UNITED STATES

NUCLEAR WASTE TECHNICAL REVIEW BOARD

FALL 2011 BOARD MEETING

Tuesday

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Little America Hotel
500 South Main Street
Salt Lake City, Utah

OFFICIALS OF THE NUCLEAR WASTE TECHNICAL REVIEW BOARD PRESENT

BOARD MEMBERS

Dr. B. John Garrick, Chairman, NWTRB
Dr. William Howard Arnold
Dr. Sue Clark
Dr. Rod Ewing
Dr. George M. Hornberger
Dr. Ronald M. Latanision
Dr. Andrew C. Kadak
Dr. Ali Mosleh
Dr. Linda Nozick
Dr. Henry Petroski

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I N D E X

PAGE NO.

INDEX
(Continued)

P R O C E E D I N G S

8:00 a.m.

GARRICK: Good morning. My name is John Garrick, and I have the honor of being Chairman of the U.S. Nuclear Waste Technical Review Board, and of welcoming you here today.

For a number of reasons, it's especially nice for me, at least, to come to this location, where I have a considerable number of roots. I had my undergraduate work down the road a bit at the Brigham Young University, and I actually lived in Salt Lake City on two different occasions, one for my second grade, and the other for my middle school years, seventh and eighth. My father was a miner, and I think I was in 13 schools by the time I was in high school. So, we lived in a lot of western mining towns, but we did land in Salt Lake for part of that time. And, I very much enjoy coming here and being reminded of a very pleasant time.

Those who have attended past Board meetings will recognize that we have some new faces on the Board. And, I would certainly be remiss if I didn't introduce those to all of you, and I will do that now. And, as I do so, I'd like the person that I'm commenting about to raise their hands so that we can all see who they are. There are three of them. There are three of them this year, and there may be about seven or eight of them next year.

First, I would like to introduce Sue Clark. Sue?

Sue is the Regents Professor of Chemistry at Washington State University in Pullman, Washington. She teaches and conducts research in actinide environmental chemistry and radio-analytical chemistry. Prior to joining Washington State, Sue was associated with the Savannah River Ecological Laboratory, the Environmental Systems Engineering Department at Clemson, and the Interim Waste Technology Division at DOE's Savannah River Laboratory.

I've had the pleasure of serving with Sue on national research council committees, and I'm sure she's going to add a great deal and make a major contribution to the Board.

Next is Rod Ewing. Rod also I've had the pleasure of serving with on committees. Many in the nuclear waste management community are very much familiar with Rod and his work. Rod is the Edward H. Prouse Distinguished University Professor at the University of Michigan. He has faculty appointments in the Departments of Earth and Environmental Sciences, Nuclear Engineering and Radiological Sciences, and Materials Science and Engineering.

Are there any departments that were left out?

EWING: French.

GARRICK: Among many honors, he has been elected as Fellow of the Geological Society of America, the Mineralogical Society of America, the American Geophysical

Union, and the American Association for the Advancement of Science. Rod had been the co-editor and author of several very influential publications on nuclear waste management.

Our third member, Linda Nozick. Linda is a Professor of Civil and Environmental Engineering at Cornell University, where she is also Director of the College Program in Systems Engineering. Linda has played a leading role in developing optimization models for planning and policy to support the national security enterprise and Homeland Security.

She has been recognized by DOE’s Sandia National Laboratories, and the National Nuclear Security Administration for the Development of Modeling Tools for Nuclear Stockpile Analysis, Transportation of Hazardous and Sensitive Materials, Enterprise Planning, and Budget Analysis. Linda has also served on Natural Research Council Committees to advise DOE on renewal of its infrastructure.

These three new Board members replace three former Board members, and I would be remiss if I did not acknowledge the superb role played by those people, each of whom served on the Committee for about nine years.

Mark Abkowitz. Mark was extremely active and engaged in the Board’s work dealing with transportation and systems modeling. For example, he brought a very important perspective to bear when the Board was reviewing DOE plans for constructing a rail spur from Caliente, Nevada to the proposed Yucca Mountain repository, and he actually spent several days in the bush following the proposed path of the spur.

In addition, he used his systems expertise to review plans for operating the surface facilities at the proposed repository. And, later on, Mark was the key Board member involved in the development of the analytical tool we call NUWASTE, and you will hear more about that later.

The second member leaving the Board is Thure Cerling. Thure is a Distinguished Geophysicist and Geochemist. He provided the Board with exceptional expertise in the performance of site geology for the disposal of nuclear waste. Thure was especially knowledgeable about how disturbances of geology can impact its containment capability. Such disturbances are tunneling and excavation activities, preclosure operations and postclosure degradation and mobilization of the emplaced waste.

And, by the way, Thure is a Distinguished faculty member here at the University of Utah.

Last, but certainly not least, is David Duquette, and together with current Board member Ron Latanision, David played a key role in the Board’s evaluation of the long-term performance of the alloy 22 waste package DOE proposed to use in the repository. David focused on the issue of localized corrosion. He argued that deliquescent salts could form on the waste package, and in above-boiling temperatures, those compounds could possibly initiate a corrosion process that would not be stifled until the package had been breached.

He organized a two-day workshop at which experts from DOE, the State of Nevada, the Nuclear Regulatory Commission, and other interested and affected parties evaluated this issue in a great amount of detail.

Now, in the interest of time, I am not going to introduce those who will be continuing on the Board, except to point out that a complete roster of the Board is available on the table at the back of the room.

It has been almost seven years since the Board met in Salt Lake City. It was in fact just the second meeting after I took on the role of Chairman. Because some in the audience may not be familiar with the Board, a few words about the role and its current activities is in order before we begin two very busy days of presentations and discussions.

The Nuclear Waste Technical Review Board is kind of unique among federal agencies dealing with radioactive waste management in that it is really the only entity that performs an integrated technical evaluation of all elements of the U.S. High-Level Waste Management Program, including waste acceptable, transportation, packaging and handling, facility design and operation, and waste storage and disposal.

Congress created the Board as an independent federal agency in the 1987 Nuclear Waste Policy Amendment Act. In doing so, Congress concluded that there was a need for independent and ongoing technical peer review of all activities undertaken by the Secretary of Energy related to the Department of Energy's obligations to manage and dispose of spent nuclear fuel and high-level radioactive waste.

Basically, it's our job to advise Congress and the Secretary of Energy of our findings, conclusions, and recommendations as a result of our reviews of DOE work.

Meanwhile, change is the operative word, and changes in the nuclear waste field have been many, and suffice it to say that those events have not come to any definitive conclusion. Nevertheless, during the past two years, DOE's work on the Yucca Mountain Project has been terminated. The Secretary of Energy has appointed the Blue Ribbon Commission on America's Nuclear Future to make recommendations of a path forward, and in the meantime, DOE has initiated a new research and development program.

That program is exploring a set of generic issues related to the development of a deep mine geologic repository to be decided somewhere, sometime, in the still undetermined future.

In addition, the new program is looking at alternative nuclear fuel cycles and examining issues associated with the very long-term storage, and transportation of commercial spent nuclear fuel. Thus, we have refocused our ongoing review and priorities to evaluate the alternatives that DOE is considering.

And, it should be noted that even during this time of transition, the Board has not been sitting idly by. It has recently produced five major reports to Congress and the Secretary. Last December, the Board released the report titled, “Evaluation of the Technical Basis for Extended Dry Storage and Transportation of Used Nuclear Fuel.” In June, the Board published the report, “Technical Advancements and Issues Associated With the Permanent Disposal of High Activity Waste, Lessons Learned From Yucca Mountain and Other Programs.” And, in that same month, the Board issued another report entitled, “Nuclear Waste Assessment System for Technical Evaluations, NUWASTE Status and Initial Results.” Thank you.

Now that the country appears to be in the process of reassessing its policies for the long-term management of high-level waste and spent nuclear fuel, there is increased interest in what other nations are doing in that area. To provide policy-makers with objective information, the Board has produced two reports that present information on relevant programs in 13 countries, including, of course, the United States.

The first report, “Survey of National Programs for Managing High-Level Radioactive Waste and Spent Nuclear Fuel,” came out in October of 2009. And, the second report, “Experience Gained From Programs to Manage High-Level Radioactive Waste and Spent Nuclear Fuel in the United States and Other Countries,” was issued in April of this year. The latter report actually builds on the information in the 2009 report.

And, I should note that a few copies of all of these reports are available on the table at the back of the room. And, if we run out and you wish to receive hard copies of any of these documents, please let us know and we’ll get copies for you. All of them can be found on the Board’s website, which is a very simple website, nwtrb.gov.

Now, I would like to turn to the agenda for today, and offer a little bit of a tease about what we can expect from tomorrow’s meeting.

Our first meeting following some welcoming remarks from Mayor Ralph Becker is John Montgomery, who is the site manager of DOE’s Records Management Facility in Morgantown, West Virginia. John is here because two years ago, DOE had requested that the Board provide oversight of the preservation of documents and records from the Yucca Mountain Project, which we have agreed to do. Since then, we have learned a great deal about what it takes to preserve the records of such a large and long-lasting effort. The Board will eventually produce at least one report that assesses the preservation activities.

Although the Board has heard previously from DOE about its new R&D efforts, this will be the first time that the Office of Nuclear Energy’s Used Fuel Disposition Program will discuss in some detail the range of projects it has been supporting during the last year.

We will start off with a familiar face, Dr. William Boyle, who heads up the Office of Used Fuel Disposition. Bill will provide an overview of the mission driving the used fuel disposition campaign. He will also describe ongoing and planned work, both for fiscal year 2011 and 2012, including the scope, funding levels, and participants. Finally, he will present accomplishments to date, and planned milestones.

Peter Swift, another familiar face to the Board from Sandia National Laboratory, will summarize the primary disposal options for disposal of high-level radioactive waste and spent nuclear fuel that has been identified as worthy of further research and development. And, he will explain why four options, repositories in clay or shale, salt, and crystalline rock, and deep borehole proposal, why those four options were chosen, and explain why other options were not. I think Peter will do that.

Mark Nutt from Argonne National Laboratory will build on Peter’s presentation and will walk us through the used fuel disposition campaigns research and development roadmap. This document represents an initial evaluation and prioritization of R&D opportunities that could be pursued by the campaign. According to its authors, it is a living document that will be revised to update the status and prioritization of R&D needs as progress is made, or as necessary, to reflect understanding, changing understanding of these needs.

DOE will then discuss two modeling efforts. Scott Painter from Los Alamos will talk about discrete fractured models that might be applicable to a repository sited in crystalline rocks, such as granite. Jens Birkholzer from Lawrence Berkeley will discuss some modeling he has performed for a repository that might be sited in clay or shale. He will discuss two examples of specific research, the evolution and characteristics of the disturbed zone near emplacement tunnels in a generic clay repository, and diffusive transport in compacted clays or betonite backfill.

Our day will wrap up with a talk by Brady Hanson from the Pacific Northwest Laboratory. Brady will talk about the methodology and results of the technical data gap analysis performed to identify the data and modeling issues needed to establish a sound technical basis for extended storage of commercial spent nuclear fuel.

Now, tomorrow's agenda, which I'll say a few more things about in the morning, will include a little more on extended storage, a discussion of transportation issues, presentations on spent fuel criticality and safety, and three very interesting panels.

The first panel considers the recently released draft of the Blue Ribbon Commission on America's Nuclear Future. The second panel brings together three participants in the extended storage collaboration program, otherwise known as ESCP, or "escape." And, a third panel is devoted to considering the waste management implications of using mixed uranium and plutonium oxide fuel, that is MOX, in light water reactors.

Now, at the end of each of our two days of meeting, members of the public will have time to comment and ask questions of the Board, and the presenters. This segment is always an important part of our proceedings. If you would like to make a comment either today or tomorrow, please sign the sheet at the back of the room where Linda Coultry is standing.

If you prefer, remarks and other material can be submitted in writing and will be made part of the meeting record. And, these statements will be posted on our website.

Now, I would like to note that in these meetings, we Board members like to freely express our views and opinions, and we want to continue to operate in that manner. But, we do ask that you realize that these comments are not necessarily Board positions, it's not necessary the Board is speaking, so any opinions you hear or infer from a Board member, a Board member's question or comment, these are not necessarily Board positions.

I would also like to indicate that it is very important for you to identify yourself if you are speaking, and to speak into the microphone, giving your name, your affiliation, and any relevant information that would identify your remarks.

So, with these preliminaries out of the way, and if our honored guest is here, I'd like to ask you to switch off your cell phones, and turn your attention to him.

MOTE: The Mayor and his representative are not here yet. So, I suggest we just start the program and break when we need to.

GARRICK: Okay. I will say this about our honored guest. It's Mayor Ralph Becker. He was a member of the Utah legislature. He is a lawyer, and we'll forgive him for that. I especially have to forgive him because my two sons are lawyers, and one of them happened to have gone to the same law school and Ralph Becker did. I don't know, they may have even overlapped. We haven't figured that out yet. And, we will look forward to his remarks when he shows up.

So, with that, we'll go into our first presentation. I guess that's John Montgomery.

MONTGOMERY: Good morning. Can everybody hear me? That's good. Anyway, we'd like to thank the Board for inviting us. And, that's a picture of our building. We're located in Morgantown, West Virginia. And, the way we do things in Morgantown, we let the people who know most about what's going on speak, so I brought along two of my technical people. Dr. Edwin Parks. Could you stand up? Also, Bob Walker, our IT specialist.

Dr. Parks is going to give the presentation on the records. So, I'd like to introduce Dr. Edwin Parks.

PARKS: Okay, Mr. Chairman, Ladies and Gentlemen of the Board, it truly is a pleasure to be hNARAere to share with you the progress that Legacy Management has made in preserving the science and preserving the records and information from the Yucca Mountain Project.

But, I need to point out one thing in a group like this before I get started. If you look through my bio, you will notice I have a double E. But, before you get too excited and ask a lot of technical questions, that's Elementary Education. So, I just want to me sure we've got that.

Okay, what I'd like to do is just outline very briefly what our task was when we were given this task to preserve the records, a little bit about the two plans that were developed to oversee and provide some guidance and provide the roadmap to preserve that information, and then share some details about how the execution of those plans had taken place, and then finally, give you a wrap-up of where we're at today in our efforts to move forward.

So, our task was--it looks very simple to transition all of the records and information from OCRWM to LM until you start to peel that onion back and realize a systematic approach to actually "Save the Science" from this project is a lot more complicated than probably anyone realized when that mission statement, if you will, was written down. And, if you see, it does flow out of LM's mission to take care of sites typically once they have transitioned and been remediated, which is not the case, of course, with Yucca Mountain, adding to the fact that the license application decision from the NRC is still pending. But, here in the AIM team, Archives and Information Management, we are the main folks in LM that do preserve, protect, and share records and information, so it's a very logical place for this mission to fall within the Department.

And, I have some idea of what we are asked to do, and here are the two plans, I'll outline very briefly to give you a high-level look at how we looked at this task when we got started. You see the two plans here. One dealt primarily with Records Management, but it also included Information Technology as part of that because in the records world, if you read anything with the National Archives, it's media neutral, so it doesn't matter if that record is electrons, if it's a videotape, or whatever it is, it's still a record, so the IT is also part of the Records Management Transition Plan.

But, because the uniqueness of the Licensing Support Network, it was deemed that that needed a plan of its own because, again, because of the ongoing decision making with the license application, and the uniqueness of the LSN, because of its litigation aspects that were there.

The one thing I will point out here in the final sub-bullet there on the slide is that there are components, if you will, of the License Support Network that are not resident out on that public website that we dealt with under the Records Transition Plan. So, it's all taken care of, it just was decided that that would be a better place to do that to handle all of those records in one process.

Now, to walk through each of those, first, the Records Management Plan, there's a couple components to that. This is the Records Management piece, and the Records Information System, or the RIS as it's been called over the years, is an electronic record keeping system that was designed and it's a NARA approved system to capture physical and electronic media and put it into this electronic record keeping system, and that's in compliance with NARA standards, and also so that you can prove the authenticity, et cetera, of the records that are put in there. We needed to capture all the records that were remaining, and make sure that we could search and retrieve those records out of that particular system, which is an electronic system, as I mentioned.

Then, we had to transfer all the physical records, and again, these weren't just pieces of paper, but in many cases it was media, maps, et cetera, and relocate those from various places, and I'll list those for you a little bit later in the briefing, and bring them to the Morgantown Warehouse in West Virginia for safe keeping. And, I don't believe John mentioned up front, but our facility is a NARA certified records storage facility, so it meets all of the same standards as if they were in a Federal Record Center. So, it's a good bragging point for us in terms of the kind of facility that we operate.

The other part of that Records Management Plan was the IT side of the house, and it's back to the RIS again, because it did have a very unique electronic component to it, and we had to make sure we could still operate this system, maintain it in its existing form, update it as required with the changes in Information Technology that are out there, and maintain our ability to do queries, because people are still requesting information, as you will see later in the briefing, and then at some point, migrate that system into a more current system that LM uses so that we can carry it forward and not lose any of the information in there over the years.

Then, the second part of that very complex was preserving the science, and this is all of the systems that were deemed the most important ones to "Save the Science," if you will, 20-some different electronic information systems, some are simple data bases, others did actual computations. We had to archive all of those systems as well, and all of the source code, et cetera, that went along with it, so that they would be there for use in the future.

And, then, finally, the LSN plan. LM assumed the custodianship of the LSN, and every month, Mr. Montgomery would be the person who would certify that our document collection was up to date, and we had to maintain it, and still maintain it, at least the collection, in compliance with the NRC requirements. But, as I believe you all are probably aware, the live portion of that website that was hosted through the NRC's portal has been removed as of about the 5th of August. And, it also talked about the archiving of that collection to make sure that it is also in compliance with NARA's record keeping requirements for long-term storage.

Again, that’s kind of a high-level look at what those plans were, and then when it gets into the execution details, things can start to change just a little bit.

First, I’ll talk about the actual RIS itself. It was quite a large effort to try and capture the 300 plus cubic feet of physical records that were still out there that had not been put into the system. We had the hard copy documents, but as RW was paring down and they were trying to decide what to do, some of the record keeping just got backlogged. So, that was one of the big tasks that we had to take on, and used many of the people--many of the people on that team that did that process were actually part of RW when it was a full-up organization doing that same kind of work.

We were able to complete that backlog back in March, and got the last record, I saved the last record, there are still other records that are out there, because the contract for the M&O is still ongoing, so there’s some contractual records that are still out there. But, all of the data has been put into the RIS.

And, then, the next, or part of that maintaining the RIS was also to take it from its old form, where basically anyone within RW could get access and go in there and look for records, because information moved around quite frequently, so what we had to do was isolate that RIS and get it down to just a select few people and get it down on smaller pieces of hardware so that it would be cheaper to maintain that as we go out, and also do that archival process as we go down the road. So, that was ongoing at the same time that we're trying to maintain the capability and get the backlog into the system, et cetera.

And, then, we also have to archive the system again so that it's in compliance with both NARA and the NRC requirements to make sure we can validate the authenticity of the QA records, et cetera, that are located in there. And, we're right now beginning the process of looking at a technical solution that would be most appropriate. And, part of that is hinging on what NARA's determination is of some of the documents within the LSN, because they're the ultimate authority that determines how long we must keep these records. That's not a DOE decision to make. So, we have delayed that technical solution until we get that final outcome, so we can do it a little bit smarter, and currently, the system runs just fine.

We had to transfer all the records, and this gives you an idea, and I didn't list every single office, but there were several offices in the Headquarters, in the Forrestal Building, out in the Las Vegas area, to include federal staff as well as contractors, folks at the lead lab, and then in Denver at the Geologic Survey, lots of places that we had to make sure we identified all the physical records, so that we could get those and put plans in place to make sure we had a good audit trail on those, and be able to get them to our facility.

Also, a couple Record Centers have been used, which is pretty typical for most government agencies to use an FRC, Federal Records Center, to store your records until they either go into permanent storage, or be destroyed. And, then, also commercial storage facilities within Las Vegas were also used. And, quite frequently, records were taken in and out of that recall facility, as it’s referred to, out in the Vegas area.

We were able to get all of those records identified, inventoried, shipped, and put into our warehouse electronic keeping system, which the list that I believe the Board has of all of the boxed material that we have, that’s what had to take place before we could compile a list, a complete list like that of all the materials that are there, but we got the last box in the door toward the end of July, and they’re all shelved and in our system so we can retrieve them.

And, then, there were some records management activities going on, and the numbers that you see up there in a sense are deceiving. The first one is not deceiving, it was a FOIA request, it’s the only one we have had so far, Freedom of Information Act request. We’ve had 27 different claims, not specifically just for Yucca Mountain. In many cases, they worked at other places on the Nevada Test Site, and Yucca Mountain was one of the places they worked at. So, those EEOICPA claims in some cases they’re not just Yucca, but also involved other sites as well. But, the internal and routine requests, that’s the deceiving part, because it says 111, which really doesn’t sound like a lot, but if you consider that some of those requests had from 300 to 2500 documents that were requested in one request, it’s quite an undertaking to be able to locate those items, get it to the people that need it so that they can do their work and carry things forward. So, again, that was going on in the background as we were doing all these transition activities, which is what we will do with collections, all the rest of the collections that we have in the LM inventory.

Then, we developed some finding aids. We’re still in the process. We’re just about finished. By the end of October, I believe we have four boxes of that 758 left when I got on the airplane yesterday, so we’re just about there. So that it makes it easier to identify documents people would need and be able to pull those out in a more timely fashion, and not waste a lot of effort and resources.

And, then, we took a lot of Legacy finding aids, many of these were spreadsheets, sometimes they were literally pieces of paper people had written things down on when they turned in documents, et cetera, and we were able to take those and put them into a form into our warehouse tracking tool, it's the tool that tracks all the boxes in the warehouse, and it's the first place we go to to try and locate things in the warehouse. And, that really makes it a lot better, a lot more efficient to be able to go in there and pull things off the shelf and do it in a timely manner.

And, then, the IT side of the house, and this is not my area of expertise, which is why Bob Walker is here. So, I will steer all the really tough questions toward him in this manner. But, we had to ensure the operational readiness of all the prioritized systems that were there. We just needed to make sure that we could keep them up and running, if you will, keep the green lights on blinking and flashing, so that we could get them archived. And, in fact, they were archived by RW as they stood down, and we had one large archive tape that had about 25 different systems on it, and from that, we have actually created an individual system archive of each one of those systems, so that if someone were to request DURS (phonetic), for example, they could just get that information that was on there and it would make it a lot simpler as time went on. But, those were all created. They're maintained. And, those were all validated.

We consolidated all those systems. The first big step was the Sahara Data Center in Las Vegas, which was the larger of the data centers. A lot of the equipment that the systems were running on there was moved or run on different servers over in the Hillshire Building, which was the last location that was up and running. And, all these systems were resident there, and then it was a consolidation process of trying to eliminate the number of literally computer hardware and servers that were running, so that eventually we could move these systems into our data center out in Morgantown, which is where they currently are today.

And, the RIS and this project called the E-mail Warehouse, which was 20-some years of e-mails that were in the system that are being maintained mainly for litigation purposes, but there also is record material in there as well, but all that was also part of that consolidation and movement effort, and we completed that on the 12th of August, and those systems are back up.

Then, the LSN. First big thing to try and save some resources, given the state of the license application process, was to remove the redundant on-line back-up capability. It was deemed unnecessary at that point. All the data was saved, it was archived. It was a back-up, it just wasn’t an on-line back-up. So, the redundant on-line back-up that was located at the time out at Hillshire in Vegas, was taken down, and the collection is now currently maintained in CACI's facility, which is our contractor that does the maintenance of the LSN out in Northern Virginia.

We have also submitted, just about a year ago, it was one of the first tasks, in fact, today I noticed is my one year anniversary with DOE, and one of the first things John asked me to do was submit the 115 to NARA to ask for the records disposition decision, and it typically takes at least a year or more for that to happen, and we have yet to hear their final decision on how long the LSN would be retained. DOE's recommendation was 100 years. But, again, that decision is ultimately up to NARA in terms of what they determine is the best disposition decision for that particular set of documents.

And, most recently, just within about the last ten days, we completed a court-ordered PDF/A set of all the documents that were on the on-line collection, including the "header only" documents that were out there, and submitted those in three different pieces, because the collection was so large, and provided that back to the NRC, which was required by court-order.

Now, last but not least, where are we at this point in time? The RIS and E-mail Warehouse are on-line. And, by on-line, I mean, particularly for the RIS, we conduct searches on that system darned near every day. A request will come in and we'll have some reason to go in there and pull a document up, or see if something is located within the RIS. So, it's on-line and it's searchable and retrievable just as it was back in the days when it was operational with RW. And, the E-mail Warehouse is up and running, if you will. It's not our e-mail system, but it's there, if someone were to need to search for e-mails, we could do that. It's fully on-line.

The prioritized information systems, we say operationally ready, and the reason we use that term operationally ready is we aren't the scientists and engineers that ran those systems. We have some very smart IT people that were able to restore them, get them back so that we can validate that the information is in there, but if someone were to ask us to retrieve a specific item, someone like myself is probably not going to be the qualified individual, but yet they are still in the same state and can run just as they did back in the day when they were being used for various research efforts on the program. And, all the tape archives were validated and those are also maintained. So, we have the on-line version, if you will, of all those systems. We also have an archive tape, a back-up tape, if you will, in case something happens and that on-line system goes down, which is typical routine practice for any information system.

KADAK: Excuse me.

PARKS: Yes, sir?

KADAK: Just a question. This is Kadak, Board.

Are you saying that you have all the hardware, the computers, that can actually run the codes that were used in your system, your Legacy Management system?

PARKS: They are running right now.

KADAK: They are running now?

PARKS: Not in every case on the actual piece of hardware they were run on. We tried to, where we could, put it on a more modern piece of hardware, but it’s the same code, we didn’t alter any of that, we just had to consolidate it down so that it didn’t take up a city block.

KADAK: Right. So, they are executable, is what I’m really trying to get to, but you’re not sure about that?

PARKS: That is correct.

KADAK: And, if one needed to go back and find something, how do one do that?

PARKS: Again, I wasn’t the individual that ran the systems, but for the IT folks that still remain with us that worked on the program, they weren’t the individuals that did that either, but they can go in and show you where the search screens are, and if someone knows what they want and they’re familiar at all with that system, they would be able to go in there and pull that back out of there. All the data is in there, the system can work. It’s just--I guess the best example I can give, if you were used to using Word as your word processing system and somebody put you in front of Word Perfect, you'd probably struggle quite a bit. But, it still works, and you can manipulate a document. That's kind of the same concept here. We don't know how to use Word Perfect. We barely know how to use a word processor, in my case.

MONTGOMERY: A good example would be, you know, it works, everything works. It would be like me looking at Chinese. I can't read Chinese. Somebody who speaks Chinese would be able to interpret the information, but the system works.

KADAK: Well, I guess the question is--

GARRICK: Andy? Andy, I think that what I'd like to do is interrupt the question and answer part of it, and allow our honored guest to make the few remarks, and then we can resume, if you don't mind. I'd like to do that.

So, Mayor Ralph Becker of Salt Lake City, we're delighted to have you.

BECKER: Thank you. Welcome, all of you who are here for this meeting, to Salt Lake.

I've got to tell you that when the request came in to visit with you, as interesting and fascinating as this subject is for me, it really was because Karyn Severson contacted me. Karyn is a dear friend from Southern Idaho, who lived in Salt Lake for a long time. We both worked for the same governor, and her husband, Lucky, is still a legend in media circles here in Utah. And, so, it gave me a chance to see Karyn, even briefly.

But, also, I've got to tell you it really is actually interesting for me to look at what you're doing. I looked at what we do in Utah in terms of our records management and in Salt Lake City and records keeping, and needless to say it pales in comparison to the volume of information that you are dealing with. And, the importance of having it available for both experts, but more importantly in many respects the public, to be able to know what we're doing in government, to have a transparent system of government.

I know that has been a very high priority for the Obama administration, sort of been working at a real high policy level with some of their folks in the White House, and, you know, hear their stories of how they're trying to transform the Federal Government into a system that is manageable, that is accessible, and that provides for an open government in a way that the public expects.

I can't even imagine the costs and work that goes into the records you are looking at here. As all of you know I'm sure, we have a special interest in radioactive waste in Utah, and it's a continuing source of great interest for a whole variety of reasons, in Salt Lake City as well, we're sort of literally the cross-roads of the west, and that means that a lot of radioactive waste moves through here. And I can tell you it’s of great concern to our public here, because we have a radioactive waste facility, low-level radioactive waste facility here in the west desert. It looked like for a while we might be a temporary storage, as I’m sure all of you know, for higher-level radioactive waste while Yucca Mountain was being built. That’s kind of off the drawing boards.

But, I could tell you as a politician, when I go door to door, and that includes this year, I’m up for re-election this year, I get at the doorstep concerns of the public, and to the extent we can make people more aware, have information more available, build confidence in what we are doing in government to address the storage issue, the better we’re going to be able to address the big issues associated with nuclear power and radioactive waste.

So, I thank you for coming here. I always have to say as Mayor, I hope you spend a lot of money here. But, I also hope you enjoy your stay, and have a chance to get out and enjoy the city and the environs that we enjoy so much here.

So, thank you for letting me just join you for a few minutes. I wish you well in your work, but also hope you’re really able to enjoy our community and the area around here. Thank you.

MONTGOMERY: All right, we’re going to continue. Did we answer your questions?

KADAK: I forgot where I was.

MONTGOMERY: You were talking about the systems, and you were concerned--

KADAK: Oh, yeah, the retrieval, in other words, how do you document where stuff is, and what is the indexing if someone wanted to go back and say I need this document? I mean, you have the LNS, you have all the DOE work packages and design documents and whatever else has been generated. How does one navigate that?

PARKS: To be honest, the first approach is to look in the RIS, because most of the technical information that was created, final reports, et cetera, including data items, and I mean electronic data items, and most times, that’s where it’s found. In some cases, it’s only in the LSN because it wasn’t put into the record system because of where it was generated. Those are the two primary places we go to. The data that’s in these different systems we’re talking about is more the raw data that is somebody who wanted to go back and find out a source, this or that, they could go back and look for some of those things. But, the actual final reports, all the scientific data, and what was documented that supported the license application, that’s all within the RIS or the

LSM. And, it’s fully text searchable, if you will.

KADAK: Okay.

PARKS: Now, if you do a text search on plutonium, you’re going to get a million hits. But, if you know what you’re looking for, if you have the date, if you have the author, or if you have some way to start narrowing that down, you can very quickly, in many cases, come to the actual document you’re looking for.

KADAK: And, are you doing this with NRC stuff as well, or just DOE?

PARKS: It’s just the DOE collection.

KADAK: Okay.

PARKS: Just the DOE collection.

EWING: So, in absence of the chair, I’ll jump in and ask another question, if you don’t mind. Rod Ewing, I’m a member of the Board.

Could you comment on the provision for public access to these records, and also under what circumstances is the Freedom of Information Act required to get information?

PARKS: That is the process for the public to access any of the federal records, is the Freedom of Information Act, for these collections. DOE has not decided to put it out in a public form, such as a website, even though the LSN was hosted, but it was not hosted by DOE.

EWING: So, a scholar writing the history of the Yucca

Mountain Project would have to use the FOIA process to get information?

PARKS: That is correct.

MOSLEH: I have a follow-on question to Dr. Kadak’s. Just to make sure that I understood what you said about computer codes. I believe you said that the computer codes that were part of the computational tools that they were using, such as what’s one is known as TSPA, kind of a major simulation code that they had, that one can actually run the same code, but in your configuration?

PARKS: The actual TSPA code is one that’s not maintained by LM. DOE has it. It’s at the lead lab, is where they have it. We don’t have a copy of that.

MOSLEH: I see. That’s not--

PARKS: Right.

MOSLEH: Is there a plan to move that, too?

PARKS: There is not currently a plan to move the TSPA.

MOSLEH: I see.

PARKS: Any other questions before I just take care of a couple slides? We’ll get there. There we go.

We have about 13,000, just a little bit more than that, cubic feet, which is basically a records box of material that’s been processed/shelved at the Business Center. And, you can just see the types of documents there, including all the recycle material when the final order came down to not destroy anything, literally boxes of recycle material as well that we maintain. There’s about 1200 boxes of just that and derivative discovery. And, currently, the LSN, as I mentioned previously, is maintained off-line, fully searchable. We can retrieve everything out of that, just like the public was able to do, so we get requests, we can do that. And, we’re just now starting the process to decide, and again, waiting to see what NARA’s final determination is, but the documents that are in the LSN are already in a NARA compliant format. So, it shouldn’t be as monumental a task, but the size of it makes it a pretty big task.

KADAK: I’m sorry. Kadak again. To address the question of need of Freedom of Information Act, why wouldn’t you put the LSN in a publicly retrievable place?

PARKS: It’s more a resource question, but--

MONTGOMERY: Yeah. The Department has made no commitment to do so. So, I mean, that’s a good question. I mean, if we were told to do that, you know, I think we could. But, at this particular time, no one has directed us to do so, and we have made no commitment to do it.

KADAK: Is it difficult to do, like separate the LSN as a separate searchable file? I mean, it is public now, or at least it was public; right?

WALKER: Bob Walker, Legacy Management, IT.

Is it difficult to do? The size of the collection makes it somewhat of a challenge to maintain it. Other than that, it's not difficult.

KADAK: Okay.

PARKS: There's about 1.6 million documents.

ARNOLD: Arnold, Board.

I'd like to follow up on Ali Mosleh's question. You said that the TSPA has moved to Sandia now?

PARKS: LM never had it, but that's who developed it. The lead lab developed it and maintained it, and they've maintained possession of that.

ARNOLD: In other words, it was developed at the site in Las Vegas. Is the lead lab now capable of running the TSPA?

WALKER: They still have the same one, yes, that's my understanding.

ARNOLD: Okay. And, what are the plans then for retrieval of that at some further end point in this process for management of--Legacy Management of that TSPA, down the road?

WALKER: As I understood it, the lead lab was going to maintain that, and if they ever were going to get ready to get rid of it, they were going to contact us and take it. But, for now, they wanted to maintain running it.

ARNOLD: Okay. So, you'll be at the end of that process, too?

WALKER: Yes.

ARNOLD: Okay.

WALKER: That's correct.

MOSLEH: One more question on that. So, does that apply to other computational code, ESB is the biggest one, but what about other codes that people use for calculation at the lab?

PARKS: We were, again, the exact number, I believe it was 26 different codes, did not include the TSPA, that RW identified as the program grew down the last couple years, this is before LM came on the scene, that they decided to maintain that they felt needed to go forward to preserve the science. That list of software, we have the code, we have the systems, and those are the ones that I talked about that are operationally ready, that if someone needed to come in and do some kind of calculation, assuming they know how to drive it, they can get on there and work it just like they did back in the program office. They're just going to be doing it from a different location.

KADAK: Right. Okay, thank you.

PARKS: If that answers your question.

KADAK: Yes.

PARKS: And, that list was provided to the Board as well, of what specific codes we have, the software and databases.

KADAK: Thank you.

GARRICK: Garrick, Board.

This question may have been asked, and I apologize for having to step out a moment, but is there any attempt at segregating the information according to any prioritization or importance level?

PARKS: I’m not sure I--

GARRICK: I suspect that 10 percent of this information is really valuable--

PARKS: Right.

GARRICK: --and maybe 50 percent of it is not ever probably going to be consulted.

PARKS: That’s really, and that’s part of where NARA comes in with disposition schedules, and that’s how those items are handled. Each data item that was a federal record that’s in the system has a disposition schedule associated with it, and the things that are less important, temporary records, are not going to stay, but the scientific data is going to be a minimum of 25 year retention, until we hear if they have any further guidance on how they want us to handle that. And, again, the LSN, we recommended 100 years, and we’re waiting to find out what their final determination is on that.

I’m not sure that completely answers your question, but we don’t have it segregated in any other way other than what the authorized disposition schedule was for those documents.

GARRICK: How much interaction is there with the developers of the information? Is there any formal structure involved that allows the generators of the documents to be involved in the preservation exercise?

PARKS: Not to my knowledge at this point. Unless John has a comment on that?

MONTGOMERY: Yes, that's correct.

GARRICK: Yes, okay.

LATANISION: Latanision, Board.

I have a follow-on to John's question. One of your slides, and I don't see a number on it, but it has a bulleted item called Assume Custodianship.

PARKS: Correct. That's under the LSN.

LATANISION: And, under that bullet, it says the object will be, "Maintain functionality in compliance with NRC requirements until a non-appealable final order and licensing proceeding terminated." What happens then? Suppose 30 years from now we're building another repository and someone wants to go back and look at this information.

PARKS: And, that's why I mentioned our recommendation was 100 years.

LATANISION: Yeah. So, it will be functional for 100 years, or--

PARKS: It will always be retrievable. It may not necessarily--NARA's requirement is not to have it up and running. NARA's requirement is that you have to maintain the authenticity of the record, and also be able to retrieve that should it need to be retrieved. The format in which you do that could be on a tape, it could be on a server, it depends on how you want to execute that. But, you have to be able to retrieve those records.

LATANISION: So, what will actually change when the NRC proceedings are terminated? What will be the impact? What will be ostensibly the change in policy?

PARKS: That's the plan we're starting to take a look at because the portal just came down. It's been live. We haven't changed anything other than the fact it's not being hosted, so we still have the full search capability. But, again, because of the size of this collection, it is a technical challenge to have full 100 percent text searchability within a collection of that size, because of the size of some of the documents. So, that's some of the technical detail that has to be worked out over the longer-term to preserve this. The data would still be there, it's just how much fidelity do you need in searchability, if you will, of going through there. But, all the original documents and data would still be there.

MONTGOMERY: I'd like to follow up on your question a little regarding the LSN. NARA came out a couple of days ago to inspect our facility to make sure it was NARA compliant.

And, it’s a beautiful facility. What I’d like to say is that in my negotiating with--my talks with NARA right now regarding the LSN, most likely, and I can’t say this for sure, that the LSN documents will become a permanent document. So, they’re still grappling with that, but they’re leaning toward making all the LSN documents permanent, so we won’t have that problem, as far as the LSN is concerned.

GARRICK: Henry?

PETROSKI: This is Petroski.

You used the term “preserve the science” a couple of times. Where does that term come from, and what exactly does it mean?

PARKS: I wasn’t there when that term came out. Maybe John might be better to--

MONTGOMERY: All right, I have to say something cooler than that, but I think we’re going to have to let Mr. Metlay maybe comment on that as far as “preserve the science.” Our interpretation of “preserve the science,” my definition and my opinion is to keep everything, to keep the science, records of the science, and to just in case we decide to open Yucca Mountain up again, and preserving the science is preserve everything, all the documentation that’s needed to reopen the facility, if we had to reopen the facility. That’s what I got.

PETROSKI: I guess a question of mine is does science include engineering?

MONTGOMERY: Yes.

PETROSKI: And, what about management of the program, is that included under the term “preserve the science”?

MONTGOMERY: I would think so.

PETROSKI: Okay.

PARKS: A lot of the management documentation, they’re federal records as well, the procurement files, all that information also has retention schedules and is part of that 13,000 cubic feet.

PETROSKI: Okay, good. So, preserving the sciences is just a shorthand for preserving everything, in a sense?

MONTGOMERY: Yes, preserving the project.

PETROSKI: Okay.

GARRICK: Howard?

ARNOLD: Arnold, Board.

I would appreciate a little bit of discussion of how you in fact cope with the constant change in IT. You mentioned Word and Word Perfect. I’m familiar with both of them, and maybe ten years from now some other program will be in use. How in the world do you keep track of all that and make sure that things in fact are retrievable, and not only the programs, but the physical hardware? I mean, going back to, you know, the computer tapes that were in cabinets the size of refrigerators, and then going to floppy disks, and so on and so forth, I’d like to hear from the experts how in the world you treat with that.

WALKER: It is a challenge. You know, what we do is we try to keep a database of the media that we have. We set up schedules to rewrite those tapes on a five year schedule over CDs or DVD or whatever media we have.

A more difficult challenge that I quite honestly haven’t done yet is maintaining a live system for years and years and years as hardware needs upgrade and try to keep the code running on something that was developed a long time ago. Hopefully, we can virtualize these systems and be able to maintain their exact functionality, and that’s what we’re trying to do.

ARNOLD: Yes, just a follow up. I go back to the fact of doing calculations with a punch calculator--no, with card CPCs. Can you deal with those?

GARRICK: I thought you were going to the slide rule.

ARNOLD: No. Well, yeah, how about a 20 inch slide rule?

WALKER: Can I deal with a punch calculator? I don’t know. I guess I would say with a punch calculator, really what you’re going at that point is the records that come out of that are what you’re maintaining, and those are entered into the RIS.

Arnold: Yes. Yes, big trays of cards with holes in them.

WALKER: Right.

ARNOLD: Do you have those?

WALKER: So, those, if they're classified as a record, then they would go into the RIS, and we would have a copy of that.

ARNOLD: And, a machine that will read them? I mean, having all those cards is not much good if--

PARKS: There's two parts to it, if I can piggy back. It's scary, I'm answering an IT question. But, one of the efforts we did with the RIS is there are documents, and they're all PDF/As, so they go forward. That's the industry standard, if you will, and that's the standard NARA uses. So, those will be readable. In some cases, those documents may call out a data item that was literally once in zeros on a tape, could have been on optical media, and we went through a media migration effort, which is a fancy term, if you will, for just taking those old Legacy items, and putting them onto servers, so that the ones in zeros, you don't rely on those old machines, don't rely on a DVD going bad, which they actually do go bad after a few years, and they're now on servers. And, when you go into that document, you can pull up that data set, whatever it was that was supporting that document. So, that's another way that we're trying to make sure that we can keep these as long as technically possible.

GARRICK: We have Dan and then Carl and then Rod.

METLAY: Dan Metlay, Board Staff.

To get back to Henry’s question about “preserving the science,” there is some science things that you might call “preserving the science” that are outside of LM, and have a somewhat different status. And, maybe Bill Boyle I can prevail upon to talk about what’s going on with respect to the sample management facility.

BOYLE: William Boyle, Department of Energy.

Yes, there are physical specimens, if you will, rock core, soil samples, water samples, that are in the sample management facility, as Dan Metlay mentioned, and the sample management facility, for those who have never been there, it’s on the what used to be called the Nevada Test Site, now the Nevada National Security Site. The power to the building is off. The building is locked. But, all the samples are still there. The rent for the building is paid for by the Office of Nuclear Energy, and we have the responsibility for the samples and specimens in the meantime.

GARRICK: Carl?

DI BELLA: This is Carl DiBella, Board Staff.

One of your earlier bullets said that you created PDF copies of all of the DOE LSN collection and gave it to NRC in three parts. I’m wondering if perhaps Mr. Walker could say what the sizes of those three files were in terabytes or megabytes, and whether that is available to other government agencies?

PARKS: It was put onto external hard drives, was the technical solution that the NRC agreed to, and there were two terabyte drives in each of those sets, so it's around six terabytes of data, which was the most optimized way to do it.

We have provided, or I shouldn't say we have provided, we're in the process of working requests for some other governmental interested parties, if you will, and that process is ongoing. But, we do have a process in place to do that for those agencies that do need a set.

GARRICK: Rod?

EWING: Rod Ewing on the Board.

Going back to the subject or the phrase "preserve the science," a fair amount of science is preserved in the open literature that is published in scientific journals. Are those papers part of this archive?

PARKS: If those papers were referenced, the technical information catalogue, that collection of documents, they were all copyrighted material, so they weren't scanned into the RIS, but they are physically located in our warehouse.

EWING: But, they would be copyrighted by the journal; right?

PARKS: Correct. We have copies of the journal articles, or in some cases, the journal or the textbook, I understand. I have not gone through all the boxes, but that material is there. And, the way it works is if you reference it somewhere, either in a RIS document, the warehouse tracking system can just point to the box that it's located in, and you go to the box and you pull out whatever the document is that you're looking for. So, it is catalogued and inventoried, and is maintained.

EWING: Thank you.

GARRICK: Henry?

PETROSKI: I have a question about this sample management facility. If the rent ceases to be paid, and if, you know, there is neglect of this facility, what happens? It doesn't sound like this is under Legacy Management.

BOYLE: No, it's under the Office of Nuclear Energy. But, believe me, the rent will be paid because it's not only the Department of Energy made certain representations to the Atomic Safety and Licensing Board, the Department of Justice also in the Appeals Court in Washington, D.C. said it would be maintained. So, the Courts have been told that it will be maintained, so I have every expectation that rent will be paid.

PETROSKI: For how long?

BOYLE: As long as there's the unappealable decision, and then people will decide what to do at that point, whichever way the decision goes.

PETROSKI: Okay, thanks.

GARRICK: Doug?

RIGBY: Doug Rigby, Board Staff.

I wanted to follow up with Andy and Ali's question. Last week, John provided some answers to our questions, a little bit. We have a continuing ongoing relationship, we plan to go and visit their facility, so we're still learning things. But, in a simple way, how we have thought about all of this collection of information is we've got a lot of physical documents, most of those have been scanned, not all, and appear in these database systems, these software database systems. LSN has provided to us already a list 300 or so pages of the names on boxes, essentially, of what's in the document system. As far as the electronic databases, we have the two active databases, the RIS and the LSN, and then there's about 15 other electronic databases that also house a lot of these records.

Now, there's a third category that we haven't had a chance to find out, get a copy of the inventory and things, and that's the old QA Software Library from the project, also called the Software Configuration Management System, various names. Now, I think that was the direction of Andy and Ali. In particular there's a lot of pieces of software that were on the project. There were unique requirements for hardware and software to run each of those systems, and on the project, you know, that was a big facility where they took care and did all of that.

From the question answers that you sent last week, it sounds like it's that software library is not in one location. There's a portion that the laboratories are retaining, or a portion that the M&O is still retaining, and then you do have in your offices some of that software. Is that correct?

PARKS: This has been one of my nightmares for the last year, tracking this down. But, it's maintained, it's just trying to get all the permissions to get it moved. The software that lead lab was responsible for is currently in our warehouse. We have that, it's inventoried, we know what's in that. That's a much smaller piece of it, to my understanding. There are about 29 Fire Kings, as they're called, which are basically lockable file cabinets worth of QA software that is with the M&O, with USARS, and we are right now, they have been issued a memo, I was told, on Friday to start the actions to move those Fire Kings filled with the QA software to a Morgantown location, and then from that point, we can do a much better detailed inventory, depending upon what they give us as an inventory of what they believe is in those Fire Kings. And, then, we will have it all, if you will, in Morgantown.

RIGBY: Okay.

PARKS: We don’t know when that’s going to arrive. They’re just now starting that process, and it’s a contractual thing, so I never make promises on when it will be delivered. But, at least that process has finally started.

RIGBY: So, at the point that you receive this QA software and have an inventory, you will share that with us?

PARKS: We certainly can, just like we did the rest of the items.

RIGBY: Okay.

MONTGOMERY: We will.

RIGBY: Okay, great. Thank you.

GARRICK: Any other questions from the Board?

(No response.)

GARRICK: From the staff?

(No response.)

GARRICK: From anybody else?

(No response.)

GARRICK: All right. Well, thank you. Thank you very much. I guess we’re now ready for Bill?

BOYLE: Good morning, and thank you for this opportunity.

I really appreciated Chairman Garrick’s opening remarks today. This is the second Nuclear Waste Technical Review Board meeting in Salt Lake City that I have attended, and it's quite a wonderful physical setting, and today is a beautiful day.

But, I also learned something else from Chairman Garrick's remarks this morning, that besides the technical matter we share in common, we have some shared common interests in our family histories in that some of my ancestors were itinerate miners as well. My grandfather and his many siblings were born all over the Western U.S., including right here in Salt Lake City, and my great grandfather, an itinerate miner, is buried here in Salt Lake City.

GARRICK: We'll have to compare notes.

BOYLE: Yes. So, I am here to provide an overview of the DOE's Office of Nuclear Energy Used Fuel Disposition Research and Development Program. And, for those who haven't been to one of my presentations before, disposition does encompass storage, transportation and disposal. For those that think in terms of fuel cycles, we're at the far, far back end. We're at the very end of any fuel cycle.

We are doing research and development right now, and I will provide an overview, because the remainder of the speakers today, and the first two tomorrow, are all participants in the used fuel disposition campaign, and they will provide more details.

Next slide?

So, in my slides today, and my overview, I will talk about the Mission, how we're organized, who does our work, how much money we have to do the work, what we've accomplished, and what we plan to accomplish. And, so, this Mission statement is from the Used Fuel Disposition Campaigns implementation plan. This was published in March of 2010, and it's conduct scientific research and technology development for storage, transportation and disposal of used nuclear fuel and wastes generated by existing and future nuclear fuel cycles.

Now, to put it in plainer English, if you will, what I tell people when they ask me what do I work on now, if they're aware of my prior history with the Office of Civilian Radioactive Waste Management in Yucca Mountain, what I tell them is well, Yucca Mountain might not be the place, but the problem didn't go away, that we still, we currently store fuel and other wastes today, we still have to dispose of the current wastes and any future wastes as well.

Next slide?

So, here's a brief history of the Used Fuel Disposition Campaign.

KADAK: Earlier than that, doesn't it, sort of 1952? Was that your history?

BOYLE: No, this is the history of this group within the Office of Nuclear Energy, which probably even the office--DOE didn’t exist in ’52.

So, it came about as a result of meeting in June 2009. The Office of Civilian Radioactive Waste Management and Yucca Mountain were still active and going at that point. In June of 2009, the parties and the legal proceeding were working out the details of the deposition schedules and hearing schedules. But, there was a planning meeting at Argonne National Laboratory to consider disposition related to different fuel cycles, or even perhaps a second repository, not at Yucca Mountain, some different rock type.

In Fiscal year 2010, the net funding for the research was at $7 million. Offices vary in radioactive waste management was still up and running at the time, and the research focused mainly on disposal, with some effort on storage and none on transportation.

And, then, the fiscal year we’re in now, fiscal year ’11, came around and we have almost $24 million for storage. And, this is after the complete shutdown of the office of Civilian Radioactive Waste Management, and so that explains the increase in funding that many of the scientists and engineers and technical staff that formerly earlier in their careers worked on Yucca Mountain, they brought that expertise over and they’re now funded on working on disposal, storage and transportation by the Office of Nuclear Energy.

We have nine national labs participating in the used fuel disposition campaign. One change, in fiscal year ’11 from ’10 is we do have a significant research and development program in storage, including transportation. And, just to remind everybody, our work says disposal R&D is not site specific, and that’s even true for storage as well. We are not doing research for storage, for an interim storage site at Place X. We don’t know where X is.

LATANISION: Latanision, Board.

Bill, just a point of clarification. Those numbers, $24 million for the usual overheads and national labs, that’s less than about 100 people, is that right, distributed over nine labs, or am I wrong?

BOYLE: Let me see. Let me do this--yes, it’s probably something like that; right. Yes, we actually have a list of UFD participants. It was updated last week, and I can print it in a very small font size on an eight and a half by eleven piece of paper. So, it’s somewhere in that ballpark. Not all of the participants, it could easily be more people than that, you know, your estimate in terms of FTEs is probably right, but the number of people, because some people don’t work full-time for us. I do want to say something--

ARNOLD: Bill, does that come out of the waste fund?

BOYLE: No. No. It’s no with an asterisk. I have no way of knowing what the United States Congress will do for fiscal year ’12, or any other future year. And, no matter what the Congress does, there might be somebody in the United States who doesn't care for what's being done, and they might file yet another lawsuit.

But, I do want to say something else about these dollars, a number of things. These are what I'll call the net amounts that end up being available for research and development, studies for the campaign. If you were to go look at the President's budget, or even an appropriation bill, these aren't the numbers you will see, because in the Office of Nuclear Energy, there is a program called the NEUP, N-E-U-P is the acronym. At least one of the Board members is familiar with it. She's at a university, and so I bet some of the other professors here may be aware of it, it stands for the Office of Nuclear Energy University Program. So, all the programs, the working, if you will, day to day programs in the Office of Nuclear Energy give a portion of their appropriation, or their budget, to fund the Nuclear Energy University Program.

So, when the President's budget says we get, let's say, $30 million, that's not really--we not only have to give money to NEUP, but like other federal agencies, we also have to contribute to Small Business Innovative Research funds, and things like that. So, what I'm listing here are the net amounts. Yes, go ahead.

EWING: May I interrupt with just a follow-up question?

So, you give money to NEUP, and they're presumably working on programs related to this subject?

BOYLE: Yes.

EWING: But, then, I don't see them included in the discussion about the campaign.

BOYLE: I was going to get to that later. These are the--I'm focusing in on the laboratories here because they are the ones who do the day to day work. But, I do like the way you characterized the participation of the universities, in that they're working on topics of interest to us. After all, when the call for proposals goes out to the universities, it does come from us. We're the ones who ask do you have an interest in helping us with this problem? But, we do not use the universities on a day to day basis to help get our day to day jobs done, like if we need, as you'll see, we're going to revise our campaign implementation plan document. We don't typically count on universities for that kind of day to day work, but there's no prohibition against it. If one of the labs, in terms of doing their day to day work, found it necessary to subcontract to a university, they're free to do so.

The FY12 number is uncertain. This number here is traceable to the President's budget. For those who understand the way the Federal Government works, we don't spend the President's budget, we eventually, in the end, spend appropriated money from the United States Congress. House has passed an appropriation bill for all of DOE, and the House is quite generous to Used Fuel Disposition. The Senate also has passed an appropriation bill for all the Department of Energy and Nuclear Waste Technical Review Board as well, and other agencies. The Senate is generous as well. The problem is is that the visions of what to do with the money between the House and the Senate are remarkably different. So, the amounts are different, the visions are different, how they're going to solve this in Conference Committee, I don't know. But, that number for 24 and a half is traceable to the President's Budget.

Next slide?

So, this is the way we're organized for fiscal year '11. Well, for the entire campaign on the lab side, and what's not shown here, the corresponding federal counterparts, Peter Swift from Sandia National Labs is the National Technical Director for the Used Fuel Disposition Campaign. His counterpart works for me is Ned Larson. I believe I showed all the federal counterparts at the February meeting in Las Vegas.

So, for the entire campaign, we today do have four main sub-accounts, Campaign Management and Integration under Mark Nutt; External Interactions, that is activities with groups like the Nuclear Waste Technical Review Board, and international activities under Mark Nutt; Disposal Research under Kevin McMahon at Sandia; and Storage and Transportation Research under Ken Sorenson at Sandia.

The odd numbering there, the hierarchical numbering is our work breakdown structure for this fiscal year. And, what’s really key is the eight, is what singles it out as useful disposition. On the next few slides, you will see that the numbers have changed.

Down at the bottom are the final appropriated funds we got after the continuing resolutions, and everything else. The vertical columns are the lab participants; Argonne National Lab, Los Alamos, Lawrence Livermore, Sandia, Pacific Northwest, Lawrence Berkeley, Idaho, Savannah River, Oak Ridge, total. The rows are the sub-accounts, and a total. You can focus in on any one of those entries you want. The thing I would like you to notice for the fiscal year we’re in now is the roughly two to one ratio of spending on disposal versus storage and transportation.

Next slide?

Now, you can see, if you want, that the numbering system here for the work/break constructor is different from the one on the prior page, and that’s because we, in fuel cycle and research and development, which is bigger than used fuel, used fuel is a subset of fuel cycle research and development, we had our own bookkeeping management system, and that was the WBS system I showed you on the prior page. But, the Office of Nuclear Energy decided to take the different bookkeeping management systems, the different parts that NE had, and combine them all into one. That led to a renumbering issue. But, again, it's the eight is what singles this out as used fuel disposition.

As part of that process, we discovered at the labs and the DOE staff, that rather than just the four major sub-accounts, we needed to keep track of activities at a finer level of detail, and we ended up with 17 sub-accounts, only ten of which are shown here. The remaining seven are on the next slide, under three main sub-accounts. We have a Cross-Cutting Control Account under Mark Nutt, and in it you can still see the campaign management, the international, so that roughly maps to the first two accounts we have this year.

And, then, Storage and Transportation is a one to one map, and on the next slide, Disposal is a one to one map with disposal. And, we went to this finer granularity just to help us better manage the work. But, it also gives an idea of the things we work on.

And, in Peter Swift's talk, he will go into, for fiscal year '12, he will follow this structure. He has slides that follow this structure and give more detail on what it is we've planned to do in fiscal year '12. And, also, I believe he has slides on what it is we're doing right now in fiscal year ’11.

So, here, the dollar figures at the bottom, these again are traceable to the President’s budget. I don’t know that we’re going to get these numbers, or what numbers we will get eventually as part of the appropriations process. But, again, what I want to focus here on is again Storage and Transportation relative to Disposal, and you can see that Storage and Transportation has risen, whereas Disposal has fallen. That’s in part, I would attribute it to two reasons. One, Fukushima happened, and even though the fuel that was in storage there, in dry storage came through fine, some of that in wet storage didn’t fare as well.

And, also, just the realization that storage happens today, and there are technical issues with storage today, whereas disposal is a little further down the road.

It was here I was going to bring up it’s not just the labs that do work for us. I have mentioned any university program work, and they do work on technical items of interest to us, and others do work as subcontractors to the national labs as well. In addition, a year and a half, two years ago, the Used Fuel Disposition--no, I think it was actually Fuel Cycle Research and Development put out an RFP for people with knowledge of fuel cycle activities, they could offer proposals on how they could help us in our work. And, I believe that there were, I don’t recall the number of proposals, but I think there’s six different teams, eventual winners of this process under they are called advice and assistance contracts. So, we have access to various industry groups, private companies with expertise in the nuclear fuel cycle.

And, in addition, and I believe Peter has a slide on this, we are looking in Used Fuel Disposition, we currently do participate in international efforts, and we are looking at ramping those up, working cooperatively with other countries on their problems of storage, transportation and disposal.

So, next slide?

So, what have we accomplished to date? Under Disposal R&D, compilation of inventories of the various types of wastes, including used fuel that exists today, but also that might exist if a different fuel cycle were adopted in the United States. And, I know there’s a long historic and continuing interest by the Nuclear Waste Technical Review Board in looking at whether DOE’s efforts in this area are integrated, and I think even this first bullet, working on inventory, shows that yes, there is integration within the Office of Nuclear Energy. It’s a realization that what other people do with respect to their fuel cycle choices in terms of what reactors they want to run, whether they reprocess or not, what fuels that want to use, ultimately does have consequences for storage, transportation and disposal.

Another accomplishment was the development, you know, working from existing lists of a generic list of features, events and processes that are relevant to disposal, that’s where any disposal group typically starts, with their features, events and processes, we identified a subset of disposal concepts for our primary research and development focus. And, Peter Swift will discuss how we did that in his presentation. We developed a disposal research and development roadmap. That’s where we list these are the technical items of more or less interest to us, and here’s why they’re of more or less interest to us. And, that’s the topic of Mark Nutt’s presentation.

We have initiated research and development in any number of areas in different natural and engineered barrier systems, because we’re not just restricted to a site anymore, looking at different rock types. And, again, Peter will talk some about that. And, we’re looking, in this last part, disposal system performance. I can this with certainty. One thing we learned on Yucca Mountain, redoing the total system performance assessment any number of times is each time you redo it, you can make improvements, both in terms of your technical understanding, but even the way you set the problem up in terms of the computer codes and that sort of thing. So, now, we have that opportunity again at the system level for different geology types.

LATANISION: Bill, another point of information. On the last point, is someone monitoring or perhaps interacting with people in Sweden on the question of the alleged corrosion of copper in anoxic environments, copper as--

BOYLE: I'm aware of that issue that the Swedes have. I've heard Claus Egerstrom say that they think they have it under control, but I don't technically work on it myself, I don't have any interactions with them beyond that. Some of our scientists may, I don't know.

In Storage and Transportation, we just this year identified and documented our research and development needs and opportunities for storage. We're working on a review of okay, with those needs, what type of tests and evaluation facility might we want to use to address those needs. And, that third tic relates to that. Do we have a deliverable on track for completion this month that will get at that, the various ways we might address our research and development needs.

GARRICK: Bill, and maybe Peter will get into this, but can you say something about on what basis you made these decisions about what should be further studied or--how was the selection process conducted, and was it a systematic, technical process, was it the Yucca Mountain experience?

BOYLE: I'm sure that Yucca Mountain experience influenced some people's assessments, but it's actually in Mark Nutt's presentation where I think we will get into the most detail for disposal, on just how did we do this. And, when you see the various criteria that were used, they're good criteria. I can't go to Lowes or Home Depot and buy meters for many of the criteria, so the people made a good faith, well documented, you know, effort in terms of explaining why we ended up the way we did.

But, I freely concede that equally competent groups might get different answers. But, it's all documented and Mark in his time will present that.

GARRICK: Thank you.

BOYLE: Another thing in Storage and Transportation is we documented the security issues associated with long-term storage. The longer you store it, in a nutshell, for those who--it's less self-protecting, which even the concept of self-protection is premised ultimately at some level, that people are rational, which I think there's plenty of examples around the world where not all individuals are rational. So, people are looking into any security issues related to storage.

And, lastly, we're, I would say, well integrated into various efforts with industry, the Nuclear Regulatory Commission, and others around the world, and even the presentation on ESCP that the Chairman mentioned, that presentation tomorrow. We're involved with it as well, we're active participants.

Next slide?

Planned Major Milestones. And, I don't have a major meter either. These are just, you know, other people could look at our milestones. We have more than this proposed for the next fiscal year, and others might choose different ones, but this is a good place to start. And, again, this has a big asterisk. Some of these may be deferred, or something might happen to them, depending upon how the appropriations process turns out. If there's less money or if the money comes in some fashion like through continuing resolutions, that that could easily impact these items as well.

Under Cross-Cutting, one thing we want to do, just a good management practice I mention the implementation plan was published I think it was in March 2010, we want to revisit that and make sure we're still doing the right sorts of things in the right way. Again, in terms of waste management integration, which is a long-standing interest of the NWTRB, we--I'll talk more about it on the next slide, or the slide after that. We have an ongoing activity to look at the whole disposition system as a whole. The choices you make in terms of storage can affect transportation and disposal, and vice versa. If you start off with a disposal concept in mind, it will have impacts on storage and transportation as well. And, so, we're doing analyses to look at these various trade-offs, what might work for one subsystem, how does it impact one of the other subsystems.

That third bullet, if you will, we fund Professor Hank Jenkins Smith at the University of Oklahoma, who made that wonderful presentation at the February meeting by phone. And, it was a very good presentation, and I can assure you if you have a chance to hear him in person, it's every bit as interesting.

Under Disposal, we have a report that's looking at, planned to look at hot granular salt consolidation. That's WIPP is an operating repository down in Carlsbad but for essentially non-heat producing waste for the most part. So, this would be tests to look at how would salt behave under the heat output either from the defense glass or even spent fuel.

We're looking at, because again we don't have a site, generic engineered barrier system design concepts, and the models associated with them, in floor disposal, in wall disposal, backfill, not backfill. We're looking at fluid flow model development for fractured or low permeability formations. Again, this represents--okay, it's not Yucca Mountain where we had a set of codes for those conditions. We're looking at different geologies. Under no circumstances do I think you could characterize the rocks at Yucca Mountain as low permeability. Modeling coupled processes in the near field of a clay repository. And, it’s again, I can contrast or compare it to Yucca Mountain. It’s the near field, certain aspects of it in an argillite repository. Certain aspects are more important for that type of repository than that same aspect at Yucca Mountain, if you will. So, we have to do research there. And, with respect to the disposal system model, we’re again, we have an opportunity here for starting with a clean sheet of paper and looking at the architecture and implementation of new systems models.

In Storage, we’re looking at an implementation plan for operating a Test and Validation Complex for storage R&D. We’re looking to produce a priority report for our data needs in storage. We plan to develop an aging management plan for the existing dry cask storage. I’ve already mentioned self-protection/material attractiveness. There’s a big difference, you know, take the plutonium in defense glass, that’s not as attractive to people who want to get plutonium as the stuff they’ll start with at MOX. So, the form of the material makes a difference. We’re going to begin clad--fuel cladding--testing at Oak Ridge National Lab, their high flux isotope reactor, which is a tremendous generator of neutrons so that we can put cladding material in this facility and irradiate it and then take it off to a laboratory and test the material properties.

In Transportation, we are going to look at criticality analysis for the used fuel as it gets older, and what happens to it in the storage canisters. And, we're also going to compile the list of transportation issues and resolutions. So, that was for FY12.

Next slide?

Assuming we get something close to the President's budget. These long-term goals come out of that March 2010 implementation plan that I've mentioned. And, so, we'll relook at these goals in our proposed update to that implementation plan.

The first bullet shows that we are looking at research and development related to the existing light water reactor fuels, those that exist today. But, if you go down, well, even the next one, we're looking at a plan for testing and evaluating high burnup and advanced fuels, different fuels. The industry is going to higher and higher burnups, and perhaps even different fuels. So, we'll need a facility that tests future things as well, not just the things that exist today.

Develop a licensing basis for transport of high burnup fuels. And, you can go through them. The last one on Disposal, develop a database catalog of potential disposal systems that could be used. It's an important task.

Eventually, if Yucca Mountain is not the right place, and that's the way it looks today, some other place or places will have to be looked at, and we can do the generic work today that would provide decision-makers input to that decision. If you have a disposal concept of the following type and the following rock type, here are the various pluses and minuses associated with it.

And, then, we also had long-term goals out to 2020, including the construction of a test and evaluation facility for high burnup and advanced fuels.

Next slide?

So, this is my last slide, and as I've already mentioned, for the remainder of the day and the first two talks tomorrow, they are all related to used fuel disposition. Peter will be up next, Peter Swift from Sandia National Labs, and he will talk about why are we looking at salt granitic rocks, argillites I call them, shales, clays, others call them. Mark Nutt of Argonne National Lab will talk about their research and disposal needs and priorities for disposal. Scott Painter of Los Alamos National Lab will talk about discrete fracture flow modeling. Jens Birkholzer will talk about modeling in argillite rocks and the various processes that need to be--in both cases, if you're familiar with Yucca Mountain, it will become apparent that even if we're using the same computer codes that we used at Yucca

Mountain, that we have to change the material properties and the constitutive models in them, and so there’s some research and development done there.

Storage and Transportation. Brady Hanson of Pacific Northwest National Lab will talk about our identification of the datagaps, which other groups have done as well, including your own group, published within the last year a datagap report. Paul McConnell of Sandia will speak tomorrow on the transportation research and development. And, John Wagner of Oak Ridge will talk about engineering analyses.

Now, I wanted to finish again with this topic of integration. I hope in particular in the Transportation and Storage, it will become apparent that they really are well integrated with each other. I mean, we have them under the same manager. Everyone is full aware that when it’s done in Storage, it goes to be transported then, and the people in Transportation know they have to take what comes out of Storage. So, I hope you see that in the presentations.

But, also, in Peter’s talk, Peter Swift, when he goes through what it is we’re doing in this fiscal year and plan in next fiscal year, he has a slide in there I think for this fiscal year that’s got one plot in it that relates to the thermal restraints on repositories. That Yucca Mountain, for example, had a thermal constraint, the Swedish and

Finnish repositories do, it was because they were saturated, they wanted to stay well below boiling. Yucca Mountain as being an unsaturated repository, the thermal limit was much higher. And, so, the geologic setting in and of itself makes a difference in terms of what thermal constraints you might have, and then the design you choose within that rock type might further constrain it.

But, the reason I'm bringing it up here is with respect to integration. The temperatures you end up with in a repository can be affected by what you chose to do in storage. Like, for example, in the United States, the current disposal practice is 30 plus fuel assemblies, PWRs, pressurized water reactor assemblies, in each of the storage units. Well, everything else being equal, they generate a lot more heat per unit length than if you had much smaller storage canisters that you were going to dispose. And, the slide Peter has shows quite clearly how all these elements are interlinked, and we are aware of it, and we are doing other analyses related to it.

I also believe in Peter's slides, what it is we plan to do for fiscal year '12, you will see that we actually have specific activities to do analyses to look at these sorts of fundamentally integrated problems. Like, for example, we will do analyses to get at the following issues. What would happen if, for example, we went with deep borehole disposal at each and every one of the reactors, therefore, removing transportation from the system. What pluses and minuses might it have. Or, in contrast, again looking backwards at Yucca Mountain, that was an example at the other end of the spectrum, if you will, no storage, disposal one place.

But, there are other variations. If we went with interim storage, not at the reactor sites, a single interim storage site versus some other number other than one, two or three located throughout the country, what are the trade-offs in terms of transportation, costs, other aspects like that, and also in that, the size of the storage canisters. Like, for example, if we do look at deep borehole as part of the system, I don't think there's any way anybody would ever get the existing dual purpose canisters down a borehole five kilometers long. And, this will come up again to show how fundamentally linked these different sub-systems of storage and disposal and transportation are.

It really does show up in the thermal effects. Like, for example, I hope we get to spend some time on the slide Peter has, by going--I am not trying to be in any way negative at all towards the current storage practice in the United States. It is what it is for good reasons, but it leads to other consequences, which might be really extended storage before they could go into certain types of repositories, or opening the dual purpose canisters and repackaging them so that you did meet the thermal goal of that repository. So, there’s a lot of analysis to be done here, and we’re kicking it off this fiscal year.

And, then, a couple more examples of integration. We are part of the bigger Fuel Cycle Research and Development Group within the Office of Nuclear Energy, and we are fully integrated with our colleagues in terms of the systems. We have a systems group under Rob Price, waste form group under Jim Bresee, and a fuels group as well, because the choices made in terms of what reactor, what fuel, what waste form--picked us, and we are integrated with them. At our annual management meeting in July in Las Vegas for used fuel, we held it jointly with the waste form group.

And, lastly, I’ve already mentioned the ESCP, extended storage cooperative program, we are active participants in that. We are integrated with our colleagues in the United States in industry, and others around the world. And, that’s the end of my presentation. I’m ready for questions.

GARRICK: Thank you, Bill. Ali and then Howard.

MOSLEH: Mosleh, Board.

Bill, to what extent would you say that your plan, current plan, reflects lessons learned from the Yucca Mountain experience, not only from a technical point of view, but also from project management and planning?

BOYLE: Yes. The people, particularly those that came over, can escape their experience. So, I’m sure each of them brings their own lessons learned. Technically, I’ve already mentioned that many of the computer codes that people will use, with the exception of salt, the mechanical behavior of salt is so much different from, you know, the rocks and soils of the other under consideration for a repository. Salt is a little different, but for the other rock types, the computer codes are typically the same. It’s just that we have to change the constitutive models and the specific properties.

Certain things are more important, like for example, in the argillites, they really, and this is true for the French and the others looking at argillites, they’re so tight to begin with, they have a much greater concern for how does the rock respond due to the excavation of the repository itself. Now, Yucca Mountain is a counter-example for everybody who had everybody been there, it was so fractured by nature, there was nothing we could do about it.

People are, technically, they’re using the same codes. They’re just having to update them, tweak them, make them appropriate for the problem they’re looking at.

With respect to management, I’ll say this, I’ll say it from personal experience. Some people might look at the participation by nine labs, some participation by universities, the industry contracts as just being a nightmare and a mess, and I was at Yucca Mountain for years, and at times, it was a mess, but I believe we did get better as the years went by. So, in terms of management, from my point of view, things are run well on the lab side under Peter and Mark Nutt and Ken Sorensen, and all their participants, and on the DOE side, my staff, I think we have learned how to deal with technically challenging projects with diverse participants.

MOSLEH: So, was this a result of a formal or semi-formal evaluation of the lessons learned?

BOYLE: Well, I'm trying to think if this has been addressed in public. The Department itself has not published, to the best of my knowledge, any formal lessons learned related to Yucca Mountain because we're still in litigation. And, it was Chairman Garrick that mentioned attorneys earlier today. That stance by the Department is based upon input from the attorneys, that as long as, you know, we're still in litigation, I doubt that there will be a document produced that others could interpret as oh, they have told us where they went wrong, and it might be fodder for a lawsuit. So, I know I have personally discussed this with NRC managers that when we finally get this unappealable decision, then things are completely, you know, closed with respect to Yucca Mountain, whatever that is, that I think there would be benefit for all the participants, through the years in Yucca Mountain, whether it was a Nuclear Waste Technical Review Board or the Nevada Nuclear Waste Projects Office, I know that Steve Frishman is here, to document that, but, I'm afraid for now the Department wouldn't do that.

GARRICK: Howard?

ARNOLD: Arnold, Board.

Bill, I'm struggling with the concept of a generic engineered barrier system. How do you see it?

BOYLE: Well, in my mind, I'll use Yucca Mountain as an example, as that was a generic engineered barrier system.

ARNOLD: For that specific--

BOYLE: For that kind of geologic setting, unsaturated rocks with no particularly challenging support requirements; right. We ended up with no backfill, large waste packages on the floor. There are other engineered barrier system concepts, smaller packages in the floor with backfill, or smaller packages in the wall--this is the French concept--with backfill. So, there are other--there's variations. That's what we can look at.

ARNOLD: But, they're kind of specific to the environment of the repository.

BOYLE: Right, if you will, it would be particularly challenging, for example, to go with such large waste packages, for thermal reasons, and in other rock types. It would also be a challenge in the argillites to go with such massive waste packages that were used at Yucca Mountain.

So, yes, I agree with your statement that as soon as you go to a certain type of geologic concept, inherently there might come restrictions on your repository.

I'll give you another one. Borehole disposal in a salt dome, at the depths and temperatures you might encounter, the drilling, it might not be doable. But, you know, other disposal concepts work well for salt.

GARRICK: I have about 20 questions, but maybe I'll boil it down to two, each of which has ten parts though. And, they're probably more for Peter and Mark.

But, one of the things that I'm always very curious about is what you are doing to develop insights on the scope of the modeling that's actually done? And, I raise this question because if you look at the Yucca Mountain experience and you try to put some attention on issues of possible conservatism, such as the lack of a comprehensive model on capillary forces, the lack of taking into account the effect of cladding, the lack of taking any credit for the inner vessel corrosion resistance of the waste package, the lack of taking any credit for the TAD materials, and the somewhat unfinished business with respect to localized corrosion, not to mention the source term which has lots of opportunities for further improvement, I look at these things and I say to myself had there been a more comprehensive model in those areas, would it have become very obvious that something like the drip shield was not needed? Had we performed $50 million worth of analysis, could we have saved $8 billion or $10 billion that otherwise is going to install a drip shield?

What are you doing in the way of the Research and Development Program to enhance our understanding and our insights about how much analysis should be done and what the payoff is for doing that?

BOYLE: I would say yes, we are working on that. And, here's how I view we are working on it, and we can either look at Yucca Mountain or even just consideration of going forward. If we knew today that something wasn't important to the end result, we wouldn't put it in, into our model, and we wouldn't have to go off and measure--if we knew today.

I think what we learned at Yucca Mountain is people were aware of phenomena that might occur, but back to the features, events and processes, didn't know positively what the outcome--what effect it would have on system performance, so they put it in.

Now, if we're lucky enough in terms of resources, both time and money, when you run a version of a system model and you find out well, this is not important, this is tremendously important, you're next iteration, you can benefit from that. You can perhaps strip some things out that are unimportant, and do more work on those things that seemingly do drive the system response.

And, I would submit we did do that at Yucca Mountain, particularly with respect to the Total System Performance Assessment for postclosure, much more so than the preclosure safety analysis for preclosure, just because the postclosure people started so many years before, all the way back to the early Nineties. There was a TSPA in 1992, ’95, the VA, and it did get better and better. It was what it was at the end, but it’s through that process of--I would strongly encourage all our scientists and managers if you know today that it’s not important, for gosh sakes, don’t put it in, because it’s just something we have to keep track of.

If you don’t know, well, let’s find out how important it is, and if it’s very important, let’s do more work on it. If it’s less important, we might consider taking it off.

GARRICK: I wanted to ask another question about the integration business. You mentioned you have a systems group.

BOYLE: Yes.

GARRICK: So, I take it by that, that you have a group that has expertise in systems modeling, systems analysis?

BOYLE: Within fuel cycle, you mean?

GARRICK: Yes.

BOYLE: Yeah, in that group, yes. They seem to do reasonable--that's not my area of expertise, but when I look at their work products, and I have looked at some of them, it seems reasonable and appropriate to me.

GARRICK: And, of course, when we elevate this to a higher level than just to used fuel program, and say to the repository, to a possible repository for used fuel and high-level waste, then the integration becomes a much larger scope.

BOYLE: Oh, yes, the systems group, which works for Monica Regalbuto, it looks at the entire system, all the way from, believe it or not, where does the uranium or other--plutonium as well, where does it come from, like they work on studies can we get the uranium out of sea water, and then they look at--so, they start at the very front end of the fuel cycle, and we provide them input to the very back end of the fuel cycle for their system studies. And, there's other groups, Jim Bresee for waste form, at Idaho National Lab, National Technical Director for Fuels is in the room, Kemal. He provides them input on fuels for these different reactors that people consider.

So, the systems group has responsibility for looking at the system in total, as well as different sub-systems at times, depending upon the analyses that need to be done. But, our responsibility is to not only do our own work in a systematic fashion where needed, but to provide them input and expertise for their system studies that do encompass the disposition part of the fuel cycle.

GARRICK: I think that this is something that, you know, down the road, the Board would like to hear more about, and may.

BOYLE: Well, it will be Monica Regalbuto from the DOE’s office.

REGALBUTO: Monica Regalbuto, Department of Energy.

The systems group is obviously a present of, you know, RW coming into the fuel cycle technologies. And, one of the weaknesses of the systems group before, for example, was it wasn’t completely fully integrated because it then had the discharge of the reactor, maybe they consider recycling of the different types of waste forms that were being produced, but they didn’t quite integrate it what we call the way-back end, which was ultimate disposal and--transportation, storage and disposal. Those areas are being added, you know, now in the current scope of work.

They have a screening process that will be producing results and, therefore, a twelve, to guide some of the R&D needs across the fuel cycle. One of the things that we did this year is, and Jeff may comment on that, is we put aside some money to allocate to support some of the models that were being used to support the systems work in RW to incorporate them into the current structure that we have. So, those are a little outdated, they're running old machines. We're investing in those codes to begin our starting point, to incorporate with the systems that work, because that part wasn't in there.

GARRICK: Yes, thank you. Linda, I think you were to raise a question?

NOZICK: I think it got answered. But, maybe we'll just clarify. This is Nozick, Board.

The communication between the laboratories, are there any that are working on specific items? How does that communication work between the researchers and the laboratory so that there is total system awareness, even down at that level?

BOYLE: Well, any given task, like let's say it's some specific study in storage or disposal, could have multiple laboratories involved. And, even at that level, they talk to each other and work together. But, then, it grows from there, like I had mentioned, in July, we had a meeting in Las Vegas where we had all labs, all research efforts in the room at the same time to talk about or comment, and, you know, problems, and they all got a chance to present the work they were doing and the work they planned to do. So, we go--we realize that we have, I wouldn't even say a challenge, a reality of having multiple participants and, therefore, it's premised upon good communication.

I think it’s on Thursday or Friday of this week, we have yet essentially for each one of those 17 items, we have regularly scheduled meetings that typically occur by phone and video because it’s too expensive to, you know, for as many different work areas we have, to always have people in the same room together all the time, but we do do that as necessary.

NOZICK: Is there a formal schedule for that or--

BOYLE: Yes, just for business management reasons, we tend to have, you know, people know in advance which phone call is going to, you know, people make a good faith effort at the beginning of the fiscal year to say we plan to have the following discussions on the following dates. Now, reality sometimes intervenes, other events happen, and they get rescheduled, but yes, we try to let people work out their schedules in advance.

GARRICK: Yes, Andy?

KADAK: Bill, I was just curious. From your high level, what is new here, from the standpoint of all this R&D that’s going on? You mentioned some facts that are pretty much readily apparent to everyone. I’m just trying to get a sense of what is the new program or the new research that you’re doing, or is it just a collection of old stuff that you’re repackaging and sort of biding time until the tables from the mountain will come down and tell us all what we will not do for the next two years until 2012?

BOYLE: Yes, I'm assuming that someday, there will be some further direction. So, I don't view it as just rehashing old things. It's been literally decades since the technical community and the United States, you know, or DOE and the national labs looked at these other repository concepts. I mean, we historically did, we did do site screening and considered, you know, looking at granitic rocks and argillite rocks, and that sort of thing, but that was decades ago. And, science and engineering do march on, and so people are working on developing appropriate tools for looking at those systems, up to date tools. And, then, as Professor Latanision mentioned, even with the system as far along as the Swedish concepts, there's always issues that require people to look at them again. In their case, it was corrosion of copper under specific circumstances.

So, we know that, that the French for argillites, the Fins and the Swedes for granitic rocks, that based on the work they have done, not everything is of equal importance, and in addition to that, some things are more important than others. So, we are free to look at that, gain from their prior rock, and, therefore, guide our work both in terms of modeling and testing, such that we can then do analyses for the people who will make this decision on what will be on those tablets that come down from the mountain, that we will have provided the technical input to that decision. They will get other inputs on political, social impacts from others, but that's where I view our job as, is to look at where, based upon our examination of these concepts from around the world, where are there data challenges still, and to develop our tools such that we can produce technical analyses as input to decision-makers when we get to that point.

KADAK: So, just to follow up, what from the Blue Ribbon Commission report, how has that affected the change in any of the work that you're doing now?

BOYLE: As of this moment, I would say none. Bear in mind, it is a draft report. I don't know what their final is going to say. Many of their recommendations, I'm sure the report identifies, is it's beyond the control of any of us in this room, some of them require legislation, but even some of their near-term actions, for example, that I think they explicitly said didn't necessarily take new laws, legislation.

I remember one had to do, I think it had to do with the Department should finalize its procedures for how to interact with local first responders in emergency groups for transportation related to Section 180(c) of the Nuclear Waste Policy Act. They made that recommendation. We haven't been doing that for years, even OCRWM got to a point and stopped. We in NE are not doing it. We're aware of that recommendation. How that plays out in the future remains to be seen. But, when that draft report came out, we did not stop Task X and start Task Y.

GARRICK: Rod?

EWING: Ewing, Board.

So, just to press a little harder on what you just said, you've acknowledged that it's been several decades since we have looked at alternative geologies in the United States, and now we're going back and taking a look. And, yet, the programs described are very generic, and in fact, around the world, we have very advanced programs in clay and in granite, and I'm not sure I understand why our analysis has to be generic. We, you know, could be thoroughly engaged in these international programs, not tweaking our codes, but using theirs.

So, at what level are we engaged with these international programs? Are we pulling out the details, or is this just a very high level?

BOYLE: At my level, it's high level, but I did mention that we have plans on being much more actively engaged. We have met with the Swiss and talked to them about participating in Grimsel and Mont Terri, and some Germans visited last week, and we actually participated in meetings with the Germans on repositories in salt.

But, let me get to this generic versus site specific, and I'll use the argillite as an example. Diffusion is a very important part of that repository concept, and it's very hard for anything to diffuse through those rocks. And, so, we considered diffusion at Yucca Mountain for certain parts of the problem. But, it's much, relatively much, much more important for an argillite repository. Our scientists know this. They can create a code that incorporates diffusion, taking into account it's much greater relative importance for that kind of repository than some other one, but it remains generic in contrast with what the French might have at Bure for their analyses because we don't have the site specific properties. We can put in good generic information, what people know about argillites from sites around the world, but we--that's the main thing about generic, is we don't have site specific properties.

We can go out and get good properties, whether it's Scott Painter doing his work on discrete fracture flow, what site, how he's getting his properties, I don't know, but I can state this with certainty, it's not from any potential, you know, repository site identified as such in the United States. That's all that's meant by generic. It's we know we have to get these phenomena into these codes. We can put material properties in, but they're not related to a site.

So, that’s all that’s meant by generic. They are good properties, but they’re not specific to a site.

GARRICK: Garrick, Board.

We, of course, noticed that tuff in the unsaturated zone was not on your list. But, I wonder, and we know the problems you have in dealing with your general counsel and talking about Yucca Mountain, and it’s essentially off the table. But, is there anybody that’s sort of looking at it from the standpoint of what it would take to engineer Yucca Mountain to the level that--where it’s licensable versus the development of a repository in one of these other geologic mediums? I mean, it just seems to me that if it’s going to cost us $50 billion to develop a shale site or a granite site or a salt site, or you name it, and that we could get the same performance with another few billion of Yucca Mountain, from the standpoint of the taxpayer, from the standpoint of logic, from the standpoint of systems engineering, just about from any standpoint, we deserve to know that.

BOYLE: I’ll give two answers here. One is I believe Peter will address this specifically, we’re not doing work on unsaturated repositories like Yucca Mountain because we already know a lot about them. It’s the other repository concepts that we haven’t worked on for decades. But, now, to your specific question here, I do know the BRC’s, you know, charge, its scope was to apparently not do what you said, but even with that, I wasn't at any of their meetings, but they have a wonderful website with all the materials posted, I do know that various people who presented to them made essentially the point that you just made. But, I have no involvement with anything, Peter doesn't, that's not in our pay grade.

GARRICK: Right.

BOYLE: But, I will say that's in front of the courts and the United States Congress.

GARRICK: Right. Well, that's pretty much the answer I expected, and I appreciate it.

Any other questions? Yes, Andy?

KADAK: Just one general comment. I'm still, I guess, troubled by the used fuel disposition program as separate from the fuel cycle program, because your focus is on used fuel disposition, when in fact the timeline that we're talking about here is probably 30, maybe 40 years. And, in that time, there will be different technologies, different reactor technologies, maybe even some fast systems that might be on the horizon. And, I just see us going down this UFD thing, whatever D means, and oh, my, someone is now developing another different reactor type that we'll have to change all the things that we're now thinking about relative to disposal, because as Howard pointed out, it is site specific. Your earlier comment about well, we don't want to dispose of big packages like we disposed of at Yucca Mountain because they have high heat load, well, maybe, maybe not.

BOYLE: No, I would agree with that. If your repository is heat limited such that it can--

KADAK: That's what I said, maybe, maybe not.

BOYLE: Right.

REGALBUTO: I'm just going to interject a little bit here. I think the focus of Bill's program right now is a very near-term focus, even the disposal is longer term, but it's still near-term activities. Part of the portfolio that is not, you know, showcased to here, is looking at the potential new types of spent fuel or waste coming in from advanced fuel cycles, which is your point, Andy. And, those are being looked at in the context of, you know, at the level of just the systems level right now. So, when we do the fuel cycle studies, that's what we account, what is the advantage of having a fast reactor economy, looking forward in terms of waste disposal, in terms of resource utilization, economic safety, transportation and so on.

The reality that we face, which is unfortunate, is that we cannot do beyond just a systems studies at this point because we're limited by funds. So if we had more money, we would invest more on advanced cycles and the effects on the back end. But, right now, because we have near-term priorities, and we have done a mapping of the BRC near-term recommendations to our current program, I will tell you what I can share with you at this point is that the areas mapped pretty straight one on one. There's a few things like Bill discussed that are not currently in part of the portfolio.

What really is the difference is the depthness of the work being done in each of the areas, and that's a function of the budget. So, if we take our near-term recommendations, what this program is doing today, and we map them one to one, which we have done on tables, you will see all the titles in there. What you don't see is the level of detail that BRC is recommending that we study and focus in. We're a little bit more superficial in almost every single one of those areas. And, maybe we have a couple that we have now, which can easily be incorporated.

So, the reality that we face is on the advanced fuels, including high burnup fuels, including fast reactor economies, and even just the what we call fuel conditioning, that is the fuel that we have to treat for the purpose of disposing, not necessarily for recycling, because some other fuel may be compromised, but we may have to treat it. In those cases, we can only do it in paper studies at the systems level. We cannot have a very good program in doing that. And, that's a budget issue.

KADAK: Kadak again.

What I think we're suggesting is that it needs to be tightly, more tightly integrated. For example, this is still a once through fuel cycle program.

REGALBUTO: Yes.

KADAK: I think we're kind of close to being over that.

BOYLE: Well, I was going to say three things with respect to your first remark. Used fuel is not separate from fuel cycle research and development. We all work for Monica.

KADAK: I understand that, but I'm talking to Monica.

BOYLE: Yes, but wait--

REGALBUTO: But, you know, for example, in the used fuel, there is another exercise that we're doing, and that's looking at the inventory. Right? I mean, used fuel is not only where you are, you may have some MOX assemblies in the future coming out of, you know, potentially the MOX program in support of the Russian--the non-proliferation efforts, and that will be burnup--and, eventually we will have to deal with MOX, even though we're not doing MOX for commercial applications, but only for support of the treaty for the State Department. So, those all different categories, we need to look at it in detail. The problem that we face is that when Congress looks at us, they're looking at 17,000 metric tons of spent fuel that we have currently sitting in the pools. So, the little money we have has to be moving to the higher priorities. The other one is a priority, and I wish I could do more work on that, and I'm doing it at the system approach, but I will tell you that if we end up with a test facility for interim storage, that will include advanced fuel cycles in that test facility. Because it wouldn't cost us any more money.

GARRICK: Okay, we can pick up on some of these discussions, I'm sure, with Peter and Mark. So, I think in the interest of keeping us on our schedule, and thank you very much Bill, we will take our 15 minute break. Thank you.

(Whereupon, a brief break was taken.)

GARRICK: Our next speaker is Dr. Peter Swift. Go ahead, Peter.

SWIFT: Okay, is the microphone on here?

GARRICK: Yes.

SWIFT: Good. Okay, thank you.

I'll start by two things. First, commenting on listing myself here as the sole author of this. Obviously, this is a large team effort, and I apologize to all those who I am not listing as contributors. Their names will come up as I work my way through it.

The other thing is that I want to call attention to the title, "Basis for Identification of Disposal Options for R&D." This is not the selection of the option for the future. This is a selection of options for R&D right now. Where is it useful to put our R&D budget now in disposal, and I'm only talking about disposal. Our entire campaign, obviously, as Bill said has Storage and Transportation in it also, but my remarks are just about disposal. So, this is not in any way saying these are the choices we will make for a repository. Rather, this is where we put the R&D money.

So, the outline that I want to go through here, first, I just have one brief statement on what the role of disposal R&D is in fuel cycle technologies right now in the U.S. Then, answer the specific question that was asked to answer. What disposal options are being carried forward for R&D? How did we identify them? And, what were the alternatives that we considered?

Then, I'm going to take some time and put a little more depth in some of the topics that Bill covered fairly briefly. What is the disposal R&D that we're doing relevant to these options? And, I will point out that we have two presentations coming up after lunch, after Mark Nutt will talk about the process, the roadmap process for identifying and prioritizing disposal R&D. And, then, we will have two detailed presentations on specific examples. And, at the end of the talk, I will hopefully tell a little bit on where we go from here.

All right, so, this is a few remarks on the role of disposal R&D. First of all, we're not starting over, and let's acknowledge right off that there already is an international consensus that deep geologic disposal is a robust and it’s a necessary solution for permanent isolation. And, we’ve got mature safety assessments internationally and no, they’re not necessarily ready for licensing those concepts in the U.S., but we have mature concepts, examples primarily in Sweden, France, also Finland, Switzerland, Belgium, but examples in clay and granite types of sites that are, in those nations’ standards, essentially ready to go to licensing. So, we should draw heavily from that. The fact that it may be licensable in Sweden does not necessarily make it licensable here. And, that’s something to think about in the R&D world.

And, this last sub-bullet there, we also have a strong basis on sites in unsaturated tuff. DOE concluded in 2008 that the technical basis for Yucca Mountain was sufficient to submit the license application. John answered your question earlier. From purely an engineering point of view, DOE already concluded there was no further work needed to submit a license application for Yucca Mountain. That site was ready, and as it stands, it still would be ready to go back into licensing. So, that’s something to keep in mind, that we don’t need, from a licensing basis, R&D on a Yucca Mountain like repository at this time. I’ll come back to that in a little bit when we talk about the thermal load management work, because there’s some interesting questions there.

Nearly all the options are back on the table. But, we are limited to generic disposal concepts, and that’s actually by law. We have to be careful with that one. We will not have site specific investigations until such time as the Nuclear Waste Policy Act is amended.

So, the goals of disposal R&D at this stage, the first one, provide a sound technical basis for the assertion that the U.S. has multiple viable disposal options that will be available when policy is ready. This is an important point. I see our goal right now to be to maximize the options, not to focus in on what is the best option to choose, but rather to keep the field open, and to put some technical basis, technical meat behind the assertion that we have many viable options in front of us. It’s a big country, lots of geologic area to work with. So, let’s put some strength behind that statement.

Second point, identify and research the generic sources of uncertainty that will challenge the viability of the generic disposal concepts. Purely at the generic level, we should be able to see now what are the sources of uncertainty that will challenge those concepts.

Increase the confidence in the robustness of the disposal concepts, the generic ones, and that will help reduce the impact of the unavoidable site-specific complexity. One of the lessons we have learned from Yucca

Mountain and other sites, the WIPP site in the U.S., other sites internationally, the longer you do site-specific characterization, once you finally get underground with a site, for example, it’s more complicated, and those complexities challenge the safety concept of the site. What can we do now to increase the generic level of confidence to minimize those future impacts?

And, the last point, develop the science and engineering tools required to address those goals. And, that’s not just this campaign, of course, within NE, DOE Nuclear Energy, and elsewhere in DOE, with universities, industry, and international programs.

All right, now, the question I was asked to talk about, what are the disposal options that we’re considering for R&D? Here’s the short answer, no surprise, you were expecting me to say this. But, the short answer is we’re looking primarily at four basic disposal options, three mined repository options in granitic rocks. I used granitic rocks here. It’s a synonym for crystalline basement rocks. It doesn’t mean just granite, but high grade igneous and metamorphic rocks. The example on the top left there is the Swedish concept, clay or shale, also called argillite rocks. The example on the upper right there is from the French. Salt, rock salt, the example here on the lower left is from the German program. And, this one alternative that is deep in geologic, but is not mined, and that is deep boreholes in crystalline basement.

But, there's also a long answer to it, and that's--and this is the short long answer, 48 combinations of environments and waste forms. This comes a little bit to the question of how do we do a generic EBS that came up earlier. All of these things go into it. You need to know what your various basic disposal environments might be, and this list is here to be complete. It's not here to do R&D on all of them. But, at some time or another, the possibility of disposal in each of those concepts has come up, all the way from surface storage to sub-seabed.

And, then, there's the waste form you have to deal with. Used fuel, at some level we will be disposing of some used nuclear fuel, spent fuel. I think that can be said with some confidence regardless of what future fuel cycles we might have. But, we also will have glass wastes, we already do. We may have advanced wastes, advanced glasses, ceramics, glass ceramics, metals, and then there are the wastes other than high-level waste. All of these need to be factored into what it is we are actually going to try to do R&D on.

So, the total set of combination of potential interests, it's very large. And, add onto that different design alternatives, as Bill mentioned, once you get underground, do you put your packages directly in the drift, do you put them in a hole in the floor, in the wall. How do you want to manage the thermal load?

The reality is you have to make some choices in what you're going to put your R&D into. So, at the broadest level, it was those four on the previous page. I think as I work through this you will see how we have taken these sort of 48 combinations and where we're putting R&D on them.

So, the question of how did we identify these options? First, and this goes back to the idea that we're not starting over, different disposal options have been proposed and evaluation for at least 50 years.

There is a consensus for at least 30 years, probably longer, but that's an easy sort of documentation point to pick for deep geologic disposal. We've got multiple high-level reviews that have come to this conclusion repeatedly over and over again. I just cite three of them here, and I apologize for doing this, but one of them is your own. It always helps to cite the Board that you're talking to.

But, going back to the 2001 National Academy's report, geologic disposal remains the only long-term solution available. That's a pretty strong statement. Your own statement from this June, one or more geologic repositories eventually will be needed in the United States. And, then, the Blue Ribbon Commission's statement on it, every nation that is developing a permanent disposal capacity plans to use a deep, mined geologic repository.

Note that the two above did not say mined. The Blue Ribbon Commission here put in the word “mined.” They did it for contrast with the next statement, other disposal options, i.e. deep borehole, have been considered and may hold promise, but are at a much earlier stage of development. I do make that distinction, geologic disposal and mined geologic disposal are not always synonymous. I think there is some basis for that in the wording of the Nuclear Waste Policy Act. Certainly, you can find that in the EPA regulations. It’s worth keeping in mind whether you’re talking about a mined facility, or some other form of geologic disposal.

KADAK: Peter, just a quick question?

SWIFT: Yes.

KADAK: What are you disposing in your studies?

SWIFT: What are we disposing?

KADAK: What is the assumption that you’re disposing?

SWIFT: All of the six preliminary waste forms, which would be prepared to have a disposal pathway, a disposition pathway for all of those. It’s not just used fuel.

KADAK: And, the problem is what is it? Is it like when you say glass, what is the glass? Is it just actinides? Is it, you know, like reprocessed waste?

SWIFT: That would be all of the above.

KADAK: All of the above?

SWIFT: Obviously, we have to--there are potentially an unlimited number of options you could imagine for future waste forms. We have to make some reasonable choices here. Our first focus is indeed on the existing waste forms, which would mean the commercial spent fuel, the DOE glass. But, believe me, we have a responsibility to consider all of the likely outcomes of the fuel cycle, of alternative fuel cycles.

The last point down here, the definitive U.S. work on disposal options, it dates from the 1970's, and this is the question what are we bringing new to the table here. We are bringing quite a lot new because the 1980 EIS, it's a fabulous summary of what we knew in 1980, but that was a while ago. So, for a lot of things, actually, it says what you need to know. But, it's now 30 years old.

So, more on this how do we identify these options? First of all, there's a report here on the right that is available on the internet. I think you may already have it. That is publicly available. That's a public website down at the bottom. It's the Rechard, et al report from last March. It simply summarizes--it relies very heavily on the 1980 EIS, but other work since then. And, it recognizes these categories of things potential media, and those are the media that we evaluated there. This is not a--it’s not perhaps the in depth definitive statement at each one of them, it’s a summary report to look at different media, we looked at different geographic settings. So, you could take any one of those media and you could consider it in saturated versus unsaturated locations. You could put it on the coast or an island or continental interior. The behavior could be different. So, setting matters.

Then, alternatives to mined disposal. Deep boreholes, shallow boreholes, sub-seabed, injection, well injection of liquid wastes, and rock melt options. And, then alternatives completely to geologic disposal, not using geology for isolation, there really are only three that we came up with here that have been seriously proposed in the past, engineered mountains or mausoleums. You simply build a big enough engineered structure that has the durability you need. Ice-sheet disposal was proposed fairly seriously in the 1970s; and space disposal. This last one always comes up, so there it is again for completeness. I will work my way back through all of these I hope fairly quickly.

Potential media. The first two, I just quickly lumped them together. Clay/shale and granitic rocks. I hope it’s not controversial to say that these are plausible likely candidates for R&D. They come right to the top of the list, because of international experience. Generic viability of disposal concepts has been demonstrated in primarily Europe, also Asia. Further R&D is needed to support a U.S. program. We can't simply say because the Swedes are almost there with a licensing program, we can do the same.

Next one down, salt. There are two major data points there. First, the experience at WIPP in this country with transuranic waste is not a heat generating waste, but we know quite a lot about building and operating a repository for transuranics in salt. And, the international experience in Germany where that program is fairly far along, they do not yet have a published--they will shortly, I think, move salt into the category of a media for which there is a mature published international safety assessment. We're not quite there yet. But, again, there are R&D questions, particularly related to how salt handles a high thermal load. That work is needed to support the U.S. program. But, again, there are R&D questions, particularly related to how salt handles a high thermal load. That work is needed to support the U.S. program.

Volcanic tuff, right now, this is one we're not putting our money on. It's a low priority because the current technical basis is already sufficient to support a license application.

Carbonate rocks, including chalk. These have been proposed in the past, and there is actually one viable concept underway in Canada for the disposal of intermediate level waste in deep carbonates, limestones. But, there is definitely less international experience here. We're not focusing on this in our program. We do note that what we learn in R&D in other fractured media, i.e. granites, crystalline rocks, a lot of that will be applicable to carbonates should they rise higher on the list. At the moment, they're not high on our list, primarily because of the lack of international database on them.

Basalt, little experience outside the Hanford site in the U.S. It's a more limited geographic distribution of thick enough basalt deposits, both fracturing and vertical heterogeneity are common in flood basalts. But, I will note that were the U.S. program wanted to go back and look at basalt again, were that to be a recommendation, much of what we are going to learn from R&D, again, on fractured rock, granite, it will be relevant should basalt sites come back up higher on the list. So, that's the page that gets us to the three media at the top, clay/shale, granitic, and salt.

Alternative settings. Saturated versus unsaturated, we have extensive R&D on unsaturated rocks. We don't think we need more at this time. Where this nation needs to go is on saturated rock. So, that's where our focus is.

The geographic location, continental interiors versus coastal areas, some programs make more of an issue here, or might put more emphasis on this than we do. For example, the Scandinavian sites are coastal sites, and it does change some of your biosphere pathway analyses. It changes some of the groundwater modeling. We don’t think that’s an R&D topic we need to focus on right now. The implications of coastal versus interior settings are secondary to simply selecting the media and the basic design of the repository.

Alternatives to mined disposal. The first one here, deep boreholes, and I’ll say a little more about them later. There have been multiple studies going back to the 1970s. The 1980 EIS identified deep boreholes as a viable alternative worthy of further study. We think it still is.

Shallow boreholes in alluvium, there’s actually one example of this on the Nevada Test Site at the Greater Confinement Disposal Facility. It’s primarily used for low level waste. There is a small quantity of transuranic waste. These are augured holes, shallow holes on the order of 30 meters deep, and three meters in diameter. They are drilled into alluvium, which is in an area where the groundwater, the water table is extremely deep. They have gone through a rigorous performance assessment, and analysis of long-term performance, and it’s robust. We’re not proposing that for high-level waste. I will note that that shallow burial depth appears to be incompatible with the Nuclear Waste Policy Act's requirement for deep geologic disposal.

I want to clarify, the Nuclear Waste Policy Act does not require deep geologic disposal. It applies to deep geologic disposal. It doesn't preclude these alternatives to geologic disposal options, but it strongly--it focuses strongly on deep geology.

Sub-seabed, and I can say more. I think this group is probably familiar with the concept, but there was extensive R&D in the 1980s that concluded it was a technically viable option. But, it may very well be precluded by international treaty. That's one for, if it came to it, that would be one for a legal analysis. We are not proposing any R&D in it because of the presumption that it is indeed precluded by treaty.

Well injection implemented in both the U.S. prior to 1975 for low level waste, and in Russia for high-level waste. We are not pursuing any R&D on liquid injection of high-level waste directly into the subsurface. I will note that the 10 CFR part 50 requires solidification of processing liquids prior to disposal. I think that would be a difficult issue to try to license such a site.

Rock melt. There were various options back in the 1970s that relied on waste generated heat to melt the host rock. None were carried forward in the 1980 EIS, due to technical complexity. And, that conclusion stands. Those are--they are intriguing ideas, but they’re not simple. More recently, some have proposed rock melt as a component of deep borehole disposal, where you, again, you use the heat generated by the waste to actually melt the surrounding crystalline rock, or alternatively, where you introduce a heater into the borehole above the waste and fuse the seal system a little bit by melting it. We are not pursuing R&D on that in this program because our preliminary work suggests that if we wanted to go to deep boreholes, you get robust isolation without going to that level of complexity. In other words, you probably don’t need it if you want to go to deep boreholes.

Last point here on alternatives. Engineered mountains or massive mausoleums for disposing of the waste. There are casual references well back in the 1970s, and you still hear people make passing reference to the idea that it might have been cheaper to build Yucca Mountain than to characterize it. But, no one has actually come up, that I’ve been able to find, with a substantive design proposal, and we’re not pursuing it.

Ice sheets. That goes back to the 1950s, people suggesting well, let the waste melt its way down into an ice sheet. It is actually--it was evaluated in the 1970s, summarized in the 1980 EIS, and not carried forward. It is precluded in Antarctica by international treaty. There are also some operational concerns, and uncertainties about its actual effectiveness in long-term isolation. We're not pursuing it.

Space disposal, the last one up there. There's actually surprisingly thorough evaluation of it in the 1970s, right down to energy demands for launches, cost, and risk assessments. It doesn't end up being viable, I say here. Economic costs and technical risk make it an improbable option. I could expand on that, but people have taken this one pretty seriously, and even for relatively low quantities of specialized materials, it doesn't look like it's a viable option.

That concludes how we got to those four disposal options that we are putting R&D onto. Now, I want to try and talk a little bit about what the R&D is and how it maps to those options.

So, the first point, Bill mentioned this, there are nine national labs involved. All nine of these labs have a role in disposal. When we say there are nine labs involved in the campaign, one of them, Lawrence Berkeley Lab, it does not have involvement in storage and transportation. We're working with the Earth Sciences Group there. Their expertise is in disposal. But, all nine of these labs are definitely engaged in the disposal part of the R&D.

There are also the Office of Nuclear Energy university programs, NEUP, and there are industry collaborators and as Bill mentioned, it is possible, we have a few such examples for PIs at the labs to write contracts directly with universities.

Bill showed this, the organization for FY12 of our disposal R&D activities, all of our activities. I'm only going to talk here--I mention in passing a couple, these two, and then I'm going to talk about what we're doing in there.

So, international activities, and Rod, you asked about how are we engaging in the international program. First of all, it's been a long time since the U.S. repository science programs had a significant presence in the international community. Because Yucca Mountain, with its unsaturated environment, a lot of the primary R&D in, for example, the European programs, which is where we're going first, it wasn't all that relevant to Yucca Mountain.

Well, it's dead-on relevant to what we want to do now, so we have--well, first of all, we have collaboration in multiple areas internationally, including storage and transportation. Brady will talk a little bit about that later. I'm not going to. I am here to talk about disposal, where for FY12, I'm very happy that we have a commitment from DOE to formally engage as a, for example, as a partner in the Mont Terri Underground Research Laboratory, URL. It's in

Switzerland. Joining this URL--actually, the DOE will have to buy in as a member of this consortium. It will give the U.S. national laboratories access to all of the present and past data collected in that laboratory, and give our team the opportunity to conduct new experiments. As we see them, we get to participate in ongoing experiments. And, the figure here on the left is an example of some of the experiments that are planned in the Mont Terri facility. This is in clay, and it’s off a highway tunnel in the Alps. This is a highway tunnel, and there’s a side access off it into an experimental area.

We also have a commitment to join the colloid formation and migration project at Grimsel, also in Switzerland. This is colloid transport in granite, and, again, this is important. We will be able to have a PI, in this case, Paul Reimus at Los Alamos, as a full participating member of that work.

And, DECOVALEX, it’s a coupled modeling and experimental validation program. It’s been ongoing in Europe for over a decade. DOE had participated in the past. That participation had lapsed as Yucca Mountain moved into licensing, and we’re looking forward to rejoining that and getting in on the start-up of a new phase of activities in the spring of 2012.

I should credit Jens Birkholzer, who is here in the audience. Jens, do you want to raise--there you go. Jens is at Lawrence Berkeley. He will be speaking later on R&D work in clay, both in clay host rock and in clay buffer. Jens is also the lead for the used fuel campaign for international collaboration. Thank you, Jens. It’s his job to actually make these collaborations happen, and they will happen. We do not have--once we get the--bought into these programs, we still have to actually fund our own individual research projects with them. Basically, we get our membership, we then have to propose using existing funding where applicable to do work in them. But, I believe this will be a success for us.

Another topic here, this thing called Nuclear Waste Management Perspectives. This is one of our cross-cutting activities. Primary research topics here. The analyses of the interface between storage and disposal. Bill talked quite a lot about that, thermal load management issues, for example, how big do you make the casks. Support for analysis of fuel cycle options. This is the interface upstream with the systems analysis group that is looking at the entire fuel cycle. Used fuel campaign’s job here is to make sure that we are ready for them with estimates of, for example, inventories from future fuel cycles, and how those different inventories, how different waste streams, what changes do they make in disposal. How do they affect disposal and storage? It’s a big job, and this is where we make sure that interface is well managed.

The last point here, social science. I think everyone recognizes that disposal issues aren’t just technical. They aren’t just science and engineering. They are social science as well.

And, we have an activity with the--directly funded at the University of Oklahoma, this is Hank Jenkins Smith’s team, if you’re familiar with his work. And, I just used a graphic here because I love it. This shows that if there’s one sort of bright news that has appeared in the last two years, we finally have a plurality of people in this country, the general public, who recognize that most spent fuel is actually stored on site. As recently as two years ago, most people in the country actually thought it was already at Yucca Mountain, or another big chunk thought it had been reprocessed. So, we’re starting to see a growing awareness of sort of the realities of waste management. We’re going to continue that work. Hank Jenkins Smith has an ongoing piece of work now looking at the impacts of Fukushima on public opinion, and a more focused set of work in Southeastern New Mexico, looking at how the operation of WIPP has changed public perception there.

All right, research activities in disposal. The main areas are these blue boxes here. We have an engineered barrier system group, a natural systems group, a thermal load management and design concepts group, and a system level, disposal system level modeling group. We also have what I think of as some support activities here, but these are big activities, engineered materials performance. This is, for example, the corrosion lab that was set up for Yucca Mountain, is still running.

We have a team that is working on inventory projections. That's large, some of them are here in the room today. The task here is to look at both low and high-level waste that would come out of the current open fuel cycle and also closed fuel cycles. There's a good report from that group that was delivered to the Blue Ribbon Commission in June. That's available on Blue Ribbon Commission's website. We can get you a copy of that if you want it, but we look at activity, volume, thermal output, which is largely a function of activity.

But, back up in these areas here, I think I'll have a little more to say in each one of those as we move ahead. I think I pushed a button I wasn't supposed to. Yeah, that's the one.

The work in the engineered barrier systems, now, how can we do a generic engineered barrier system. We can't do one that will work in every environment, but we can look at what would work generically in a clay/shale environment, what would work generically in granitic rocks, salt, and deep boreholes. In a sense, this is actually one of the places where generic work is most useful because you don’t need to characterize too much about the far field. What you need to know is how the far field will establish things, primarily the water chemistry in the emplacement environment of thermal conductivity. But, it’s an area where generic characterization of the far field does tell you quite a lot about the immediate environment you might get in the tunnel, in the emplacement area.

So, things that we have done in the last year, evaluated engineered barrier system configurations, material properties for backfill and sealing, just establishing what’s out there available in the way of configurations that would work and properties.

Clay/metal interactions at elevated temperatures, thermal hydrological mechanical constitutive and reactive transport modeling for bentonite. This is work that I think Jens will talk more about. A disposal system evaluation framework model, this is essentially a cataloging device for looking at how the properties of engineered barrier systems affect the overall system. And, we have completed a test plan for laboratory-scale crushed salt consolidation experiments.

One of the things that we need to know in the salt disposal concepts is how rapidly would a crushed salt backfill reconsolidate under heat, and where would the moisture in it go? How much moisture--you can control the amount of moisture you put in it. What do you want to do about that? We’re going to approach that first--there have been proposals to look at that directly on a subsurface field scale in Carlsbad. We’re going to look at it first at a laboratory scale.

CLARK: Can I just interrupt?

SWIFT: Yes.

CLARK: Just to clarify what you’re talking about here, and this is Clark, Board. These are plans for R&D as opposed to actual R&D that’s currently being conducted?

SWIFT: No. The stuff in blue, I should be able to show you a product from this here for each of those. This is--yeah, I’m a little bit mixing--I should have been clearer on that. On each of these slides, the blue things are things that we did in FY11.

CLARK: Well, for example--

SWIFT: But, they’re going to continue forward.

CLARK: --the very last blue line, my question is have you actually done experiments, or do you have a plan, you’ve developed a plan to do experiments?

SWIFT: We have a--it’s a test plan, and the equipment is ready to run. We will be running it soon, early in the next fiscal year. But, that last one, the crushed salt consolidation, it’s a firm test plan ready to turn the tests on.

CLARK: And, so, out of your whole list there, how much of that involves scientists in the lab doing experiments?

SWIFT: On this page, not that much on this page. Give me a break and I’ll get to the next one here.

CLARK: Okay.

SWIFT: But, fair question. Now, over on the right here, that’s actual lab work from this year. But, in the natural systems, the types of things we looked at there, discrete fracture network simulations. Scott Painter is going to talk on that one in detail after lunch. Effects of spatial heterogeneity in Kd’s on radionuclide transport. Experimental work on plutonium colloid behavior, and that’s the photograph on the right. That work came out of the Lawrence Livermore Lab. Geomechanical modeling of the excavation damage zone in clay and shale. I think Jens will probably touch on some of that. There’s also some work done in sale on that also.

Unsaturated and saturated flow through clay, Jens will touch on what we’ve actually done this year in that one. And, we have done some experimental work related to direct disposal of a specialty waste, electrochemical refining of pyroprocessing waste, directly disposing of the sale waste forms generated by that process in a salt repository. There's been some experimental work done at Idaho and some at Sandia on that one.

CLARK: And, so, can I just follow up with a question?

SWIFT: Sure.

CLARK: All right. So, this is actual experimental work. Is all this completely funded by the DOE-NE activities, or is it leveraged against other programs? For example, I suspect it might be leveraged against Office of Science BER when it comes to the plutonium colloid work?

SWIFT: Yes, on that one. That will be a yes.

CLARK: Okay.

SWIFT: And, the discrete fracture network, and you will see Scott talk about this, that's leveraged some work the Swedes have done. But, we have paid for this work.

CLARK: I know, but what I'm struggling with is your budget is only 24 million.

SWIFT: Yeah, how did we get all this?

CLARK: Yeah, and so somebody has got to have a day job somewhere.

SWIFT: They do. Bill's estimate of the number of FTEs, or it wasn't Bill's, it was one of the Board members estimated how many FTEs might be working on this. The truth is there are very few people who actually charge their time full-time to this project, almost none. Yeah, it's an R&D

project, it’s not--this is not the same sort of science model, science/business model that we used on the Yucca Mountain project where we had people committing to a full career. No, these are people who are working part-time on things that fit well with their other R&D.

EWING: Just to follow up on this subject of colloids specifically. So, how does this help you in your overall program? Because work like this was done many years ago, so it’s not a surprise to find plutonium--

SWIFT: Transporting--

EWING: --hydroxides. So, this is very nice, but does it go someplace in your program?

SWIFT: Eventually, I would like to be able to show whether or not these colloids are stable in the conditions we might have in a deep repository. I mean, obviously, you can make stable plutonium colloids in the near surface environment. Are they stable at 500 meters in a saline brine? I mean, it’s--I appreciate the question, but I think it’s premature to be saying what’s the direct applicability of this when we don’t know what the repository is going to look like. We do know that the question of how well does plutonium transport as a colloid is going to be relevant to many disposal concepts. So, I think it’s--

EWING: I don’t disagree with the value. I just point out that, you know, there are similar studies from previous years, and for your generic studies, I'm just wondering why a trip to the library wouldn't be as good as this investment at this stage.

SWIFT: I think if I came to you and presented a trip to the library, you wouldn't be happy with that, Rod. But--

EWING: Well, that's probably true.

SWIFT: Okay, take a note on that one. Thermal load management, and this is one, you know, any one of these slides I'm just zipping through here is worthy of a full hour of discussion. I'm trying to give you a sense of what you might want to ask to see later at a future meeting. This is a topic where I think this is one of the truly interesting and important areas for further exploration.

We have a report that is internal draft review right now. That's what the figure on the right is from, but I'm perfectly happy showing it here. The purpose of this task is we started out, it's both thermal load management and design concepts. You can't talk meaningfully about a thermal load management strategy until you have something that looks like a representative concept for a design. What do the drifts look like? What's the spacing? What media are you in? How big are your packages, and so on, there are so many design variables, you have to narrow it down.

So, the first thing we did was we, the first bullet here, developed representative design concepts for repositories in each of the media, where we specified things like drift spacing. A key variable that we allowed to vary in the analyses, you see it on the X-axis of the graph here, the number of PWR assemblies, we varied the type of waste you could have also, but for this graph, it’s PWR. Number of assemblies in a package, but we held the spacing of the packages constant, or else you end up with too many unconstrained problems. So, we identified design concepts, identified representative waste streams for thermal analysis, and for this first year’s work, we focused on used fuel, and we did look at MOX fuel, which runs hotter, used MOX fuel, and glass waste. But, we’re going to repeat this work with other waste streams as it--in future years. This is what we got done this year.

So, anyway, the graph here that you see, the point here is that let’s say you want to put in a temperature constraint, you’ve got a clay or a granite repository and you don’t want to boil water in the clay buffer that surrounds the waste packages. You want to keep the waste package surface at 100 degrees or lower. You are limited to four PWR assemblies per package for this particular underground design. This is consistent with what the European programs were finding. Salt with its higher thermal conductivity and generally people are willing to take a higher temperature constraint in salt, we chose 200 degrees C, which is what the

Germans are using for a temperature not to be exceeded on the waste package surface. And, although for the purposes of the representative design concept we used started out with four PWR assemblies, you could go higher in salt. That works for PWR, it doesn’t work for MOX. MOX is hot enough, I didn’t show that plot, but you want to be careful with that.

The vertical axis, there is the storage time that you would have to go to on the surface, or conceivably in a Yucca Mountain like repository, in a well vented, ventilated underground repository, how long would it take to push that down for the number of assemblies per package? How long would it take to push the temperature down to the desired constraint? So, if you were going with a granite or a clay concept, and you wanted to go for big packages, you’re talking many centuries of surface storage, not decades, centuries. This is, I think, a fairly important conclusion to come to.

We’ll come back to it at the end, but in case I don’t get there, I’ll just mention it now. This is the one place where we think it would be fruitful, useful to go back and look at a Yucca Mountain-like design, not Yucca Mountain, but what we call an open emplacement strategy, emplacement strategy without backfill, where you get a lot more options for cooling. You can go, because you can have forced ventilation in the underground after you put it in there. It does probably mean going back to look again at unsaturated sites, which clearly there are reasons associated with the groundwater chemistry and actinide solubility, why that may not be what you want, also metal performance, engineered barrier performance, but you might get quite a large payoff in the size of the package you can dispose of. So, we think it's worth going back to look at that using purely generic representative concepts to consider where a good solution is. I didn't say optimal, but just a good solution for package size and emplacement strategy.

KADAK: But, Peter, that's sort of a misleading slide, because you picked an arbitrarily low surface temperature of the package, and I'm not sure what the thermal loading is of your packages, but, you know, most of the time, we're talking at least several, I think 200 degrees C, if not higher, of the waste package. That curve looks way different.

SWIFT: Those are true, but those are not arbitrarily low surface temperatures. Those are the surface temperatures that the European programs are looking at. 100 degrees C in the waste package, that is what's in the Swedish analysis. It's what's in the French analysis. But, 200 degrees C is what's in the German analyses. Those are picked on the basis of not wanting essentially to bake the clay and fracture it. You're not trying to make a ceramic backfill.

KADAK: All right, that's on the clay, but how about the granite?

SWIFT: Well, the granite concepts rely on a clay buffer in the near field surrounding the package.

KADAK: But, you see what we’re getting to, we’re getting to a site specific question here.

SWIFT: No, it’s media specific, it’s not site specific.

KADAK: Well, I know, but what I’m suggesting is you need to do the site specific to be able to make this document Useful, because otherwise, you’re reaching conclusions that when you start looking at the specific location, you’ll have very much different results, and if these kinds of studies drive you to a different concept, you’re using the wrong foundation upon which to build this house.

SWIFT: This is one I do think the Board should more on this subject.

KADAK: Yeah.

SWIFT: I think this is a relatively robust conclusion. The bottom line conclusion, that consider those numbers, number of assemblies in a package, and these are PWRs. Does it say somewhere on there?

KADAK: No.

SWIFT: Yeah, it does, down at the bottom. Yucca Mountain design concept was handling 21 pressurized water reactor assemblies per waste package. A granite or clay repository based on existing safety assessments in France and

Sweden are down in the range of four. The Germans, for example, in salt, even with its higher thermal conductivity and its--because of its low water content and because you don't get dramatic changes in the permeability of the material as you heat it, in fact, it improves, it flows, the Germans and I think the U.S. also would be willing to go to quite a bit higher, you know, 200 degree temperature in salt, but the Germans, they're limiting themselves to three assemblies per disposal package in the Gorleben design. These are much, much smaller packages than we were considering for Yucca Mountain. And, that's the message I'm trying to get here, and I think it's a pretty robust conclusion.

KADAK: The question is is that the right conclusion, three or four fuel assemblies per waste package, or is there a design that will accommodate higher package loadings? Because you've got to look at the entire system. We've been through this path before.

SWIFT: And, there are other variables you can work with here, waste package spacing in the underground, surface decay storage, aging, which is on the vertical axis there, ventilation, which was part of the Yucca Mountain strategy and is a more difficult concept in a saturated zone repository where you have to keep the repository dry for the period of ventilation. There are also of course the one I think you may be headed towards, which are separation strategies for future alternative fuel cycles.

GARRICK: Peter, we’re getting into an issue where we may have a timing problem.

SWIFT: Yeah, thank you.

GARRICK: We’re already in the discussion session, that’s right. But, what about the burnups that the Europeans are doing that’s behind this?

SWIFT: I don’t honestly know the answer to that one. Maybe Mark Nutt might. I mean, what was the burnup assumption on these? This was--

GARRICK: That, in keeping--

SWIFT: Joe Carter might know. But--

GARRICK: Yeah, in keeping with Andy’s comment, that’s going to--that’s really changing.

SWIFT: Sure, obviously, there was a specified burnup for this analysis. I got a feeling it was 60 gigawatt days.

CARTER: We used the 60 for this analysis.

SWIFT: Joe, I can just repeat it, but, Joe, go ahead.

CARTER: I’m sorry. Joe Carter, Savannah River. We participated on the study. We used a 60 gigawatt day burnup, five year cool, low cool in the period for this particular study. But, that’s comparable to what the Europeans are doing with a 50 gigawatt burnup.

GARRICK: Well, that’s pretty robust.

SWIFT: Yeah. Sorry about getting hung up there. I don't think this one is important. The PI, the lead on this for us, obviously, Joe Carter has worked on it, providing the inventory inputs to it. Ernie Hardin has led this work for us. The Board has seen Ernie before. It's a good topic.

The generic system level modeling, I used one graphic here. It happens to be a graphic of a deep borehole, but we have developed generic PA models for repositories in each of the four disposal concepts we're looking at. These are highly simplified models. In some ways, I think this Board might be pleased. We designed them to be tools that would quickly tell you what the major drivers were likely to be on performance. Is this system likely to be waste form lifetime dominated? Is it likely to be diffuse and transport time dominated? These are not licensing tools. They are tools that will pretty quickly tell you where the strength and weaknesses of each concept are.

With that said, these are pretty simple models, highly simplified geometries and the only one that we've put thermal behavior into is our deep borehole model, where of course the thermal behavior is the main performance issue. Can you establish conductive flow?

MOSLEH: Is there a report on this?

SWIFT: There is. I don't have a reference for it up there. Again, that one has not been through DOE review yet.

That was an end of the year report that the team just completed about three weeks ago maybe. I'll put a note on that to Bill and Jeff. There shouldn't be any problem.

Engineered materials performance. And, this is not my area, and if the Board wants to know more on it, we should get the right people here for you. But, I know the Board cared very deeply about the material performance analyses, the experimental work that was done on Yucca Mountain. We did start testing on Alloy 22 in 2006, 2007. That testing is continuing. We did not want to turn those tests off. That's good data. Let's go ahead and finish those tests out.

So, we're looking both at immersion and deliquescence in humid air. We're looking at, in the deliquescence testing, a range of nickel chrome alloys, not just Alloy 22. We're also looking at stainless steels, 303 and 304, different salt assemblages. There's actually direct relevance here to storage performance and the corrosion of storage canisters, particularly in coastal environments, where you have relatively high salt content and humid air. And, so, that's the experimental work that we have continued, and that's still going on right now. David Enos at Sandia is the PI on that.

In response to a question that came up earlier, yes, we are familiar with the copper corrosion issues that have come up in Sweden. We are tracking those. We're familiar with the literature. We are not at present doing experimental work that's relevant to it. We're very curious to see how that one plays out.

And, we're, for other disposal environments, that's our last point there, we are working on a gap analysis for other environments and other materials.

LATANISION: Peter, that photograph on the left looks like an important one to me. Is that a--that's a distribution of salt on an Alloy 22 coupon?

SWIFT: Yes.

LATANISION: And, the salt is characterized in terms of composition and water, the deliquescence?

SWIFT: I am guilty of showing the slide that you know as much as I do about. I know what you just said.

LATANISION: Fair enough.

SWIFT: We have to get David Enos to answer that question.

LATANISION: This is being done at Sandia?

SWIFT: Yes, it's the--you've been in David's lab at Sandia?

LATANISION: Yes.

SWIFT: That's where the work is done.

LATANISION: Okay. It still looks like an important slide.

SWIFT: Yeah, I think it is. This should be quick, just a couple of slides here on where we're headed in the next year.

First of all a plug here for Mark Nutt's talk that is coming. When we put together the FY11 plan, go back to Bill Boyle's history of the campaign, when the Office of Radioactive Waste was phased out at the end of--well, one year ago right now, and our budget in used fuel in the R&D program suddenly went up, we put together the R&D program that I just went through for FY11 without the benefit of the detailed systematic prioritization effort that Mark Nutt led, and many, many people participated in it, which was completed in March.

So, basically, what the initial plan for FY11 was done on the collective wisdom of the management team and the PIs, I think we did a pretty good job. We went back through and did a systematic look at the R&D needs for disposal and validated many of our decisions. Some we realize we probably didn't need. For example, we put some money on biosphere pathway work, and we realized pretty quickly on that that was not going to be useful in a purely generic world. You don't know what your biosphere looks like until you have a site. So, Mark will talk in more detail on that.

But, the work that was done for this report, which is available on the internet publicly, that work did inform the planning that goes into the next few slides for FY12.

So, now, in FY12, budget uncertainties, assuming they're all fully resolved, and engineered barrier systems, these are selected topics. There are more, but I took these topics directly out of our work plans that are still in--they're not signed off yet by the campaign and DOE program management, but they are close.

When Bill showed some slides earlier, he showed the milestones that were predicted, proposed for 2012 that mapped these activities. So, it is the same information that Bill showed and that I'm showing, just different ways of looking at it.

So, in the engineered barrier systems, phase mineralogy in the barriers, the cement and clay primarily. Coupled process modeling, both in crushed salt and in clay. Radionuclide transport work in clay. And, again, Jens will be talking about some of those, the clay work, when he speaks. Radiolysis effects on used fuel degradation. A point here is that UO2 was stable in reducing environments, but can you get a localized oxidizing environment on the surface of the fuel rod, due to radiolysis? And, if so, what gets mobilized. Laboratory studies of crushed salt consolidation. That's the work that the test plan was completed for earlier this summer. And, looking at thermal conductivity as a function of porosity, and chemical and material properties of salt that are relevant to brine mobility.

Natural systems. Hydrologic flow modeling in representative media, and Scott Painter’s Discrete Fracture Network Modeling is a good example of that. Transport in the far field, radionuclide speciation, sorption and colloid-facilitated transport. An example there would be the colloid work that Paul Reimus will be doing in Switzerland. Continued documentation of spatial distributions of geologic media and related properties. I didn’t talk at all about that. You saw some of that work in February from Ernie Hardin, just compiling basic geologic maps and other related information that may be relevant to the site selection process when we get to it. Where are the clays in the United States? Where are the salts?

This work has been done over and over again, but we need a good up to date set of information to work from when the time comes. And, develop and maintain our own archive of generic disposal system material properties. We want to make sure that everybody in our campaign who is modeling disposal systems is using the same range of material properties for what they claim are the same materials.

Thermal load management and design concepts. I think I talked about that, but we have a ways to go to expand the work that has been done to look at other design concepts, including the so-called open emplacement mode without backfill. And, look at expanded range of waste streams from advanced fuel cycles, and start trying to come up with some generic cost estimates.

Generic disposal system modeling. Migrate the generic models we’ve got into a common platform, an architecture. We have one picked out. It’s done through GoldSim, but what we have should all have the same look and feel by the end of the year. Use these models to support fuel cycle options analyses. This is the work that Monica Regalbuto talked about, where we will indeed provide the appropriate input to the fuel cycle systems team, looking at how different waste streams will affect disposal options.

We are working on a generic safety case study, how do you build generic safety cases in the European context of the overall basis for concluding that an option is viable and safe. Mark Nutt is working on that. Michael Voegele, who is here in the room, is working on that with us.

Advanced disposal system modeling. We have a very modest effort here. We are not on our own in used fuel, looking at next generation advanced performance computing. However, we are keeping tabs on what options are available for us. If--it’s not an if, it’s a when this country gets back into licensing on a repository, I don’t think we will be using these simple GoldSim based PA models. I think we will go back and look at advanced modeling tools, and we want to be ready for that.

KADAK: Could I ask--

SWIFT: Yeah.

KADAK: Are you basically giving up on the TSPA approach?

SWIFT: No. A TSPA of the scale, the Yucca Mountain TSPA, is not going to happen until we have a site. That is so site specific. The simplified generic PAs are, by necessity, far simpler. But, I do imagine that when we get back into licensing, we will be looking at a--nothing wrong with the Yucca Mountain TSPA. But, I doubt if that's the exact set of tools we use ten years from now.

KADAK: The Board may have a view about how you might want to do that.

SWIFT: That would be something we should explore.

GARRICK: We have three or four more minutes, max.

SWIFT: Okay. Sorry.

The engineered materials performance, that the corrosion lab work. We're expanding that. We're actually migrating that entirely into our management responsibility into our storage team, because that's where the main issues are going to be in the near term. So, we're expanding the existing work to look at more materials actually used in storage, and separately, we're looking at cladding and testing. Bill Boyle mentioned that at both Argonne and Oak

Ridge.

Features, Events, and Processes work, we have a generic FEP, Feature, Events, and Process, catalog and we are doing what we can with generic evaluations. These are not screening in or out. That has to be done site specifically. But, generic observations on how each process matters for each of the various options that we are looking at.

Inventory projections--

ARNOLD: Arnold, Board.

I scanned this and the next one, and you don’t mention natural analogues. Is there nothing more to be learned about natural analogues?

SWIFT: We do not have a separate activity in natural analogues; that’s correct. I think until we are back into site specific environment, basically the natural analogue work that’s already in the literature will get us to the next step. I appreciate the question, more about that one.

Inventory projections. Our primary inventory so far have focused on the existing once-through fuel cycle and the existing waste. We have work to do on alternative fuel cycles.

And, I think I’m almost at the end here. We have an activity on low level waste disposition. We have to develop inventory estimates and we are indeed tracking what disposal options are available for a low level waste. No, it's not DOE NE's responsibility to actually dispose of it, but if we have alternative fuel cycles under consideration that may significantly change the low level waste streams that are being generated, we believe it is a wise, prudent thing to do to keep track of what disposal options are available for that waste stream.

International activity. I talked about that one there. We will actually, I hope, get underground. Nuclear waste perspectives activity, again, I think I covered that one there. Looking at the interfaces with storage and transportation, in social sciences, public opinion surveys, this is Hank Jenkins Smith's work, some catch-all, other things here, including one that Mark Nutt will talk about after lunch, an update to disposal R&D roadmap.

The last point here, a science competition. Budget permitting, which is uncertain, we hope to reserve a fraction of our budget for internal, this is designed for our own PIs, there are other processes, the NE University Programs for external competition. We hope to generate proposals for our own PIs for work they would like to see. And, this model has worked well, for example in the waste form and separations group. We had hoped to do that this past year, and frankly, we couldn't make it happen primarily due to the CR, we didn't really know what our budget was until so late in the year, and I don't want to commit to a multi-year R&D award, essentially, internally without some confidence it's actually going to go forward. So, that last one has a pretty big question mark on it.

And, that was it. I apologize for running long.

GARRICK: Well, it's a very good discussion, and a very good presentation, too. We may have time for one question. I'm not sure we have time for one from Andy, but we'll take it.

KADAK: Just a simple one. Does all of this background review of options, and all that stuff, will you come out with sort of a document that describes if you have to pick, this would be the type of medium that I would like to go after because it has the best properties for disposal of whatever it is that you're going to be disposing?

SWIFT: Okay. My preference is not to do that. I think the most useful thing we can do right now is to stay flexible, maximize the number of options we have rather than focus in perhaps prematurely as this country may have done before on one particular.

KADAK: Well, let's just say three good ones, and if it has these kinds of attributes, the kinds of things you're looking at now as part of your R&D, that it would be really a, I'm not saying pick one type, I'm just saying ranking the technology.

SWIFT: Okay. I struggle with what it is we're optimizing on, if you're doing that.

KADAK: Not into the environment part?

SWIFT: Right. They're all pretty good at that, and I mean, we concluded, the DOE concluded in 2008, that Yucca Mountain was licensable, what more was needed? The projected releases from any of these mature concepts that have gone to licensing, Yucca Mountain, the Swedish concept, projected releases and doses are very, very small. So, the--

GARRICK: I think you've answered it.

SWIFT: Yeah.

GARRICK: I think you've answered it, and it's closing, last question, closing comment.

LATANISION: You know, I understand, Andy, what your point is in raising the site specificity issues, but honestly, I think at this stage in history, what I'm hearing is a smaller staff looking at a broader portfolio of questions, in anticipation of the fact that at some point in the not to distant future, we will be faced with making decisions that are more site specific. And, so, in order to maintain an intellectual base for making those decisions, these folks are trying to look at a broad spectrum.

GARRICK: Now, how's that for a--

LATANISION: And, frankly--

GARRICK: --characterization.

KADAK: Absolutely perfect.

LATANISION: Well, frankly, I think that's exactly what they should be doing, at this stage.

GARRICK: That's a good note to end on.

LATANISION: Let's have lunch.

GARRICK: Yes. 1:10, we'll resume at 1:10.

(Whereupon, the lunch recess was taken.)

AFTERNOON SESSION

GARRICK: All right. Well, we will commence with our afternoon session, and the questions that we've all been asking about, where is this headed, will now be answered by Mark Nutt with his Roadmap. Mark?

NUTT: I'll start out that I did have the opportunity to present to the Board several years ago, and at the end of the talk, there were no further questions to be asked, so I'm hoping to keep my streak alive, but I really doubt that's going to happen.

GARRICK: I doubt if that will happen with this Board.

NUTT: A little outline of what I'm going to talk about is I'll set the roadmap in context with some of the recommendations that have come out of the Blue Ribbon Commission. I'll then give a little background of the history of the development of the disposal roadmap, and the application of a systematic process we use within the campaign to develop our disposal R&D roadmap, the scoring and weighting we use, some discussion of the quantitative results, a synopsis of the high ranking issues, an overall conclusion we drew for moving forward, and how we have recently applied it, and hopefully have time at the end for some Q&A. So, I did leave time for questions.

As we know, the recommendations that came out of the Blue Ribbon Commission have asked for prompt efforts to develop as expeditiously as possible, one or more permanent geologic disposal facilities. Well, prompt doesn't mean just dive in and get going. You need to put some thought into it to develop a way for moving forward.

They also gave recommendations of near-term improvements in the technologies available for storing and disposing of spent nuclear fuel and high-level waste, and longer-term efforts for potential "game-changing" technologies and systems.

The program, the disposal R&D program being implemented by the used fuel disposition campaign is supportive of these goals. But, again, I will point out our boundary condition is generic R&D on issues until future policy is established. But, the generic R&D should be supportive of future site-specific activities. So, it went back to the question earlier as to why we're doing the things that we're doing. The efforts underway, we are fully aware, need to be supportive of future efforts by the U.S. to move to site-specific deployment and development of a disposal system and disposal facility.

A little background. We, for the past 25 years, as we know, U.S. efforts have focused on disposal at Yucca Mountain. And, the decision by DOE to longer pursue it has necessitated the investigation of geologic media and concepts for waste that could be generated under future fuel cycles, including the once-through and the advanced fuel cycles. As Peter talked earlier, it led to the various media that are being investigated by the used fuel disposition campaign.

We have looked at disposal in a range of these media since ’87 in the U.S., and internationally, they have looked at it for a number of years since then. Progress has been made, but there are still gaps in knowledge that can be filled through R&D.

Our U.S. labs have participated in these programs and conducted research to a limited extent. They have participated with the Japanese, with the Swiss, with different programs. But, a comprehensive disposal program investigating these media and environments has not been part of the U.S. program since the mid-Eighties. We’re putting this comprehensive disposal program together, developing it, and executed it under the Used Fuel Disposition Campaign.

Background of the roadmap. As Bill Boyle showed earlier, we stood this program up in 2009, and FY10 planning, we realized the need to develop a roadmap, a research and development roadmap. At the time, Mark Peters was the campaign director, the National Technology Director. He had put one together similarly for the waste form campaign within the fuel cycle program, when it was stood up and felt that we needed to have one put together for the Used Fuel Disposition Group to get us moving forward on the right foot.

So, FY10 activities focused on gaining understanding of the other disposal concepts, what's the state of the art around the world and internationally amongst these different media, different groups, what are the key technical gaps. In doing that, we had a disposal R&D roadmap workshop in June of 2010 at Argonne, and through it, we obtained a broad list of R&D opportunities really with no priorities. And, subsequent to the workshop, we, within the campaign, worked to identify additional opportunities.

We felt at the end of 2010 that we weren't ready to put together a roadmap yet, so we issued a status report in September and deferred the roadmap completion until FY11. Again, we needed to further identify opportunities, and then obtain information to support a prioritization by UFD management.

So, in FY11, we established the process for prioritizing the R&D issues. I'll talk a bit about how that was done. We held a second roadmap in December of 2010, and these workshops involved people not just within the campaign, but we tried to pull expertise together from across the laboratories that had been involved in high-level waste, used fuel management, to give us information and help us identify the various areas, information areas for prioritization that I'm going to talk about in a minute. We developed what I call an information prioritization that I'm going to talk about in a minute. We developed what I call an information prioritization matrix, developed draft documents and circulated for review, and completed the roadmap in 2011.

As Peter mentioned, this was not just my effort, not just a few people's effort, we used a broad number of people within the campaign, within the laboratories helped us in the workshop, reviewed documents, reviewed this broad information matrix that I'm going to show you a snapshot of in a minute, and really tried to capitalize on the expertise across the complex to help us put this roadmap together.

It is on the NE's, DOE NE's website, is publicly available. Much of the information--I'm going to give you a very high-level look, but you can pull it off, you can read what we did, you can read the synopses that are in there, and you can go down even further and look at the scoring, look at how individual issues were weighted and ranked, and scored.

The fuel cycle technology program, as Monica mentioned earlier, is using system engineering techniques to identify which fuel cycle technologies to pursue with R&D. Within Used Fuel Disposition, we're using system engineering techniques, looking at storage, concepts and storage activities, and Brady will talk about that later.

While system engineering techniques aren't directly applicable to doing R&D priorities for disposal research, the method can and has been applied. And, I will talk about it within this talk. And, again, the goal is to conduct R&D on generic systems that could be used in future development efforts. There is a reality that funding will be limited. The choices on what we do and when to do it to best support future development will need to be made.

What we started with within our systematic effort is to look at what are some objectives. You always start what are the requirements. We started with what are the objectives. And, given the uncertainty of what would be a regulatory framework for a new geologic repository, we went back to objectives based on international safety documentations, namely the IAEA, and started with containment, limited release from both the natural and engineered systems, and as a secondary function of dilution, we feel that the two primary functions are containment and limited releases. If you can get dilution through your hydrologic modeling, it’s more of a secondary function.

KADAK: Excuse me. Did you look at time scales of containment?

NUTT: Not--

KADAK: Are you still stuck with the million years, or are you going to do something--

NUTT: We did not look at a specific time scale in doing this. We utilized the features, events, and process structure to identify the issues. A question was asked earlier about the PA process, and we're still following it within the program. We applied it here and identified what would be the R&D issues to look at.

From the FEPs process, we came up to features, mapped the various features of a disposal system, back to the objectives. Took the next step of well, what is the identification of the R&D issues. And, the word "issues," it came from an issue resolution type approach that was similar to past site characterization plans that were developed in the U.S. So, you will see within the document, or within the talk, the use of the term "issues" and that's where it came from.

From the FEPs, features, events, and processes, we used the processes to define what the issues would be, and from that, we started with the Used Fuel Disposition FEPs list that was put together in FY10 to identify the features, the process that led to the issues.

From there, we started asking questions related to each one of the issues. The first one was the generic applicability. Can we, this issue be addressed through generic R&D? It goes back to the fundamental basis of the program, we're a generic program. If it's no, if there's no part of it that can be addressed, if it's really site-specific, really design-specific, then there's no need to conduct R&D on it right now, and it essentially was put aside. Still on the FEPs list, still ultimately needs to be considered as you move forward in a safety assessment of a future site, but in generic R&D, we can't do anything.

There are some aspects that could be partially addressed. It could be that the data or the parameters needed specific to that issue are site-specific, but you could develop models and methods using representative data from cooperation internationally, where you can improve models, and those would be worth doing.

There is other R&D that perhaps you could fully address the issue through generic R&D. You could get the data you needed. You could get the models you needed to do it. And, of those, we kept for consideration both the "partially" and the "yes," so they stayed in for the future consideration.

The next question we asked--

GARRICK: Mark, did somebody actually define what the means by which you achieve this resolution? In other words, what constitutes a "no" and what constitute a "partially" and what constitutes a "yes"? Do you have a high enough resolution in those definitions to--

NUTT: I'll say it was a judgment. It was a judgment among the experts and the people we had looking at this specific issue, whether we felt it could be done. You will see if you go to the roadmap and look through it, the vast majority fell under here.

GARRICK: Yes, that's what I was thinking.

NUTT: There were a few that fell under "no," but--and a few that fell under "yes," but the vast majority of them--actually, quite a few fell under "no." As Peter talked earlier, a lot of the biosphere issues, we felt that you really needed site-specific information, that there's just no point in doing anything now, so they fell off. But, the vast majority have fallen under here, so a lot of it focuses on method development, model development, technique development, getting read for the future implementation.

GARRICK: Thank you.

NUTT: Sure. The next question was what's the importance of the Safety Case? And, in it, we used the NEA definition of a safety case to support the prioritization of the opportunities. In it, we look at the safety assessment. What's the importance of an issue related to the safety assessment, knowing that this is both media and design specific. The next question is what's the importance of design construction and operation. You know, for example, is the behavior of an engineered material, concrete, known well enough to include in the facility design? Or are there special construction, fabrication and operational techniques that are required? Or have they been demonstrated?

The last category was Broad Confidence in the

Safety Case. There may be issues that are--that may not be important to either the safety assessment or the design construction operations. If address could really build confidence in the overall safety case? So, it was another category we had under the overall Safety Case.

We ranked each one of these as we went through as a high, medium, and low.

KADAK: Are you going to go through an example of how this is applied?

NUTT: I'll show you where you can see where the examples of how it's applied. You won't be able to read it up here, but I'll show it.

KADAK: Thank you.

EWING: Let me interrupt as well. I'm pleased to see the phrase "Safety Case," particularly the NEA definition. But, that's generally not used in the United States as an approach. I mean, it's a probabilistic risk assessment. So, was there a rationale behind using the safety case instead of, say, Total Systems Performance Assessment?

NUTT: Well, we wanted to look harder. I would argue that the Total System Performance Assessment falls under that part of the Safety Case.

EWING: Right.

NUTT: So, we are looking at it with respect to that, but felt that we needed to look broader. So, we are looking broader. In fact, as Peter mentioned earlier, we are doing work in fiscal year ’12, looking at generic safety cases that are looking more on the European approach.

EWING: So, as an example of the safety case would include, often includes consideration of natural analogues and natural systems, so that would be potentially a subject for your effort?

NUTT: It wasn’t a subject for this effort. We didn’t look at the analogues, at how they--the analogues could play into the--you will see in a minute, maybe the state of the art of what you know about one of the issues.

GARRICK: Rod, you’re not suggesting that analogues can’t play a role in a probabilistic approach, are you?

EWING: Not at all.

GARRICK: Okay.

EWING: I only wish they would. If the approach wasn’t so--we’d be able to use this--

GARRICK: Well, it depends on how it’s done.

EWING: Yeah, okay.

NUTT: The next question was what’s the state of the art? How well do we understand an issue? And, this really was part of the reason it took so long to put this together, is looking at all the issues we had, and there was roughly over 200 of them, a lot of them media-specific, of getting our hands around the state of the art.

We looked at broad categories, either an issue is well understood, or there were fundamental gaps that we felt, in method, data needs, or both. We also said perhaps an issue could have--it has maybe a good technical basis, but it could have an improved representation, perhaps conservatism, the model being used now is conservatism, perhaps we could improve that. Perhaps we could improve both confidence and improve defensibility. So, we had a broad category of different rankings of the state of the art for an issue.

We leveraged on the international work that’s been done in the U.S. and in other countries, really using the expertise of the folks in the campaign and in the labs. This is really--the two workshops we had really focused on this. We could very quickly go through the rankings with the safety case. There would be some debate, but it was really on flushing this out that took us a while.

The next question was what’s the importance and the adequacy of the information that we have or need with respect to the decision points. Essentially, how much do we need to know and when do we need to know it? And, again, UFD is supportive of implementation of the disposal system as it progresses through a variety of different decision points. Right now, we’re looking back at generic systems before any decision point, but we realize the issues we’re looking at may have different importance or priority as you move through the different decision points and implementation.

We looked at these different categories, the site screening, the site selection, the site characterization, and the site suitability or licensing. So, as you move down here, the types of information you need right there--I'm not going to go through each one of them, they're in the roadmap, but for each one of them, we evaluated the importance of the information at that time as either high, medium, and low, and the adequacy of the existing information with respect to that decision point is either being completely sufficient, partially sufficient, or insufficient. So, we went through each one of the decision points, and looked at the information, the importance of the information with respect to it, and how adequate is the information we have today. And, that gives you a timing of when things need to be addressed and should be addressed. So, it allows us an understanding of when it needs to be completed to support future decisions.

Where this can lead you is an identification of R&D topics. And, understanding the overall importance of each issue allows you to develop appropriate plans to address them, and there's three information items that would be needed in order to benefit the topics, evaluate the topics against the issues. What's the primary decision point that you're going to support? How long do you need to complete it? And, how much is it going to cost you. So, with the issues ranked and identified, you can then look at topics and use this to judge when and prioritize what topics to go address.

So, prioritize issues first, that’s the roadmap. Identify and prioritize the topics second, and that’s what we do in the planning.

This impossible to read chart is out of Appendix A of the R&D roadmap. Again, you can find it on the web. It’s an Excel spreadsheet. You will see each issue with the title, and then each of the categories I just talked about with rankings, low, medium, and high, and then with some text to discuss the commentary associated with that issue, and associated with the rankings and why we did things the way we do. It’s a very big spreadsheet. There’s roughly, I think, over 210 issues or FEPs that we have identified that we addressed. A lot of them are, again, media specific. So, if you get down to the natural system, you will see these broken out four different times for each of the media we looked at.

LATANISION: Do you suppose we could get a copy of something that readable, a handout? I mean, I would love to see what you’ve got in there, but I can’t read it on this, and I can’t read it up there.

NUTT: Well, we can, like I said, it’s on the internet. You can pull it off there. We don’t have--I didn’t bring copies with me. I suppose we could--

LATANISION: Okay.

NUTT: The issues are ranked. We worked through science scores and weights the different categories. We had a team of UFD lab, national laboratory and DOE-NE staff, facilitated by a decision analysis expert to come up with the scores and weights that we applied. They can be changed to reflect different judgments if we want to get together a different group of people and go through the scoring again, we could do it.

And, establishing the relative priorities, we used the basic principals shown there. The overall priority of an issue we felt is a function of the importance of the issue to the safety case. The importance to each decision point, and the adequacy and state of the art. So, we took those three. Going back to the generic question, the issues that could be addressed partially or fully through generic R&D were retained. Any of them that we felt could not be addressed, we put on the side. And, again, they would have to be addressed as you were moving forward in a safety assessment. But, for the purposes of R&D, they were not ranked or prioritized.

The importance of an issue to the safety case we felt was relevant to all decision points. Well, it is relevant to all decision points. The contribution of the three components may differ, so the weighting of each of the safety assessment, the design construction and operations with the overall safety case may differ. In looking back at the scoring we did, they really didn't differ that much. There's just one point that was different between them.

We felt that issues that were important for near-term decisions are of higher priority than those for longer-term decisions in the future. So, when we do the final score and we ranked issues that had higher priority near-term, they ended up ranking higher.

Issues for which the current state of the art is either well understood or where the currently available information is fully adequate to support a particular decision point were identified with low priority with respect to that decision point. So, if there was an issue that we felt was adequately addressed for the site screening decision, it ranked very low for that one.

Issues that were evaluated for different media, and we did look at media-specific priorities for a variety of issues, mainly in the natural system.

GARRICK: Were there other attributes considered besides the safety case, like efficiency or benefit or cost?

NUTT: No.

GARRICK: Nothing? Don't you think that would really change the picture dramatically? When you're at the point of a decision, those are the kind of questions you have to ask, what are the costs, what are the benefits, what are the risks?

NUTT: Sure.

GARRICK: You’re only asking the question here what is the risk.

NUTT: And, we’re looking, yeah, at the technical side.

GARRICK: Yes, and I’m not sure you’re getting your money’s worth when you do that with respect to establishing a path forward.

NUTT: Okay. This chart shows, and again, it’s out of Appendix B of the roadmap, what we did, we evaluated the quantitative scoring results and conducted some sensitivity studies to make sure they made sense to us. Again, the quantitative scores are in Appendix B. The sorted priority rankings served to identify a relative priority of the issue, of R&D issues, by which, again, topics can be identified and evaluated against the prioritization of issues. While the numerical scores are provided and sorted, they should not be construed as an issue by issue ranked priority list.

What we were really looking at was where they fell within the broad table. We picked cut-off lines essentially that were the two needs in what we were seeing, and said well, these ranked high, these ranked medium, and these ranked low. So, it was a judgment by the team that was developing the score and weighting. It turned out we had roughly a third that fell under each one of these. This broad number of zeros down here, the ones that either scored as being something you could not address through generic R&D, so they automatically fell to zero. So, it's really these that are worth considering.

KADAK: Could you give us an example of the top three dots there? What are those?

NUTT: Right there?

KADAK: I'm just trying to gauge what you've come up with as findings.

NUTT: I'll continue, and when we get done, we can talk, but I'm going to walk through the high-level findings we had.

KADAK: Okay.

NUTT: Again, while the scores were computed, while they're numbers for foundations expert judgment, both in the information that was provided and in how they were scored and ranked. And, what we used this for was to identify an overall subject ranking of each broad topic area. Again, if you go to Appendix B of the document, you can see what the exact score was for each one of these issues. But, again, I will caution you not to focus on is this one higher than this one, higher than this one. These are all the highest ranking scores. There's some even underneath it, it's just a cut of the final spreadsheet.

We, in working through the roadmap, we came up with some cross-cutting issues, as Peter alluded to earlier. We have efforts underway, a design concept development. Prior to about January, we weren't doing any work in this area, but realized that there was a need, as we were putting together a generic R&D program, to have some idea what the disposal concepts could be, what could be the EBS materials, what could be the configurations. So, we started an effort this fiscal year, given the importance to coming up with these design concepts, and looking at how thermal management can affect them.

The next one that's high is the general disposal system modeling that Peter talked to earlier. I'm not going to spend a lot of time on that.

Another one that we felt, but it came out with a low priority, is perhaps in the future, developing some R&D technology development facilities where we could look at different testing capabilities for fabrication techniques. But, at the current time, this is ranked low.

Knowledge management, we feel we're going to be generating a large amount of data, and as we heard from the Legacy Management folks, it could be a lot of information to manage, so we felt we needed to start thinking about how to go about that now.

The development of future site screening and site selection tools that could perhaps make it more efficient as we move forward into the next iteration.

Development of experimental and analytical techniques to support site characterization, and the use of underground research laboratories. As Peter mentioned earlier, we are pursuing working internationally, through an international collaboration, doing collaborative R&D work in URLs.

LATANISION: Mark, in a conceptual sense, does retrievability appear as a conceptual issue at all, or should it?

NUTT: I don't know if that's really a technical--I think there's a lot more policy involved with retrievability.

LATANISION: Well, I agree, but there would be some very severe--

NUTT: It could probably have design considerations, but it's something we have not looked at when we were putting this effort together.

LATANISION: My point is just that this could, I mean, if the decision were made, policy decision were made that the waste fuel should be retrievable, that would have an enormous impact on you.

NUTT: It could.

MOSLEH: Well, any other function of a high level change will alter the whole process.

NUTT: For the natural system, the highest ranked issues, and this is looking--the chart I showed earlier, the big one that couldn't be seen, looked at individual issues or FEPs under broad categories, and we did a synopsis where we rolled them up into higher level broad categories, for example, seismic processes, flow and transport pathways, and we looked at it for the different media, and came up with some rankings and prioritizations at this broad higher level. We felt the highest ranks issues are flow and transport pathways in crystalline media. You're going to hear from Scott Painter who is going to talk about modeling work that's being done there. Excavation disturbed zone for borehole disposal and shale media. Jens will talk some about the characteristics of clays and shales.

Hydrologic processes for salt, chemical processes for shale, and thermal processes for shale. And, this is just a few of them, again, that we felt rose to the top.

KADAK: What's the significance of the shading?

NUTT: The shading indicates where R&D is being done in other programs.

KADAK: I see. Okay.

NUTT: On the engineering side, we didn't do the ranking based on specific engineered barrier materials. But, we looked more at the main component of the engineered system and the potential processes that could affect performance.

The main reason we did that is the specific EBS are very dependent on design concepts that still need to be developed to a point where the EBS components important to waste isolation could be identified. And, a lot of the EBS materials can be considered to a large extent independent of the host media. But, again, their performance is inherently tied to the safety case. So, we looked at the components of the EBS, seals, waste containers, buffers and backfill, and looked at those to what are the importance, given the categorization that I showed you previously.

This is a chart that shows again at this higher level, where we thought each of the high-level issues came out. And, again, you can see this from--it’s in the document itself. Gladly, we felt the highest ranked issues were overall higher rankings for waste form, waste packaging and buffer and backfill materials. And, I will just remind the Board, or inform the Board, that in regards to waste form performance within the fuel cycle technology program, UFD’s responsibility is used nuclear fuel. So, if there is a direct disposal option that involves used nuclear fuel going into the repository, we characterize, understand the degradation behavior of that. The waste form, the separations in waste form campaign is looking at the degradation of the waste forms themselves, how they behave over geologic time, and UFD and the waste forms integrate, are well integrated and us providing them boundary conditions and them providing us the information we need to develop--to link into the repository work we're doing.

What we found with the waste materials is the degradation issues ranked higher than the inventory. The inventory is important. We've got work underway to quantify it, but what we really want to know is how it degrades.

For the waste package materials, it's the containment issues, and the chemical processes that affect the containment, rather than processes such as hydrologic processes. You want to know its containment capabilities versus how it behaves after it's breached.

Chemical process for the buffers and the backfill generally ranked higher than others. We want to know the geochemical processes associated with those materials.

Seal and liner materials. Issues related to both the chemical, mechanical and thermal processes ranked higher than radiation or nuclear criticality effects.

We looked at other EBS materials, but again, these tended to rank very low.

Overall, the chemical process in the EBS ranked high, higher than others. We're really focusing on the chemical side, but we realized that they're strongly coupled to both thermal hydrologic and even mechanical processes within the engineered barrier system.

We came up with one overarching conclusion after going through all this to move forward, and it’s with respect to the site screening decision point. The roadmap and all the work we did indicated that we feel there’s sufficient information currently exists to support a site screening process within the U.S. should a policy decision be made to go there. And, it’s somewhat obvious. We’ve done site screening and site selection before. We could do it again if asked to do so.

What we do feel is the R&D that we’re doing today and in the future could provide much needed information to support these future decision points. So, there is a reason to do R&D. We feel it can provide benefit as we’re moving forward. So, why we’re keeping the expertise from the Yucca Mountain Project, there is benefit of doing the R&D that we’re doing right now.

How we’ve applied the roadmap is, as Peter said, we started FY11 activities without the benefit of a completed roadmap, and we used expert judgment of the PIs, the scientists, the management team to put together the plan.

We had activities set up in fiscal year ’11, but we made a decision to defer starting work on them until we completed the roadmap, so we could make sure we were doing the right things. And, once we had our workshop in December, ran through the matrix that we put together, we found that there were some, except for about two areas, the allocations and the decisions we made for fiscal year ’11 were correct and appropriately applied. And, it was essentially biosphere pathways and infiltration and soil.

So, we re-allocated the money that was used for those to start up the design concept and increased funding in regional geology and tectonic hazard work. We also started the stakeholder social science R&D.

The roadmap has been--information has been used extensively in developing our fiscal year ’12 plans, and the outyear planning that’s underway.

KADAK: Excuse me. Could I just interrupt just for one moment?

NUTT: I’m done. You can--

KADAK: Oh, you are? Good. Did I interpret--well, could you leave that last slide? Are you saying you are now looking at sites, increased funding in regional geology and tectonic hazard work?

NUTT: We’re not looking at sites.

KADAK: How about areas? Regions, I’m sorry, is that a correct interpretation of that slide?

NUTT: That’s correct.

KADAK: Okay. Have you decided on--one of the things the Blue Ribbon Commission really was interested in was how do you do a site screening process? Have you started looking at how you do such a site screening?

NUTT: No.

KADAK: Do you intend to do that?

NUTT: I will defer to my Department of Energy colleagues.

BOYLE: We’re not doing it now, but other than the--I won’t even say other than the open and transparent. I’m not aware of any particular difficulty in that process. The U.S. did it once before. Every other country that has gone ahead with a site has done it. From a technical point of view, I’m not aware of any issues. There might be in terms of could we do it more openly and transparently? I wasn’t personally involved in the work in the Eighties. I don’t know exactly what they did. I do know the outcome of the last decision process, December 1987.

KADAK: But, I think one of the points of the Commission was, as I remember, John, they asked us to do this, help them figure this out.

GARRICK: Right.

KADAK: Was, you know, when we do site characterization, we want to do some preliminary screening, but how do we do that to a point where we’re not spending $10 billion for site characterization per site?

GARRICK: And, how do we do it against the right set of attributes that are--

KADAK: And, it sounds like you’ve got a whole ton of attributes here, but two significant figures of precision--

BOYLE: I understand the issue, and we have to be careful going forward. I interpret what you were--that area you were questioning about, Peter mentioned it as well, we’re looking at having electronic databases, where we can map out where is the shale, where is the granite, where do the people live, and that sort of thing. And, is John Kessler still in the room? Yes, he is. We presented some of this work we did last fiscal year at the High-Level Waste Conference, and we have to be careful as a society not to get hung up on sub-system measures, because that’s I think based on the question John posed on our earlier work, and also Wes Patrick from the Center of Nuclear Waste Regulatory Analysis, it’s quite easy to fall back into what I’ll call the trap of 10 CFR Part 60, which was sub-system base. It would be easy enough on sub-system criteria like depth to granitic rock, population density per square mile, even in a country as big as the United States, and with its diverse geology, we could rule out everything. But, we have to be careful that we at least keep the ultimate goal in mind, which is did we safely get rid of the material.

And, that’s always a tougher thing to do. Then, you at least need these generic, at least some insight into what will be the generic system performance of the entire system.

GARRICK: Okay. George, you've been quiet.

HORNBERGER: First, just a comment. I looked for your unreadable chart, and when I pull up the PDF, you go to Appendix A and it says it's on a separate PDF, but it's not a hot link. So, maybe you could at least--

KADAK: I found it.

HORNBERGER: You found it?

KADAK: Yes.

HORNBERGER: Never mind.

KADAK: But, it's also unreadable.

HORNBERGER: But, the PDF, you can scan, it's not--but, my question is at least for the university, if the science departments go together to do priorities, and you had physics and chemistry and biology and math and geosciences, magically, the priorities would come out to separate out across those disciplines. And, I'm curious if you going through your roadmap, would your procedure ever, would you ever contemplate that LBNL would have 60 percent of what is high priority?

NUTT: No. I guess part of the diversity, we had every lab involved, we had every lab on the workshops, and the workshops were long because people were discussing the issues. So, there was a lot of checks and balances, I'll use the word, so I think in the end, the process we used, the judgments we used, you know, the scorings are based on the expert judgment of the people in the field. I don't think anybody gained the system.

GARRICK: Rod?

EWING: Just a follow-up. Rod Ewing on the Board. A follow-up to that thought. So, as I understand it, your meetings consisted entirely of people from the DOE complex; right?

NUTT: Yes.

EWING: So, as discussed previously, the DOE complex, since 1987, has been focused on a particular rock type, and during the follow 25 years, the rest of the world looked at lots of other possibilities. Do you think if you did the same thing, but used scientists from these other international programs, that is, the people who are actually involved with granites and clay and even salt, say in Germany, would you get the same priorities?

NUTT: Potentially, not. I think some of the people we involve, we made a very heavy effort to involve as many people as we could from the national labs that were also involved on those programs. And, we made sure we had the folks from LBNL that were involved with the clay sites and the granite sites. We really tried to bring people in that had that involvement. Could other people rank the issues differently than we did?

EWING: Well, not just any people, but the people with direct and recent knowledge of the science and progress related to these other rock types.

NUTT: They could.

GARRICK: Ali?

MOSLEH: Yes. We brought this up earlier to a couple of questions, but it’s kind of a little bit strange that you have gone through such a systematic very nice, organized process on a single attribute/performance. And, I think, to me, it’s kind of an example of lessons not learned from previous experience where we saw kind of a single issue or concept and lack of integration of activities, reflected in this by the way that the focus is just a single attribute. And, I think retrievability is a good example. You know, the moment you bring performance and function, functionalities that might be needed in a generic sense, many of these things could change, would change the design concept and the priority in terms of, you know, attributes you have identified.

Along the same line, and kind of a different way, you have the stakeholder, you have initiated research, and I think I saw one stakeholder communicating with the public, but not extend that to other stakeholders, industry and whatever else one can--so, are these part of what you could modify kind of your approach with, or update it?

NUTT: I guess I’d be interested in what other input you, perhaps as the Board would consider would be attributes, we should consider.

GARRICK: Good.

NUTT: I don’t need them now. One time, I will say we are revising the roadmap this year, as we said earlier, it’s a living document. We plan on revising it by the end of the year. So, as the key lead on work in this thing, I would be happy to take your input.

GARRICK: All right. Howard?

ARNOLD: Arnold, Board.

This was an effort by a lot of people and a lot of groups. Did you end up with any strong dissenters?

NUTT: Surprisingly, no.

ARNOLD: I wish you had.

GARRICK: I thought the workshop idea for getting input on this is a very good one. It’s used extensively by the National Academies to deal with specific technical issues. But, I wanted to ask about them a little bit. You partly answered one of my questions. One of the questions I had was what was the duration of these workshops, for example?

But, what I was really wanting to know is did you establish a protocol for the workshops, and did the participants have instructions in advance of the workshop on what, to make it effective and efficient?

NUTT: I'll divide it into two parts. The first workshop we gave, it was June of 2010, we gave some directions, but it was really to start getting people engaged, getting the lab's participants involved, getting information out of them.

The second workshop that we had in December 2010 was a lot more formal. We had put together the table that, the illegible table up there, provided it to the workshop personnel and said, "Come in and be prepared to discuss your input in these areas." So, we asked for them to provide them back, populated with their best judgment, and come in to discuss them. That's where the give and take was. There was quite a bit of discussion on a lot of the issues. And, you said how long were they? Two days. So, we were putting a lot of information, a lot of discussion.

It came back after the workshop, a smaller group of us that were heavily involved in the roadmap development, went through the big matrix of information we put together, tried to fill holes, clean things up, and provided it back out to all the workshop participants, because we didn't want to change things that they had given us in the workshop. So, we wanted to make sure that what they provided us was what was in the document, give them a chance to review everything that was in it. And, they did. We also provided them back with the document itself and said, "Here's the conclusion we're drawing from it," and got feedback back from them.

GARRICK: How did you decide on the participants? Was this based primarily on expertise?

NUTT: It was expertise, it was each of the labs, we contacted essentially the leads within UFD from each of the labs, and said we're having this workshop, here's where--who do you want to send to support this. So, it wasn't me saying I need you and you and you. It was contacting the labs to give us the expertise that they thought was best.

GARRICK: To pick up on Dr. Mosleh's question, was there any consideration given to going outside the complex, going outside the Department?

NUTT: Not when we did it.

GARRICK: Okay, thank you. Yes, Ron?

LATANISION: Just a short question. Given the international experience in Sweden and Britain, and our own experience in the United States, it would seem likely that a high priority in terms of site selection will have to be placed on the public attitude about location of a repository in the proximity on that public. Is it your view that this roadmap will serve as an effective assessment vehicle or screening tool once that kind of decision might be--

NUTT: No, this roadmap is the technical issues associated with each of the--

LATANISION: Well, how will we go about determining at which site--let’s suppose in some reasonably short period of time, three or four different communities have expressed an interest in such a site.

NUTT: I’d say you’re on a completely different program.

LATANISION: Really?

KADAK: Maybe different planet.

LATANISION: Well, how do we go about making a decision about what sites to choose?

NUTT: I’ll let Peter--

LATANISION: Okay.

SWIFT: Peter Swift. The work Mark is talking about here is designed to help prioritize R&D, not for site selection. You might actually find, let’s get on that other planet, you might find a really good site that didn’t need any R&D. This doesn’t tell you much about that. This is designed to tell us where we get useful R&D returns for our investment, and that’s not a set of site selection criteria.

LATANISION: No, but the question is on the table should we have a set of site selection criteria.

GARRICK: Yeah, the question is should that be the end game.

SWIFT: Right. We’re not in a position yet, that’s where Mark turned to Bill Boyle earlier, we’re not in a position in national policy space where we can answer that question.

GARRICK: Thank you.
EWING: I'm sorry, but why are we not in the position-- Ewing. Why are we not in a position?
SWIFT: Because the Nuclear Waste Policy Act is still applicable. We work under it. It's the law.
EWING: But, that doesn't prevent us from thinking; right?
SWIFT: Point well taken. We will meet another planet later.
EWING: I rest my case.
GARRICK: Any other questions from the Board?
KADAK: I have one.
GARRICK: Yes.
KADAK: I was scanning your report here, and I'm trying to understand when you did your rankings and your priorities, is there an explanation as to why a particular topic was rated high and medium and low? I see the numerical, you know, I can see the numbers, but I don't see why that is so important in any context.
NUTT: You almost have to look at the document. The real details are back in Appendix B. That is the Excel matrix.
KADAK: Appendix B is an Excel spreadsheet.
NUTT: Yes, that's where you see the scores, high, medium and low, sufficient, adequate, that's where the

rankings are at. And, then, there's discussion in that appendix regarding each issue. From there, we then developed the algorithm by which to do the overall score for the issue, and then we rolled the discussion up to different levels to talk about it.

KADAK: I'm still--okay, if you say so. But, I don't know, has the Board staff reviewed these two documents yet?

MOTE: Yes, they were assigned. Which document is it?

KADAK: This is the roadmap, and then there's another one on the disposed--so has the staff reviewed those yet?

MOTE: Not that one, no.

KADAK: Is there a plan to do that?

MOTE: Yes.

KADAK: Because I think, as Mark suggested, if they're going to be revising it, I think it would be helpful for us to have input to the revisions.

GARRICK: Okay. Anymore questions? Staff?

(No response.)

GARRICK: Audience?

(No response.)

GARRICK: Thanks very much, Mark.

All right, we're now going to hear from Scott Painter. He's going to talk to us about some specific modeling.

PAINTER: So, this is a technical talk. There will be some detail here. That’s by design. But, I think, or hope anyway, that it also illustrates some broader points about the program, how we’re addressing or developing capability to address disposal and media that has been neglected in this country for a long time. However, leveraging results from overseas programs, however, leveraging results from different DOE programs other than Used Fuel Disposition Campaign.

I’d like to acknowledge some people that worked on this, particularly Carl Gable at Los Alamos National Lab, who is our Mesh Generation Specialist, and Jeffrey Hyman, a grad student at the University of Arizona, who has been working with us. And, I also want to acknowledge people in the Swedish program. I’ve had the opportunity to work in the Swedish program for more than a decade, and put together some of the transport simulations that supported their safety case. And, this work is influenced by that work.

An outline of my presentation is here. I’ll start by giving some background, the need for discrete fracture network, what a discrete fracture network is, international experience, and then I’ll move on to talk about our work on developing of new discrete fracture network flow and transport capabilities, and some example simulations.

So, this work is primarily oriented toward granitic rock, although there are applications in other medium. So, in granitic rock, the primary pathways for transport from repository to the accessible environments is through interconnecting networks of fractures. Granitic rock tends to be fairly sparsely fractured, but it still provides pathways for transport.

Flow and transport in fractured rock is very challenging. I think most hydrogeologists or sub-surface hydrologist would agree that it’s one of the most challenging topics you can address in hydrology. A traditional way to approach that has been to replace the fractured rock mass with an equivalent porous medium. But, experience both from the field and from theoretical work suggests that this really does not capture some of the primary phenomena, channeling, scale dependence, complex directional dependencies, and highly skewed breakthrough curves.

And, I shown an example there in the corner, which is trajectories that I extracted from a discrete fracture network. These are streamlines for the flow field, and they have been color coded by the amount of radionuclide mass that’s carried on each pathway. And, you can see there’s one red pathway. That’s where most of the mass is transported, and it snakes through this spaghetti tangle of pathways. So, this is an example of extreme channeling, and this is an example of phenomena that is not adequately captured with continuum models. So, we really need some other approach.

KADAK: So, where do you get the data that supports your model?

PAINTER: I think that might come a little clearer in a moment. So, the figure there is a schematic on sort of some of the range of models that we have available to us doing flow and transport modeling of a fractured rock mass. We're talking about the discrete fractured network model. And, what that really is is any sort of approach that tends to explicitly represent the geometry and the properties of discrete features. It could be fractures, usually fractures, but at the large scale, it could be fracture zones model is a feature.

And, of course, we can't map all the fractures in the field. This is not possible. But, what we can do is go to the field, understand the distribution of geometries, the apertures, how things are arranged in space, create statistical models of that, and then generate stochastic realizations of the network based on the statistical models. And, so, this is a typical approach.

Clearly, it's computationally demanding, but it's only been in the last few years where it became feasible, due to advances in computing hardware, to actually do this for full site scale.

So, SKB's, SR-site safety assessment, which was recently completed in support of their license application for the repository, relied very heavily on discrete fracture network modeling of flow and transport. And, I think this is very important because it’s a clear demonstration that a high quality safety case for a complex site can be constructed based primarily on the discrete fracture network representations.

A similar approach is being used in Finland, and it’s also important to note that the results that they have found are very difficult to reproduce with the conventional continuum model. And, this is an example.

This is an example from my work for the Swedish program, and what I’m showing here is the layout of the repository, the individual dots are locations of waste canisters, and they’re color coded according to whether they had a connected pathway to the surface or not. And, so, the red ones have no connected pathway to the surface. And, the trajectories shown are the top pathways that are contributing to dose, and again, they are color coded by the amount of radionuclide mass that’s carried on each pathway. And, if you look over here, if you look at the figure over here, you can see that this one red pathway snaking through, again, this is the one pathway that contributes the most to the overall dose. So, again, we see this high degree of channeling.

KADAK: Can I ask you to stop here? This is the statistical representation of what you believe the fractures are in the rock, it might be carload--I'm sorry.

HORNBERGER: It's one realization.

KADAK: Perhaps just one realization then. How do you validate such a model?

PAINTER: Okay. So, there's a lot of work that went into--it's not belief--it's a lot of work that went into developing and understanding, quantitative understanding of the fracture network there. So, SKB and their consultants have gone through a many year effort to understand the distribution of fracture links, transmusivities of the fractures based on pump tests, geophysics, outcrop studies, the whole range of things available to them, to develop a, you know, representation, a statistical representation of how things are arranged.

KADAK: So, they do borings to find these fractures?

PAINTER: Oh, absolutely.

KADAK: And, do they become a fracture pathway?

PAINTER: The holes?

KADAK: The holes?

PAINTER: Well, actually, in these models, there's a great deal of complexity that you can't see here, but all engineered structures, tunnels, boreholes, ventilation shafts, access shafts, all that is represented in the model, in addition to a stochastically generated fracture network, there is a background deterministic network which is deformation zones which are known and mapable from the surface.

ARNOLD: Arnold. Just to continue the effort to understand it, this is a realization, so you then compile a lot of realizations, as in the TSPA, you end up with some horsetail charts, and that's the way I remember it, yeah.

PAINTER: Yes. I mean, just because of the difficulty in doing these flow and transport simulations, the number of realizations is limited to ten. And, this is one of the reasons that we have started developing new and more advanced flow and transport capabilities so that we can actually do a better job, using more realizations, for example. As Peter pointed out in his talk, what's licensable in Sweden, may not be licensable here.

And, if you want details, I can point you to this SKB report, which I had the opportunity to coordinate, and it gives some details on the transport calculation, and some of the supporting data.

So, we're developing a new discrete fracture network capability. So, this capability will be needed to assess fractured granite sites, if we get there. It's also needed now to look at some of the unresolved scientific issues with transport in sparsely fractured rock. And, also, it's useful for understanding flow and transport in the excavation damage zone near clay repository tunnels.

So, we believe that the existing research and a small number of commercial codes are really not adequate. I list some reasons there. But, one of the things to point out is that a lot of these are actually quite old, and they were really built before the days when we had, you know, a roomful of clusters of computers and sort of modern computing capability. And, they also have pretty limited capability for transport. They're more oriented toward flow.

So, what we're doing is currently developing prototype capability. We want to use that to really understand how to do this in a very efficient and robust way. And, then once we do that, then we'll start implementing in a parallel toolkit framework, so that we can do massively parallel simulations of discrete fracture networks. And, where possible, we're leveraging existing capability that's been developed internationally, and from other DOE programs.

So, overall strategy for prototyping is shown here. We're using a finite volume method for flow for reasons of local mass conservation. Once we do that, we'll do advective particle tracking to establish transport pathways, and then post-processing those results to account for retention processes like matrix diffusion/sorption. So, this is a pretty well established strategy for fractured rock.

And, the implementation detail is shown below. We've written new code to actually generate the networks, and they we’re piecing together existing tools, meshing tools, flow tools, some transport codes to do the rest of the calculation. And, we have conducted this through Python scripts, so that it looks more or less seamless to the user.

HORNBERGER: Scott, just a quick technical question? Your previous cartoon looked like an intersection of disks, which as I’m familiar with, this looks like an intersection of planes. What’s the latest technology for generating the effect?

PAINTER: Yeah, okay, so we were agnostic about that actually, so our factors are polygons. They can be anything. They can even be random. We have experimented with random polygons, for example. So, yeah. I think generally there are representative disks or ellipses, but you may be site specific.

LATANISION: So, what are we supposed to take away from that graphic?

PAINTER: I’m going to show several of these in a minute, and maybe explain that a bit more.

HORNBERGER: It’s nicer than the little polka-dot thing.

PAINTER: Okay, so this is largely a grid generation issue. So, we need to triangulate each fracture as a two-dimensional object, while ensuring that grids match at the fracture intersections. And, this is still an active area of research. You can go into, say, the applied math literature and find papers on it right now. And, the reason for that is that for arbitrary geometry, it's not possible to ensure that you can generate a high-quality grid of a reasonable size because of certain pathologies of problematic configurations.

For example, if two fractures intersection over very small links, then you have to have a very fine grid around that. If you get triple intersections, then you get mesh elements that have a very high aspect ratio, also problematic. And, so, most of the previous work on this topic has sought to generate a discrete fracture network, and then to modify it to remove the troublesome features.

And, I think our new contribution here is that we actually constrain the generation of the network to ensure that we never get a pathological configuration. That's what I will be talking about in a moment.

We are also looking at another that's less well developed to allow non-matching grids at the interactions. And, there, we take the complexity out of the meshing and put it in the flow solution, but I won't talk about that anymore.

Okay, so we've developed a method for generating a discrete fracture network to order age, which age is some minimum link scale that the user specifies. And, so, the way this works is you specify a link scale, and then as we stochastically generate fractures and put them in the network, we check to see whether the new fracture causes a problematic configuration, and if it does, we reject it.

So, an example for rejection is if the fracture causes an intersection that is less than H, it’s rejected. If it causes an intersection of intersection, then we reject it. So, you can see like in this figure on the right, the red and the green fracture intersect with the pink one, and if we move these two close together, then you would have to mesh very finely on the pink fracture to resolve that, and that could be a reason for rejection.

More on the meshing. So, once we have generated the network, we mesh it in our existing meshing software LaGrit in such a way that nodes on the line of intersection are common to both fractures, and the lines of intersection are preserved using a conforming Delaunay triangulation, the technical term.

At the intersection, control volumes lie in two fracture planes. So, if you look at this picture, you can see the--I show both control volumes and the underlying mesh, but these little white polygons are the control volumes. And, so, each control volume that lies on an intersection, would actually lie in two planes. Now, I can give a more concrete example of that in a moment.

A bit more detail on how we do it. So, basically, we put nodes on each fracture independently. Then, we remove nodes, they’re within some distance h of each intersection.

So, we excavate the grid, and then we put new nodes on those intersections, and then we mesh each fracture independently, and then merge the meshes and eliminate the duplicates. And, you can show formally mathematically that this creates a conforming Delaunay triangulation on each fracture, so that the intersections are preserved exactly and the control volumes match up.

So, if you can imagine that we take these two fractures and rotate it so that we're looking down the line of intersection, each control volume that lies on that intersection would have an X-shape there, so it's supports the plane part of it, another plane.

Some more networks. There's a lot of technical detail I won't go into. We develop methods for coarsening the grids away from the intersection to allow you to put the resolution exactly where you want it, which is around the fracture intersections, but it gets coarser as you get away from the intersections. And, this is important to keep the meshes of reasonable size.

So, I talked about meshing.

HORNBERGER: Scott, just another quick technical comment. You talked about generating the grids. How about the apertures? Are you using cubic aperture loss, so you have to have apertures as well?

PAINTER: Yes, in practice you would. I mean, right now, it’s specified. But, in practice what would happen is some length transmusivity relationship is usually the way it’s done.

HORNBERGER: Okay.

LATANISION: Just a point of clarification. So, you have two fracture planes intersecting at a point of intersection. Do you assume the flow volume along that linear intersection is greater or less or what? Is there an assumption made about the flow volume in that intersection?

PAINTER: The flow volume? No, I mean, I think the-- okay, an aperture is associated with each connection between control volumes, an aperture and an ability to transmit the fluid. So, for those control volumes that lie on the intersection, they’re kind of egg-shaped, there’s one transmusivity for this one and one for that one.

LATANSION: Yeah. So, what is the significance of the intersection then? I mean, what effect does that have on the flow?

PAINTER: Well, I mean, you ultimately solve the flow in the whole network, so the issue is you have to grid it in such a way that you preserve intersections, so that the mesh is interconnected.

LATANISION: Okay.

PAINTER: Okay, so these are example of pressure fields solved on the two networks, a smallish one on the left.

We’re injecting fluid in the top and removing it in the bottom, so you can see the color scale in pressure. And, then, the one on the right is a much larger network where you zoomed in on local detail, injecting on the red fracture, which is the high pressure part. So, you can see that it would generate quite complex flow paths from these networks.

So, I talked about meshing and flow and another aspect of the problem is transport. So, we are using a control volume flow solution. It’s fully unstructured. The control volumes could be any shape. It turns out that that’s not enough information to give you a velocity field, and you need a velocity field to be transport, so we’re using a method that was developed, that I developed in another program to reconstruct the velocity field based on a constrained least squared solution on each control volume.

And, the figure there shows some of the validation for that. When you’re looking on the plane of one fracture, we’re injecting on one corner and withdrawing on the other, we have an analytical solution for that configuration, and we’ve compared our reconstructed streamlines to the analytical solution. So, we think it works quite well. It’s reasonably simple to implement.

This was implemented in another program, an EEM program. We implemented it in 3-D there because we were only interested in 3-D. So, now, we’re going back and reimplementing it in this campaign in 2-D because each fracture is 2-D.

So, I've talked so far about network meshing where you place a two-dimensional mesh on each fracture, and then these are connected up in three-dimensional space. That's a good strategy for a lot of the issues we need to address in this campaign. But, it's not sufficient to address some of the open scientific questions, so we also started looking at the more complicated situation where we do that meshing, but then extend the mesh so that it fills in the space between fractures. That's quite hard, actually. We've got some progress here which is shown with these two fractures. So, the trick here is you want to produce tetrahedral control volume mesh where each fracture is composed of the faces of some of the tetrahedra.

So, this is an example of two fractures, and here I've cut away the mesh between the fractures so you can kind of see what the face of the tetrahedral mesh looks like on the fracture planes. Then, as you move away from the fractures, it's a fully three-dimensional mesh. So, we're pretty excited about that. This is hard to do, and we think it's going to be a really powerful capability to look at a lot of different issues.

Okay, just summing up where we're at and where we're going. So, we're still finishing up the prototype capability that I mentioned. We're almost there. We need to do a little bit of work on the transport side and also on the fully three-dimensional part. We want to start using that prototype capability to test and refine algorithms. So, what we really want to know here is how you do this robustly and efficiently. And, we want to know that in enough detail that we can write very detailed specifications to hand off to people who would want to implement it in a massively parallel tool kit that can run on, say, a big super computer.

Parallel to that, though, we think we can also start using the existing prototype capability to start looking at some of the scientific issues, range of applicability for continuum versus discrete models for example, and something I have been interested in for a long time, which is the role of small versus large features in controlling performance. For example, how important is the sub-fracture aperture variations on overall transport. And, I think that's still an open question.

Then, we want to implement the algorithms in the high performance computing version. We're currently looking at capability that was developed in Environmental Management's Advanced Scientific Computing for Environmental Management, the ASCEM program. The Amanzi code there we think could be a platform for deploying this algorithm in a parallel way.

Then, once we do that, then we think we can revisit some of the scientific issues that we want to address, but doing much larger networks.

I include the references there. And, this concludes my talk.

GARRICK: All right, questions?

LATANISION: Yes, Latanision, Board. Excuse me for being dense, but I just want to make sure I understand what you're doing here. Suppose we take a simple case where we have two planer fractures intersecting, and there's a ling of intersection between them, so you're feeding that line of intersection presumably with water flowing at each plane, that would suggest to me that you have a larger driving force along that channel, along that intersection. But, does it necessarily mean you have a lower resistance to flow so that you get a larger volume along that intersection, or is that not the point?

PAINTER: I think that you're driving flow, but it's some of the boundary conditions. So, let's say that flow is across here, and you have an intersection here, so you've got your flow through the intersection into the other fracture.

LATANISION: But, that sounds diffusive. You're not modeling diffusive.

PAINTER: No, it's both, it's both pressure, it's Darcy Law groundwater flow.

LATANISION: Yeah, well, that’s what I’m thinking of. You’ve got a driving force and a resistance, so it will determine how much flow you get.

PAINTER: Right.

LATANISION: But, is the flow channeled along the intersection, or is it not?

PAINTER: Not in this model.

LATANISION: Not in this model? Oh.

PAINTER: But, keep in mind that you have--it’s discretized. So, if you want to put high permeability on the control volumes that are on the intersection, that’s the modeler’s choice. So, you could be.

LATANISION: Okay.

GARRICK: So, there’s no mass flow balance or mass balance in this process? I’m asking a stupid question. If you have flow along a fracture, you also have, do you not, some matrix diffusion? How do you account for the mass balancing of the flow?

PAINTER: Sure. Okay, so, the strategy is that we solve the groundwater flow equations, and that’s water balance. Okay? So, that’s all taken care of. Okay? And, then, after that, we then do particle tracking to account for transport, and the particle tracking does--there’s a post strategy that’s well established that accounts for the effects of retention like matrix diffusion and actually quite a range of retention processes. So, that's also accounted for. But, it's kind of a decomposition strategy. We don't try to do it all at once. It's a smart approximation basically that allows you to do the transport without overwhelming the codes.

GARRICK: I see. I need you to educate me on this.

Yes, Rod? Oh, and Ali after Rod.

EWING: So, for the transport, does it involve the geochemistry, it is reactive transport modeling?

PAINTER: In principle, it could be. I mean, we generate mesh, we do what solution we could to reactive transport modeling on that mesh.

EWING: Okay. Is that part of the plan for the--

PAINTER: That is not part of our--

EWING: This application, this would be necessarily, I would say; right?

PAINTER: Well, I mean, usually you're dealing with very dilute concentrations of radionuclides. As long as the groundwater chemistry is not changing a lot, then you can do it in more approximate ways that are quite adequate.

EWING: Okay, thank you.

GARRICK: Ali?

MOSLEH: I was encouraged by the fact that you were moving in the direction of parallel computing. Of course, with that capability, you probably would be able to do a much more comprehensive model uncertainty treatment. Do you plan to do that?

PAINTER: That's one of the main motivations for building new codes rather than trying to buy a commercial code, for example.

GARRICK: Yes, George?

HORNBERGER: Again, just a quick clarification, a follow-up on John's question. He mentioned matrix diffusion. Now, until you get to your tetrahedral representation, your quote, unquote matrix diffusion is really dead-end fractures?

PAINTER: No. What we do is we, and this is the way the Swedish program does it, and the way we're doing it in other DOE programs, is that we trace particles without any retention processes, just purely advective, establish streamline flow paths. Okay? And, then, we have semi-analytical methods that account for matrix diffusion based on the streamlines that are extracted from this complex network.

HORNBERGER: But, you don't have any matrix flow processes?

PAINTER: Oh, no, no. And, that's a very good approximation for granite.

GARRICK: All right, any other questions? Very good, thank you.

All right, we're now going to hear from Jens.

BIRKHOLZER: All right, so what I will try to do is talk in a little bit of a broader sense, not as much detail about some of the R&D activities related to disposal in clay and shale. My name is Jens Birkholzer. I'm at Berkeley Lab, and I'm the lead for the Nuclear Waste Program at Berkeley. The same time as Peter mentioned, a few months ago, I think in the spring, they asked me to take on the role as the Lead for International Activities, which is mostly an advisory role. When I think it happened--too long, that I do think that we need to reach out to the international community and bring that expertise in. And, so, he asked me to advise and promote such activities, and I'm thinking we're doing that now. And, with that, I mean actual collaboration, not, you know, being part of a panel or being part of a, you know, IAEA sort of review, sort of talking points of a panel.

All right, this is what I will talk about, a little bit on the background of clay/shale repositories. I want to discuss how I see how we conducted R&D planning, why we chose to conduct certain R&D and not other issues. And, then, I will discuss two examples of--they cover probably 70 percent of the work we currently do at Berkeley in the UFD program. There is additional work, but these are the main projects. There's several of our scientists involved. I'm mostly leading those activities, but if the actual expertise is not necessarily with me particularly, if we talk about that second topic.

All right, shale repositories are, I think it was mentioned before, three countries are actively engaged in choosing shale as the host geologic environment. That would be Belgium. This is actually a soft clay. France and Switzerland. One of these countries really doesn't have a choice, that's Belgium, but France and Switzerland do. They have been looking at granites in the past, but went away, and are now really mostly focusing on these two sites in an indurated hardened clay for very good reasons. They are stable mostly, and they have low permeability and the absence of fractures, which of course we have to ensure diffusion dominated, so diffusion is very important.

There is an aspect of self-sealing that comes handy because we are creating fractures as we open those repositories up, and then we ventilate them and we bring waste heat and backfill, sorption, many clays are strongly sorbing and there's typically reducing environment. So, all those are good reasons to go into shale or clay. We do have a wide variety of shale in the United States, so that could be quite a promising way to go.

I think it's recognized in the international community there are various performance drivers, but two are mostly relevant to the safety case. One is do we understand what type of degradation we induce? Do we make those shales from a diffusive environment to an advective transport environment, at least locally near the tunnels? And, how long does that take? How long does that disturbance last? The question that never really came up at Yucca, I think it was mentioned before, because it is so permeable to begin with, that we really didn’t care about a little bit of an increase in near-tunnel permeabilities.

The second thing is if we do rule out that the long-term transport is advective, then diffusion really comes into play, understanding it better, making sure that we’re not conservative, and that we do have a good grasp on sorptive behavior.

So, I guess when we started out, at least in my mind, and I don’t want to generalize that, I had sort of these steps in mind to go through a decision process, and then finally to go through scientific projects to achieve the objectives that I think Peter and also Bill laid out in slightly different words. I would say that somewhere in a few years, whenever it is necessary, when we are supposed to look at a site within the United States when that chance comes up, we need to have science and engineering tools that we can apply to assess safety. We need to have those confirmed, and with which I mean confirmed against data, against experiments, and ideally conducted on the ground, and eventually have a sound technical basis, including understanding of uncertainties.

So, review science gaps, roadmapping priorities, then developing capabilities that we don’t currently have. Of course, we need to assess that. Create an improved process understanding, and finally, validate it with data. The subject of generic came up. Generic in that context means, to me, only that we’re not looking at a disposal site in the United States. It doesn’t mean we’re not looking at data. It doesn’t mean we’re not looking at real rocks. It doesn’t mean we’re not looking at shale somewhere else. We have to do that, otherwise, we’re dreaming things up. So, we’re looking abroad to do that. And, generic simply means it’s not site specific in a sense that there are no plans for disposal for a specific site, but it’s specific to an indurated clay, for example, looking at Mont Terri or other sites abroad. Now, that’s important to understand.

So, we did that I think in 2010, we sort of loosely came up with the state of the art, and we checked where particularly international programs still had issues and technical advances that needed to be made. There are reports available. Then, we took those, and that’s what Mark reported upon, prioritized and chose what are really things that we should start with. And, we are now in a phase where we have or are developing capabilities that we don’t currently have. We started with improved process of understanding and hopefully, pretty soon, we’ll start engaging with some of the international field experiments, which bring us on as partners, as analysis and modeling partners.

And, to make that entirely clear, all that, review of activities, has been done looking abroad. We need to look abroad. And, again, I want to stress that we are trying to actively collaborate with others. To me, it's really important that we do work on projects together, not just look at what others have done. And, we will have the chance to do that, and I'll get to that a little later.

This is a bit of a shopping list, and I really don't want to go through it. We put that slide together I think a year, or one and a half years ago, before we did the priority, a roadmapping exercise. These are the issues that we're currently focusing on. Multi-species diffusion processes, I'll talk about that scientific topic a little bit, and the disturbed zone evolution. There are several aspects to that, understanding stress changes due to excavation, understanding how you induce additional fractures due to ventilation and thermal stresses, self sealing as a function of time, and how do you actually model that, how do you model the sequence of stages in a repository from excavation, all the way to the backfilling and bringing heat in, and then long-term future performance of that.

There's some specific topics, some of those feeding into these areas, some of those are sort of separate issues. And, then, there’s also a category that has to do with understanding geologic conditions, understanding heterogeneity, understanding possible seismic events or fluid intrusions. Now, some of these are site specific, can really only be analyzed in a site specific context, and we are not going into that.

For example, if you do want to understand the impact of bedding planes, you can do some sort of generic research, but is it relevant for the United States? That will depend on where we go.

So, with that, let me go over these two examples. Both of them are why I stole that slide from Peter, at least that graphic. Both of them are really at the interface between EBS and the natural system, engineered and natural system, because you can’t really look at the near-field host rock without knowing what you’ve got, or your waste package, and you can’t do the opposite either.

The first topic is looking at disturbed zone, being able to predict the disturbed zone behaviors, a function of time and how it impacts flow properties. Again, the second topic, diffusion in compacted clay and bentonite.

Let me start with this one here. Just a few of the basic issues. We go through repository stages. We excavate a tunnel. We’ll see stress changes. We’ll also see some desaturation. All of that induces fracture patterns, which are somewhat dependent on bedding planes to make things a little more complicated. We start ventilating, often with cyclic relative humidity changes that rise out your rock even further, creates stresses on your rock and induces more fracturing. There's some--for that from old railroad tunnels and other activities.

Then, you start putting your bentonite backfill in. You get further desaturation of your rock because you suck in waters to saturate the bentonite. You get swelling pressure, you bring different water chemistry in. Waste packages, of course, are waste, generates heat, so you get thermal stresses. And, all that then leads to an evolution of EDZ or disturbed zone as a function of time. While, with time, there will be some sealing of the fractures and your flow paths go away. Now, do these extend very far into the rock? They don't. They are typically constrained to maybe a meter, maybe a little more radially, but they can extend longitudinal along tunnels, and then could be pathways either to certain fracture zones that you might encounter along your tunnels, or maybe to your shafts, and other flow paths.

Just an example, up here, I don't know if you can really see it, so this is an experiment conducted with two types of clays from Mont Terri and also from Bure in France. We start with an initial state. We dry it out as if we were excavating and ventilating, and then we wet up again. This is deformation, and then what we can see is the change of the deformation mechanical properties as a function of saturation. And, of course, there is reversibility, there's histories, which one needs to understand.

Now, chemistry does affect mechanical behavior. This is bentonite. As it swells, and it's function, there's a different test conducted, different water chemistry, that's pure water, and then you have higher salinities and swelling really depends on what type of waters we have in there. Now, all of that does affect flow path permeabilities. Again, I'm hoping you can sort of make out what this is. This is permeability as a function of distance from a tunnel, measured at Mont Terri. So, I can't even read that very well, but I'm assuming that will be sort of a typical shale permeability of 10 to the minus 19, 10 to the minus 20, and that can be as high as 10 to the minus 12 right near your tunnels. And, that changes as a function of time.

Same here, we have maximum permeability close to your tunnel, 10 to the minus 12, and minimum 10 to the minus 18, 10 to the minus 19. So, these are permeabilities that we need to be worrying about. And, in order to be able to predict that behavior, we need to include various couple processes, mechanical, thermal, chemical and how that affects hydrology. Which brings us to capability development. We don’t start from scratch, really. We have coupled geomechanical flow codes which we used for Yucca and for other geothermal, other application, we have geochemistry codes. We need to add certain things to those, and we have in fact added, for example, elastoplastic behavior here on the mechanical side. Diffusion, I’ll get to that a little later on the reactive transport side, and then we couple those together to be able to include some of the interdependent chemistry and mechanics, which for example is that the water chemistry affects your stiffness, or your swelling behavior, and in the opposite direction, compaction of the bentonite could affect your transport behavior.

So, we coupled these together. We did add, as I mentioned, some additional things specifically for relationships, maybe I could go through that a little more quick. This is something that a model has been used in Europe for bentonite and clay behavior, soft clay behavior. What it essentially does is it allows to include the mechanical behavior as a function of saturation state. So, if you typically have a failure envelope that links sheer stress to total stress, independent of saturation, it goes into a third generation and shows a different type of failure envelope as you have a higher suction. So, that model has been implemented in our simulators.

We also are starting together with some of the

European programs to think about dual structure models. That allows us to more easily include chemistry. So, what he means is you treat your clays as microstructure mostly for mechanical purposes, and then you have a microstructure where you look at the particle level. You look at the electrochemical charges and you will be able to better include diffusion processes that affect mechanics. So, we're linking mechanics to chemistry with that.

And, some additional, some work we did on modified Hooke's Law, improve relationship between stress, fracture, aperture, and permeability. I don't want to go into detail here.

LATANISION: Latanision, Board.

Why is it considered a diffuse double layer rather than a compact double layer in the middle? That's concentration dependent; right?

BIRKHOLZER: Yes.

LATANISION: So, you're assuming that you have a very low concentration of whatever species you're looking at?

BIRKHOLZER: When I say diffusion, it's really diffusion against or with the concentration rate. So, this is basically non-flowing water, and this is free water, and because of the electrochemical charges, cations tend to go into that non-flowing sort of thin layer on the clay surface where anions tend to stick here.

LATANISION: So, they’re bound to the surface?

BIRKHOLZER: Yes. Which means, depending on what type of small pore sizes you have, some of the water here is free water, but it might not be interconnected in a very compacted bentonite, which means that anions might actually not transport at all. And, these are the things I mean with diffusion.

LATANISION: Thank you.

BIRKHOLZER: Okay, this is sort of some of the early work we did in applying those new models and, again, there’s a lot of information on there, which I probably can’t explain in all detail, but it’s for us to get some more system understanding, how do these systems behave. This is a generic, this is a purely generic modeling example, but it’s based on some of the Mont Terri clay properties, the Opalinus clay properties, bentonite, it’s based on the febrox bentonite, it was placed into the test site. And, then we’re taking them out and we’re running them through a sequence of a repository, looking at different locations and time, locations and space as a function of time, sorry.

For example, temperature right at the canister/bentonite interface, at the bentonite/rock interface, and then into the rock, we see how saturation in the bentonite actually started at .65, but then goes down as a result of heat, actually. Close to the rock interface, bentonite is able to pick up some water. That heterogeneity in saturation induces the heterogeneity in the mechanical properties, which in turn changes somewhat the stresses.

I could also have plotted how permeability evolves as a function of time. I could have plotted a failure envelope. How close are we to inducing fractures and things like that. So, generally, these models work. Now, we need to make sure that they work correctly.

Some future ideas. One of the things that is really lacking is a solid understanding of predicting how fractures are growing and how they seal as a function of time. We had some ideas on conducting experiments. I don’t think we, with the funding available, we can do it next year. Hopefully, we can do it later.

We have these triaxial loading cells that can put mechanical stresses on these specimens. At the same time, we can measure flow, we can measure chemistry and transport. So, we could run some of these experiments as a function of chemistry, thermal and also stress alterations, and see how do these fractures behave as a function of time with a clay specimen. And, nicely, we just developed a smaller scale triaxial that one can place into the Synchrotron. So, you can look at these processes as a function of time as they occur ideally.

On the right, that links a little bit back to

Scott’s talk here. I think one of the things that’s lacking as we think about disturbed zone is how these fractures are being generated, how they connect longitudinally. And, for that, it would be nice to be able to use Scott’s tools and think about these disturbed zones and is there a connector, which is hard to see, a connector pathway along a tunnel. What are the conditions that create a connected pathway, and how does all that change again as a function of self-sealing and time.

Now, validation. I really want to work with the international partners for two reasons. We don’t have an underground research lab in clay in this country, and they have, and they have been working there for a long time. They’re still doing a lot of experiments, very relevant experiments. So, we can validate our models, but more importantly, we actually work in teams that are conducting experiments right as we speak. So, this is something that we want to engage in as a part of DECOVALEX starting next year, a half scale heater test at Mont Terri. It’s actually located right hear, I think it’s two or three years of heating, mostly looking at bentonite behavior, and then a full scale test, a little bit like our drift scale heater test at Yucca Mountain, 50 meters long, ten years of duration, basically testing all the engineering and natural system components in a repository tunnel in a clay and shale rock, and we can be part of that as part of the Mont Terri project, which I think will get us up to speed and ahead of the game very efficiently in a few years.

Okay, that's the second topic, and it goes back to your question about these diffused double layers and the question where the water sits in highly compacted clays. The notion that different ions will behave differently in such environments, and that the apparent diffusion grades are typically smaller than you would expect in a higher porosity medium without electrochemical effects included. We are about to put those dependencies into our reactor transport models.

In fact, we've already tested some of the approaches, and I don't want to go into detail. But, essentially, one can solve for the charge of a mineral surface using surface complexation approach, which are fairly well known in environmental modeling. You can calculate diffuse layer thicknesses. You can then solve for the potential as a function of distance from surface, and then finally, you will diffuse solutes separately, depending on their speciation and depending on whether they stay in macro or micro pores. So, that's working with tests against some experimental data.

But, what's really not existing is a lot of data to calculate those models, and we recently got Jim Davis over at--to Berkeley from the USGS and he is planning a suite of experiments that would analyze the diffusion as a function of compaction state, as a function of temperature, as a function of total concentration, starting with uranium as an analog, and probably go into some other actinides and radionuclides at some point in time.

So, we start with some of the sort of traditional experimental setups of diffusion cells. But, then, want to be able to look at our smaller specimens to speed up, because these experiments are very slow, to speed up some of those results and go into the Synchrotron to actually look at diffusion.

Again, we need to think about validation. We need to think about working with international URLs. I’ve been talking to the Belgium program about some diffusion experiments they started 23 years ago at their HADES facility. It’s pretty incredible, transport distances of about 2 to 3 to 4 meters, 23 years. Anyway, so that could be a test for some of our models, and this is just this really unrelated topic. This is about colloid facility to transport in a fracture zone, but I just wanted to stress that there is similar research, transport research that we can do internationally as part of the colloid formation migration project that Peter mentioned that DOE hopefully will become a partner in, and we can also do advective diffusive transport studies and validation of those internationally with relevant field experiments.

And, I think that’s it. I really don’t have a summary, because it’s all ongoing stuff and all ongoing work, but I hope it explained a little bit why we’re doing things and how we’re doing things and what we’re doing, and where it hopefully will lead.

GARRICK: Thank you. Questions? Yes, Doug?

RIGBY: Rigby, Board Staff.

It’s very interesting work you’re doing. Now, are you doing modeling in the fracture zone now with your continuum models?

BIRKHOLZER: You mean the disturbed zone?

RIGBY: The disturbed zone, yes.

BIRKHOLZER: So, far, and I think that applies to most problems, it is mostly a continuing effort that you try to describe your permeability changes, continuing permeability changes as a function of distance. I have seen some work done, some initial work done with discrete fracture models, looking at connectivity, but all of that does not include any studies on fractured growth, mechanistical studies on fractured growth enclosure, and I think that’s sort of the forefront of science right now. We haven’t done that yet.

RIGBY: I notice you’re using, you know, FLAC 3B. Have you contemplated switching to the UDAC 3B for that to be, because that should be able to, since it’s the discrete modeling aspect, you can do the fracture?

BIRKHOLZER: That’s a possibility. We’ve contemplated that. We’ve also contemplating using tools that are more integrative. Right now, you have a FLAC tool that’s an industry tool which you cannot do your own little things in. I mean, there’s certain possibilities of doing user based interfaces, but it is not a very tight link, or super tight link with the transport or reactor chemistry codes, and so we’re rather working as part of a geothermal program and including mechanics directly into our flow and transport codes. Will that solve the issue of generating fractures? No, you probably need different approaches. UDAC might be one. There’s probably others, too.

GARRICK: Yes. Andy?

KADAK: A general question relative to the Swedish program--or, the French program. You’re working in clay. How were they able to proceed with their design, given what you’ve phrased as what I would argue as uncertainties in modeling and predictions?

BIRKHOLZER: Well, I think one of the assumptions and the French one as the safety case assumptions is that you transport halfway is mostly diffusive. There is a, I wouldn’t say a primitive, but a less mechanistic approach, or attempt to understand disturbed zone properties. And, there's also an engineering approach in terms of every-- trying every sort of 500 meters of repository tunnel to excavate and carve out a little bit of a higher radius, a larger radius, and then place bentonite into that larger diameter, so that longitudinal pathways might be interrupted. That might fly, it might not fly in this country. And, it's not that the French are done. They're still striving to improve their safety case in that regard.

KADAK: What does E in EDZ stand for?

BIRKHOLZER: E stands for excavation damage or disturbed zone. I like to drop that E because it's not just excavation that creates degradation. It is ventilation for a while, it is the heat that is being emplaced, it is the bentonite, all that disturbs your need for your environment. So, it's a subset of the DZ, disturbed zone.

GARRICK: Any other questions. Yes?

LATANISION: Latanision, Board.

I'd just like to return for a moment to the question that I asked Mark earlier in the afternoon. I'm not sure, is Mark still here? And, you know what I'm hearing in this conversation now, and what I heard all afternoon is research that certainly would inform the process of making a decision based on a multiplicity of sites, if there were sites identified. If it's a granitic site, there may be some questions that you're answering with your research that may have to do with fractured density, or flow body, and so on, that would affect the quality of that site when you characterize it. So, I'm not sure I understood your answer. You seem very definitive in saying that this research is not related to--maybe not explicitly related to establishing criteria for site selection, but certainly it informs site selection; right? Or, am I missing something?

NUTT: Mark Nutt, Argonne National Lab.

What I said was that the generic research we're doing now needs to be applicable to a future site selection process, or a future siting process, or a future site specific implementation process.

LATANISION: Right. So, it informs the site selection, it's not a set of criteria, but it does inform the site selection process?

NUTT: It could.

LATANISION: I'm glad to hear that, because otherwise, I would have a hard time understanding why you called it research. Okay, that's a much better answer. I'm happy with that. Thank you.

GARRICK: Yes, Andy?

KADAK: Well, Mark was up. I have another question for you. The one thing that I was interested in was you said you based a lot of your criteria against IAEA safety standards; correct? Did I hear you correctly?

NUTT: We used the IAEA overall criteria to establish what would be our objectives in the systematic process, so we had containment, limited release, and as a secondary function--

KADAK: Okay. And, I asked you earlier about timelines. Now, did the IAEA give any guidance on for how long these standards should be applied?

NUTT: I can't recall, but we did not include any timelines in the assessment we did for the roadmap. There was no specific period of performance.

KADAK: I know you didn't, but did the IAEA have any period of performance guidelines?

NUTT: Not that we--not that I recall.

KADAK: Someone gave you a no really quickly.

BOYLE: William Boyle, DOE.

That's my recollection as well, that the IAEA fully realizes that around the world, different countries have already chosen different time periods for assessment. And, the main concern of the IAEA is whichever one you choose can end up being successful, you know, protective of the environment and human health and safety. So, to the best of my knowledge, they haven't weighed in and said you really ought to limit it to this amount of time, or anything else.

KADAK: Okay, thank you.

GARRICK: Okay, any other questions?

Okay, I'm going--we're a little ahead of schedule, so I'm going to declare a recess until 3:30.

(Whereupon, a recess was taken.)

GARRICK: We're going to now hear from Brady Hanson on the difficulties of gathering data.

HANSON: Thank you. Good afternoon, and thank you for this opportunity to talk on the Storage and Transportation issues. As Chairman Garrick said, I'm Brady Hanson from Pacific Northwest National Laboratory. I'm the Team Lead for what we call R&D Investigations. I'd like to apologize for Ken Sorenson, who is the manager of all of Storage and Transportation. He would have liked to have been here, but he is actually in Russia, and today, he gave a talk almost identical to what I'm giving, trying to build up more of our international partners, and collaborate on this program.

So, just quickly, I'd like to go over what the objectives of the Storage and Transportation task is, briefly what our organization is, but the bulk of my time will be spent on our technical gap analysis that the team that I led performed this fiscal year discussing the methodology and the draft results that we have. The report is almost finished, and will be out shortly, discuss then the path forward and some of the key accomplishments that we had this fiscal year.

And, like Peter mentioned this morning, I just wanted to reiterate that within Storage and Transportation, we do have members from eight of the national laboratories, and we are also very closely teamed with NEUP, and I wanted to just take a second to explain how that works. As Bill mentioned, they get kind of their scope and request for proposals from things that we write, saying here’s the types of needs that we have. The universities then bid on them, and through, you know, panels go through and choose the best ones. And, then, they get to operate on their own, which is really good for the universities, but we do collaborate. So, for example, there are three proposals that have been granted within the Storage and Transportation realm. We do invite them to meetings and telecoms that we have, and try to work with them to make sure that while independent, we’re kind of steering them in directions that would more benefit the program.

So, just as an example, one of the grants was for looking at degradation of neutron poison material, and they were very focused on degradation in the pool, and we said well, we don’t think that’s near as important as degradation in the dry storage package during vacuum drying conditions, things like that. So, we helped steer them towards something that’s really going to help us out.

Okay, so quickly going through the three major objectives for Storage and Transportation. The first one is develop the technical bases to support continued safe and secure storage of used nuclear fuel for extended periods. So, I want to make very clear we believe that storage, wet and dry, is safe. We are only focusing on these extended periods. We are not trying to say that anything that the NRC or current industry practice is wrong or bad, but we're looking for times longer than what they currently are looking at.

Second objective is focus very much on retrieval. And, this goes back to both what Bill and Peter said this morning in terms of making sure that Storage and Transportation are well integrated with the disposal side. As Peter talked about, we may not be able to dispose of these large packages. Well, we already have almost 1500 dry storage packages loaded in the U.S. today. If we have to move those, and they can't go into a repository, well, then, we're going to have to open them and pull the fuel out. And, in this case, retrievability follows the NRC definition, which is basically being able to use the same means to unload as you did to load it. So, hopefully, fuel is not falling all apart, you're not taking a vacuum cleaner to suck it out, you're using your normal grapples, if you will.

The third objective is develop the bases for transport of high burnup fuel. That one is called out separately because right now, it is, I will say, relatively easy to ship. Low burnup fuel, by definition with the NRC, that means below 45 gigawatt day per metric ton. They have the data to support it. They believe it’s safe and can be done. What they don’t have is the data on high burnup fuel, particularly the cladding. And, so, while you can transport high burnup fuel, it’s not as easy, it’s not as general as you can do with low burnup fuel. You have to go on a case by case basis. And, so, we’re looking at what information do we need to make so that it’s easier.

And, then, the second part of that is being able to transport all fuel, low and high burnup, after dry storage. And, where that really comes about is we really don’t know how the NRC is going to behave, how they are going to ask questions. In fact, the Board’s report that Andy and others led that came out last December, you know, talking about this kind of issue, there’s a disconnect in some respects between Part 71 and Part 72. Some of the definitions aren’t exactly the same. You are allowed to have slightly different things in transportation.

And, one of the issues that’s been raised in the past is okay, you’ve had a canister that’s sitting in dry storage, whether it’s one year, whether it’s 100 years, whatever the time frame is, now you want to transport that. You have to show that that package still meets the transportation requirements. If there’s been any degradation, and we don’t know that there has been, but if there has, you need to be able to show I still meet those transportation requirements. So, that's what is in that third objective, and that will be discussed tomorrow extensively in the talk by Paul McDonnell.

So, to develop these technical bases, the Storage and Transportation effort has structured six different teams or work packages, where each one follows the guidelines in the Office of Nuclear Energy roadmap, and that is using theory, experiments and modeling to come up with a science-based solution.

I wanted to briefly just show the structure that we have for Storage and Transportation. We've all heard from Bill this morning, who leads the effort as NE-53. Peter and Mark, you heard from earlier, as the Campaign Chair and Deputy. I mentioned Ken Sorenson, who is unable to be here today, and then the six teams or work packages underneath him. I just wanted to point out the orangish-yellow boxes, if you will, are our DOE counterparts. So, at every level, we have a federal employee that we work closely with and integrate with to help lead the work.

So, as was mentioned earlier today, the first three, the R&D Investigations, the Test and Evaluation Capability Development, and Security all started in FY10. Transportation was a new start this fiscal year. Next fiscal year, so just a few weeks from now, we're actually splitting off a lot of the scope that was in R&D Investigations because there’s really so much to do that we’re making separate teams for Engineering Analysis, which John Wagner from Oak Ridge leads, and he will be speaking on that tomorrow. And, then, also an Engineered Materials, which is, I’ll call that more of the experimental side of things.

So, a little more in what each one of these work packages does. R&D Investigations was in charge of this technical gap analysis, specifically for storage and what was done was looking only at normal conditions, not accident conditions, and only for commercial spent light water reactor fuel. We have not looked at advanced fuels yet. We will later in the program. We have not looked at MOX. Those things will add some complications and other challenges that we will address when the time comes.

Security has been mentioned is focused very much on the self-protection standard of the fuel. What happens when we drop below that level, what additional security might be required for both storage and transportation. Again, Paul will talk tomorrow in detail on what the transportation task is.

Test and Evaluation Capability Development team. So, based on the work that was done to identify the technical data gaps, this team has gone through and looked at where can we do the work. What facilities do we need? What capabilities are necessary? So, they have done a very stringent systems engineering approach to look at that, and to then report that to DOE so DOE can decide what they want to do.

Again, Engineering Analysis that John will talk about tomorrow focuses on using existing codes and models to help us come up with the long-term predictive models for how the materials, that's fuel, canister materials, et cetera, will behave over a long time. It's also looking at what we call off-ramps. I emphasized, you know, a big part of our program is retrievability in case we do need to repackage fuel down the road. We prefer it stay together in assemblies. If, for whatever reason, that doesn't work right, we'd like to have some off-roads. Can we still transport fuel that may have degraded? And, that's where the work that John will discuss tomorrow on burnup credit, moderator exclusion, things like that become very important.

And, then, lastly the, again, the experimental side where our near-term focus is, of course, on the canister because that's your primary boundary, very important to look at any corrosion aspects, especially on the closure systems, meaning bolts and seals, as well as welds. But, we're also looking at cladding starting next year, as well.

So, starting to move towards the gap analysis, what's the current technical basis, where does the NRC come up with saying dry storage is okay? Well, a lot of it, not exclusively, but a lot is based on the results that came from what is known as the Dry Cask Storage Characterization Project. It was a joint effort between EPRI, Department of Energy, and the Nuclear Regulatory Commission. But, it had its basis, if you will, way back with the Nuclear Waste Policy Act, Section 218, that directed the Secretary to team with industry, which was mostly through EPRI, to help develop the data to show that dry storage was okay.

So, back in the Eighties, fuel was transferred from the Surry site to Idaho, loaded in casks that were instrumented to look at temperature profiles, and the main gist of the testing was to make sure that temperatures were okay, that things were within predictive models. And, sure enough, it was.

Well, that test ended and the fuel sat there in the canisters then for about another 15 years. At that time, the Surry plant was getting close to needing to relicense their ISFSI, and so it was decided well, why don’t we open one at a cask there at Idaho to make sure that things are behaving the way we hoped they were. And, that is really what is in this project report that I have the reference there. I think John was in charge of that, at least part of it, so you can ask him the questions.

But, the long and short is they opened up that cask, and virtually everything looked about the same as it did the day you put it in. Fuel looked okay. The internals of the cask looked okay. They did a lot of testing on things afterwards and said, hey, this looks really good, so that forms the basis that NRC has for saying okay, longer term dry storage is okay.

The two bullets in red, though, are what I have added to say, you know, for a very long time, most of us said, hey, if we just survive that first 20 years, when the temperatures are really high, when the radiation levels are a lot higher, if we can get by that, we’re okay. After that, things become a lot easier.

Based on some very recent results from Argonne National Laboratory, for work that they were doing in support of the NRC, so it was an NRC contract, not DOE, what they have found is that at least for high burnup fuel where you have significant amount of hydrides in it, that as the temperature drops, the cladding actually becomes brittle and breaks fairly easily.

So, suddenly now, there is this concern from, you know, there used to be times when we were saying gee, should we try to keep the temperatures cooler in packages? Now, it’s gee, do we need to keep them warmer so that we don’t have this brittle behavior?

The other main thing is in this test, the highest assembly average burnup was under 40. So, definitely below this threshold for high burnup fuel. And, we don't have similar information on high burnup fuel.

KADAK: Brady, the other thing you might want to mention that Doug pointed out to me, was that when those original casks were loaded, they were loaded dry. And, I think, you know, your recent study shows humidity being a real problem, and you might want to make that distinction.

HANSON: That's very true. When the individual assemblies were shipped to Idaho, so they obviously came from a pool, but they were dry in their transportation cask, sent to Idaho, where they went to what was the TAN facility then, loaded dry into the cask. So, none of them underwent the prototypic vacuum drying. And, as we go through what our plans are, you will see that, you know, we are concerned about that, and we want to make sure that what we do in the future is always prototypic. So, thank you, Andy.

So, just quickly, regulatory timeframes. Until just a few months ago, the NRC said under 10 CFR Part 72, that you can apply for a license not to exceed 20 years, and then you can apply for a renewal once you're getting near the end of that, again, based very largely on this characterization project that was finished up around 2000, final report in 2002. They have now been willing to say you can go for a license for up to 40 years, and have an extension for up to 40.

ARNOLD: Arnold, Board.

I'm just curious what they expect you to do if they don't extend the license.

HANSON: That's actually a very good question for what NRC refers to as the ISFSI only sites, those places where the reactors have shut down and there's basically no infrastructure, no pool, anything like that to mitigate a problem. It's one of those things where, you know, it is safe, it's working fine. But, if something were to ever happen, we'd like the means to address that.

It's also a little bit different when you look at the waste confidence rule, where that was just issued back last December, where the Commission said gee, we have a fair amount of confidence that you can store fuel for up to 60 years after the reactors shut down. Well, since reactors were licensed for 40, almost all of them are getting 20 year extensions, that puts you at 60 years, 60 years beyond that says, you know, the Commission has a fair amount of confidence that you can store for 120 years. You start getting into situations of well, how much of that is wet versus how much is dry. The regulations and all that are not necessarily all that clear, other than 10 CFR 72 applies mostly to the dry storage since there's only one site, the Morris Site, that has an ISFSI that is a pool.

ARNOLD: But this issue is a separate one. It has its bite. If you can't get a license for the reactor, that's the real purpose of this waste confidence rule, is to get a license for a new reactor, because if you don't have a waste confidence rule, you can't get a license for a new reactor.

HANSON: Correct. So, I just wanted to point out at the very bottom there when we're talking about extended storage within the Used Fuel Disposition Program, we're simply defining it to mean any period of time beyond what the NRC currently licenses. So, again, we don't have issues with the 20, the 40, the 60, the 80 years. It's for the much longer times that we need to determine if there are any issues.

So, we start getting into what are the requirements you have to meet? Obviously, it's whatever is in 10 CFR 72. But, the NRC has put out some NUREGs, that if you follow the guidance in those NUREGs, you're pretty much assured to be able to get a license. The key things are maintaining subcriticality, maintaining confinement, making sure that the bad stuff stays in, the environment stays in, and you keep oxygen out, protecting workers and the public from radiation. Again, NRC has as a requirement retrievability, and thermal performance as it relates to meeting all of those previous requirements.

So, once you know, okay, what is it I have to meet, you then have to identify what SSCs or structures, systems and components do you need to look at and evaluate. So, we came up with ten, the first one being the fuel, the pellet itself, the UO2. The second is cladding. The third, the assembly hardware that holds that together, because that helps with retrievability obviously.

Then, in the casks, you have the internals which is broken down into the basket materials and the neutron poisons. You have the container itself, which again most of the focus is on the closure systems, meaning welds, bolts, and seals. Neutron shields, again, that's mostly for protection of the workers. I'll discuss that in a little bit. Your overpack, whether it's the metal, the concrete, whatever, is important.

Your pad that it sits on and things associated with it, like the rebar is important. And, then, we've added in monitoring systems, just because what we envision as part of this program is a near-term R&D effort to gather the data, to develop predictive models, so that industry can use that to say based on this data, we're good to go for a license, at least for an initial license. When it comes time for extensions, we believe that, again, following what's in the NE roadmap, that using an engineering scale demonstration is key for numerous reasons. Number one, it's an integrated system. Number two, as Andy pointed out, you're going through all the prototypic drying cycles and things like that. But, number three, just from a public confidence perception, you know, if we're saying hey, we've got these demos with high burnup fuel every "X" number of years, we're going to open them and look in them to make sure everything is okay, it basically will be able to inform the fleet if we ever come upon any woops that nobody anticipated.

But, in order to minimize the number of times we would have to open one of those, we're looking very strongly at developing instrumentation that we can have either inside these demonstration casks or be able to interrogate things from outside. Then, have to identify well, what are the degradation mechanisms I can have? You know, it's caused by some kind of stressors. This is far from a comprehensive list. It's just a set of examples, but broken down that you will have thermal stressors.

So, again, you know, the temperatures that you get during vacuum drying, that's really one of the primary issues that affects numerous things, such as potentially hydride reorientation and the cladding, how the temperature changes over time. I alluded to if it gets too cold, maybe it becomes brittle. Of course, you will have radiation stressors, mechanical stressors, mostly the pressure inside the fuel pins, but any vibration. You know, we all just found out about the earthquake there in Virginia that affected the North Anna plant. You know, while we are fully convinced that everything is fine and safe and dandy with those 25 of the 27 casks that moved up to four and a half inches, I think it said, you know, that’s true because those casks are not very old. If they were 100 years old, would there have been an issue? We don’t know. That’s one of the things you need to look at. And, also, the chemical stressors, mostly the hydrogen that’s in the cladding, and then any water or oxygen that may get into your system.

So, we went through and said okay, based on all that, what are our gaps and how do we prioritize them? So, we did a very extensive literature survey. We used the FEPs documents that had been generated, both by Yucca Mountain and by the disposal side of the UFD program. I want to stress that for the report that we’ve been working on, we have only looked at normal conditions. We have not looked at transportation yet. Paul’s team in transportation is doing that on their own, and those will be merged next fiscal year.

But, the biggest question we ask is how important is that structure system or component to licensing? And, we just made the rule that any importance to R&D cannot be higher than what that importance is to licensing. And, I will give you an example very shortly.

Then we asked a number of other questions, but I want to emphasize that those questions were just answered qualitatively. So, for example, what is the likelihood of occurrence? We did not go through and try to come up with a, you know, well, this is a one in ten to the sixth, or anything like that, it was just very qualitative. If things are normal, can this happen, and, again, based largely off of the literature survey.

So, with that, we started off with what we call some cross-cutting or general gaps. The first one was saying temperature profiles. The reason we’re concerned about this is, again, as I said, if the temperatures get too low for some of these high burnup fuels and we become brittle, it might create an issue when it comes times to either move them or transport them. So, what we need to know are the actual temperature profiles, and not the conservative ones that we typically generate. Right now, the regulations are very much geared towards what’s your peak cladding temperature. Those are pretty easy to calculate because you can make some very conservative assumptions to get those. But, to come up with an actual one becomes slightly more difficult I’ll say. So, we’ve started that, and under EPRI’s ESCP program that John will talk about tomorrow, have some volunteers from vendors to step up and do some of the same.

Drying issues. We looked at that. You know, the industry has approved procedures for drying. We’re not saying that those are wrong. Our big question is even if you do a proper, normal drying, how much water might be left behind. The biggest reason we're asking that is using former Yucca Mountain vernacular, I can FEP screen out an awful lot of corrosion mechanisms inside the cask if I can prove there's water below a certain amount. So, there are different approaches you can take. You can try to do a calculation to say okay, for each mechanism, how much water is too much? Or, you can try to say how much water really is left in there? So, we will see which approach we take. That's still being debated.

I mentioned monitoring. Again, the big thing there is how do we minimize personnel exposure? How do we keep costs low by not having to open casks more often than necessary. But, to be able to, at least in these demonstration casks, to be able to determine what's going on, do we have additional rod failures occurring, or not.

We also want to re-examine the cask that was looked at as part of that demonstration project earlier, first, because we now have an additional eleven years of storage, so we're trying to make sure that nothing else is going on would be nice. For example, you know, getting a little ahead of myself, there are some disagreements internationally as to mechanisms that might cause delayed hydride cracking in fuel. If the Koreans are correct, they say that delayed hydride cracking might actually be more of an issue at lower temperature. Being able to look at one of these casks that's sitting there at the Idaho National Laboratory, we're not under an NRC license, it's a whole lot easier for us to open that up than it is to go to an ISFSI.

Second, one of the other casks about six years ago when they were trying to put on a quick disconnect valve for doing gas sampling ended up breaching the confinement barrier. So, over the last six years, we've been having escape of the inert helium environment and air getting in. While it's always been said in dry storage, as long as you maintain inertness, you're okay, well, we've lost inertness here. We know we're okay because Idaho is still sampling these things. They have not seen any release from the rods. And, so, we think this is actually a very good data point to say gee, even if you do somehow have a breach of a seal, it's not like you have to act immediately in order to solve it because here's a case that shows, and that we hope will show that nothing bad has gone on.

But, once we've opened them, it gives us a platform to add some of this instrumentation that I was talking about, and test that, as well as to, you know, it's been now eleven years since the DOE has opened a cask, and a lot of the people who did it, the facility where it was done no longer exists, so it's a good way of getting practice, so to speak.

I'm not going to say much on subcriticality. That's going to be John's talk tomorrow, but I know the Board is very interested in that. And, the last cross-cutting one is what we'll call fuel transfer options, mostly because we didn't have a better name for it at the time. But, the issue there is trying to figure out how to make sure that whatever we test is prototypic.

Obviously, we can load a cask at a current utility site that has a licensed ISFSI, and say okay, let's open it. But, right now, the only way that utility has to open it is putting it back in the pool. The question is if I put it back in the pool, do I cause crud to spall off of the rods that could affect things? If the temperature of my rods, after only 10, 20 years of storage is still well above 100 degrees C, probably even above 200 degrees C, and I now put it in a pool that's at 30 degrees C, even if I control the temperatures so I don't have thermal shock, the question is do I cause, for example, hydrides in the cladding to precipitate out because I'm now really cold. Now, when I take that to the lab to look at, it's hard to know what had precipitated before versus because I had just put it in a pool.

And, not only that, but now after I pull rods out, what do I have to do? I have to redry that cask. And, as I had mentioned, drying is one of the highest stresses that you will place on the system during this. If I dry it twice, and go to examine it in the future, and I see something bad, I don’t know well, was it just because of the long time, or because I dried it twice. So, we have a big effort to look at what do we need to do, and what is valid in order to make sure we have the right data.

LATANISION: Before you leave this, Brady, just a question. The hydrides and lower temperatures may lead to some degree of brittleness in the cladding. But, presumably it would only fail if it’s subject to some mechanical stresses. So, thinking about North Anna, the question would be is there any fuel on that site in dry storage that would have been there for a sufficiently long time for the temperatures to cool to the point where brittleness might be of concern, and if that happens to be the case, is there any monitoring to indicate whether there has been any release?

HANSON: To the best of my knowledge, and John, maybe you can correct me, the fuel at North Anna, none of it is high burnup fuel, so odds are that the amount of hydrides are low enough that it wouldn’t be an issue. I don’t think it’s been in storage long enough. I would have to check to be sure, but I don’t think so.

LATANISION: But, is there monitoring that would detect a release if in fact there might have been a release?

HANSON: Not inside the cask. I mean if they had been able to check to say we know we have no leaks from the cask, but there’s nothing inside to say did we fail any rods.

ARNOLD: The integrity of the outer can.

LATANISION: Yes.

HANSON: So, now, I'm going to quickly just go through some of the more specific areas that we looked at. And, I do have to say that this is the slide that pains me the most when I have to give it, just because I spent the last 18 years working for Yucca Mountain doing spent fuel oxidation and dissolution. So, it really pains me to put up and say that as much fun as the fuel is, and as interesting as it is, and gee, it's the source of all the dose, et cetera, but in terms of licensing, nobody really cares, especially under normal conditions. If the cladding is working, if the canister is doing its job, the fuel doesn't matter, which is why the importance for R&D here was all given lows, because it can't be higher than its importance to licensing.

Looking at the cladding, however, that becomes very important for maintaining retrievability. That was given a high, so again, we looked at a number of issues, some of which might be good. If I anneal out radiation damage, in theory, I make my cladding more ductile. The reason it got a medium is not so much that it's a problem, it's we need to understand it better so that when we're doing tests on cladding, we fully understand, well, how much damage might have been annealed out, so we can correctly apply models to it.

The effects of hydrogen, both embrittlement and reorientation, as well as delayed hydride cracking were important. Oxidation, that’s one of the ones that it should not be able to occur during dry storage because I should have an inert environment and I should not have enough moisture to make it happen. But, the figure in the lower right is actually a test that was done at Argonne as part of the Yucca Mountain Project, where they put segments of commercial spent fuel in a vessel with at most, I believe it was like one and a half milliliters of water, and put it in an oven at 175 degrees C. Every few months, they would take it out, look at it, add water back into it, put it back in the oven.

Well, after a year and a half, they found that the cladding had split end to end on these three to four inch pieces. When they did the examination, they were able to see that it’s because you had 18 percent through-wall oxidation of the Zircaloy on the fuel side. And all of us are scratching our heads because there isn’t a single model out there that I found that says you can oxidize Zircaloy that fast at that temperature, and why the fuel side oxidized, but not the water side it’s basically we have no idea, so we said until we understand that mechanism, we’re going to give it a slightly higher importance so that we can look at it.

Creep comes about mostly because the vast majority of tests that have been done are high temperature, high pressure, therefore high strains, and if you run a test for three months and you say I see no creep, you're tempted to say well, that means there is no creep. Well, it means there's no creep in three months. When we start talking decades and centuries, you become concerned that maybe low temperature creep might be an issue, probably won't be, but we want to look at it and be sure.

KADAK: Brady, back on the box, that one, did you run a control, namely a sample without any water in it just to see whether it's not just a degradation mechanism associated with the fuel and the clad?

HANSON: No, that had not been done.

KADAK: Okay. So, we're not impugning, if you will, the oxidation at this point?

HANSON: Right.

LATANISION: Is that correct?

HANSON: Yes. Moving to assembly hardware, again, you have things like the nozzles, the grid spacers, grid strapping that holds everything together, that's important from a retrievability standpoint. But, there really aren't very many mechanisms that can occur to lead to further degradation. The corrosion and stress corrosion cracking is actually something that occurs during reactor operations, and the question is while it sits in dry storage, can there be anything that helps promote it or furthers it along, if you will.

Fuel baskets, while it’s nice to maintain your configuration and important for that, again, the temperatures are lower, there’s no internal pressure like there is on cladding. Therefore, there’s really not very many mechanisms that have much potential to do anything.

Neutron poisons become a little bit more important. Just, to date, all people who have done dry storage have been able to successfully show the NRC that there is no credible scenario for flooding a cask during dry storage. And, you know, we can buy off on that for 20, 40, 80 years. If I start talking much longer times, is that still true? We don’t know. If water can get in, obviously maintaining neutron poisons to prevent any potential criticality is very important. But, the main reason that these ones got mediums is before we split off the Transportation Group, we knew that the requirements for transportation are in an accident, you have to assume that you have a flooded cask. If you have a flooded cask, maintaining neutron poisons is a real nice way to prevent criticality, although John will talk about some other methods tomorrow. So, again, that’s why those ones were rated a little higher.

Neutron shields. It’s not that we don’t care about workers. It’s just that by the time neutron shields have the potential to degrade, your neutron source term has dropped low enough that it becomes a virtual no never mind.

Getting into the container, again, that’s your primary boundary. So, there are things that are very important. Probably just to make the Board happy, I’ll point out that one of the issues that the Nuclear Regulatory Commission has raised is the idea of marine environment, which is mostly can I have deposition of salts, or they are also talking about what they’ll call industrial pollutants if I’m downstream from a coal plant, or whatever, am I plating things out on my cask that could lead to potential deliquescence and now when I drop below a certain temperature, can I promote things like stress corrosion cracking, things like that. So, those were rated high.

In terms of the R&D program, for example, the Japanese and the Germans have been doing programs in this area for almost 20 years now, and our plan is to team mostly with them and use the data that they have gathered, and not so much us going after it on our own.

LATANISION: Brady, just a question. There must be a lot of experience in the chemical process industry where comparable materials are exposed to the atmosphere all the time. You know, I don’t think anyone is greatly concerned about exterior or stress corrosion cracking. I can understand why it’s an issue, why it might be of concern. But it seems to me it would be a very improbable scenario.

HANSON: We believe that you are correct. I think the reason that this came up again, maybe John Kessler can help me if I misspeak, but the Japanese, because all of their sites are coastal, over the last five, seven years have done a lot of research, and the conclusion of the research was this could be a real issue. The problem is if you look at the amount of salt and stuff that they use, it's almost to the point of being ridiculous. So, even the NRC has said, you know, okay, we just need some data to kind of show that yeah, you're right, that it can happen, but it's not really going to be that likely.

So, the last thing then is the concrete issues. The interesting thing here is, you know, we gave a lot of it low, but I have to admit one of the nice things we had in interaction with the industry was they said well, hold on a second, you know, our opinion was gee, if I see concrete cracking or spalling off, I just make a new overpack, or I build a new pad and just move things.

When you talk to the industry and you find out well, one, there's worker dose associated with that. Two, a lot of the sites where they have their pad, they actually don't have room to build another one. So, if the pad starts failing, you're kind of in having some issues there. So, a couple of the things did get increased up to a medium importance.

But, I also want to say this is another area where the UFD program is relying very heavily on the EPRI ESCP program where EPRI has programs looking at concrete degradation, not necessarily specifically for dry storage, but for the containment buildings for reactors, for the pools, et cetera. So, we're going to use a lot of the information that they're able to share with us on concrete. But, again, just so people are aware, you know, again after the earthquake in Virginia, it was reported that there was some concrete spallation off of the NUHOMES storage units at the North Anna plant. So, it is a question that NRC will most likely be asking.

So, now, at the end, what have we done? We have done our gap analysis that we went through. I am very pleased that through Jeff Williams, the deputy director for NE 53, he was able to send the draft report out to industry. We had a meeting with them just a couple weeks ago, with NEI, with EPRI, some of the vendors have supplied us some comments, the utilities. And, the good thing is, you know, we listened, they listened, there's a lot of good things that we know we need to look at, possibly address based on what they said.

In some areas, we've agreed to disagree, such as, again, because of our need to consider repackaging for disposal "X" number of years from now, retrievability is higher up on our list than it is on theirs. But, we hope to have comments addressed in the next few weeks, and then the Rev 0 will be issued definitely before middle of October.

And, then, as odd as that sounds, we're already planning to do a revision of that gap analysis by July of next year. But, the main reason for that is now we're going to combine the gaps that the Transportation Group looked at, but we're also going to start looking at design basis accidents, particularly earthquakes and cask tip-over, to say how much degradation can we have of any of the materials and still survive those types of things.

That lets us then be able to inform the policy makers of, well, how long do we have to have this in storage before we have to move it to something else, repackage it, whatever, although there are, again, off-ramps that I know the industry group will talk about tomorrow.

We also have a report planned for April 30th where we're going to take all of these high and medium gaps that I've just outlined and prioritize them in terms of which ones need to be funded first, given the limited funding that we have. But, within that report, will also be more details on that the proposed testing and modeling means are to close those gaps. And, again, we're working closely with industry. We have the NEUP partners invited to come in to our workshop. So, we think this is very doable.

And, then, just lastly, to discuss what Bill had said about this upcoming report due, you know, a week or whenever September 22nd is, the test and evaluation capability development team has put together a functions and requirements document based upon the data needs that have been outlined. The team went, they did surveys of the different facilities in the U.S., and now they are writing this report that says what's there that we can start immediately in doing the short-term, and near-term testing again to develop the data, to develop the predictive models.

The bigger thing comes in order to do this engineering scale demo, again, until we answer that question on that what I call the fuel transfer options, wet versus dry, multiple redrying, we can't really move forward without affecting the data unless we are able to build what's called a dry transfer system. It's something that RW had looked at a number of years ago. EPRI was heavily involved. I know the Board in the year 2010 have a report, also discussed the dry transfer system. So, we are very seriously looking at that as a means, not only to help us with that demonstration, but if we are asked to follow through with Blue Ribbon Commission recommendations for moving fuel off of these orphaned or ISFSE only sites, you might have to have something like that to repackage, you know, pull something out of the storage overpack and put it in transportation.

And, the big thing is to have a five and a ten year plan by June of next year. So, a lot of work being done, but I think we have a very strong basis for it, and a very strong team with the DOE labs, industry, and universities as well, you know, will play a big part in this.

So, with that, any questions?

GARRICK: Thank you. Howard?

ARNOLD: Is it still the case that the whole rest of the world is in a mode where they will take it out of a pool and reprocess it and never go to this, or is anybody anywhere else looking at dry storage R&D?

HANSON: The Japanese are looking at it because even though they have a reprocessing plant, it’s not big enough to handle everything they’ve got. So, for example, prior to Fukushima, they had a deal with a city, I can’t remember its name, to say we’re going to build an interim dry storage site there. It will be there for a maximum of 50 years, and then we will move it somewhere else. And, where that somewhere else is, they don’t know. The Germans are very much looking at dry storage right now. The one shortcoming, in my opinion, of their program is while they do very good inspections of the casks that they’ve got fuel in, to date, they have not opened one yet to see what the inside looks like, and they don’t have plans to do so either. But, we’re not the only ones.

GARRICK: Questions, Andy?

KADAK: Yes. Just a couple of questions. In terms of the objective, we've had this discussion before in terms of storage, transport and disposal criteria, there are some who believe that for storage, it has to be retrievable, in other words, removable. For transport, the integrity of the transport cask is the key issue, not the integrity of the spent fuel. When you get to the storage site after transport, you get back into the retrievable mode. When you get to disposal, you probably don't care much except for geometry. So, the condition of the cladding varies as a function, and that affects obviously the importance ranking of your table. In other words, if you don't care about the condition of the clad, that kind of research isn't really that useful. So, where does this thing settle out now, relative to the NRC requirements, because they are different?

HANSON: They are. And, you know, a good point I forgot to mention. When we do the revision of our gap analysis, one of the things we're going to do is look at the other gap analysis. So, we're going to go line by line through your report. We're going to, in theory, by then have the gap analysis that the NRC has done in this last year. At one of the EPRI ESCP meetings, NRC did present their gap analysis. The gaps are all virtually about the same, but the priorities are different, and part of that is, just as you said, we have a much higher worry, if you will, about maintaining retrievability all the way until we get to disposal or even reprocessing.

One of the members of our team at Savannah River, we had him contact three of the different companies who have talked about doing reprocessing in this country. Two of the three said, you know, you'd better believe that when we receive the fuel, we want it as intact assemblies. One of the others said yeah, we don't really care.

The reason they want intact assemblies is when you reprocess, you don't just mix everything all together and be happy with what comes out the back end. You're trying to make a product with very definite specifications on uranium enrichment, the amount of plutonium, how much minor actinides in these advanced cycles you have in there, and in order to do that, I can't just have verbalized fuel and know what I'm mixing in order to get my desired product.

So, it is a matter of who you ask as to how much priority they put on on that. But, under the assumption that it will be the department who's responsible for ultimately loading a waste package, assuming we go to disposal and just having worked 20 years in hot cells myself, it will be a whole lot nicer if I can just pick up an assembly and move it over. You know, the issue of has it failed in the sense of are we able to have clad credit, that one we're not worrying about yet. We'll wait until the disposal folks tell us if that's necessary or not.

KADAK: Okay. The second part of the question is in terms of the dry transfer, and maybe Adam or Rod can answer this question, right now, the utilities are loading larger and larger canisters. Are those canisters transportable, or are we going to have to figure something else out?

LEVIN: Adam Levin, Exelon Generation.

The canisters that we are loading right now are transportable canisters. So, as an example, we're going to be moving, or actually Energy Science Solutions will be moving the fuel from Zion pool into dry storage into Magna Store Systems, and the canisters that are going to be used are transportable canisters. At some point, if we decide to transport those canisters off the site, we will have to construct the dry transfer facility at the Zion site in order to be able to do so.

KADAK: The dry transfer facility is to put it in the cask?

LEVIN: That would be taking the canister out of the concrete overpack that it will be in, and placing it into a transportation cask.

KADAK: But not to take the fuel out?

LEVIN: Right, that's correct.

KADAK: So, I think that's a significant--

HANSON: I wanted to say, you know, we've got two trains of thought within the UFD program, you know, the transportation folks are very much, you know, doing exactly what was said. I just need to move from a storage overpack to a transportation overpack. In terms of supporting this engineering scale demo I was talking about, if we--it's probably going to be cheaper to build a dry transfer system similar to what RW envisioned than it would be a new TAN-like facility. Under that condition, we're talking about the ability to actually open the cask and remove fuel assemblies, and potentially even extract rods in that.

KADAK: But, why would you want to do that?

HANSON: Well, again, as part of the demo, you're needing to test and say did I have any creep, did I have, you know, have I had--

KADAK: Oh, for the test facility?

HANSON: Correct.

KADAK: One last comment, and that is again, and Adam, you can correct me if I'm wrong, and Rod, but for seismic, these casks, the storage casks on pads are designed to slide in seismic events, not to tip over. So, that's why you see sliding as a permissible design criteria.

LEVIN: I'm sorry, I missed the middle part of that.

KADAK: I said the storage canisters, casks on pads, are designed to slide. There's a certain friction coefficient that’s assumed to allow it to slide under high seismic loads, so it doesn’t catch and tip over.

LEVIN: That is correct, and in fact at North Anna, the casks did move several inches in some circumstances.

KADAK: Right.

LEVIN: The tip-over accident itself is a hypothetical scenario as far as even under NRC regulations in terms of the design. But, you know, I also appreciate the fact that the casks tip over is something that you need to look at because when you do put the casks on a pad, it is exposed to external forces that you don’t know what might come along 20 years from now, you know, a tornado, a generated missile, or something of that nature that could potentially tip a cask.

KADAK: Okay, thank you.

GARRICK: Any other questions? From the Staff? Carl and then Doug?

DI BELLA: Carl DiBella, Staff.

On Page 12, you talk about the cross-cutting need for temperature profiles. And, the way that can be read is you’re talking about temperature profiles of the fuel rods and the cladding, which is very important, I do agree with you. But, I hope it also includes, and this is my question. Does it also include the confinement boundary temperature profiles?

HANSON: Yes. We are very interested in all the material temperatures, including the weld, seals, bolts, et cetera.

RIGBY: Doug Rigby, Board Staff.

In comparing our report with your report, I think we found that you've captured a lot of the same issues, at least the ones that we thought were important, that certainly you've captured them. The only exception may be in the area of some of these degradation mechanisms, they occur over time, there's different conditions that happen over time. Some of the mechanisms either might sequentially appear and tend to disappear, or there might be some coupled affect of some of these mechanisms.

So, my question is I didn't see that, I guess, real clearly in your report. Is that something that you think is much of an issue? And, secondly, one other point we raised is that the fuel, when it comes out of the reactor and goes into wet storage, there's no special characterization done of material properties really of real close observation. And, of course, after the drying process, it's welded or sealed up in a canister or a cask, and again, there hasn't been any good characterization done at that point.

And, then, we go through time through storage, and we look at it, and so, in a sense, if you don't really clearly understand the initial state and starting point, you mentioned this a little bit, how big is this issue? Is it important enough to do something to better characterize on the front end at some point? I guess those two points.

The third point, you've mentioned that if there is water, there may be some degradation mechanisms. And, I think in looking at your report, we agree that there needs to be some sort of opening. We recommend that you open up typical casks to really examine whether any of these issues are there. In your report, you mention opening the castor casks and the REA cask. We would probably add we need to open maybe some of these other ones to see, in particular, those kind of mechanisms, if they might be there.

HANSON: We're all for that, and we're going to work with the ESCP committee to see if anyone is willing to do that. It goes back to the issue of right now, you know, utilities don't want to open something that's already sealed. You're going to have to pay an awful lot of money for that. But, it goes back to the only facility they have for opening it is back in the pool.

And, so, until we answer the question of does that skew the results I'm trying to look for, we don't really want to do that. You know, we agree with you in terms of characterization. You know, as we're talking about this engineering scale demo, there has been a number of people who have said well, gee, you've characterized the fuel, you put it in, you do your vacuum drying, and then you open it up right away to see what it looks like. I have to admit that's where we're hoping that our monitoring will be able, as well as I want to stress, you know, the R&D program that we're talking about putting together is pretty comprehensive, and I'm fairly confident that we're going to generate enough data out of these individual tests to support licensing.

At the same time, though, the need for engineering scale demo is because, you know, as you said, in order to have all these different coupled effects and make sure that there isn't something that, you know, just one thing alone does, is very important.

But, I also want to say in the report, we make clear that we want to avoid the mistake of saying, you know, what's the time to failure for this mechanism, you know, whether it's creep or delayed hydrite cracking or whatever, because you don't have to go to failure if you then have vibrations, whether it's from an earthquake, whether it's from normal transportation, whatever that can cause it to fail. So, I think we are looking at it, but you're right in the next revision, it would be better to talk about couple effects.

GARRICK: Thank you. All right, well, thanks, Brady.

Bill Boyle has had a chance to think about some of the discussions that we have had, and before we hear from the public, I've agreed to give him a few minutes to provide his collective reaction to some of the Board's questions.

BOYLE: I appreciate this opportunity. William Boyle, DOE. Because there were any number of questions that came up in my presentation, in Peter's and Marks, in particular, that essentially got at why do we in UFD, Used Fuel Disposition, why do we do what we do, and in particular, with respect to siting and criteria, if you will. And, so, I want to discuss some of that, but in the end, also get to we really do look forward to your input on what it is we do. And, might we consider doing other things?

Now, back to siting of repository, now that we're not looking at Yucca Mountain, or perhaps even interim storage facility, my sense is, you know, why aren't we moving more quickly was perhaps some of the comments. Rather than address that directly, we do what we do on the schedule we do based upon what is in the President's budget and ultimately in the appropriations we get from Congress. And, so, we can look at the FY11 and the FY12 budgets, the FY11 appropriation as finalized, and we can look at the two bills passed for Fiscal Year 12 by the House and the Senate, which are different. And, they do tell us, plus or minus, and I don't think any of us really presented the words, is to focus in on these more generic studies. There really isn't any language that I'm aware of that says get after siting and new repository ASAP. Develop criteria for a new repository ASAP.

Those words are not there, and I would submit if you look at the FY12 appropriations as passed by the House and the Senate, both Houses of Congress are fully capable of giving us very specific instructions.

The FY12 House appropriation tells the Nuclear Regulatory Commission and DOE to get back to work on Yucca Mountain. The Senate Bill tells us not to, and in addition, gives us $20 million more than the House did for UFD specifically, to work on other things, and it wasn't to work on siting criteria ASAP. So, they demonstrate they know how to give specific instructions, and they haven't in this area yet.

KADAK: But, Bill, just to comment. You're operating on a continuing resolution. There is no budget; right? So, your monies are what they were back in 2008; is that right?

BOYLE: We finally got an appropriation in the April or May time frame.

KADAK: So, you're outside of the continuing resolution?

BOYLE: Yeah, the whole Federal Government did, I think, and my recollection was they passed an omnibus appropriation that said here's what you get for the rest of the year.

KADAK: Oh, okay, I'm sorry.

BOYLE: So, now, with respecting to siting in particular, I was the one who said earlier, you know, with respect to technical criteria, we did it in the United

States, we can look at other countries. I am aware that perhaps within the United States, maybe we could do a different job with respect to how do we take into account the views of the affected public for these sites.

But, I would like to raise some history in the United States, but that might be particularly challenging, and in the end, it gets down to well, which public are we talking about. For example, I know one of the attendees today was Darryl Lacey, who is a representative for Nye County, Nevada, and Nye County is certainly an affected public, it was for Yucca Mountain, and they have one view of what should be done there.

Another attendee today was Steve Frishman, a representative of the State of Nevada’s Nuclear Waste Project Office, and that group has a different view representing the public, and I think there are other attendees from other counties in Nevada other than Nye, each of which might have their own views. So, it’s like well, okay, which public are we--whose views should trump the others, if you will, or which should get more weight in such a consideration. They are not monolithic, if you will, and that’s true not only in the United States, but in Spain. Spain looked recently for volunteers for a storage facility. They ended up in a situation, I think this happened in the United States as well, where the most locally affected community is all thumbs up, the Federal Country level government favored it, but an intervening level of government was thumbs down. So, it’s not a problem that’s peculiar to the United States, this donut effect, if you will, I believe it even has a name. It is a challenge.

And, it showed up in the U.S., if you will, also if people remember in the United States, we did have the Nuclear Waste negotiator, which was independent of the Office of Civilian Radioactive Waste Management in the 1990’s that looked for completely volunteer sites, and there were many participants in Phase One studies and Phase Two studies, but none of them ever went to completion as part of that process.

In part, I’m most familiar with the letter written by the Governor of Wyoming at the time, Governor Sullivan, who essentially said not on my watch, the Federal Government might be trustworthy instant by instant, but it’s always subject to change, and in the end, you can’t trust them.

In addition to that, was the experience of the Goshutes, who participated in that process, did not go to completion, but eventually entered into discussion with the industry in the United States, and did go to completion. They got an NRC license to operate an interim storage facility that does not operate today, and I think if we asked Mayor Becker about it this morning, he’s completely happy that it’s not operating today, whereas the Goshutes are probably disappointed.

So, again, it’s a question of how do you weight the input from the different members of the public? And, I don’t know the right answer, and if you have input on it I would be interested.

GARRICK: Well, we have one example with WIPP, how it was weighted.

BOYLE: That is true, and we also have examples from Finland and Sweden that I submit are relevant up to a point, but they’re not dispositive to use the legal term, that although we can look at their experience, how they were successful, it may not be as successful in the United States unless we get the importus part of that process, their constitutions, their cultures, and their society, which I don’t think will necessarily happen.

Also, with respect to siting, another observation in the Blue Ribbon Commission Report was everything else being equal, confidence is undermined if you change the rules in the middle of the game. And, all three federal agencies involved with high-level waste disposal changed the rules as time went by. DOE, NRC and EPC. I’ll state that they changed them in part because they were directed by Congress to in the 1990’s, to be site specific, and later in response to an appeals court ruling, they were changed not for arbitrary and capricious reasons, but because there were reasons to change.

If we were to do siting today, develop siting criteria, because Part 63 and 197 of the EPA’s rule, they’re specific to Yucca Mountain. We really shouldn’t use those. We’d have to go back and use 10 CFR Part 60 and 40 CFR 191. Those were the two rules in place that when the NAS came out with their recommendations for what to do with Yucca Mountain, they essentially said don’t do it that way. Go with a more systematic approach.

So, if we were to develop siting criteria for today, using the existing applicable non-Yucca Mountain specific regulations, we would, I’m almost certain those regulations would be changed in the future, and we would be painting ourselves right back into the corner of we changed the rules after the game had started, which as the BRC observes, generally undermines confidence.

So, in part, I want to urge some patience with the process. I believe some people presented to the BRC observations, if you will, that it was impatience in the United States with the 1982 process that led to the unraveling of the whole process. And, also, with respect to why we do what we do, we have two tasks on our plate in Used Fuel Disposition. We have an existing light water reactor open fuel cycle that’s producing spent fuel today for certain storage, it’s questionable what will happen with that for disposal. Maybe it will be saved and reprocessed some day. But, even for some of that fuel, odds are, some of it will never be reprocessed and needs to be disposed of today.

So, for the existing cycle, we have challenges today. We also have on our plate alternative fuel cycles, fast reactors, accelerator based systems, and all the different fuels and waste forms that come out of that, we have to be aware of that and are working on it. So, what should we give the higher priority to? The problem we have today for storing the existing light water reactor fuel and disposing of some of it, or instead, concentrating on future fuel cycles that don’t even exist today yet. And, we’re interested in your input there, as well.

We have chosen for now, and I think most groups would, when faced with near-term challenges and farther out in the future challenges, most groups as a management process usually focus on the near-term.

So, finally, I wanted to get back to communications. We’re not where we were at Yucca Mountain. We’re at the end. We were involved, in DOE, in an adversarial legal proceeding, and that’s where I believe I know I made the presentation to the Board where I brought up that for certain technical issues, we probably wouldn’t discuss them because they were subject to legal proceedings. We’re not there anymore. It’s any input you have, we’re back at square one, if you will, for interim storage, some repository other than Yucca Mountain, so we don’t have that problem anymore, so any input you have on the work we’re doing, or what priority we give it, we certainly welcome that.

But, I also make the observation that by law and practice, the Board does communicate with the Secretary of Energy and both Houses of Congress on a regular basis. And, some of these challenges that we face as a country are not directly addressable by the people in the Used Fuel Disposition Campaign. They are best addressed in the President’s budget or in laws passed by Congress. You communicate with them more frequently than we do, and if you think a different path--if you have communications to offer up in that arena that would help the country out, I fully encourage you to, as part of your communications, make your points known.

GARRICK: Thank you. Thank you very much, Bill. Those are excellent observations and--

KADAK: Do you want some comment?

GARRICK: I think they certainly will be a factor in the Board’s planning of its direction and emphasis as well.

Having said that, I’ll now let Andy say whatever he wants to say.

KADAK: I think we’re very sympathetic with your problem.

GARRICK: I like the openness of this. This was excellent. He is absolutely correct that they have not been able to communicate in this manner in the past, and this can be very helpful.

KADAK: And, that's where I was going to go with the comment, and that is what I heard today was again an emphasis on the technical, you know, and where the project fell down, and I think the program fell down was it was too much emphasis on the technical, doing the right thing technically and sort of ignoring the external audiences, whatever they are. You mentioned only two. There are many more than that.

And, I think the DOE should be reaching out much more about what you are now doing to show the public that maybe this is a brand new clean slate and it's time to engage with you about what you think is important for siting criteria. And, that's where that gentleman from Utah, I forget his name, Smith something--Jenkins Smith, Oklahoma, I'm sorry. Jenkins Smith has a lot to offer to be able to say all right, if we had a site selection, or site characterization process, which should it be.

And, that's where I would in fact be putting my money, because without getting that done, all the rest of this is a waste of time. We'll be here 25 years later, $10 billion or more later, saying the same thing. Well, Governor

X said no, and then he was the Senate Majority Leader and he also said no, and the President wanted to get elected and he said no. And, there’s no guarantee unless you get the public buy-in early, and now you’re in that stage early enough where you can make it an open process.

So, I think discussing site selection, site criteria processes is really, really important on your list of things, because otherwise, it’s not going to work. And, it’s really the transparency question I think that’s really the lesson.

The other comment that I have is a question, and that is one of the things that the Blue Ribbon Commission did recommend was not having DOE involved in this program. Now, do you have any thoughts about that?

BOYLE: I am not speaking for the Department of Energy, even as a DOE official. But, as I said in my remarks, all of us that work in the Used Fuel Disposition Campaign, to the best of our ability, try to do what we believe the laws have asked us to do. And, if the Congress decides that they don’t--they want a different arrangement, well, it’s up to them.

KADAK: I mean, clearly, you own the technology. You know this stuff. You will in some way be involved, but not as potentially DOE or whatever DOE represents.

BOYLE: I will, I remember a lot of this. Dan Metlay has been involved a long time as well. Such a bill actually passed the United States Congress once in the Clinton Administration, and President Clinton vetoed it, and I believe it was the next year, it passed the House or the Senate, and the other House just ignored it because they knew it was going to get vetoed again.

But, in that time frame when people, when it was under consideration and almost became a law in the United States, short of President Clinton’s veto, it did involve non-DOE taking it over, and people used to discuss that because of the expertise, some of the people would probably get hired in, and our salaries would probably go up, because Federal employees are notoriously tough to get rid of, and if they go to a different arrangement, they need compensation for that risk. So, a fair number of people actually might like it.

ARNOLD: Can I just chime in at this point? If you go to a new entity that runs the project, you still need Federal oversight. I mean, there had to be--

BOYLE: Yes, I believe the Blue Ribbon Commission acknowledged that by essentially saying that the Congress would ultimately, in the end, still have a say on the purse strings, just as they do with other independent agencies as well.

GARRICK: Thank you. Thank you very much.

Okay, we have now come to the point in our program, and we're right on schedule, for the public comments. I have two. I haven't checked the list in the last hour, so I will do that, but I have two people who wish to make a comment. Mr. Frishman and Mr. Ando.

FRISHMAN: Thank you. I'm Steve Frishman with the Nevada Agency for Nuclear Projects.

First of all, I have to tell you that this is the first time ever that I have not felt compelled to debate Bill on what he said. I guess our positions have changed slightly. And, I also want to thank him for the initial part of his discussion, being an introduction for something that I want to talk with you about. And, it's a topic that I have spoken with the Board about before, but before all of you were ever on the Board, and before almost all of the Staff, the existing Staff were here.

This goes back to Bill talking about how both the Used Fuel Disposition program, the Board, the National Academy, and many others rely on that 1980 EIS for the alternative, being deep geologic disposal. And, it keeps coming back because that's where the U.S. policy began in terms of an official document. That's what led to the Nuclear Waste Policy Act.

But aside from just relying on deep geologic disposal, it also had a defining factor in it for what deep geologic disposal is. And, deep geologic disposal, in its discussion, relies on the concept of multiple barriers, and it’s very clear about what it means by multiple barrier, both natural barriers against loss of waste isolation and engineered barriers. And, it states what the purpose of engineered barriers is, and it very clearly indicates that the purpose of engineered barriers is to provide a redundancy in the very early period of disposal in order to assure that the fission products do not escape. And, they speak in terms of a millennia.

And, that got carried through into a couple areas. Once that EIS preferred alternative was in fact adopted in a Record of Decision, the Nuclear Waste Policy Act followed that. The Nuclear Waste Policy Act, in the site recommendation guidelines, lays out factors to qualify and disqualify sites. And, it admonishes that geology is primary. And, it also speaks to multiple barriers.

Now, the next place we see it come up is in the Nuclear Regulatory Commission’s licensing rule, Part 60, 10 CFR Part 60. In 10 CFR Part 60, there are first, a provision called a subsystem performance requirement, which speaks to substantially complete containment. Substantially complete containment was a subject of a number of meetings between the NRC staff and DOE, and I remember them from way back, and the author, or the primary author of that section of Part 60 was there, and he was asked, “What do you mean by substantially complete containment?” And, he said, “I mean it doesn’t leak for a thousand years,” because substantially complete containment for a thousand years.

So, then, at the same time, in Part 60 in the definition of disposal, it speaks to the either prevention or delay of loss of waste isolation, and that prevention or delay I believe, and have talked about this before, is modified by that subsystem performance requirement, but is essentially complete containment for a thousand years.

When Part 63 came along as a replacement for Part 60, that definition remained, but the subsystem performance requirement was gone. And, now as sort of a response to the necessity that was thrust on us by the 1987 Amendment, the concept of engineered barriers has gone far away from what was laid out in that original EIS that we all subscribed to for the part that we like. And, now, we’re looking at engineered barriers or people are looking at engineered barriers in a way that was first felt to be not correct way back when the Nuclear Regulatory Commission, the Commissioners were required under the law to concur in those original DOE site recommendation guidelines.

In those guidelines, there was an opening in site screening and comparing of candidate and nominee sites, there was an opening that would allow looking at engineered barriers' contributions to sites, and two Commissioners kept the concurrence from taking place until the NRC agreed that engineered barriers in comparing sites would not be permitted to be used, other than equally. You couldn't apply engineered barriers to change or to overcome deficiencies in one site and maybe not in another. You could not use them to compare them on sites.

So, that sort of set the stage for where we are now, and we're where we are now only because it became obvious that Yucca Mountain would not make muster without heavy application of engineered barriers. So, all of a sudden when a position were--the delay part of the definition in Part 60 is all that is propping up the idea that engineered barriers were all right to be used in that manner. In fact, we tested that with the Nuclear Regulatory Commission, and it was--we had a contention go down, meaning thrown out because as it was put to us, 10 CFR Part 63 does not require that the contributions of various barriers be quantified. And, as it turns out, it's a good thing for those who would like to go on with Yucca Mountain, because it turns out that there is one engineered barrier that the site's long-term isolation is reliant on. But, the NRC rule does not require the quantification.

And, I remember in one meeting years ago when we were talking about this that NRC, DOE, the State and others, and people were talking about well, how would we quantify it, and someone said well, is a 2 percent contribution of geologic or natural barrier enough, and everybody in the room said no. Well, what is enough? And, everybody in the room said I don't know.

So, we're in a situation now where I guess what I'm trying to get you to think about is in the presentations today on the Spent Fuel Disposition Program, we see sort of the feeling in some of the research, or R&D directions, that it's all right to look at how to improve on engineered barriers, so we can rely on them some more.

And, John, I thought what really triggered me to speak today was your comment about can't we just engineer Yucca Mountain some more and do it? Well, the response was it's engineered as far as it's going to get engineered. It's as far as we, DOE, think it needs to be engineered to get through a license with NRC. So, that, to me, is just the last in decades of the creeping misinterpretation of what was originally meant that established U.S. policy for deep geologic disposal, because if you like that policy, you have to like the concept of defense in depth, the way it was laid out in that proposal, because otherwise, I don't think that proposal carrier the strength of policy that it would otherwise.

Well, enough of that lecture, and hopefully, you won’t ever have to hear it from me again. And, the other is, as Bill suggested, once we get over the point of an unappealable decision, I would be glad, with the State of Nevada, to work with you to go through a Lessons Learned.

Thank you.

GARRICK: Thank you very much, Steve. Our next speaker, is it Mr. Ando? I don’t know how to pronounce the name.

Linda, do you know who it is?

COULTRY: I don’t. I saw him earlier, but--

GARRICK: He gave up? Bill answered all his questions maybe. Okay, then next it’s Rod.

MC COLLUM: Rod McCollum, Nuclear Energy Institute. I just want to very quickly clarify something that Brady alluded to in his talk about the North Anna NUHOMES casks. Those are the horizontal modules. He alluded to spalling on one of the modules. There was superficial cracking on one of the unloaded modules, one of the empty ones. The ones that were loaded had no observable indications whatsoever, and that kind of makes sense because when they’re loaded, that dampens the vibration, indeed, the seismic design of those things is intended to protect loaded fuel.

So, I just, for the record, there’s no indication that would raise concern with the integrity of anything in those loaded casks. And, there’s no concern with the superficial nature of the cracking that was observed on the unloaded one.

GARRICK: Very good. Adam?

LEVIN: Adam Levin, Exelon Generation.

I just wanted to share with the Board a data point, I guess is the best way to put it. We had the opportunity earlier this year to go back in and reopen the cask at Peach Bottom. We have TN-68 metal casks down there, which have no canister in them, and the closure for those casks requires two metallic seals, and we discovered that on Cask Number 1, the first cask that we placed on the pad back in 2000, the outer seal had begun to corrode and leak. We made the decision to bring that cask back into the plan, and we off-loaded the fuel that was in it. Now, albeit, it was relatively old cold fuel, and I think when we originally loaded it, it was only about 6 kilowatts, or so. But, we did unload all the fuel and we did do one additional step beyond just the inspection of the cask itself for which we're actually just going to replace the seal and put it back out on the pad.

We went ahead and vacuum sipped all of the fuel that we took out of that cask, and I just wanted to report to the Board that we did not find any subsequent leakers. The fuel was loaded without any leakers when it went into the cask, and after ten years sitting out there and being reflooded and vacuum sipped against, that fuel did pass without any leakers. So, just a data point for the Board.

GARRICK: Did you do the additional task of writing this up, writing a report?

LEVIN: Actually, we're in the process of providing some information to EPRI, and hopefully we'll be able to publish that.

GARRICK: We would be very interested in that.

LEVIN: Okay.

GARRICK: Thank you.

KADAK: The physical inspection, did you do a physical inspection besides just sipping? Did you look for cracks and anything like that, I mean, like indications?

LEVIN: We did not look for any, other than just the visual foresighted inspection along with the sipping.

KADAK: Was the helium covered gas still in the cask?

LEVIN: Oh, the helium covered gas was still in the cask. The way those casks are designed, there's actually an over-pressure system, if you will, that provides about three or four atmospheres of helium between the seal rings. And, when that over-pressure system depressurized, that's when we had the indication that the outer seal had leaked.

KADAK: Okay.

LATANISION: And, could you just describe the corrosion that triggered all of the events?

LEVIN: The corrosion that occurred was due to actually something that we are currently attributing the design of the weather cover that sat on top of the cask itself. There was a--I forget exactly what it was, but the weather cover itself had a penetration in it, which allowed some instrumentation to go through that weather cover, and water leaked around that penetration, followed it down, and along the outer seal of the cask, it created some leaks in that seal?

LATANSION: Did you see some penetration into the cask?

LEVIN: Not into the cask itself. From the seals, okay, through the seals that we had there.

LATANISION: Okay, thank you.

GARRICK: Yeah, thank you.

KADAK: Could I just put something on the record in response to Steve’s comment.

GARRICK: Yes, but speak into your microphone.

KADAK: I think one of the things that changed after the 1980 statement, and I think you mentioned it, Steve, was the requirement for essentially complete containment for a thousand years as one of the guiding criteria. We’re now three orders of magnitude higher than that, a million years, so to criticize--I mean, if you even take Yucca Mountain without the engineered barriers, so called, you probably would have had a substantially good case for a thousand year containment, substantially complete containment. And, if you call an engineered barrier the canister, or the waste package, I don’t think that’s a problem.

FRISHMAN: As I said, the reason for the 1000 years substantially complete containment comes from the 1980 EIS where the 1000 years was intended to assure redundantly that there would be no leakage of cesium and strontium, fission products.

KADAK: Correct, I’m agreement with you, and I’m saying the requirements that we have to meet today for the same substantially complete containment are close to a million years.

FFRISHMAN: The issue was the fission products. The issue was not the actinides.

KADAK: Okay.

GARRICK: At that time, a thousand years sounded like a long time. Then, it was 10,000 years. That sounded like a long time. Now, it’s a million years. What do we expect next.

HORNBERGER: I’m hoping we have a repository within a thousand years.

GARRICK: Well, I want to thank all of the presenters today. I think the Board learned a great deal about what you’re doing. I think we also learned a great deal about the constraints under which you’re doing it. And, we very much appreciate it. I was impressed with the candidness of the presenters today, and we hope that process continues, and we look forward to seeing you in the morning.

And, with that, unless there’s questions or issues, we will recess until 8:00 a.m. Thank you.

(Whereupon, the meeting was adjourned, to be resumed at 8:00 a.m. on September 14, 2011.)

C E R T I F I C A T E

I certify that the foregoing is a correct transcript of the Nuclear Waste Technical Review Board’s Fall Board Meeting held on September 13, 2011 in Salt Lake City, Utah taken from the electronic recording of proceedings in the above-entitled matter.

October 6, 2011

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