineered surface barrier you're trying to keep vegetation on.

So as a picture of our trenches, we like to consider the deserts and even some arid environments as either two soils you can classify them into; you can call them young soil or you can call them an old soil.

And the two have very distinct different properties that from the grossest sense, you can really pick out even from (inaudible)images. And these young soils have no development.

It takes a long time to get this stuff

developed. They have high infiltration rates, loose matrix and very little soil horizonation. When you look at these older soils with strong development, this is your zone of carbonated accumulation that flows right around here. We were looking at the differences between these mound areas where these soil are biotebated versus these interstate soils that have been pretty much stagnet for years.

These have a much more clay, a lot more horizonation and much more hydraulic conductivity.

So, I'm going to sort of kind of walk you through the idea of this soil chronosequence now. This is one we do -- this is one of our favorite ones. I think we have about seven of these in the U.S. ranging from the Olympic mountains in a cold tropical area down to humid Arizona where we have sort of 93 millimeter per year rainfalls. This is one of lowest rainfalls that you can find in the U.S. right here. We dated a lot of these using Burrell dating coin 36. And now it is sort of developing these grates with time. To give you an idea of the scale of these, this is a -- generally, you will find these older soils on the higher parts of the Piedmont, and the younger soils on the lower part of the Piedmont.

The nice thing about this paper that we just had come out, we are really looking at this, it is hard to read on here, but it's a QF 3. We dated this thing precisely to 2900 years old, well, 2900 to 3200 years old. So this is a time period within you guys frame of reference. And if you look around here, that's this soil that's all over the place.

So I guess when you are thinking about setting a waste barrier, you may want to consider these processes that can take what was there and sort of reorder it and become something new.

So we take these soils and dig nice deep trenches, sample them and look at how sand, here is on the left, we have 1,000-year-old surface and on the right, we have 100,000 year surface. You see where the sand is decreasing with time. We are getting increase of silt down deep over here. And that's really what we are looking at when we talk about pedogenesis and desert soils and these are proxies for extreme climate events that happened in the past, these future scenario development.

And what we are using a lot of this for is to really look at do we know much about paleoclimate and can we model a paleoclimate climate from the back to the present and come up with reasonable estimates? If we can, maybe we can go forward and look at how climate change will affect some of these soils. And one of the biggest worries with some of these soils is the fact that they are significant storage of salts.

Some of these salts are okay, salt banks no big deal, chloride, no big deal, but there is a lot of nitrate in these soils that's accumulated. On the order of this old soil over here on the right, has about 500 kilograms per hector of nitrate locked in the top meter of the profile. So if something were to, say increase rainfall or you remove that AV horizon and suddenly allow the water moisture to pump through the system, even though groundwater is probably about 70-meters below, eventually you may have some environmental consequences that you have to deal with. But the key with a lot of these is that you can really use this as direct evidence to sort of see how your soils might evolve through time and maybe how your barrier evolve through time.

So that's the abiotic processes that are happening on a larger scale. One thing, you notice when you look at the desert and the interspace vegetation, is that there is a lot of biotic processes happening across the surface, maybe only 20 to 40 percent vegetation cover but there is still something significant with those. And what you have under these biotic burrows is a lot of burrowing that will disrupt soil structure. You are going to have a lot of organic matter and root decay and turnover.

And you are going to have a lot of translocation of minerals. So these are sort of what we can call disturbed soil and continuously moved over and the structure is destroyed periodically and they operate in a much shorter time scale, much smaller scale.

So this is really -- originally when we did this work, it was a scale issue. We are trying to use distribution of plant vegetation on a surface to really scale hydraulic properties to rainfall run-off models.

So when we looked across the landscape such as Yuma, Arizona, you can see how the vegetation kind of follows patterns on these young soils the actual wash of this, you sigh a much more vegetation as we move out to the intermediate soil, this soil is the 320 who, 2900-year-old soil, vegetation starting to dial back and as we move back into the pavement area, vegetation moves from being laterally, to being confined to channels.

So now, we are going to get into some of the slides that show you how vegetation is really a function of soil -- vegetation distribution and size can really be a function of what the soils are and the subsoil materials. This is data reported in the northern Mojave where we looked at young and old soils, the young soil being a holocene soil, a Paleocene soil being an old soil. And you can see that the canopy volume is at three different sites, and every site, we had a significant difference in canopy volume and plant type.

We did this in the providence and the other thing you see is this age of soil. This is the same previous, when I showed you those graphs of AV thickness horizon development, we go from a young soil here to old soil here. And you can see the total canopy volume is always going to decrease for a layer, a plant in the desert even though the number of plants stays the same. What you see say is a shift from layered to an ambrosia dominated system.

And I also point out some of these (inaudible) that I will be show you later. We've done a lot work that characterize these spacial properties using these little mini (inaudible). So when we consider that same slide of young and old soils from before with the loose matrix on the top and the low salt to these high salts on the bottom, we measured root density.

So you can really see how the rooting pattern going to change. The green, the darker, more roots and the blue is no roots. And as you age these surfaces, you can really find the amount of water that's going down and that really allows the layer to sort of concentrate its root where the water's going to be. So this is a good way to determine where your water might be flowing as to root pattern. On your caps, it may be a little different because you have that disturbed environment and you can see the roots when you freshly plant a piece of vegetation on them, they seem to go crazy.

These are well established on the order of a hundreds of years old that have really sort of come to equilibrium, (inaudible) So we can model this from our data and really show this is cumulative distribution of roots and the circle and annual net water flux downward in the triangles. And generally what we see is that on the older surfaces, you have a shallower depth of penetration of the water, you have a lower rooting depth.

So we went to the Nevada test site, developed another chronosequence really related to cover evolution. And we are really concerned or interested in how the interspace soils vary with time versus these this under canopy soils. They had 4 different soil sites out there ranging in age from about 100 years old out to a freshly related area out to a very old Paleocene soil that was on the order of 45,000 years old. And we saw our token decrease in hydraulic conductivity of the surface with time.

But what we didn't see was any change to hydraulic properties under canopy. So the nice thing was that the burrowing activity was continuing to keep the hydraulic property at the same levels whereas the interspace which is generally going to be more of your area was changing with time rather dramatically.

So I wanted to get into a little more detail by using micro measurements to really pick up -- the idea was to use micro measurements to really look at the larger scale heterogeneity. So we took hundreds of measurements of unsaturated conductivities allowing using as many infiltrometers radiating radiating away from laria and lisium paldin (phn) at the Nevada test site. And one thing to note is that there is a lot of measurements that are double potted or measuring saturated conductivity.

If you could read this scale on the right, this is 10 to the minus 3-centimeters per second or basically you can figure this line right here is about 4-centimeters per hour. And all these numbers are well above 4 centimeters per hour. So these are very highly conductive systems. And when you start over here on the left, you're underneath the canopy and as you go past the one, you get out into the interspace.

So when you look at the saturated conductivity at zero, there is very little change from this particular very young alluvial soil as you move from the under canopy out into the interspace.

As you start to drain these pores and notice again that these fluxes are high, as you start to feel under a little bit of tension, these pores under the canopy are much larger and drain really quickly and the conductivity drops off very fast. And if you get the negative minus 4.5, you can see you've almost lost an order of magnitude under the canopy but the interspace is still conducting high. There has to be some caution when you're talking about some saturated conductivities but it's really that when you get to unsaturated, it's that dropoff in hydraulic connectivity that help determines when you are using soil physics that really dictates conductivities will shut down as a function of large pore drain. So that was kind of the controversial result of that paper. A lot of people always say, well interspace soils are always going to be lower in conductivity than under canopy.

That is not necessarily true. If you have a high conductivity interspace, you can have lower conductivity underneath the plant. And by lower, we are still talking about five or six centimeters per hour still. It's all relative.

We did the same measurements on the chronosequence soils looking at canopy, these lighter bars versus the interspace soils. And again, we see similar results that the canopy tends to remain at 8 or 9 centimeters per hour whereas the interspace, you start to see that decrease.

So the idea here is that we can use the distribution of plants to really scale out our hydraulic properties related to the idea of service age, decrease in conductivity to generate random fields basically of hydraulic properties with surfaces.

So that leads to the plant mound and Yuma discussion and how these have become archaeological studies which are a problem for the Department of

Defense. You start -- as I mentioned before these young surfaces, you bring in a plant on the top. You have burrowing activity, the burrowing activity increases the height of the mound. You also get allvian inputs. But eventually what happens on these surfaces as this is a well developed desert pavement surface, it's not necessarily the infiltration that decreases a lot, it's already decreased but you really start rerouting surface waters to some of these plants. And when that happens they lose their run-on. And without only 90 millimeters of rain a year, it's not enough to survive so they eventually die. They die, they collapse, and you've already lost a lot of material because of the burrowing activity. So these are very low points of bulk density. They are probably 1.1-gram per cubic centimeter.

As it deflates with the demise of the plant, you are left with this depression and or these features on the right here that really shows you these circles. These circles were deemed would think would not be too hard show but it is. So how does this really apply to surface barriers?

I want you guys to take away from this that the engineered surface barrier is a geomorphic land form and will evolve with time. Generally, it's higher than the surrounding environment and as we all know, the higher you put something, the more energy it has and the more ability it wants to come down. And a lot of our soils start off that way. They start off as head water deposits of depositional sediment that erode and eventually a pulse of water comes through and sends it down the lube and then it becomes a soil.

There is a strong feedback between the soil and the vegetation that occurs through time.

I went through most of those. And then there is ultimately these through time, five, ten thousand years, these are going to come. They are going to move from that young soil I mentioned in the desert to that old soil in the desert, mostly related to the Mojave covers.

You're going to see that decreasing conductivity, the increasing water retention capacity that splits from matrix flow to macropore flow. You're also going to see this development of horizons. The main thing that we often worry about is this switch from having -- you have so much water available to fulfill your potential of operation. When you start evaporating, you have less available for transpiration. At some point, you are going to kill off vegetation when it no longer has enough to survive. This is more of your long-term impacts.

As a quick show of how we can use this stuff for modeling, we're going back 40,000 years right now with some paleoclimate simulations. We use current storm patterns in Yuma, Arizona. We try to send them backwards in time and then use almost a inverse, modeling with our data, the distribution of various salts and clay minerals to determine whether or not our models are within reason.

We don't have good -- I don't have a good model fit to show you right now but we do have a nice distribution of salts throughout the last 3,000 years that would be simulated. It does not necessarily match up with our current distribution but that is a lot with the milly more liter versus the milligrams per gram that I showed you earlier. Again, this goes back to those concentration flux measurements that really need to be adjusted.

So here's kind of that idea, can we take this 400 year old surface and look off to a thousand years and really look at the distribution of these salts and how they evolve with time on analog soils near engineered surface barriers.

Well, I'll quickly mention this incipient soil formation. You guys are really worried about incipient soil formation that's really quick fast soil formation and the Military is too. It's been funding most of our work and that's really related to height heat detection. How quickly you disturb the soil, it changes thermal and electrical properties, but for how long, we don't know. And a lot of the detections that are in place right now are really utilizing this change to detect IDs in the field.

So to summarize, these analog soils for engineered surface barriers, they allow a good extrapolation well beyond historical time. I believe that the rates are going to be much slower through we present in the literature of pedogenic processes than they are for anthroprogenic processes like your soils on barriers. The accumulatory nature of theses soils, it can really use the benchmark simulations for long-term possible scenarios on engineered barriers. And I think also this couple abiotic development can aid decisionmaking and I'll be curious to see how or if you guys think that the ways that we could come up with would really affect performance assessment outcomes.

And to wrap it up, I just want to state again that pedogenesis is a slow process in the desert but I don't think it is when you're talking about these engineered soils. Everything can happen much faster. So thank you.

>>CHAIR: All right, I'd say let's be back at 12 after.

(Break taken)

All right, let's get the panel discussion going so if you can take your seats, please.

>>> And what we wanted to do first, we had a list of questions up on the screen already but we wanted to introduce the four remaining panelists that did not present. Mark Phifer has been introduced before

so I don't think I will go through the bio for that. And then each one of those four panelists, if you have anything to state, any kind of inside recommendations that you would like to share with the audience, take a few minutes to do that and I know Mark did want to do that and then the other people.

>> Mark: Okay, it's clear from all the talks and information that we have, we have a lot of information but, you know, we're having to make decisions with imperfect information and we have to make those decisions. We can't always put them off until we have perfect information.

One thing that leads me to conclude too is that we have to be very careful whenever we think in terms of talking about having final cap that you can just walk away from.

I think it's clear that's not something that's going to be able to be done.

And whenever we are talking about having model support, we also have to put the model support in terms of I think the timing of the projects that we're doing because we are doing to be required to make decisions to begin operations of things before we have all the information we would like to have.

And we're going to have to do that and be willing to do that, but give the decisionmakers what we think is available at the time.

We can't just stop there.

We are going have to continue to do research, do work to improve our understanding of the systems and to provide more confidence over time and sometimes it's not going to be providing confidence, sometimes it's going to -- we find something we are going to have to change in the field, change our operations change our concepts and things over that nature.

And we have to be prepared to do that.

Now, a lot of the things that we will need to do to do model support in my opinion should be risk-based as Dave was talking about but it also needs to be in terms of when are we going to do things in these projects because you're not going to have the -- well, us for example. We have faciles that we are actively disposing in now, okay.

And we have permission to do that type of disposal but we're continuing to have to develop more information for those facilities.

Well, the information that's needed for the operations, the barriers that we have in place now is more necessary than the closure caps that are coming 20 years later because it's going to be so much more information developed that we will need to consider.

So in my mind, model support should also not just be risk but where are you in the project and what parts of those projects are most important at this time? And then, a lot of what John Toukes talked, about looking at what are the most important features of the individual facilities? Well, we don't want to need to have the most model support on the things that are least important but more model support on the things that are most important. And so we need to have a graded approach on our model support that include risk, importance, phase of project and things of that nature.

I will put in a plug in my mind for the DOE system which includes maintenance plans that go through operation, through design, through closure, and into post-closure that we are having to evaluate things, having to evaluate new information we see coming our way, having to do R&D ourselves, having to look at what's going on in the field with operations. And when changes are made, we have to evaluate those to decide whether or not that still fits within the safety envelope.

And I think that's a very good way of doing things that you continue to do that, that you have to continue to do that so you can continue to give confidence to folks.

And I will have to say, I hope that we never have to reach the point where we are doing the level of you know, model support that you guys did because I don't think the level of risk is anywhere close to what you. (Inaudible)

So that is my opening comment that I would like to begin with. So thank you.

>> CHAIR: Thanks a lot Mark for that. The next panelist is Kent Bostic. Kent Bostic is a certified groundwater hydrologist with the American Institute of Hydrology with a MS from the University of

Arizona in groundwater hydrology, formerly of the UMTRA project, technical approach document to provide the technical basis for NRC acceptance for unsaturated covers and develop compliance strategies for licensing of the 24 UMTRA disposal sites. He also wrote the hydrology section of the safety analysis report for licensing of waste -- isolation pilot plant.

Recently Mr. Bostic has designed evapotranspiration covers for material disposal areas at the Los Alamos National Lab and the RCRA compliant covers for the waste areas at the Oak Ridge National Lab. He is currently consultant to the DOE on the UMTRA program project.

Kent, did you have a few minutes that you want to spend?

MR. BOSTIC: Yes. I'm sorry but I'm going to talk about tailings again. Since you all know more about tailings, we stick with that.

Recently, we had a conference in Grand Junction and it was brought up that UMTRA covers were changing and at first was perceived that it might be a problem. But the more we look at it, we don't need to be alarmed and just see where we go from here in the future.

And as when the compliance strategies were developed, all those sites, the covers was an interval part of how it functions with the tailings and how it functions with the groundwater hydrology, and geochemistry and all those things account to whether r disposal cells is meeting its performance requirement according to the regulations.

Now, I'm in agreement that we should maybe look at what maybe a degradation of cover components means to the overall performance strategy. And for instance, a lot of these UMTRA sites, the tailings are fairly innocuous. For instance, Lolan, (phn) you can do a leach test and not drive any hazardous constitutes or radiological parameters out of these deposits. They never even went through a mill.

So for instance, if you say the cover was failing because ponderous pine fell off on the cover and exposed the materials, you know, we consider in the designing of that, we consider tree fall and disruption of cover by root ball. And because the materials were not toxic, it was really no problem from a radiological or other standpoint. And that was a tradeoff that we recognized, you know, for a waste disposal everywhere in the period between 50 to a thousand years, tree falls is probably a method of failure of cover. If the cover is less than five -- 60 thick. So that's why monolithic covers were designed to be very thick and there are sort of the sacrificial material at the top that has protection for freeze thaw and allows some pedogenesis, but the idea that deep within the radon barrier, you would have some protection against infiltration and radon exposure from these processes over the thousand year period.

The design period didn't go much beyond a thousand year period because we thought we were even stretching it at that.

But in our design, we were not confident beyond that. But as time went on, originally in their process, it was just viewed to be an earth-moving process -- that UMTRA was a earth moving project and we were going to meet a radon standard and clean up soils to the radium and thorium standard and then, midway through the project, the groundwater regulations were imposed upon us where we had to meet water standard MCL at a point of compliance.

And it was just serendipitous that of course, these covers that were being designed for radon attenuation using clay because clay retains moisture, and it can meet the radon standard that they had a hydraulic conductivity. But there was never a design standard and conductivity and it was not part of the regulations. And originally it was thought, well, you know, if we have a saturated conductivity and a cover, that NRC would accept that, if we had a low saturated conductivity.

But then we found out that in areas where there was a lot of tailings salts and a lot of uranium in the he tailings and other hazardous constituents that we couldn't meet a point of compliance standard even with the 10 to the minus 7 cover standard for hydraulic conductivity.

So we begin to look at the covers and we said, well, you know in the desert, there are not going to be any saturated covers. They are all going to be unsaturated and so as you start to consider the unsaturated flow properties through these covers, the hydraulic connectivity goes way down.

So we decided that also, we could save a lot of money by not having a geosynthetic liner in the cover if we could demonstrate that these covers operated under unsaturated properties and that we could build a monolithic cover that would behave as a infiltration barrier. And so that's kind of our thinking and why those covers are like that.

And we recognize that now, the properties are changing but, water does not move very fast through the tailings.

The tailings actually in most of the monolithic UMTRA cells, the covers sit right on top of the tailings. So the tailings are actually in relocated cells. They are engineered materials to the conductivity similar to what it would be for the radon barrier.

So water is not going to move fast through the tailings. It's going to move at a very, slow, slow rate. There is transient drainage from water that's already in the tailings.

Initially, there was an objective of producing dust flow -- I'll finish up -- off the pile from wind blown stuff. So they put a lot of water on the pile and that water is still draining in many cases. But the idea is to look and see now, how the change in cover affect the overall performance so with that, I think to take away from the meeting is that we don't need to retrofit all these covers or go out and do a real heroic effort.

But let's continue the monitoring an interval process of how it relates to performance assessment and just make sure that they are still achieving their original objective so. With that, thank you.

>> CHAIR: Okay, thank Kent.

The next panelist is John Walton. He has a Ph.D in chemical engineering from the University of Idaho, 1991, currently professor of civil engineering at the University of Texas in El Paso.

>> MR. WALTON: Yes, I -- one of the things we're trying to look at here is how we can increase confidence in the systems and model confidence. And

the part we have not looked at is improved engineering design is the way to increase confidence in these systems. And what I mean by that are several things. One is, I think the system should be more modular rather than monolithic and the reason being, if you look at the scale effects of unsaturated flow, you'll find that unsaturated flow works very, very effectively around small systems like trenches for example. It works poorly. Same thing with saturated flow as George pointed out, more slope in a smaller system.

So I think if you take the modular system, you will get less flux of water through it. Secondly, I think that the engineered barriers like the geomembranes should be deeper and wrapped around the waste. We should look at the cover. We should look at not the surface of the earth and start there but down at the waste and build up.

And the backfill should be not against the fast the waste but against the surface.

And that can do several things. One is that now, our clay layers don't see freeze thaw. We don't see as much desecration. Root balls and trees don't affect things that are deeper. And clays, I don't know what will happen but higher affected stress is going to help the compaction, the holding compaction.

The other thing I think we should look at in moduler systems is that we should encourage groundwater recharge between the models. If you have low trenches, or more circular models, you can get infiltration to groundwater between them. What happens at that scale, you see dispersive mixing and you lower the concentrations in groundwater because your concentration groundwater has to do with release rate divided by the flux of water.

And so when you look at that, you look at both sides of the equation. Part of that side of the equation is how much clean water is coming through that solution. So those are my comments.

>> CHAIR: Thank you very much. Kerry Rowe contributed a couple of times.

MR. ROWE: I didn't think I had anything to say but I now have a few things to say in response to some other comments.

And some of the things are really drawing together comments that others have made during the workshop. But I think we have to keep in mind that the level of engineering required really has to fit with the nature of the waste and the risk. And that what is the right solution for Ken's tailings is not necessarily the right solution for disposing of low-level radioactive waste coming from a plant for example.

So we really need to think about what is the risk? What are the challenge in terms of monitoring? What is the cost of clean up? I heard somebody at the workshop, I can't remember who it was, say the cost of clean up is humongous, why don't you put the cost to engineering in the first place, especially a new facility. And that is a pretty good argument. It's a pretty good argument we should think about.

And so, we really need to evaluate the waste. We need to evaluate the entire system question. And in a short while, we get to what about the geomembrane which you have to look at geomembrane in the context of everything from its geological and hydrological environment through to what's in the cover, what's in the waste and what's below that.

So it's not just a matter of thinking about the geomembrane in isolation but where does the geomembrane fit in the system? If the -- this workshop is really focused on covers, and if the covers are really important to you, if it's really important that you don't generate leachate, in other words, percolation through your cover, then, I think you need some sort of redundant system. Putting all your eggs in one basket, it's really critical so I'm shooting here it is a significant risk. It is not necessarily a wise thing to do. So I guess I'm going to finish up with where John's comment was; I'm surprised that there's been so much emphasis on the cover without very little discussion of the line system. And I understand that one of the reasons might be that we can't rely on liner systems for hundreds of years.

Well, I actually think we can, but to have it is still better than not to have it. It's going to cost you more and that's why I'm saying put this in the context of risk. But assuming it's sufficient risk and then you really are relying on that cover, to me, then to me, it make a whole lot of sense to have a liner system, in fact to have a double liner system with a monitoring lab because then, if you're picking the stuff up on the liner, you know you got a problem with your calibration collecting it before it escapes and you have a monitoring lab underneath your second and beneath your geomembrane which I was talking about earlier in the workshop, if this is really important to you, why would you treat it with less respect than any hazardous waste?

>>CHAIR: We put together some questions for the panel discussion here and they are a little selfish. They are very specific. NRC staff is looking for help, looking for suggestions, recommendations, anything that you might have with regard to certain things.

Over time, we noticed that there are certain parts of engineered covers that are relied upon more than others, so be it either transpiration to remove the water, be it a clay barrier, be it a geomembrane depending on the design, where you're located, there are certain parts of the covers that are relied upon more than others and we kind of picked those out and applied this idea of model support to these particular components.

The last three questions are more general so if you did have a more general recommendation, general insight, general idea of where there is an information gap or areas where you think the guidelines should be changed or what the follow up activity should be, our last three questions are related to that.

The first couple are very specific. I'm really trying to pull out some ideas as far as something to support because a lot of these covers that we do get, the claims are that they do last for hundreds of years, 100 percent efficiency. And so we are looking for like more than just modeling results, we are looking for model support that would help that.

So if we go to the first one, we have the BB Institute and design and engineered surface cover providing modeling results demonstrating more water infiltration through the design cover for 200 years.

The estimated -- that should be water budget clearly shows the membrane as the main barrier within the cover. However, the geomembrane processes were not simulated and then assumptions were made with regard to the geomembrane.

What independent lines of evidence can be used to support or invalidate the model results of the covers most significant barrier, the geomembrane? Could a confirmation program be set up, performance confirmation program be developed to provide that information? And I have here, Dr. Rowe's the first one. And if you're repeating something you said in the presentation and you're extended out, that's perfectly fine.

>> DR. ROWE: I think I will begin with a comment that I've made several times in that the model is no better than the assumption. So I think the first place you have to start is by looking at what assumptions went into this modeling.

There are some many common mistakes that are made in terms of design, not just in terms of modeling, whether they model or not.

And I think the first thing to do is to make sure that you get an independent peer review of the design to really provide at least some confidence that somebody has not made a mistake. And as one of the speakers this morning said, you people make mistakes, that it's human. That's why you do need a proper peer review.

So I think that is a crucial aspect of that, not just in terms of the calculations done for the leakage through the geomembrane, but how does that fit into the entire system? As I said before, because other things are going to affect that and you make a set of assumptions and if they are too narrowly defined, they don't actually apply to the situation you're dealing with.

So I think it really has to look at how the geomembrane fits in the system.

There are certain situations where geomembrane will be perfectly good in one occupation and not good in another and that's not because of the geomembrane its self, but what's happening around it.

A second aspects of course is the construction because the geomembrane is no better than as it has been constructed.

In terms of the design, we need to make sure that we got methods in there to say, control animals getting in and chewing at your geomembrane, not that it has much nutritional value but if they are interested in getting on the other side, they will chew through the geomembrane. So you need something to protect for that. You need to think about the settlement issues.

George showed this beautiful picture this morning of the geomembrane popping up and experiencing a large strain. And it's really good that it can experience large strain but if you're looking at long-term performance, strain are induced, not likely induce by gas but if it's settlement, it can also be an issue.

That's where you have to ask yourself about the nature of the waste. Is it going to be a high probabilty of sediment? We heard examples in this worshop of resin. Mark talked about an example where he's got very serious concerns about it.

Those are from two different design situations so you need to look at this in the context of calculating what the leakage will be through your geomembrane.

In terms of the construction, as I said, you got to make sure you got a good construction plan. There are details that people often don't appreciate that are actually important in terms of being in the construction plan in the first place and then of course the quality control, the quality assurance that George talked about are absolutely crucial.

As I indicated and as he indicated to you, not all geomembranes are the same. You got to make that you got a good geomembrane. You got to make sure that it is installed properly. So all of these are really key.

Now, you talking about what the analogs are for leakage through the cover. As George indicated in his presentation this morning, there is quite a lot of data around, from New York state on, what is coming through covers and how that changes with time.

So it's a good data on what's leaking through primary liners and secondary liners. So that gives you some idea of what sort of things might be expected and

I agree where George that with a properly designed cover, you probably got a better change in terms of the geomembrane. But in term of the other components of the system, there is potentially greater risk.

You got look at the risk of the drainage lab blocking up? In some cases, it does not block up, it's never actually draining properly, failures occurred simply because people have forgotten that if you have a drainage, it has to be able to drain somewhere, not build up in the cover.

That is the sort of thing that hopefully will be picked up either in the design mistake or with the construction quality assurance if it is a construction issue. I think all of these things need to be looked at. There is evidence around that gives you a pretty good idea what the leakages can be and to expect a leakage to be zero is probably pretty naive unless you put a tremendous amount into the design and unless you have really, really careful design to minimize it as well as the appropriate construction controls.

>> SPEAKER: Thank you George. Mostly to reiterate what Dr. Rowe said but first, we would like

to talk about the geomembrane itself and address the question in particular, these lines of evidence for the membrane longevity itself, the 200 years in question.

And I believe there are quite a few of them. I work at Greens also, GSI but the Germans has done a tremendous amount of work Guard Sayinger (phn) they are not allowed to release it but this work at PPI is significant for longevity. Bell labs it was cable shielding laboratory and they worked in conjunction with Dupont.

We are not winging it at a couple of hundred years. There is some nice sets of data that suggest that will suggest that polyethylene will easily last and in a buried condition, can do it quite handily.

Dr. Rowe was very helpful and how he stated that, how you did that without notes, but this system approach is so important.

These materials are relatively fragile compared to what you're discussing. They need to be put in the ground with a design knowing the raw materials, having a good specification, good QC, good QA, have a leak integrity survey, know that it's performing after it's installed and then, that maintenance.

I hit all your topics again but it's nice to be on the same page.

>> SPEAKER: Thank you Dr. Walton.

>> PANEL MEMBER: I don't have a lot to add but one of the obvious things that we would question is if we get a black box performance assessment come in, then, I would hope that it would be flunked, that it would be pass, be thrown back and they would have to show performance assessment. The other issues I think that's out there in complex performance assessments is this feedback between what's assumed in the performance assessment model and what happens in reality, how often the performance assessment is done well before the thing is ever constructed.

It is not clear particularly in the more complex remediate system that is there is clear feedback between the performance assessment models mixed with assumptions, that all those are well documented and get put into the construction and quality assurance plan. I think that is a real gap that I see out there.

The other thing, that it's looking more and more after this workshop, to see all these failures, is that perhaps we should stop and look at these systems as walk away and instead when somebody does an application with a private company, they should be given a perpetual annuity to look at monitoring and repair of the facility.

>> CHAIR: All right, thank you.

Mark?

>> Mark: Josh stole my thunder. If I were the regulator on this one, I would say fix this problem where you don't have any basis or any support for your main assumptions. And by the way, you do not make up for that by promising things in the future through a performance confirmation program.

But I think the other questions -- the other answer to the questions, are more to the point that there is a lot of information available on the geomembrane function over time and so it should be relatively easy for the Black Box (phn) Institute to support their assumptions.

When I first read this, I thought oh, this is a trick question. This almost looks like the state of Nevada's impression of the DOE's safety case for the Yucca Mountain Project, because they accused us of having the least data for the most important barrier which was our LR 22. And I thought, okay my name is on there because somebody wants put me on the spot.

But at the same time, we were very well aware of that and so we got a lot of data on that particular allie and the trouble is we had to throw out a lot of that data because the QA pedigree was not good enough. And so we ended up using this small percentage of the data.

So all of those kind of things play into that and they have already been mentioned by the other panelists, QA is very important. And quality control, I would think that in a membrane, it's how you put it on that is probably more important than some of the other things because I can just imagine putting it on uneven surface and creating pockets where you would actually collect water or otherwise create problems.

So, that's where your performance

confirmation program, as you put it in, you confirm that the assumptions you made in your model actually reflect what you did in the field. And that's what John was talking about.

And he's picking on me again when he talks about the impasse between the performance assessment and engineering functions. When we compared notes before doing the license application, the engineers came over and said, okay, you have made these assumptions. We found 20 assumptions that they said they would have to actually write into their engineering specifications to make sure those assumptions could resemble realty. And some of them were undoable and so we compromised on them.

So there are serious questions about if the Black Box Institute (phn) is making assumptions and not checking with the people that actually do this kind of work, install these kinds of systems that you may be making assumptions that are totally unrelated to reality.

So, but if I were the just primas facie looking at the case right there, if I were the regulator, and I should turn to be a regulator instead of implementer sometimes because it looks so much easier. I would say this is not a license application that we can accept for review. Bye.

>> SPEAKER: I would like to ask George Koerner what specific tests have been done for different microbial communities? And how long have those tests been going on if they have been done for different microbial communities?

>> MR. KOERNER: I think this leads to the next question that's coming. He has a biologic factor in there. And if we can -- I don't have a direct answer for you. The biologic on HDPE, there's nothing to attack. There is no chain end to go after.

The flora, you really want to control the water and you get will rid of the flora. As far as the fona is concerned, like Dr. Rowe mentioned, get rid of the food source behind it or make a barrier so they can't go through it.

Will they go through a geomembrane? Certainly. A rodent will go through a geomembrane. A rodent will -- he likes the heat in the cover.

We dug down and they stay right above the geomembrane and the reason being, they like the warmth but they are smart enough not to break through to get to the gas. And it's amazing that a squirrel even knows that, a rodent knows that.

But in answer to your direct question of microbes, maybe Dr. Rowe knows that.

>> DR. ROWE: I'll just make a comment. In terms of a real live test, I think it has to be the geomembranes that's being used.

George talked about some (inaudible) We recently exhumed the geomembrane full landfill after 25 years and in fact, they are performing remarkably well. Except for some depletion of antioxidants, which you would expect that after 25 years, their performance is exactly what you would be expecting. There is no evidence whatsoever of attack from microbes and there is no evidence of any significant migration through the barrier system either in cover or in the baseline.

So, I totally support what George was saying.

>> CHAIR: Thank you. Another question one and two up, anybody else from the panel, on either

question one or two? Or else, I will move on. Go ahead.

>> SPEAKER: I guess the first thing I'd like to say about question one is whenever you had the estimated water budget showing the geomembrane is the main component to water here; in my mind, all caps are ET caps.

And it's whether or not you need barrier layers, resistant barrier layers in conjunction with ET because in most sites in the U.S. that I know, ET is going to be the main component getting rid of precipitation.

At our site, ET is going to account for about two thirds. The barriers we need because our rainfall exceeds our evaporation potential.

So I think that we should always in most cases -- well, I guess I shouldn't say always. In most cases, I think we should consider caps first as an ET cover and then, do you need the resistive barriers to compliment the ET? And we should try to design the systems to compliment the natural settings that we have and optimize the ET before we even get to the barrier.

The other thing I would like to say in conjunction with some of the other comments, I know that at Savannah River site, the things that we do with the PA are taken very seriously for design and for operations. For example, I know from the work I have done with RE area, all the assumptions we have ended up going to the operations group and all the assumptions there are kept like a safety case basis and they have to maintain those assumptions that are impactive of operations. And think time there is a change in there, we have a process that we have to go through to evaluate whether that change that they are wanting to make impacts the PA.

Similarly, to our salt stone facility, we not too long ago, designed a vault to a new design for vault. Well, I represented the performance assessment on the vault 2 design team. I was actually put on the vault 2 design team to say here are the things that have to be considered from a PA perspective. And that was things like groundwater, height, location of groundwater. A lot of it was the waste had high sulfate loading so it was sulfate attack on the concrete, use of HTPE and the rad field associated with it.

So we made the design folks consider things that they might not normally consider because they were going to be impactive of the PA which we had two way communication. So I think some of that goes on and it is a very helpful process to have that.

>> CHAIR: Thanks Mark. Let's move on to the third question: And Ken, I think you already talked to this so I don't know if I should skip you over. I'm just kidding.

>> KEN: Recent studies has shown artificial compact will draw near the surface increase after a few years may allow release atmosphere due to desecration cracking, root growth, development of secondary instruction features between clays. The hypothetical model demonstrating no increase in radon release through the cover for 200 years. This water budget clearly shows the compacted both soil layer as the main barrier within the cover, however, significant assumptions were made to simulate this barrier. Again, independent lines of evidence or model of support can

be used to support the cover's most significant barrier of despite degradation process, as described above.

Or the other way around, to invalidate it? Jody, did you want to --

>> JODY: This relates back to one of the questions we had in Session 2 about the balance of the effect and within the program, UMTRA program. Right now, one of the questions we are asking is can we just allow mother nature to take her course, let the vegetation develop and as you indicated in the question, that can cause some cracking, cause a whole lot of drying which is probably the moisture fill in the pore space and radon barrier, is probably the more important barrier for radon attenuation. So it is an important question in these tradeoffs.

I think one of the first places we have to go is back to the assumptions that went into these early models, really conservative. They assumed really dry condition to begin with, okay.

And what we are monitoring now is much wetter, so start with that. Another thing in questioning the early assumptions that the highly radioactive material and most of these tailings is down closer to the bottom and there is very low activity on the top.

So you got this de facto radon barrier perhaps over the surface of the tailing so that kind of begs the question when we revisit the actual design based on assumption, do you even need that radon barrier?

Is it really performing this key role when we are suggesting that it is in the design stages? And I think we have to revisit all of those. If it is, if it is critical, then, we probably will have to keep the plants off -- try to keep it moist and because that's -- would be the first line of defense and that's why all these things were built to begin with.

>>SPEAKER: I guess if I were going to add to that, I don't think we have to worry too much about plant intrusion into the waste because the tailings are very salient and usually have a PH of about 1 or 2. And so than regard, there's almost a chemical barrier to plant roots and of course, the uptake by plants because it would be toxic to the plants and the plant

would die and undergo some type of stress.

In terms of the tailings, contaminated soil are -- likely contaminated soils were put on top of the tailings before the cover was placed and so those typically provide an extension to the radon barrier. And so for instance, if these were sort of to migrate naturally and the ET type covers, that we would have a very thick cover that could -- you can't allow some soil formation processes to occur in the top of it, still not lose your infiltration capacity or still prohibit infiltration at depth.

And one of the things that I was saying about modeling is that really, you know, you can't stop the modeling at the top of tailings because you have to look at how the water moves through the tailings. And even if you predict ET modeling or some kind of simulation that you do that you have filtration through, the radon barrier is still not going to move very quickly through tailings because of the low unsaturated hydraulic of the tailings.

And so my proposal is that we look on each at each site on a site by site basis -- the whole idea is to reduce maintenance. If they don't have to go out and cut trees and spray and so forth, then the maintenance costs are reduced and can we allow that and allow these things to go through the natural progression into an ET cover.

And you know, probably siltation of these rock covers will provide a soil rock matrix. And towards the end of the UMTRA project, they started making rock matrix covers because it was realized that was the in-state and some of the earlier ones were just straight rock. But we can look at those on a case-by-case basis and see which ones need to undergo some additional engineering processes and make sure they still meet their performance assessment.

>> CHAIR: Thanks Kent. John?

>> JOHN: I would say, again, first thing is the PA flux because this is inconsistent what we heard at this workshop. These properties do change.

But the other thing is the question would be since we have a lot of systems just like what you described that are real, what you can do is just go measure radon at all those sites and see if it's within dose standards. And if it is, then, this is adequate.

>> SPEAKER: John just said what I was going to say since I don't work in this part of NRC, to me if you want to validate or invalidate the impacted clay barrier this scenario, do what Craig Benson said. His reason why most of us are engineers because we want to know how things work. And if they are working, go out and observe it, take measurements for radon over the top, take measurements for uranium concentrations underneath.

Those two things will tell you a lot of if it is working or how it's working.

You might need to understand that there is a lot of variability in both of those things and not to misinterpret them. But if you have a lot of facilities, and you can get some direct information and if it's not too expensive, that seems like the quickest path to getting where you need to go.

Given that, I know there are a lot of solutions that can be made even if you observe some things. So as Jody indicated, the radon, one of the biggest things is the presence of moisture, that and the presence of moisture. Thick cover, wet cover, thin cover, low moisture, high radon. And of course, the interesting thing with mill tailings or in uranium in low-level waste sites, is you are fighting two competing battles. So things that you might do for radon might be bad for mobility and vice versa.

>> CHAIR: Anybody else from the panel would like to comment on this?

>> SPEAKER: I would like to make one comment on these compacted clay liners as well. Craig touched on some of this that the exchange processes that happened in these clay liners and how you tend to go from a packed sodium clay to a calcium clay that you're going to desecrate and shrink your entire material.

I know that one of these potential hypothetical models and probably not including some sort of precipitation input or even dust input that's going to move a lot of calcium material through the profile that actually intercepts these clay layers. You need to have exchange and removal of sodium in this exchange of removal of sodium and replace them with calcium and they you're going to get these not necessarily desecration cracks but natural shrink swale is going to happen.

So when we talk about perhaps if we want to decrease radon, we are going to have to add water to these if they do dry out. You may want to be very careful about if you do, say put -- you're in the west and add a lot of hard calcium water, you may in fact dry desecration even more. Or if you were back east, and you have a lot of sorid water, you may be able to put that right into that material and have it sorid it up and seal itself on its own.

>> CHAIR: Just hang onto this microphone because the next question is for you, not by yourself but you're the first one listed. I am not going to read the front part because it is pretty much the same thing but in this case now the main barrier has been identified as evapotranspiration, in other words, the roots picking up, marker was saying 70 percent in Savannah and so forth. Now, you're looking for confidence for the next 500 years. You saw it before.

>> SPEAKER: I was hoping to hear it one more time but that's okay. Independent lines of evidence.

Well, I believe Jody's probably got the best idea of the analogs. If you look around the landscape and you need to validate that your ET covers is working for 500 years, you need to find out that's amenable to 500 years and see how it's evolved. And that goes back to Gerry's landscape modeling when you put an item on the ground surface, it's going to evolve even over 500 years. If we don't have a clear understanding of how that may evolve, we may not know where those nit points are going to develop and where erosive potential is going to take place. And we're clearly not going to know what's going to happen over the next 500 years, with transpiration potential and precipitation.

At a minimum, we can't look at an analog soil and determine what happened to that over the last 500 years. I'm not sure how we can have extreme confidence in what's going to happen over the next 500 years to an ET cover. Even though we may engineer it like crazy, you have to have a lot of confidence about the analog soils.

>> SPEAKER: Second of course, what Todd is

saying there in trying to develop the screen scenarios of what changes might take place, another value in that is bounding those scenarios that are reasonable future stakes that we may have to deal with in that time frame. Oftentimes we get the question from stakeholders and others as well, what if you have two times the precipitation, three times the precipitation, four times the precipitation over that? Well, that may not be reasonable and if we're reconstructing climate, and from climate models or reconstructing climate, we can bound and say, well, no, the last 10,000 years, about 150 percent precipitation has been the max.

More reasonable upper bound for that scenario. So it is really important to define what those scenarios are and screens we talked about before, what those reasonable scenarios are that may occur, changes that may occur in the soil of the climate and ecology over that period of time. And again the analogs are probably the best way to do that.

>> CHAIR: Anybody else from the panel want to comment on this question?

Dave?

>> DAVE: What I would add to this when you are talking about performance confirmation for ET covers, I think it is important to evaluate the stresses and events to that, to the ET cover, which would be things like climate change. Joel Hubbell showed an infiltration test they did to try to look at increasing infiltration whether it's climate change or manmade sources.

The Hanford barrier fire looking at the effect of fire on the vegetation and I think you have to consider biotic too, extreme change in biotic and the one thing I would point to that came to mind might not apply to sagebrush but other types of materials would be like something like locust. I remember reading an article about locust somewhere in the midwest where they were coming on and they were so aggressive, they would eat the paint off the house.

So, I think like just that mentality, though, what are the stresses to your vegetation and your cover? And then, either having your performance confirmation with elements to look at those stresses or if you can do some direct things to try to measure, and look at analog.

>> CHAIR: All right, thank you David.

The next one, is it possible to set up a screen framework of scenarios for the future?

I have an example. I'm not sure -- and Jody is the one I was talking to about this and that idea just kind of intrigued me. And I wanted to see if Jody had a few sentences to make about that?

>> JODY: Sure, that is kind of what I was talking about earlier in a presentation earlier, trying to screen those scenarios. I did it in Yucca Mountain and maybe not describe in that detail but possibility, yeah, certainly, I think it is possible.

How realistic are these scenarios? You have to go through how good is the analog. You have to go through that screening process. So yes, I think it is possible.

>> CHAIR: Hans?

>> HANS: I have a quick question for Jody: How can you looking at different scenarios, how can you quantify those with regard to actual performance

modeling? How would you take that scenario and give it some quantitative aspects? Boundary conditions, infiltration; is that possible rather than just talking about vegetative cover and all the things you talked and actually get down to the details of the model?

>> JODY: Well, we attempted to go to these analog sites and measure what were the key parameters. And I think there is probably, the first place you would go and look at the uncertainties just as you would in looking at parameters for modeling of current condition, look at the uncertainty of the value. You take probabilistic approach like Cliff had proposed in his paper in 2002.

>> CHAIR: Anybody else want to comment on this idea?

>> SPEAKER: When you are looking at a performance assessment, for instance, I think in terms of the long time frame, one of the critical things is what happens with erosion. And for instance, if you have erosion, your ET cover gets thinner or conversely, you can have gullies going into the waste.

And what's most important is what kind of storms you assume that you are going to analyze for your performance assessment and the occurrences of hose forms. For instance, if you have a lot of say short low intensity storms and you're distributing your rainfall like that, you may not sufficiently anticipate the facts of erosion on your cover, and whereas if you have a couple of very intense storms, your cover may fail almost instantaneously.

And so the way around that is to keep the cover slopes low, less than 4 percent, limit the amount of run of the cover slopes. And we also for conservatism, designed under bare soil conditions, because you have less ET that way. And of course, your road supports are much greater under soil conditions.

So that's how we sort of perturb the model. This was for the MDA TNL performance assessment at Los Alamos.

>> SPEAKER: You mentioned the Yucca Mountain Project features of instant processes approach. That was a bottoms up approach.

Several of the European countries now are saying that we have enough experience that when we are looking at repository sites, we can pretty much take the lists that have already compiled. But one of the big problems with this is communicating what this all means. And so they say that the more -- since we have a lot of experience and we don't need to do the nitty-gritty bottoms up for similar systems when we propose them, the thing to do now is to make a list of your safety functions within your system.

Here are all of the things. How do they provide safety? And then to group your FEPs around them. And they say just when it comes to explaining to people where increased infiltration, rodent burrowing or whatever comes in, instead of talking about features of instant processes and having their eyes glaze over, if you say, this is something that meets this safety function here, and this barrier here is designed to protect against that particular FEP, is just a way of turning things from a bottoms up to a top down approach. That's really much easier to explain to other audiences, just something to consider.

It's not perfect yet, but, the Belgiums, the French, are collaborating on how to write this up so it is usable as a communications tool as much as anything.

>> CHAIR: Next question is the idea of this catalog of analogs.

I heard that from Craig Benson, just wanted to see if Craig wanted to give a little more detail on that.

>> MR. BENSON: One of the things I see as a I listen to this and I think about it as an engineer, I have lots of information about near term performance and maybe over several hundred years that we can make predictions. But when we talk about very long predictions, the analog is going to be really the main stay of our ability to at least, bracket what the future might hold.

And I also think that's the hardest piece of information that we have to get at. We have lots of information for a lot of engineering properties for geomembranes and swale materials that we're using in containment systems, but information resource on analogs I would argue is probably less diverse and less filled at this point.

Like Todd's presentation about what you've been doing in your area and characterize the long-term analog for that area. And Jody's done some for DOE sites. What I was wondering is whether we could create actually -- if we looked at potential disposal regions or areas, whether we can actually go and create catalog of analogs where we might rather than waiting for a site to come up, but actually go out look at it, what is the likely scenarios where we might place these facilities and start to begin that investigation. Do you want to characterize what are the long-term hydraulic properties, the long-term vegetation properties, likely climate change that we might see in certain areas and create this kind of catalog of information which mimics the catalog of information we have right now for near-term engineering properties.

That was an idea that some of us have been talking about probably for some years now. I would like to get some feedback from Todd and Jody what you thought of that concept.

>> SPEAKER: Well, it's funny to see this word catalog of analogs. We have a report that we wrote for the Department of Defense called Catalog of

Analogs, Soils of the Middle East in reference to Yuma proving grounds.

So their main goal was to can we test this piece of equipment in Yuma and how analogous is that to this area of Iraq or Afghanistan. And they loved it. It came out really well.

So they think the possibility of making such an analog across the United States would be a real doable thing.

And I could see it being really useful. I think that how different soils evolve -- for the long-term simulations and perhaps more on the research side than the performance assessment side.

I keep hearing that we have to draw that line between the two and I agree, some of this may be overkill but at the same time, the possibility is there as I think EPA was mentioning, that if the opportunity is there and money is there, it can be done and maybe it should be done regardless.

And soil will evolve and we know that and to develop a catalog of analogs would benefit I think the engineering community as well as the scientific community. Just to be able to put everything into the context of what the possibilities are and having some place to test and measure that and even follow that with time as well with instruments in the barriers. And see how they look and compare with instrumentation on the barriers and see what major differences we are seeing through the course of time, go further up slope to an older soil and see what that is showing us as far as maybe carbonated accumulation. But I like that word catalog of analogs for sure.

>> SPEAKER: Others aspects of, this we are not starting from scratch. Folks in the ecology community, soils science community aerial climate, people doing aerial climate reconstruction in regions around the country. People have looked at plant succession different places around the country. There is a lot of information to be gleamed from a lot of work that's been done in the natural sciences in general could go into a catalog. And you don't have to send out people like Todd and myself and Terry and Steve and start characterizing this from scratch. There is -- a lot of information is available to us.

>> SPEAKER: Later this year there is going be an open file report from U.S. GS which is basically, a short version of a very long compendium of language logs that we considered for the Yucca Mountain project, but the more germane one is the put out by the Spanish put it together, a very nice catalog of both low-level safety, high-level waste potentially useful analogs.

And so, you are right on the mark. That was basically, a starter. They are hoping other people will pick it up and expand it.

And so, there are starters already and what you're referring to is something that could very nicely be added to the catalog that they have already created.

>> SPEAKER: If I can add a comment, but in a different time scale you're talking about, but Craig's commented that there is a lot of data around; I would argue there is still not enough data around. And in his presentation this morning, George said that data from the 2002 report, that's basically ten years since that data was collected, we should be collecting more of that data, I mean it's being collected but goes in reports and nobody's really analyzed it. It needs to

periodically collected again, re-analyzed so that we can continue to learn how the engineered systems are behaving over time.

That's not an especially expensive thing to do but, it needs to be done, not just once but regular but on a five or ten year basis.

The other plea that I would have is that when facilities are built, and I have encountered this when you go to exhume them 20, 25 years later, you don't have the original materials to compare with. Particularly an important program project, I would like to see samples of material actually stored and cataloged and somebody making sure they know where they are so when somebody does go back at a later time to look at them so we can really compare apples and apples as opposed to trying to backfield what the original was by looking how its performed over time.

>>SPEAKER: Could I ask one more related question? I agree with you, Terry too, we need to do it on both ends. For both Terry and George, one of the interesting things that was done in Hanford when they looked at asphalt barriers, as I recall, they went back

and looked at natural asphalts and analogs, natural asphalt deposits. And I wonder if there are some analogs with natural polymers perhaps, not polythene because that's certainly an engineered problem but analog that that might be in the environment from which we could look at long-term degradation processes, that may be too far fetched but I thought that height be a part of catalog of analogs as well.

>> SPEAKER: I'm not aware of any natural material that is really sufficiently close to HTB or polyethylene that could be used in analog. Maybe George knows.

>> SPEAKER reactor that maybe rubber at the best but, it's provocative but no, I do not know anything that simulates polyethylene.

>> CHAIR: These remaining questions or last three are the more general questions but before we go on the this took would anybody out here at the table has had a question and George will hand the microphone?

Terry: I support the idea of the analogs and talking about in particular, ET designs.

Very useful, critical, should be a major part of our plaining aspect.

But in that process, I would caution us do not forget about the wild card, the catastrophic event that can occur. So I think we need to design around using the analog as the basic concept to design around and then test that against the what because in ecology, it happens.

Anywhere in the United States, anywhere in the United States, anywhere in the world, you're going to have a catastrophic event in this team frame we're talking about. When we talk about 200 years, or 400 year in vegetation, that's nothing.

I mean we can go the entire eastern forest, in the United States changing composition the last 400 years. We have had major dramatic events throughout the southwest and episodic events. They are couched as being different types.

South Texas, you have a hurricane come through, Buelah came through, dropped 42 inches of presip, 50 miles in on flat land.

You know, those are the event that do happen sooner or later and we just need to be aware and test our designs. What if the sagebrush suddenly disappeared? We are in sagebrush decline in the western U.S. So what happens if we lose it for whatever purpose? Then what happens? So just a word of caution.

>> SPEAKER: I guess I would add my support to the idea of catalogues for erosion as well, but the one thing to keep in mind with erosion, just like the U.S. DI, that was done, an awful lot of work on natural erosion and erosion and agriculture system. But the sort of structures that we are looking at very different shapes and they have very different properties. Soils are not soils. They in a lot of cases broken up rock very far from any sort of naturally equilibrium. And we attempted to do a little bit of this in the 90's to try to band the predictions on Siberia and give some confidence. But it would be really good to actually do surveys of poly (inaudible) you go back to Europe where (inaudible) are 200 years old, where you should measure the infiltration properties, the erosion properties try and reconstruct some history on them and actually measure them.

One of the big problems we had, (inaudible) measure the land forms in those days, we can actually treat that sort of stuff and get very accurate information. So I would add that to the list of analogs.

>> SPEAKER: When we are looking at the catalog of analogs, one of the things you ought to be looking at also is what's going on in the deeper zones greater than two meters depths for both of these sites because we need to know what's at the depth of interest which is our waste form which is going to be below grade.

So knowing what going on at the surface is important but knowing what's going on at those deeper depths is critical for long-term. What are fluxes? What's moving?

>> SPEAKER: I would also like the put John Walton on the spot with regard to catalogues of analogs and what we might be missing and how we can capture that uncertainty with the analogs that have disappeared over time.

>> Well, I'm certainly no expert on analogs.

I just have made comments that I think other -- Dave is referring to the thing, that analogs are problematic and that we know what's lost but we don't know the initial or the starting conditions. So they are inherently biased because we don't know how many nails were (inaudible) we just show how many somebody dug up and they are preserved. And that's the fundamental bias of natural analog. And I think people are aware of that but you have to be extremely careful with natural analogs that we are aware that it is not an objective thing at all, it is the rare case that we are picking out and we have to analyze them that way.

That's all.

>> SPEAKER: The one thing I would add FOR this, that these people to think about how stable or chaotic these system are that we are looking at using analogs nor because if your system is reality stable, then, I think you have a much paper success of using analog and eventually, that it turned out that you made a good decision with it whereas if your system are chaotic or unable, it's a small perivation in the conditions today can lead you at a much different

pathways in the future. And so, the soil science I think is a good area looking at the natural soils and how they have evolved can hopefully be used as soil engineering or something here.

We can definitely learn from those experiences and hopefully try to determine when we are in that more able night example when we rain that more chaotic state.

Investigate at go to meeting would like hook a question, anybody? No.

All right, it's 12:30, and you been very patient. Thanks a lot and I want to thank the panel.

I think we got a host of really good ideas from the panelists today which I thank them.

We missed the last three questions information gap, recommendations for guidance and for future work. We will try to capture those ideas during Session 6. Thanks a lot.

And 1:30.

Lunch break taken)

>>CHAIR: Okay, if we could have everybody's attention. We would like to begin our final session. Recommendations on Assessing Engineered Barrier Performance, Identifying Future Research Needs and Discussing Existing Guidance.

So we've had many sessions.

We have 1, 2, 3, 4, 5, 6 sessions. The first session was states overview chair by Susan and Steve salmon who dock was their reporter and I would like to introduce Doug with the NRC and in the uranium recovery group of FSME.

Doug.

>> Hello, everybody hear my okay, him in the uranium recovery group. Been at the NRC about three years, technical reporter for the states way back on Tuesday morning.

So not only do I have to super rise what happen more than almost three days ago but I also have to do it right after lunch.

One other quick comment is that at times over the last couple of day, I realize that sometimes the benefits of being a regulator and that walk ask a lot of questions but we don't necessarily have to answer them. That is up for licensee does.

So sometimes that is good and sometimes not good. I only got one slide will do more than just read those because if I just read those, it would take less than 12 minutes. The first thing I kind of picked up on in the presentations in the states was the limitation of the current status.

There is a lot of uncertainty in identifying reasonable design periods.

Those time periods and there is a need for a lot of times for direct NRC guidance early in that process.

The modeling and monitoring approaches are non-uniform and lot of that relates to different site conditions and the theme that kind of jumped out at into, everybody developed site specific approaches and to a lot of consistency for what was done or Texas.

Another part of that is that regulatory frameworks can be very different depending on the waste type.

There is it can be some different figures between the low-level safety uranium mill tailings but at time, that can be difficult to explain to the public as far as why something is done at a certain site but not some place else.

Another thing that popped up is that those requirements often change over time and I'll talk a little bit about that in a minute.

One other aspect that we noticed is that there is a big difference between a site that has not been built yet and a site that has been built.

A lot of times you're forced into dealing with a decision that was made a long time ago and that can really lead to a lot of uncomfortable situations and can be really more difficult to deal with.

And I was just thinking about how do you go back and develop a monitoring strategy for a site that's already been built and it's you're in a really tricky spot.

One thing that has come up in some of our discussions after is just the difficulty in being able to make a decision and the need to make a decision.

Mark talked about this a little bit this morning and Larry and I talk I had about this as well, a of times we have projects going on and heed to make a decision and can be an intimidating and confusing to try to hear what we talked about the last coup become of days and to be able the really make an informed decision that you have tomorrow basis for.

And the last thing I was going to mention on this current status is kind of reflects some of those other issues that communication with your stakeholder is important and you need to make sure you're doing that and you doing that in a way that is effective and you can recognize those uncertainties and the limitations of what you're doing especially when it comes to modeling. You don't wants whether over and better be up front as you can be and acknowledge it.

As I mentioned, the second thing is consistency. The approaches that we noticed tended to be very site specific and a lot of that comes out of the regulatory approach but also the waste forms can those types of things and can make it difficult some times to explain those different approaches and why something worked some places and don't work some place else.

That relates to the waste forms and this kind of goes back to the new site verse old site issue.

There is a lot of things if we could start now but some of those things are already done and we kind of have to live with them.

In terms of the cover approach: Water balance covers look to show potential in certain areas. And I would think in Colorado and Washington, they recognized and seen that there is some benefits to those time of approaches.

The barrier type covers seem to be more appropriate in more humid environments but also in some of the arid environments. One of the important things you should remember is that the containment design performance can be enhanced by geosynthetics.

Part of -- one thing that is important here is that the cover approach is dependent on a lot of things but an important one is the regulator familiarity and comfort, and drive a lot of times is what approach is used in addition to the location.

One last aspect of the cover approach is that performance monitoring after the cover is built is important to substantiate the analog's condition. To be sure, we talked about this quite a bit over the last couple of days to make sure what you analyzed, you have some data to validate that and make sure that you are accurate.

In terms of flexibility, one thing that was apparent, knowledge, experiments, materials and public policy will all change over time.

And this is especially true for regulators industry, you learn things different, just learn from your past experiences.

But the -- kind of the difficult ones to work with there is the public policy. You can end up with a vastly different scenario than what you initially envisioned. And one thing interesting that was interesting to hear as well is recognizing that materials change. That can be your natural materials properties but also your engineer materials and listening to Dr. Koerner speak, that didn't exist 20 year ago and to try to be in that kind of a situation where they may actually be better but, there is kind of a time lag to be able to gain that experience to know whether its really better or not.

Following along with the idea of flexibility is improvement. It was a bit apparent that we need to recognize that we will learn things and you have to have the ability to make those improvements. And two specific examples I can think of it was the radon barrier and that just came out of knowing more about the site.

Another example would be at the Barnwell site where they developed the enhanced caps in response to seeing the tritium issue there.

And it is important to make sure that the containment system monitoring is integrated with overall just to make sure you are performing as you want to perform.

One thing that came up I think initially during our discussion on Tuesday was just the need for funding. And this has kind of popped up again, at a couple of different times during our meeting.

This follows along with the flexibility and improvements, but the need for a full cost accounting of the long-term monitoring and maintenance and to the importance of having a clear funding source or solution for those long-term monitoring. There is many different ways you can do that but you need to make sure that mechanism is there and that if there is a way do that.

And one other thing that's come up several times is the difficulty in being able to completely walk away from a site.

You know, we talked a lot about monitoring and then, maintenance and how things change and to think about those thing, you recognize that it can be difficult to actually get to a point where you can walk away from a site.

And is that really appropriate or not? The last thing that I was going to mention was just talking can community of the practice.

Sit apparent that there is a lot of work going on to try to come up with a better understand for cover and develop covers develop better covers but like I mentioned before, a lot of time, it seems like those kind of things are focused on a particular need at a particular site.

And it's been good to have all of us here and be able to learn those things that are different but we need to make sure that this happens on a more regular basis one of the recommendations was maybe something like this should be consider today be more often maybe annually and if we can't do this time of settings, maybe already other methods we can set up to the part petitioners and regulators have an ability to talk and listen and bounce ideas off each other because we don't always have the resource to be able to contact the experts or those types of things.

So, that's my slide.

>> Thank you.

S thank you very much.

That was an excellent report Doug.

The next one will be on the federal overview also part of session one, the chairmans were Jake, Phillip, Brian and the reporter was George Alexander.

Jake?

>> JAKE: Thank you. First of all, I would like to thank George for putting together a summary of meetings and took excellent notes and gave me a whole range of grades. I will go through a lot of them really fast and just hit the most important points. And I want to thank Brian for helping us put together together these slides.

So I'm going to go past these slides because these are just summaries of what was talked about but let me go back to the last one which is the research needs and panel discussion because that's the part most important for us.

First one was, monitoring immediately adjacent to the containment structure.

That is an extremely important issue for us. We have just worked on a new reg document on tritium releases at the Brookhaven site. And one of the things that really puzzled us and was a real eye opener was that they didn't know about -- they had the monitoring well but it was six years before knew that any release was taking place.

So they had to come back after long period of time and lots of tritium had gone out into the environment.

This is a B&L Frookhaven new reg report currently under review and should be out about the public domain within -- this month.

This is also very important issue at nuclear power plants because based on new regulations particularly, 20.1406 and the tritium releases at many nuclear power plants part of our guidance in reg guide 4.21 which is minimum fish and contamination, has asked for monitoring very close to radioactive components or radioactive structure systems and components conducting radioactive fluids. So in other words, you have to have a good design that prevent any releases.

We understand and we know that you cannot have zero releases so what we are saying is that you have to detect it as soon as possible and then, remediate it soon.

In this connection, I also like the talk from Mark talking about settlement because it was low activity waste to do the experiments to look at dynamic compassion, how much it is going to settle much in advance of even going ahead with the dynamic settlement tests for the actual facility. That is one aspect of things that we would really like for the sites.

Deep monitoring and we have talked a lot about it in this session and particularly, we had a lot of focus on the cover materials but like Ken talked about and others, we need to know what is happening the waste material. So we have talked about this in our group research for really finding out what is there under the waste and the unsaturated zone.

Joel's talk about the work they are doing was very relevant to this meeting because he's doing that stuff basically to verify or validate some of the models that they have on deep Vadose contaminant flow.

Field measurements with regard to scale, that is a really important topic.

We for many years have known about just to give you an example, the flux meter that we have developed by Glenn looking at the fluxes from the covers. And what we found out from Craig's research was that the flux meters may not take into account the heterogeneity particularly if you look at many of presentations talking about preferential flow and based on the work that he did, they did have very large lysimeters. And that is something we may want to think about.

Continuing use of performance assessment results to prioritize research, I mean that is an important aspect. And years ago when we did a performance assessment methodology for low-level waste disposal new reg 1753 on Dave's early slide and you can get that from our Internet site.

When we did performance assessment at that time, it was not very advanced at that stage and looking at the properties of the cover materials, giving some distribution on the properties. And what we found out and basically the question from me and others in our group is what would you assign for the hydraulic conductivity of clay for instance, if there was a concrete barrier?

And we always thought about a narrow distribution showing very low probabilities. And when that happens, then, the performance assessment the way it is done, then will show that nothing comes out for that particular period and everything comes out after that when you assume the cover. So that is why we needed more field scale measurements of these properties for performance assessment.

Independent measurements that complement each other, I think that is an excellent idea and of course the important thing for performance assessment would be like giving flux through the covers for instance and moisture content and direct way of doing that. To relate that to the flux is a difficult issue. We need to look it into.

Finally, direct measurements and water potential with respect to timing, it goes direct to the previous item, basically, getting those types of indirect results which can somehow relate that to flux through the materials.

I had a brief conversation with Loren Setlowe who worked on -- who was not part of our group and is working on revision or looking at 40 part 192.

That for us is very important because everything that we do is related to some target and the target must be NRC legislation as long as -- as far as we are concerned. Sometimes we face a little bit of problems because for instance, most EPA regulations are concentration based and ours are more like flux based.

So when one we were looking at radon emission from some of the sites, yes, we saw some good results as far as concentrations were concerned. We were wondering how would that relates to our regulation where flux is concerned.

That's basically what I had to say and if Brian, if you want to add anything to that.

>> BRIAN: I didn't have anything to add

other than just to Thank George Alexander again for doing a grate job. We appreciate his efforts.

Thank you.

>> CHAIR: Thank you very much Jake, Brian and George.

The next session, session 2 focused in on degradation processes, session chairs were Craig Benson, Jody Waugh and reporter Brooke Traynham from NRC and also Vanderbilt University.

>> All right, I thought Jodie and Craig were going to join me up here on the panel. Apparently not since this was your session.

All right, I'm just going to begin by giving a brief overview of some of the talks because there was a large variability in the topics that were discussed.

The first was Jody and one of the major points that he talked about was the idea of unintended ecological consequences. And in my opinion, after his talk, it can no longer be considered unintended because we are now bringing to light some of these ecological processes that are used to being neglected when we were designing these covers.

The second idea was the idea that we should be designing these covers and renovating covers to seek the minimization of the maintenance needs. And this of course is going to reduce the overall cost of maintaining these covers and hopefully, bring some of the long-term issues to the near term when we were initially designing them.

The second session was Craig Benson and he discussed some of the soil development processes that will be influencing the performance.

And one of the first ideas that he brought up and one of the first times it was brought up in a conference was how mother mature is going to be altering the engineer's conditions in a very short time period. And they brought up several field examples of how this is occurring on much shorter time periods than we original thought. And the idea behind this is very simple, some of the denser soils are going to become looser over time and the structured soil will be gaining structure.

And the questions that come out this is what kind of structures will be developed and of course what time scale will they be developed on? Craig also mentioned the hydraulic properties of the finer grain soils and how over time, regardless of the initial condition, we are seeing this trend at all of the sites that they are becoming more similar. And this is actually a really interesting observation because you know, if it -- if the humidity and the temperature of the site is really irrelevant to the hydraulic conductivity we are seeing 10 to 20 years after construction of the cover, that is really powerful information, especially when we are trying to model the system.

The third talk was by Gary Willgoose and he discussed a much grander scale process, the geomorphology. And this is something I have not really heard discussed very often. I did my dissertation on engineered covers and this is something that was pretty new to me which was the idea of trying to model some of the points on the cover that might be good candidates for armoring. And this is going to be the most sensitive points to erosion over the long-term.

The big take home message from this process is that the erosion is not uniformly spread over the cover.

So, it's up to us to once again, try to predict where those points are going to be.

The fourth talk was Steve Link and he gave us a really nice overview of some of the vegetation observations that he made working out in the arid west. And one of his major recommendations was we can't really predict what's going to happen to vegetation and therefore, his argument is that we should by keeping a database so that we have a lot of information available.

And the final talk was looking at yet, again, another aspect of cover preference and geomembrane and geosynthetic.

Kerry gave us a really nice overview of the short term and long-term, our risk to the GM degradation.

So I'm just going to -- the next two slides are an overview of some of the major degradation processes. And the first is a list of physical processes that we identified throughout the session.

And we talked about freeze thaw, differential sediment which a lot of these came up in many other sessions as well, retention of the burrow soil structure, and this included the (inaudible) during that construction. The UV degradation and the thermal degradation which is really specific to the geomembrane erosion, and the pedogenesis.

From the biological side of things, this was brought up over and over again, this idea of unanticipated ecological consequences of design. And one of the major risks to the cover is going to be the biointrusion into the compacted clay layer. Burrowing organisms and roots are two of the major intrusion.

And third was the chemical processes and this was once again, really focused on the geomembrane and that was the oxidation and the exchange mechanisms.

So two of the questions that sort of guided this session in some of the researches, how can the degradation process be minimized and what strategies can be used in order to reduce some of the impact.

Quality assurance, this is something that's going to be in some of the other summaries as well, come up over and over again. And it's very important to ensure the quality of the initial state of the cover before we start looking out in time and figuring out how we can fix or predict some of the longer-term risks.

And it's also going to be important to identify the processes that are actually going to matter. And as someone a spent a lot of time trying to parameterize biological components, I can tell you, it very difficult. And the first step before we actually try to parameterize a lot of these variables, is going to be figuring out which ones are most important.

So, which plant species or which function of the plants will be the most important. It's also require us to understand the total system.

This is aother idea that's come up over and over again.

>> It's great to look at a component like vegetation and it's important to have a database but ultimately, it's really only going to be important in the total risk of the system.

And finally, Jody recommended that we come up with uniform intruder scenarios and this is ultimately going to be determining the performance objectives and the cover features that are going to be related to the objectives.

This is just a continuation of some of the overriding statements that were made and the further away we get from equilibrium, the more energy that's going to be required to maintain it.

That's why renovation is now an option for some of them. The tradeoffs are going to be present throughout this process. And so we need to figure out as we tried to diminish one risk, how that will affect the other risks. And we do not want to increase the risks of certain components just by trying to mitigate others.

And finally, it's going to be important for us to not only define all the specifics of the components as we have done on some of these talks but also to understand how they are going be coupled together and this is going to be guiding into, meeting into the modeling.

So these are just the list of the challenges from this session and the first is gaining long-term insights from our short-term monitoring. We don't have a lot of experiences with the covers so trying to make long-term predictions is going to be difficult. Can the predictions of the long-term impacting be evaluated effectively in the short-term?

We don't really know that yet but that's one of the things we have to deal with.

Scaling is a major issue because a lot of the data sets that we have, especially with the biological components are short-term. So how are we going to be able to scale that up to over long time periods?

Developing future scenarios; this is going to be very hard to try to standardize across these sites, something that we are going to need to work on.

The designing and monitoring plans must be guided with the end point in mind.

Understanding the rate of evolution of the echo systems with develop levels of engineering. If the evolution of the echo system is going to be happening in a humid site at a much more quicker rate, then, it will be a very different host of components that we are going to be looking at.

Disturbance: Disturbance is something that is going to be another a major challenge, is going to have a much greater impact on a system that's not an equilibrium, where the natural feedback systems have been disabled.

And this is just another brief discussion on the time scales and it's going to be really important to understand a range of the time scales that these degradation processes will be operating on and this starts all the way from day one. We talked about quality assurance and quality control for construction so that from there, we are moving up to our daily and seasonable time steps, so this is going to include precipitation, temperature. From there, we are looking at annual and tens of hundreds of years and this is going to be plant succession.

That -- when you are trying to parameterize something on a daily time step compared to geomorphic time step which is tens of thousands of years, it's going to require a much different level of refinement. And finally, soil structure is going to be developing on -- the soil structure is developing on much shorter time scales than thought. So this is going to require us to refine some of our pedogenesis and some of our ecological time steps a little better.

So in summary, unintended consequences must be considered when trying to diminish one form of degradation. We don't want to encourage other forms of degradation by trying to diminish one form. The function must be clearly determined. So, having a database of plants, that's if that's one of our goals, we need to have that in a context and understand how that's going to be helping us in the total function of the system.

And this really highlights once again the importance of understanding the function of each element within the total system and delineating the management pathways.

This probably is the most important slide which is the recommendation. The first is going to be investigate the long-term performance of the geosynthetic materials within the low-level waste environment.

There are several mechanisms, degradation to the GMs that were brought up in this session. So this would be an area of potential research.

Validation of land form evolution models, the

LEM model that was presented was very interesting and has yet to be really been applied and analyzed within the context of the covers.

So that's going to be an interesting research area.

Developing the guidance on vegetation design. This is going to be important, plant properties will is be promoting sustainable vegetation that will essentially be planning the water balance of the cover.

The fourth is to link observe near-term changes to the soil hydraulic properties with the long-term observations from analog.

So analogs are one tool to really go out in time and try to understand and anticipate some of the long-term changes. So we need to be able to especially from a modeling perspective couple those with some of the near-term observations and the biological database that some people have proposed that we keep.

And finally, the last recommendation is to study how disturbance and catastrophic events will be affecting the vegetation and cover performance.

The idea that ecological components are

important is still relatively new so there is still a lot of work to be done in this area.

These are the questions that were presented at the beginning of our session and so I just wanted to put those up there to remind every one what was guiding us.

Thank you. Anything you want to add?

>> (No audio)

>> SPEAKER: We looked at changes in states but it's those big events that happen every ten years, 50 years and those with difficulty to capture and difficult to design for.

>> CHAIR: Thank you very much, Brooke, Craig and Jody.

The next session was focusing on monitoring. William Albright, and Craig Benson. And Robert Johnson was the reporter.

>>SPEAKER: My first slide was blank. Said I will be brief. I should have had my third point here about monitoring and modeling because it's been my experience that people who monitor usually have less to say than the model, kind of goes with the territory.

Tried to start the argument yesterday so I apologize for that.

A few general comments and then a little bit of suggestions about research opportunities. When we deal with covers, monitoring at least in my opinion need to be put in the context of direct measurement of performance which is always percolation.

It's so easy to get the calculations right from instrument data on percolation. It's so difficult to get any estimate of percolation that is a substitute for a direct measurement.

And we're generally big believers in drainage lysimeters for that purpose, put all the measurements in the right context tell us about performance of cover. And given that, other forms of monitoring whether soils instruments, or plant parameters or whatever, can be put in a good context and add a lot of interpretation and enrich understanding of how these cover systems work.

That was one point I wanted to put in there.

Second is most of us a with a few exceptions in this group have come out of soils and geotechnical engineering background and tend to underestimate the importance of echo process and this has been a really interesting group this week to see how much this group appreciates the importance of those processes and really design elements and cover design. Jody of course, everybody know's Jody's contribution to that and we have all become aware of that painfully so and some of us less painfully so. But we need to understand and probably develop better monitoring approach to plant and ecological processes.

Modeling can focus monitoring and monitoring can improve modeling. That discussion has to go back and forth. Recently at DOI, we built a new building and moved all the modeling, people that collect data in the old building, we talk to each other even less which is a really bad idea.

It's necessary. It's necessary to do both and we should keep that in mind. Each side and being more of a monitor, I tend to emphasize, I tend to see the mistakes of modelers but I know it goes both ways.

We always tend to go in our own directions and it is important to have these kind of talks and meetings to recognize that and actually I think Tom should be commended for bringing this group together, been one of the most interesting meeting I have been to. A couple of opportunities, deep vadose methods? Not very good and we all know that. One of the differences between cover monitoring and deep vadose, monitoring, the covers engineered system did appropriate to put it in lysimeter. But deep vadose situations are almost always undisturbed, natural systems and would be very inappropriate. But a deep vadose climate in a drainage lysimeter because you lose all the natural processes. So my friend, Glendon once suggested that sometime in his career he would like to see the development of one good vadose system and think that should be a primary research just to refine our deep vadose for monitoring.

Scaling vegetation and ET methods to landscape scales, knowing and including the stuff that John talked about and the remote sensoring stuff, that is really interesting stuff to me and leads to the next bullet which is a indicator of change. Sometimes these instruments can be remarkable sensitive, can see what we can't see with our eye and that's neat. All those different wave lengths those guys looked at, the communications have changed and water stresses evapertranpiration and some really neat methods and that is a really ripe area for development of methods.

One of the things that I think happens is this is the old monitoring/modeling controversy do not count, the data and how that propagates all the way through the entire system.

I think that's something that would be really good to do at least at the PA level, to propagate your uncertainty starting with calibration errors and going all the way through. And I think we will all be surprised at how large those uncertainties are. And I have to thank Kent personally for this.

I occasionally mentioned the properties of uranium mill tailings and the fact that there may little or no area moving though that. I thing that would be really helpful for those that design and look at cover systems for those facilities to get some data, even monitor type, again, I'm fascinated by the idea of being able to go out to a mill tailings site and it might be hard to remove a sample, take it back to the lab. That might be fraught with difficulties but taking in situ measurements or doing what we can to look at one of those sites and I think there may be some potential for that kind of thing.

I left out any discussion of what Bob Bachus had to say about subsidence. The subsidence talk was -- it had some marketing aspects to it and I thought it was a great idea for putting subsidence ad monitoring within a waste repository.

A brilliant idea of putting in just a flexible tube in there and monitoring what the pressure subsidence, that is a great idea.

So I think that is a good recommendation and I apologize for not putting that on the slide.

So this that's all I have. Any questions? Very good.

>> CHAIR: Thank you very much to Bill, Craig Robert Johnson.

The next session focused on modeling.

And I have to say parenthetically, what I said came true, the monitoring people talked about modeling during the discussion and the monitoring talked about modeling during their discussion. So obviously, they are connected at the hip. So I would like to introduce Dave Esh and Chris Grossman , Chris was our reporter and Dave was the Chair along with myself.

>> SPEAKER: I'll introduce Chris. He will go over our session. I had the pleasure of working with Chris for a number of years now. He's a systems performance analyst in the Division of Waste Management in Environmental Protection like I am, worked on performance assessment high-level waste, low-level waste and decommissioning sites; has a Bachelors of Science degree in civil engineering from Purdue and Masters of Science in environmental engineering from Clemson.

His interest include playing bad poker, the letter L and things that are shiny.

>> MR. GROSSMAN: Thanks Dave. I like to let Dave introduce me in anyway he pleases because I get to live vicariously through that and unfortunately, this one was true to form, especially the bad poker part.

I'd like to just provide a summary of some of the talks that we had and a list of the key recommendations.

We had six great talks I felt and covering a wide range of topics related to modeling experiences. We started out with large scale general performance assessment approaches and we delved down into more complex modeling level approaches. And then we finished up with some remote sensoring techniques and how to integrate that with modeling to assist the modeling experience. So on behalf of Bob and Dave if they haven't already expressed their gratitude, I would like to extend that for all the hard work and preparation that went into those talks. Thank you very much.

So now that I have softened you up with the gratitudes, I will give you a few of the recommendations that were based on my hearing of the discussions and the presentations and so, the speakers can ready their tomatoes if they see their favorite topic was missed.

I stated at a high level here, the first one being and these are not necessarily in the order that we heard them, but I like to arrange things in the way I approach modeling, so I start talking high-level, work down in the details, the data and then finished up with validation type activities, and then finally, the monitoring. And I think that is a good approach for some of the recommendations we saw here. The first recommendation being that modeling should rely on greater approach. And I think the examples being that initially, the scoping type calculations, you want to look at general processes, figure out what is important, use that information to drive data collection needs. The further refine models for your later iterations of your modeling exercise. And in the later iteration, you delve down into specific factors determine importance from the general processes in the beginning, and they use the results to drive indicators or to determine what indicators may be appropriate for monitoring space based on performance.

And so, that leads then to kind of the second bullet here with the system level approach.

There was a lot of discussion about modeling of the engineered system and its place in the entire disposal system or whatever the particular facility may be.

And then, moving on to additionally, looking the at integrated and coupled processes, particularly we heard things about coupling evolution type processes into the modeling, and as well as processes that respond to changes in other parts of the system so that we capture some of their behavior and the uncertainty associated with their behavior.

And since I mentioned uncertainty here, that's one bullet I left off but infused into each one of these recommendations is the proper treatment of uncertainty and consideration for uncertainty and both the data level, and the modeling level and how that affects the results of the modeling that was used.

This level of detail, well, the one I think unifying message I heard is "it depends" from yesterday's session. I think that is a good approach actually. It is dependent. It is site dependent. It is also a waste dependent. I think I heard that mentioned, it's dependent on the time period of interest for the particular site as well as the regulatory structure that the site might be operating under.

And so there are areas where you may need to devle into more detail of he processes, features. It may be instances where that's not as needed.

The 5th bullet here was data framertization. The messages I heard that field data is important, and that data collection should focus on what is sensitive or what can reduce the variance in our understanding of the performance.

Model validation, this was particularly true for near-term modeling exercises. This should rely on field data in that applying model validation to different sites is not a good idea, it's very site specific and should be done on a site by site basis.

And then, finally, true to the area nature of modeling, we come back full circle to the iterative approach and using performance assessment results or modeling results to develop indicators and then, link that to your monitoring programs so that monitoring focused on performance, in those criteria.

So with that, that's the summary of the Session four, and if there are any questions or if anybody wants to throw a tomato up here. Feel free.

>> CHAIR: The next session focuses on model support and you can see a progression here. The next session focuses on model support, Hans, George Alexander and Brooke Traynham was the reporter. George?

>> GEWORGE: Thank you Tom. We had quite a bit of time to polish this up in the last half hour so I apologize for any omissions and errors and hopefully, we can clear them up in the coming site, specific ERMs.

There were a couple of sessions we wanted to clear up that we start with the session overview: We started with Dave anbd Abe's presentations. Dave pesented on overview of model support and ABE presented on the activities that go into model support. And one of the overriding recommendations that we had out of this workshop is that the model support and all the monitoring should be risk-informed, should be graded and iterative and that is something that seems to come up in every one of our slides. And just everybody here has reiterated that we don't need the extent of model support that might be needed for Yucca Mountain project, some of the smaller sites.

And then, we moved into some more specific presentations. George kind of presented on geomembrane performance and model support for that. A lot of the earlier periods of performance relies on geomembrane. And then, moving into the longer term performance, we had to rule on natural analog, and Todd presented on pedogenesis.

Just a quick overview of model support: It is critical element in decisionmaking and confidence building. It's something that I think is growing in popularity and understanding with licensee and modelers.

One other point to make is the complexity of the model should not be greater than model support. And once again, model support activities should reflect risks.

Some of the best practices that Dave pointed out: That multiple lines of evidence are preferred, direct observations are preferred to indirect observations. Again, that would be risk-imformed, and that we have use of expert ellictitation. And preferably, this is independent expert ellicitation, not just a group of guys hanging out after work.

And we can use accelerated experiments and natural analogs for some longer-term model support that we can't get to otherwise. And also to support the full range of expected conditions, not only to capture some of the average but the more extreme events as well.

Just a couple of the information gaps; I'm afraid we didn't capture all of them. One of the important ones that John Walton mentioned was the information gap between the modelers and then, the construction years later. For some sites such as Savsnnah River, they have to build these models now. Then the covers have to be built for 20 or 30 years.

And you need to make sure these assumptions, they are documented and carried through to the construction process. Another point is performance confirmation data and re-evaluation.

Kerry Rowe mentioned that there is always a possibility for more data and perhaps a repository for this data and then a re-evaluation of this data every five to ten years as the science changes and our understanding changes. Maybe we need to go back and look at some of the fundamental research and make sure we still agree with it.

I know I don't agree with some of my earlier papers that I published. Don't pull them up.

Also, we need temporal spacial variability -- that was kind of a nervous laugh like you guys believed me.

Temporal and spacial variability, we want toan make sure we capture and again, and make sure you capture catastrophic event, some of the extreme ecents. And some of these events looking at the natural analog, we've see the effect but don't really know what the event was that caused that.

So, in summary, the model is no better than assumptions going into it and we need to make sure we test those assumptions. The next bullet point is Dave Esh's contribution over lunch. So I don't want if there is some deep meaning or random. Assumptions chaotic, typical of Dave's contributions.

Assumptions should not be too narrow to indicate the total system performance. And the QA/QC pedigree should be robust. We need to understand the system as a whole. And George kind of mentioned we need to understand for instance how the geomembrane interacts with the cover and how the waste form interacts with the cover.

For instance we have these very fragile materials and we need to understand and make sure everything is in place properly to perform adequately. Some of the recommendations that we had listed was a systems approach, not just looking at these as single independent components but looking at these as a whole.

Synegistic effects of processes, looking at some of the diaganol and Dave mentioned how some of these processes interact and create synergistic effects. Independent review can be very valuable.

The use of double composite cover where we can have double composite covers and capture perhaps see how well these materials are performing by measuring runoff in between the covers.

And showing QA/QC redundancy here is again the level of engineering required should be aligned with the level of risk, the cost of monitoring, the cost of cleanup within the total system. Engineering design and data should be re-assessed. This is something that John Walton mentioned. We should not be afraid to step back and instead of just moving forward with the continual design if it is not working as best as some other design, perhaps step back re-evaluate the system. And the suggestion of possibly, using moduler designs instead of these huge covers and that maybe would reduce flux, increase dispersion. So we should be willing to step back, look at that.

Again, monitoring should be aligned with performance conirmation and evaluating stresses and events. We should be looking at events such as fires and changes in buyout in this case and change in effects on infiltration. And one of the other stronger recommendations was the utility of the catalog of analogs It seems like there was a general consensus that this would be valuable for us to work on putting together to have this data repository. There were some limitations that I think we can hopefully try to address as we are moving forward and that is the potential limitations in the diversity of the analogs.

Also as John Walton mentioned, the bias and these analogs we have the analogs currently existing what about the other ones that have disappeared looking at the exposure conditions and we have a lack of analogs for some material and some conditions such as geomembrane.

And that was it for the recommendations. So, we have some hopefully during the next session, we can address some of the other issues. Thanks.

>> CHAIR: I think they did a really good job summarizing. There was a lot of information that was said during that time and I think what we're going to go is we're going to be taking the technical notes from all the technical writers and be going through that and making sure we catch those things that we did catch in the summaries here and because I can think of a few instances where I remember somebody recommended something or pointing something out, and it was not captured in the overall summary. But that was not expected that we capture each and every detail.

So, we are going to be doing that.

I will be asking the technical writers to send in their notes and then, Tom and and I and other people will go over that more in detail. I say we take another break and after that, we open up to the general people what they think they might have missed, additional insights because we are trying to wrap this up and capture everything, the major thoughts that people have here. So let's take ten minute come back.

Thanks.

(Break taken)

It's been a lot of interest in can we get copies of slides.

We will sit down. We have all the slides and will sit down next week and talk to management with regard to how we can archive things and make them available.

So we are asking all the presenters, we need your release. We have all of them and we would like to put them on a website, community website and share them with everyone. We won't put them as powerpoints, but PDF files so that kind of locks it in.

With that then, Hans, could you please lead us in the discussion. What we like to do is try to capture even more good ideas, recommendations observation. We had very good overviews of the sessions. Now, we'd like an opportunity to hear from all of you with regard to ideas. So Hans, you want to introduce the topic, go through the points that we see here with bullets. But I think there were a couple of people that wanted to make general statements. There were 3, should be do that first, start with that and I can go through this list and see if anybody wants to add.

>> HANS: During the break, there was a lot of great conversation and I was talking about Paneuf and the people from New York State. And as you can imagine, I am very interested in activity in microbial activity and geochemistry. And we heard from Kerry Rowe that there seems to be no evidence of effect on the geomembrane. I think as one of the topics, we think about big animals like gofers and other things but what about the small community? So I would like to have Bob make a comment on that.

Bob?

>>BOB: Thank you Tom. The data we completed from the landfill probably is going be one of the most biologically induced environments that you are going to have for liner system, while I'm not familiar with any impacts due to biological degradation of the geomembranes that we are using, but what we do in fact see and looking at -- and staying with the comments that were made during the workshop here with respect to consideration for the performance of the entire containment systems, all of its component, that holistic conncept of the design, we do see biological cloggings of our drainage blankets. If you got a drainage blanket within a liner system to reduce liner system and minimize leakage, then, biological clogging is an issue, and as been an issue at landfills.

It is easy to eradicate or repair by having access to the leachate collection system and being able to basically repair them in at least, key areas.

It's not that every leachate complexion line within the landfill has to have the accessibility but key lines within key cells should have accessibility such that you can get in to maintain them that way.

So, with that...

>> CHAIR: Thank you very much.

The other thing was during our discussions, one of the things that came up was what happens, now you have to go back 20, 30 years after the facility, the geomembrane, the textile, the clay, whatever, you don't really know the original state or condition of that.

So Kerry Rowe talked about archiving material. Kerry, would you like to expand on your idea?

KERRY: I guess my concept was we really need to have somewhere secure that archive this information s so it can be obtained again in many years time. That would deal with specifications, ideally, the design drawings, the specifications, and samples of the material. And sufficient samples so people can do some tests 20 years, 30 years whatever it is down the road to check what this material that hadn't been out in the environment had done versus what was in the environment, so future control. And the data collected as part of the QA/QC should also be documented with that. So we got what was -- the material's actual behavior when it was put in place, a sample material that has not been exposed to the conditions, and the details of how its placed, designed, placed and installed.

If I can, I would just like to follow on from Bob's comment, biological clogging certainly is an important issue.

As he mentioned, regular cleaning of pipe is a good thing to do. We've actually been able to show -- people speculated in the 90's dissolution of limestone, the like. We've actually been known to show quite clearly that it's active biologically induced so when you get calcium carbonate precipitate, that carbonate is coming from the biological presses. You can do that to stabilize it with chemistry.

>> CHAIR: And to finish off Dr. Rowe's comment, we were talking during the break, one possibility if you wanted to have a national archive of material specifications, patents, obviously could be with NIST because NIST I think would be a fair broker and could keep information proprietary.

Also during the break, Kevin Leary had some interesting comments about the work that's being done out at DOE at the Hanford site.

Kevin?

>> MR. LEARY: Thank you. First, I just wanted to throw out a question or comment about episodic events, a few had an opportunity to talk about that. And that is projections now are about 150 % increase normal precipitation, if climate change proceeds. But my question all of us need to think about is how is that going to affect the frequency of a100 or 500 year storm? Is it going to be 10, 50, 40? And is it going to increase the intensity, decrease the intensity or stay the same? I think that is really a challenging fact or something we all need to ponder in our design because I don't think we really have a good handle on that and something we need to start thinking about.

In regards to some of the stuff that -- some of the ideas I've had, we are starting to implement at the Nevada test site -- let me digress for a quick second.

My first two years out of college, my undergrad from soil science at Oregon State University, my first two and a half years I spent mapping soils in the Amagosa Desert. And a lot of you probably don't know where that is but it is adjacent to the Nevada test site and the baby site of Yucca Mountain. And I thought, what did I do to get punished to do this?

DOE gave me a shovel, a pick and a pry bar and I was out in the middle of nowhere digging holes in the desert. But those two and a half years taught me a lot about natural analogs, soil plant relationships, shield morphology, plant behavior.

And from that time, I have carried a lot of those concepts into my professional career. And let me give you an example. I think soil pedogenesis, I think we need to look at soil pedogenesis from another perspective as well as trying to learn what our future barriers will look like. But I think also we need to look at soils from the perspective of how can soils and pedogenesis help us strengthen the design of our barrier?

And from that is one of the ideas or concepts

I came up with. And we're going to implement it on a barrier that I'm trying to get installed on two landfills at Hanford. And that is and digressing for just a second again, a lot of these fine texture soils we are going to put on native soils, oftentimes of coarse texture. So that itself is going to form a capillary barrier.

I don't know if a lot of people think about that. We thought about that on this design at our barrier we are building. And we are using silt and soils on top of amoni sand. So we don't think it's going to be a problem. We have not modeled it yet but we think it's going to be thick enough, it's not going to be a problem. But I think in a lot of other sites throughout the complex, when you start doing that, you might want to think about your interface between your barrier material and your native material and will it cause a capillary barrier? And do you have to route the water around that system?

Do you have to build a subsurface trench drain and how long will that last for you out the water? But anyway, along those lines, one of the things that I noticed when I was mapping soils was every single hardpan, petri-calcium (phn) horizon or dura pan that I saw, all started at a capillary barrier, every single one of them, if I can get the hole deep enough with my pic and my pry bar. But what that taught me is, this is an opportunity to take advantage of soil pedogenesis in the barrier design.

So one of the things that we are going to do on a trial basis, one barrier we are going to construct on my site here coming up is I'd like to lay down a layer of lime in between the silt loam and the native loamy sand material to basically accelerate soil pedogenesis in forming a hardpan. And then some of the other study sites I want to do in Nevada in Hanford is use jetson, clearly jet board -- because we got over 900 buildings in Hanford that we have D&D, so using some of that jet board drying it up and maybe put it down and serve as the same function.

All you're doing is accelerating soil pedogenesis to form a hardpan. So that's one of my ideas.

Another idea I had and I have already had a written paper and had a workshop on it pertinent to this workshop is -- and it's kind of a catchy phrase; it's called a permeable absorp of liner. And basically, if you know your waste stream, you know the quantities and types, you can build a liner out of reactive materials, or say radionuclides, you can lay down ply sealer materials for say tec or iodine, you can put down certain resins, therefore you don't have to totally rely on the performance of your liners or your cap. That stuff will stay in place.

Your biggest challenge is again, what I said earlier in the session was institutional control which brings me back to another thing I learned in mapping soils; every single soil pavement soil that I mapped was a fine textured soil and had a vesicular trust.

There was never an exception. It was either silt loam or fine sandy loam soil. And as soon as you broke that crust, it was really susceptible for erosion.

So we can sit back and talk about how well this armoring is going to work, but if we don't keep people out like vehicles or people just walking across these barriers, it could really accelerate the degradation of that cap.

So I just wanted to kind of leave you with one final statement and that is, keep your eyes and minds open when you're looking at things in nature, in analogs.

Right now, I'm mentoring a student from the (inaudible) Casey, could you stand up?

This is Casey Mitchell from the (inaudible) tribe. Casey is working with me and trying to learn more about barriers. But that's one of things I keep telling him is oftentimes, the simplest solution is right in front of us for complex problems, we just don't see it.

So, in closing, keep your eyes and your minds open to try to find solutions to all these challenges we are facing right now. Thanks.

>> CHAIR: Maybe we can go through that list. What I'd like to see is if people have additional input on the things up on this slide here?

The first thing we had is identify degradation processes affecting performance. I think it seems like we really did an outstanding job with that.

Is there anybody here that believe that there was a certain degradation process that we have not really captured yet, besides like a tsunami or meteor strike or something along that line without getting into FEPs?

Does anybody believe there is a certain --

>>MR. WILLIAMS: I'm Alexander Williams. All the degradation methods that were presented or types that were presented have some degree of assumption of site abandonment or lack of maintenance or however you wish to term it.

Well, long before burrowing animals or trees put roots down into waste, Bubba and Leroy were going to back up the dump truck and front loader and help themselves.

To make a long story short, within DOE, Congress assigned DOE the job of cleaning up the abandoned Title 1 uranium mill tailings sites. In addition to the sites, there were thousands of vicinity properties. Now, many of these had wind blown tailings because the tailing piles had been abandoned by the mine and mill operators. But in many cases, people had taken tailings or other materials and had used it for fill essentially all over town.

So, the human intrusion is something that is very important once you pass the threshold of assuming that sites are abandoned or are not being maintained because when you start to see large tree and root balls being a path for failure of covers, that's all quite true and I would readily agree with that. But there is a presumption that the site at that point has been abandoned.

And I can assure you that Bubba and Leroy and the front loader can do far more damage in one day than a tree going for 40 or 50 or 60 years and then falling over will do.

So I believe that one of the issues is custody of sites. Now, under UMTRCA, Congress has assigned custody of sites to DOE and it's being done by our Office of Legacy Management. But this is an important consideration. I believe that Congress made the right decision when they did that.

It's not everything Congress does that I agree with but that's one case where I think was really smart.

And you have to I believe accept the notion for at least some of these bio-intrusion problems that they are a subset of a site abandonment scenario.

Now, let me go one step further on the UMTRCA issues to a more general topic which is the UMTRCA standards were issued in the early 1980s in a previous job at EPA. I was on the work group that wrote those standards so I have some slight knowledge of them.

The UMTRCA cells were built to match the conceptual cell models that EPA used in their rulemaking. They appeared to be functioning as designed and meeting the EPA standards.

I realize that there are some people here who said some unkind things about some of the UMTRCA designs but if they are meeting the standards, what's the issue?

How good is good enough? Now, there also was an issue involving groundwater. And many of the UMTRCA sites, the tailings were stabilized right where they were. And in those cases, you have an issue if you have observed groundwater contamination separating out whether the contamination is from operational activities, or whether they are from something in the tailings pile now after it's been stabilized.

I remember I gave a presentation to a college class almost 30 years ago. My comment on the uranium industry is that tailings were simply being taken and dumped on the ground on a place that looked good at uranium mills and that there was no groundwater contamination at many mills, and that the rest of the mills I opine they didn't know about groundwater contamination because they never looked for it.

So, when you see groundwater contamination at a mill, you need to stop and think, where is this coming from? Is it a relic of operational activity or is it something coming from the tailings and impoundment after stabilization?

And that is a fair question to ask in every case I don't think anybody knew about groundwater trouble at uranium mills until EPA discovered it in the mid-1970's. So this is a problem that probably occurred well before then and was identified I believe only shortly before UMTRCA was enacted.

Anyway, I wanted to bring up both of those two issues and I thank you for your attention.

>> CHAIR: Thank you for bringing that up and we do have two technical writers now so we are capturing your thoughts.

>>SPEAKER: Yes, I would -- you can argue semantics but I would suggest that your first engineered barriers in the waste and the waste form, how do you put it down, how do you compact it? Do you equate preferential pathways through it? Is the release going to be controlled by diffusion and by chemical reaction? And to me, that dominates uncertainty, a lot performance assessments. And so I would argue that's a primary barrier we didn't really touch it here. So that's the barrier in my view left out of it.

>> SPEAKER: Just an observation on the land use control: It is a great idea. I'm glad that the legacy management is going to manage the DOE sites. But if we look in the regulations for high-level waste,

EPA says you should control land use as long as you can but do not take more than 100 years worth of credit for it in terms of preventing human intrusion.

And I think the point is wise that we cannot predict the future and to rely on anything that the federal Government does well, now continuing a hundred year into the future belies my personal experience any way.

>> MR. ROBERTSON: Hi, Gary Robertson, Washington State: First day of the session, I brought up the fact that we should rethink the institutional control period of 100 years and I think that probably came up that date, maybe in the late 60's, early 70's. And I'm wondering if folks did the probabilistic studies about civilization?

I would guess that it's probably 99 percentile and I would like to have that recalculated by somebody because, boy, as a regulator, it is tough especially after this meeting to hear about all the uncertainties, even uncertainties with the natural analogs to go out and talk to the public, and say we're going to leave in a hundred years because that's all we can factor in.

So I would suggest that somebody do that kind of a study along with the studies you're doing to take things out to a thousand years, 10,000 years, a million years.

>> CHAIR: anyone each? Wait a minute.

>> SPEAKER: I'd like to respond to that. At least one study on the appropriate period for institutional control or inadvertent TO human intrusion that is being done, for example in support of the low-level waste disposal at Nevada test site.

And that was done through an expert elicitation talking to sociologists, well drillers, all sorts of folks -- actually it was not oriented at institutional, the duration of kinds of institutional control but that is one of the things that came out. It was oriented at the probabilty of somebody drilling through a site at some point in the future.

But the duration of institutional controls came out of it and I would argue it is a site specific parameter and may only be -- it's one of those things you can't go out and measure so you would have to come up with something like an expert elicitation to come up with the value for it. And I have seen an awful lot of performance assessments that the implied value for the probability of effectiveness of institutional control has always been one.

And that's an implied stalactic discreet distribution of one. And I would agree that that needs better basis.

But there is some precedent for doing that, getting that sort of information.

And I just want to add one little thing, that in session two, Craig was looking for a new word to describe degraded covers, evolved covers, change modified covers. I got a word for you as they change from their finely engineered constructed state to a more natural state, getting naturalized.

So the process -- the process of naturalization of covers. This is live going across to country, there Craig.

All right, you want to dig deeper? I like that terminology. I think I will start using that.

Something I wanted to just bring up basically

UMTRCA comments that I kind of heard the last couple of days and I'm not quite clear on where they are coming from.

I think we had a lot of discussion about covers and changes in property but this gentleman's comment about things are still functioning the way they expected and there is really to get all worried about it and that is a very valid comment.

At the same time, though, I guess I'm -- I have not heard anything that has been presented here that suggests that there are problems with UMTRCA site or any other site.

I think the issue is largely looking at what we know about our knowledge today about the engineering properties and the biological properties of covers and how comparing that perhaps to what we had 10 or 20 years ago and reflecting on how things have changed, how that might influence how we develop designs, conduct performance assessment, and what we might do next to go to the next generation. I think that's what I believe is the purpose of our workshop. And I don't think we tried to single out any type of containment facility as not functioning. I really haven't heard that.

We really tried to talk about the principles and the mechanisms that we ought to be thinking about going forward. So I wanted to bring that up because I think that is an important point. I said my piece.

>> CHAIR: Anyone else with a comment, make a statement? Go to the next question.

>>SPEAKER: Okay. I have some recommendations on designing for catastrophic events. so I did some expert elicitation at lunch time with a buddy and we talked about it and but, I'd also like to talk about the CJ cell and how that was planned for a catastrophic even. The cover design, even though it is in the area of sediment and deposition. It's close to the -- it sits on the medical shelf at Crescent Junction which is along I-70.

And we put a sacrificial plow of macro shell of cell on the upstream you of the site when the disposed cell was built and four cells and as they took the macro shell (phn) out, we had them place it in a triangle so it divert surface water flow and that's just kind of a creative idea if you have waste rock, what do you do with it? If you -- par pit it on gradiant site that will protect against Flooding another idea for we're in the from pros of locating mixed waste disposal cell and oak RIDGE and will are some sir letter waste put in there too but the idea is to have rich top disposal and why rich top disposal.

Well, a lot of people look for brown files they are industrial areas and prone to loo flooding and if you ever, purchase area where is why 12 is and bear creek valley, they are very narrow, steep and feature ace long become of Sam threes can which are not God for waste disposal and if I try to increase the size of disposal area, you wind up flick ago hill slope, creating a spring AND so basically, all these trying to locate the waste area between a drainage pattern is complicated because we are limited in the area.

So, what I'm suggesting is hill top disposal. And the reason for that is in Tennessee when I first moved there, all the soils in the valleys are about a foot thick and there's no deep soil that's suitable for plowing or anything like that.

And I'm thinking why is that happening and if the burrow for all the waste area are on top of the hill where there is 60, 70, 80, feet of sample light, and being from New England, that was counter-intutitive because you also have the type of accumulation in the valley. And recent Nashville floods is a reason that I can see as the natural analog as to why there is no soils in the valley.

Every four or five thousand years, there is some kind of catastrophic flooding events that obliterates these soils. If there is no soils in the valley floor, probably won't be a waste area there for more than a couple of thousands years. So if you go to some place where you have a thick soil mantle on top of the hill, then, that would be the safest place for the disposal area.

And I think that you know, like we have a lot of pride and humor when we are talking about, oh, this synthetic layer will work this way and if we double it, it will work even better.

All that means nothing if the entire disposal disposal cell is swept away. Kind of my idea for this disposal cell is that if you want to get it out of -- solve the groundwater issues, you pull the cover far enough down the hill that it will create a base recharge shawdow and your water table will be that distance below the vertical distance that your cover extends down the hill. So essentially you can make coscal (phn) requirements for disposal of hazardous waste.

And then, you get the benefit of the thick beta zone under the cell with 60, 70 feet of sample light.

So that's a just a thought to think about for people. Like I'm all about if there is enough money, I would love to take all the waste and put it in some kind of disposal cell out west. But you know, regulators and budget doesn't allow you to do that. The public doesn't want transfer waste so we're having to make do with putting very hazardous waste, radioactive waste disposing of it in a humid dry climate.

This is kind of my dea to throw out for disposal of waste in a disadvantageous situation making the best out of a bad situation. Thanks.

>> CHAIR: Thank, Ken Bostic.

Are there other comments or other suggestions, questions? Yes, go ahead.

>> SPEAKER: Just a quick one. I think there is a scaling question more than anything else.

We had a lot of conversation about events and occurrences that happen like cracks develop in the clay liner and small holes get punched in the synthetic liners. And it occurs to me, we haven't really addressed the question of when does this kind of occurrences, renewals become issues.

And I think it is a modeling and scaling problem but just like to throw that issue into the mix because it does get to be important as we go into these long-term management intervals. When do you need to actually go in and make some kind of repair? Or should we be focusing some of the technology concepts on how to do repairs on some of these smaller events?

>> CHAIR: John, John Gladden? Other comments, questions. Why don't you go on to the next question.

>> HANS: ALl right. We'll go on to the monitoring strategy recommended total monitoring strategy to see if we had anybody that wants to add to that. Actually I have 3 quick comments comes for that.

I think some things that maybe weren't emphasized enough is this conceptual model. If you want to monitor the right area, you really need to understand your conceptual model, understanding conceptual at 00 and understand your conceptual model at year 100. And you might have a really different conceptual model by the year 400.

If you have an additional -- in addition to that, a water budget, I just can't overemphasize the usefulness of a water budget that you can believe in or beleive it is very closely accurate for getting down what is really important to your barrier, and the components of your barrier.

I always emphasize that over and over again with the water budget. That really says a lot for the year 0, for 100 for 20, the change as time goes along. The other thing I wanted to mention we also should not forget with the international group, I know some people -- I think George was mentioning some people outside of the United States that were working on geomembranes.

I know for monitoring and I was asking Craig if you remember his name -- but I just saw an excellent presentation at the waste management thing on Spanish Nuclear Regulatory. They had some huge monitoring experiment going on and they built a waste form and cover over that, and another engineered cover and it is just littered with monitoring devices that are embedded and it is like a 6 -- I think 3 to 6 year program.

And I was going to -- I don't have it out now but it's just to sort of make the point to make -- there is a lot stuff going on and we are not the only ones dealing with these issues and a lot of different things. So we should remember that. Also look across the border, something going on in Mexico, something going on in South Africa, something going on in Russia, really similar to that.

And the third thing I wanted to make is consideration with the modeling and monitoring. And what I thought I heard is that maybe it does not make that much sense to do too much effort in modeling of the engineered cover itself is kind of small.

We have to look at the whole system, try to integrate that part -- I think that's sort of the way it is done nowadays where you kind of make the cap and cover fairly simple. But if we are going to do this iteration with modeling and monitoring and if you want to get information from your model to the monitoring and the monitoring to the model, that part I guess I got -- I'm not quite sure about that and but if you're really not emphazing the modeling of the engineered cap, I'm not sure how you can exchange information if you want detailed monitoring of your cap, but you're doing this sort of larger scale modeling.

Those were the three points I just wanted to make sure the technical writers caught that.

>> SPEAKER: In order to do that Hans, if you could make sure you remember to find that article and we will put it in.

>> HANS: I still have the wastes management thing and I was going to bring it down during the break and forgot.

>> CHAIR: Other comments on motoring? Oh, here we go.

>> Mr. WARD: I had a couple of comments on monitoring. From the papers I've seen presented and certainly from what we know to be the current practice, we're still sort of focusing on these point sensors, very limited zones of influence and very limited potential for long-term use.

We know there is not a lot of evidence of heat dissipation units and these type of things being functional for the type of scales we are talking about.

I think we probably need to take a new approach to designing these monitoring systems. There's a lot of new emerging technology in geophysics. For example, lots of people are still putting in aluminum access to neutrons. We have them for horizontal measurements at some of the interfaces, the different transactions, but a simple change to something like PVC or fiberglass would allow you to use some of the electronic things like crossover GPR that has a much wider range of interrogation and neutron tool has a zone of influence from about 15 centimeters to 30-centimeters. But with GPR, you can interrogate 10, 20 years the space between two (inaudible) integrate that, you can integrate over increasing spacial skills so the whole idea of skill attendant becomes moot with these type of measurements.

One other point that we observed in the recent burn of the Hanford barrier, I don't think design of modern systems really take into account the effects of fire. We spent a lot of time before the fire trying to protect instruments on the surface from being burnt and this is something that we need to think about.

And finally, back to the geophysics, a lot of techniques but when you have cables in the surface that are sort of running willy nilly all over the place, wrecks havoc, and you spend a lot of time filtering the data and we have to look at a bit more of the design and installation of cables. And so that you can at least monitor parts of the burrow or cover that would be representative of the response without having to deal with the noise issues from cables and other near surface infrastructure.

>> SPEAKER: Yeah, I know in Amsterdam, a big

project going with the geo physical thing, and they have pipes running all over the place crisscrossing and and yet they seem TO be making progress and I was just going to ask...

>> SPEAKER: One thing I wanted to add to Andy's comments is we have a what's called a FIELD lysimeter test facility. So in addition to modeling and some performance data from the Hanford barrier, we also have a huge facility called field lysimeter test facility. You can go underground. Some of the columns of soil are on large truck scales heavily instrumented and done various experiments, different type of vegetation, and we use that data and lug that into our model.

So we just don't totally rely on field data and natural analogs. We have a lost data that we generated from the lysimeter test facility. Nevada test site also has a facility very similar, a little bit smaller scale and I highly recommend any folks out there that are ever either up in than Hanford of down in that test site, to get the opportunity to go out and look at those, because they are very impressive. Just one other thing I want to mention in regard to neutrons access which is what Andy mentioned that I'm constructing is and I didn't hear it really talked about that much kind although kind of peripherally and that is root intrusion into your waste. Oftentimes we put a bio-barrier there but how do we know if it truly works?

So an idea I came up with and it was endorsed by several people, is to find the material that's clear and still allows you to go horizontally under your barrier, underneath your bio-barrier so it allows you two things; you can monitor moisture and you can send cameras in to visually look for roots to make sure that your bio barrier is functioning.

One other thing is down in the Nevada test site, when you're down there, another thing they have that is very, very cool is they have a neutron access tube calibration facility. And they've got several types of tubes that you can use for neutrons. And then they have several arrays of TDR around that so no longer do you have to take a sample and gravimetrically dry the soil. You can actually keep your count versus

TDR reading. It's a really slick way to get your neutron calibrated for various types of tubes. Thanks.

>>MR. LINK: Just a quick -- Steven Link -- monitoring issues for soil water. I Just wanted to say plants are good at that too if you don't mind doing lots of pre-dawn work, pressure water all over this place at various depths.

>> MR. ANDRASKI: I was going to follow-up on Steve's comment. What he mentioned, you can possibly use plant water potential as an indicator for soil water potential.

That would get around and also, you're sampling a large volume. But just to follow up again on the use of plants, the possibility there and it might even tie into determining plant intrusion into waste material, to actually sample the plant to see what they are picking up. It is a technique that we have used for monitoring tritium contamination and even plume distribution where we use the plants.

It is a non-invasive monitor into the sub-service. You cover a large volume because you're actually capturing from the full root volume. You can do repeat sampling as one catch. If a fire comes through, you just lost your monitoring system.

>> CHAIR: Any other comments Roger?

>> ROGER: Thank you. I think we seem to be thinking in a deterministic sense especially when we use more complex models and if we're going to be doing comparisons between monitoring and modeling, it will be really important we act to reflect ranges in your modeling because you're not going to match. You have to go in recognizing that and when you are working with stakeholders, you need to be able to illustrate that we are expecting things to happen within some range. So I just want to emphasize that with the new computing power improving every day. I think we need to keep moving towards trying do these more complex models to reflect those uncertainties may still use them deterministically for control lines, but if you are comparing, it is important to do that.

>> CHAIR: Any other comments on that topic? You want to go to the next question?

>> Wait a minute. Here we go.

>> MR. SETLOW: Loren Setlow, EPA. Thank you

for that kind introduction, Tom. I want to clarity something in the notes that were put up for this particular session. There was some discussion about monitoring of the total system.

I had asked a question of the panel and the discussion that evolved about what kind of recommendations that they would make in terms of additional suggestions that they would make for us as we consider our review of our regulations for UMTRA and review and revision of 40 192.

And John Gladden I believe made a recommendation, very, very interesting discussion saying that the monitoring should not be focused necessarily on the monitoring ring for the point of compliance but in fact should be taking a harder look at ways of monitoring the compliance system itself.

That is the barrier system and so on. And then, I believe Steve Rock also had made a suggestion about the use of horizonal wells as a technology. And I would very much like to see that as a specific recommendation as a suggestion of a panel in terms of things that we, EPA might want to consider in its review of the regulation.

Thank you.

>>CHAIR: The next one would be -- somebody was talking about the monitoring, the miracle modeling.

I think Chris had put up -- Chris and Dave had put up summary and recommendations for that session. Anybody, think there was something missing or any additional insight, something a little more strongly emphasized?

>> MR. WILLIAMS: One of the problems -- Alexander Williams. One of the problems in modeling is that much of the site data that is available is accurate to only one significant figure with perhaps some uncertainty. Yet, modeling results typically are being reported to more significant figures.

And there is a problem here with a disconnect between the input data and the output.

>>MR. SYKES: Roger Sykes. Real quick, one thing I would like to emphasize is this idea of hybrid approach to modeling where you got different levels of modeling detail for the same problem. And we gained a lot of insight by trying to compare the results from a

detailed model as well as a relatively simple model as part of that distraction you learn a lot.

>> Any other comments on modeling Dr. Go to the next questions?

>> Okay, this is the one on model support.

Session five was a model support, lines of evidence, same thing. Anybody think there was something missing, something you would like added, additional insights or just a comment?

>> SPEAKER: TOM: I have a comment.

>> CHAIR: Tom.

>> TOM: Yes, Tom Nicholson, Office of Research. I think one of the things you were talking about, a catalog of analogs, I think the U.S. Geological Survey, especially but other groups ought to think about sharing information on deep vadose zone monitoring you're talking about putting observations underneath the cover and maybe even under the liner, then the question is and we asked this question yesterday in the monitoring session, what would be the appropriate methods? Now, we heard from some people that maybe some geophysical methods might be

appropriate but what I would recommend is the catalog of analogs be expanded not to just vegetation and plant succession soils but also to deep unsaturated zone information.

>> CHAIR: Would anyone else like to comment? Any other comments?

>>SPEAKER: Okay for my panel group, I had the last 3 questions here and follow-up activity.

I never did get those questions to my group but this apply to everybody, now. Let's just start with the first one with the information gap. I think we listed maybe like a hundred different items of information gaps but is there anything in particular you would like to see more emphasized. This is like the top 3? This is the most urgent. This is the one that gives you the most bang for your buck.

Anybody want to get that down on the record?

>> JOHN: John Toukes with Neptune & Company. Well, it's hard to say in general because it is such a site specific issue of what information gaps are there.

But in general, I'd like to see more information about the biotic activity. And for example, what we saw a lot of nice information that Terry put up in his slides of, you know, root depth distributions and burrow distributions and things like that. And that's the kind of information that is, well, one, it's site specific but there is not a whole lot out there in the literature at least that we've been able to find and we need to get ahold of Terry's sources I think.

And so I would like to see more of that for example.

>> TERRY: Well, I agree that given that it is a design where the vegetation or the biological system is important, then, we do need to know more about those special subsurface dynamics, architecture, distribution of the roots, depth. Also, any other associated activity microbial that might in turn affect the vegetation. So there is a lot of aspects in the biological area that we need more information on.

And then to have the information on successional dynamics however we get that, to be able to project more accurately over time how these things will change over time.

>> JOHN: John Toukes again. I want to add one more piece of that is something is sort of lacking s plant soil concentration ratios for different chemical and radionuclides.

We are relying on Bays 1984 for that sort of information and it's very plant specific too.

So anybody who wants to go out and do those studies, that would be most welcome.

>> KEVIN: Kevin Leary, DOE Hanford. I just wanted to revisit Gary Robertson's comment. It has a lot of credence and that is institutional controls and revisiting that.

I think you can build the best system in the world regardless of whether it fails or not, but if you have Bubba and Leroy coming along digging things up all that engineering is gone by the wayside.

You need to start with the end in mind really is important and I think a need is to look at ICs from a probabilistic standpoint, looking at a specific site say like Whip or Hanford or Nevada test site where you look at the population, future land uses. You are going to take a lot of things into account, future climate change, pandemics, a whole bunch of things. But I think that is really important because again, as I said previously, you can have the best engineering in the world but all it takes is one individual get out there and screw everything up.

>> CHAIR: which sort of leads us to our next topic, identified potential improvements for existing guidance. Anything here somebody want to get down? We heard that now from numerous people with institutional controls.

I think we captured that. But anything else anybody want bring up, think of something?

Some improvement John. Was that you pointing out raising your hand. Looks like you wanted the guy in back of you.

>> LARRY: Larry with the state of Colorado. With respect to guidance, that would be a wonderful thing from my perspective.

Every day many of my tasks involve reviewing documents that have been submitted specifically for liners or covers and we search all around for the latest and greatest information. I wish I had the experience with me every day that I see in this room because I'm expected to have all that experience and of course I don't.

So it would be wonderful if the NRC could come up with, you know, some type of newer guidance on beginning to end on cover liners, how to build cells. And I know that's why we're here to kind of put our ideas together. But I can tell you it's really something that has been lacking and we are really looking to this group to put that out so we can use it back in our states.

>> SPEAKER: Larry, I think it is a great opportunity to do that. We actually have a lot of different agencies here not just NRC but DOE and EPA and GS we, got alphabet soup on federal agencies here.

So there is really a collection of folks who could spearhead this.

I do think that would be very valuable here. We have guidance documents but they are pretty old and something like that would be helpful.

>> That's what we've been using up until now.

>> I think some of it is almost 20 years old

now.

>> MR. ROBERTSON: Gary Robertson. Again, as far as guidance, I'm going back to uranium mill sites, and our experience in western nuclear. We had the company do a lot of experimental testing on water and it was impossible to dewater those tailings.

And at Don mining company, same situation. So they started pushing dirt over the wet tailings to stabilize them and they ended up with a 3-foot layer because we are requiring them to put HDPE down at a certain point. The whole cover is going to 18 -- 15 feet thick.

They decided to do the EPA radon calculation with that three feet of soil. They met it, met the radon emanation rate. Kind of puts into question, the current guidance and I'm glad you're rethinking that but the suggestion is -- I know there's probably a lot of sites out there that track ricks, they drill wells into the tailings.

We got a lot of data that you can refer to.

>> In the high level waste, Abe and DOE, in the high-actually level arena, we actually appreciated

the guidance on human infusion and how deal with it.

I don't know what the situation is in low-level waste but will there needs to be some kind of guidance package maybe inner agency expert elicitation or something that everybody can use so that not everybody can use so that not everything is vulnerable to attacks on the same issue.

For example, there is a difference between advertent and inadvertent intrusion. In the high-level waste, the advertent becomes a marker for this generation.

And you know, it was pretty callous on the part of EPA the way that they wrote that regulation. At the same time, there was a reality check there, you can't prevent these people from bringing in their skip loader. One way to prevent that by the way, is those institutions that have been maintained for hundreds of years, if not a thousand, like (inaudible) are those that are locally important. So if there is a local ownership of the site, I think that is a key and then, you can start trusting long-term land use controls and that kind of thing because the memory will be locally inherit.

But anyway, and then, the other thing, the information gap thing, I meant to raise my hand before but we were handicapped -- in fact, we relied on Hanford data for plant uptake of radionuclides from soils. And we were criticized about that by the international review team that we had come in saying all the money you spent, you could not afford to do your own uptake studies?

They had a good point there but perhaps the U.S. Government should do a variety just like a catalog of analogs. We could have a catalog of update studies from different soils and different plants because that kind of research is extremely expensive because you are looking at live radioactive material which we were. The state of Nevada and Nye County could use it but we could not. Figure that one out.

>> CHAIR: Thank you. Other comments, questions? You have a comment. Okay.

RICHARD: This is Richard Chang from the NRC. We are in the very preliminary stages reviewing exist guidance for new reg 1620 and considering the possibility of working on the updates and consolidation of uranium recovery guidance for the decommissioning and reclamation.

>> SPEAKER: I wanted to repeat something I talked about in my introduction presentation and just see if anybody has any comments on the recommendation from the National Academy if any of these are either supported or not here.

And let me just go over them again. They were to develop guidelines to increase direct monitoring of barrier systems, commission and fund assessment of performance on a regular basis; establish a set of observatories and operational facilities to assess performance and the field scales, support validation, calibration, improvement of models to protect the behavior. And lastly, EPA and NRC should develop performance-based guidelines for assessment of containment systems performance as an alternative to prescriptive design.

>> CHAIR: Anybody have any comments on those, something you disagree with, something you think is out of -- any comments on those?

Okay, then we will go on to the last one. Wait a minute. Sorry.

>>SPEAKER: I was actually a member of that committee that wrote that report. There were two things that we discussed that maybe didn't come out in full conclusion but certainly in there. One of the things is what I mentioned this morning -- two of the things I mentioned, one of them was the need to go back periodically every five or ten years and look at the data being collected like that 2002 report that we talked about this morning, and reevaluate what we know now.

Based on all this data that's collected, it sits on shelves because people don't have time to go through and put it all together. And particularly, if the data from a number of different states and jurisdictions, nobody feels the responsibility to do it unless there is a responsibility by EPA or whomever to see that that's done on a periodic data.

You lose the value of all that data that is collected. So that was one of the things we were pushing for. And the other is really this issue of you can have all the guidance you like but unless somebody is carefully checking what's being followed, you got no confidence in what comes out. And there are many, many failures that occur because of very obvious reasons. You look at it and say, how dumb can you go.

I gave an example this morning, putting a drainage system in and have nowhere to drain to in a cover. Do you then get surprised that water pressure built up and you got a slide? No. There is a need for peer review of these designs. If it is an important design, you shouldn't just be relying on the designer. Sure, a thousand is a (inaudible) price but that's not really the best solution. It is better to have a peer review to minimize the risk in the lower case in the first place.

>>SPEAKER: But what you're implying is that you want regulatory oversight and you also want an independent peer review. The question is to what extent should that independent peer review be?

>> SPEAKER: Well, I think there should be two levels of it. One is the level of the design and the other is the level of the quality assurance,

quality control. That's got to be independent so that you got a real independent check.

And there are some jurisdictions that require that. And so it's not impossible to do. And the proponent should be paying for it.

>> SPEAKER: Would anyone else like to comment on that? Okay. Yes. Yes, Dave, over here.

>> Speaker: I had a couple of things from the previous discussion. First, the plant transfer factors; I thought I saw come through my email in-box a more recent report by IAEA on plant transfer factors. That would be better than your 1984 reference, perhaps for a few elements.

Then, the institutional control say of a hundred years in particular for Part 61. It was not pulled out of thin air even though it might appear to be. There were workshops that were held throughout the country and a lot of debate that went around it and that was kind of a societal decision at the time, I would call it where that number came from. It may have been biased by what went on at Love Canal and a few other very public examples of difficulty with controls.

But nonetheless that's where it came from. I'm not making a statement one way or the other about whether a hundred is appropriate or not.

The last discussion by Dr. Rowe, in particular, something that I talked about a few other times that I think is really important. But this ability to collect, to steal, interpret, to catalog information on these topics that people can make use of it when they are there designing a facility, evaluating a facility; I have that need all the time. And I won't tell you how much time I spend sometimes digging for information with google searches and what have you, looking for a piece of information that I know has to be out there. I don't know where it is, I just know it has to exist somewhere.

If you can push that process forward of having that information in a form that's accessible and people can make use of it, I think that would really help. And personally, I would say there was a time where I needed some information about partitioning and soil during surface water transport and I was looking for some reports on it. And one of our NRC colleagues was retiring and said, come to my office if you want any reports. And I always like reports so I went to see what he had and I was digging through his reports and not only did I find a report on partitioning radionuclides with sediment and transport, but it was conducted by NRC and it was on the stream system I was looking at and it was in his library.

>> SPEAKER: Okay -- oh Roger? Why don't you go ahead.

>> ROGER: All right. And then we go with the -- one thing I wanted to say, I find that the differences between Part 61 is and Part 40, sometimes yeah, sometimes that sets me back every once in a while, that's one thing. But anyway, we are going now to recommend follow-up coordination. I heard a couple of times from a few people that they thought this was a very good meeting, especially just because you did have the caliber of people that were here and from all walks of life, and from all different organizations. And this was really a good opportunity to exchange information.

But I'd like to hear -- one other thing I was going to say, for the people on web stream and if do you want to call in with questions or comments, you should call in at 1-888-566-6344 and the pass code is 15103.

So the phone number was 888-566-6344 pass code is 15103.

Don't turn it on now because we are not done here but just so people who do want to comment, they are welcome to go then.

>> SPEAKER: Are there any comments on that, the recommended follow-up? Obviously, one of them we heard is please get the slides together for this presentation and put it on the website.

We heard that recommendation and we are going to act on that as best we can. Other comments?

>> JOHN: That's a good one. But on previous one, Dave Esh's comment about trying to find documents and finding it in his colleague's office, those remind me that one major improvement to existing guidance would be to make it available electronically.

I mean, even within NRC, there are countless new regs that I can see it's a tease. I can see the title for it or I see it cited somewhere and I go on to the site and oh, that one is not available in PDF. So I know there are some effort. I don't know how fast it's going to get these some older ones and some not so old getting new regs and other documents into the electronic form but any more and faster progress toward that would be greatly appreciated.

>> SPEAKER: Are you talking all the way back to 75 John or --

>> JOHN: On occasion. But some are much more recent than that, don't seem to be available too.

>> MR. BEAM: Doug Beam, Wyoming. I was just wondering in terms also of contacting people if you're going to put out a list of registrants and maybe some emails and then if one of talks I really liked and wanted to follow up, I could send him a email. Thank you.

>> CHAIR: Hans, you want to comment? We are planning to have a new reg CP. CP stands for conference proceedings of this.

I was going to say this at the end. I was just overwhelmed with the talks. These were incredibly great talks, a lot of good information.

We are going to ask each of the speakers if they choose to, to go back and revise their extended abstracts and make them longer, more detailed, provide more reference URL sites, whatever. I think that the gathering of such incredible knowledge and intellect really has helped make this workshop one of the most outstanding ones. This one I went to, London Heath PNL was organized back in 1982. And I've been to many since then, and this one is extremely good because of you, the presenters and the panelists and the audience.

So the gentleman from Wyoming, yes, we will have conference proceedings.

Yes, sir?

>> MR. POWERS: Chuck Powers. I want to make sure that we don't confuse what we just talked about with what it was that Dave Esh was talking about.

If you are really serious about trying to figure out what mechanism to use, begin to actually institutionalize development of an analog library and catalog of it with the early sample library that Dr. Rowe was talking about. And the way in which information and the cross-checking of that would have to be organized, and its relationship in turn to the different regulatory regimes which might therefore use it.

It is a complex issue itself that requires a sustained effort to try to figure out what you are really talking about and would probably take 3, 4, separate well organized conferences with that goal in mind to figure out what the actual recommendation would be.

I've been to many conferences which sort of end up with this general point and that's all that happens with it. Somebody has to take it and actually figure out what you mean both substantively in terms of how you want to go about drawing in the people who would help you figure out how to organize those matters and then what kind of institutional structure to put it under in relationship to invariably, different regulatory regimes which will make use of it.

>> CHAIR: Thank you very much for that comment and follows up on the earlier one with regard to what is the follow-up after this meeting. So we

appreciate that.

You have a comment?

>> Mike: Mike Newman, Neutron Energy: Not really, I was just going to ask if it might be possible to get the list of participants and contact information out before the CP comes out. That might not happen until next spring.

>> SPEAKER: We are having a meeting and the organizing committee, when is it Hans, next week or the week after. And we are going to be talking about how we are going to organize the conference proceedings. So we will make that as a recommendation of can you get the registration list out before then? Any other comments?

SPEAKER: There is a list of the people that were participating, people giving presentations and on the panel, technical writers and co-chairs in the very last page of the program. But I know that's not what you're asking, I realize that.

>> CHAIR: Any other questions or comments? Is there any -- Loren?

>> MR. SETLOW: Loren Setlow, EPA. A little

follow-up on the document availability. I just wanted to mention that the log that we had set up discussion form actually has a library of documents which include as far as I know, a pretty complete collection of the original regulatory publications as well as the decision documents, Environmental Impact Statement and economic assessments associated with the original followup, UMTRA regulations. So you can if you want to get that address, you can just send it to me at Uranium Review at EPA.G0V and I will send that location to you.

>>CHAIR: All right, I'll see if anybody's online that want the ask any questions.

Could you unmute the line people up there?

Is anybody -- I heard more noise before.

Okay, so all right.

That concludes the workshop and I want to thank you again. This was not a luxury workshop and I appreciate you sitting through to the end and for the quality that was brought with.

(applause)

(Whereupon, the workshop was officially concluded)