COMMISSIONER: Good morning. We reconvene this morning on topic 16, high level waste, and I welcome from the US Dr Nutt and Natalia Saraeva. Counsel.

MR JACOBI: The Argonne National Laboratory is located in Illinois in the United States and was formally established in 1946. It is a multidisciplinary science and research centre integrating researchers and experts of industry, academia and other government laboratories. The research undertaken there seeks to understand and address issues of global significance such as clean generation, environmental sustainability, technological innovation and national security. Dr Mark Nutt is the principal nuclear engineer in the nuclear engineering division at Argonne. He also holds the position of national technical director of the Department of Energy, Office of Nuclear Energy, Nuclear Fuels Storage and Transportation Planning Project, NFST. His team is performing activities to support implementation of the 2013 administration strategy for the management and disposal of used nuclear fuel and high-level radioactive waste.

Ms Natalia Saraeva is a nuclear engineer at Argonne and is also involved in the NFST, leading the execution strategy analysis effort. Ms Saraeva has previously been a staff member at the Blue Ribbon Commission on America's nuclear future, and the Commission calls Dr Mark Nutt and Ms Natalia Saraeva.

COMMISSIONER: Good morning. We do want to explore Yucca Mountain and the plans and how it progressed, or perhaps didn't, but firstly, can you tell us where the current US plans are for a high-level waste facility?

DR NUTT: As of right now, I would say they're a little bit uncertain. I assume you followed the developments of the current administration's position that (indistinct) not a workable option, and convening the Blue Ribbon Commission, American's think that a future which necessarily no one participated on. Following that, the Department did a strategy in 2013 that called for - essentially it adopted or endorsed several of the recommendations the Blue Ribbon Commission made and laid out what could be accomplished over the next ten years for (indistinct) storage facility and began siting and worked towards another repository (indistinct) had been some development since then regarding Yucca Mountain where the Nuclear Reactor Regulatory Commission staff issued their safety evaluation reports regarding the repository and from there, it's essentially a direction from our congress on which way to go first, yeah, and that's (indistinct) for the last few years. So (indistinct) it's really doing groundwork activity, open storage and disposal, to essentially be ready for when a decision is made to proceed with national policy towards disposal and storage.

MR JACOBI: Dr Nutt, I was wondering if we could perhaps start right at the beginning and think about the issue of and the technical qualities of high-level waste and their implications in the context of storage and disposal. I think we've got a graph that might pick up the issue. This is the graph on slide 1. I'm wondering whether you could give us some context and explain from that graph, with respect to the reference to high-level waste, the implications of its characteristics to the way that it must be stored and disposed of.

DR NUTT: So this graph is from the International Atomic Energy Agency standard called Classification of Radioactive Waste, and it covers all radioactive waste generated, being from low-level waste or intermediate-level waste or high-level waste, but the real, what I call, discriminators on which level they had are on the axes. The half-life and the materials or such longevity of the radioactive materials (indistinct) and then on the Y-axis is the activity content, how much is there, and spent fuel and high-level waste tend to have very long-lived elements in the waste. They tend to have pretty significant quantities there. These aren't - they're hazardous for public exposure and need to be isolated, shielded, protected, the public needs to be protected from it, and the general consensus for ultimate disposition is geologic disposal.

MR JACOBI: I'm wondering if we can come to a second slide and deal with the discrimination that exists between the fission and activation products and the actinides, and perhaps you can explain the implications of that in terms of long-term storage and disposal.

DR NUTT: Okay. So this is from a (indistinct) International Atomic Energy Agency document and it's showing essentially the relative activity compared to natural uranium ore of what comes out of spent fuel and the different components that contributed to that activity. The red curve is the total radioactivity. The greenish curve is from fission products and activation products, from fission uranium and materials inside the fuel becoming activated from neutron absorption. The lighter coloured line is the actinides and their daughters that build up around uranium absorption of neutrons where you got plutonium, americium, neptunium, some of the higher actinides.

Early on after discharge from the reactor, the activities - it's very hot (indistinct) the shorter-lived fission products that are in spent fuel. As time progresses, those decay away and some of the longer-lived actinides become dominant. While this (indistinct) activity in terms of - you know, it can be radioactivity, it can be heat. Heat tends to follow the same hyperdistribution. So when you discharge spent fuel from the reactor it's in the hottest condition, so there's a need for some storage on site. Typically with light-water reactors that are being deployed (indistinct) spent fuel pools at the reactor site and more circulation in the pools allows the fuel to cool off for a period of time, and then once it's cooled a bit, you can then (indistinct) in terms of perhaps moving it to

dry storage, transporting it, and ultimately disposing of it.

MR JACOBI: Is the distinction between actinides and the fission activation products significant in terms of long-term disposal? The fact that it's the actinides that one is essentially having to shield from and manage, is that significant in terms of the way that the geological disposal facility is designed?

DR NUTT: Possibly. It depends on the design and the environment that the repository would be in which of the radionuclides would contribute most to the long-term risk. There are some long-lived fission products that have to be managed and disposed of: technetium-99; caesium-135, I believe. It's either 135 or 137. I always mix them up. So there's a few other long-lived fission products that don't show up on this curve because in terms of radioactivity, they're very low, but when you get out in the long time frames when you're looking at dose rates and being protective to public health and safety, and certain environments and certain repository concepts, those can tend to be dominant radionuclides.

If you look at some of the work that the Swedish have done, the Finns have done, it tends to be those longer-lived fission products that you have to remain protective of. The actinides in a lot of those environments tend to be very insoluble, so they don't migrate. Even if the waste package would happen to degrade and the waste form would happen to release the material, they don't tend to move in several geologic environments, in what are called oxidising environments. It was like the Yucca Mountain site. They tend to be a little more normal, so you can get contributions from (indistinct) and the long-lived – some of the long lived fission products.

MR JACOBI: I just want to pick up in terms of the major waste sources or major waste streams, particularly in the United States. I am just interested to know in broad terms where the main sources of radioactive and nuclear waste, where they are generated?

DR NUTT: In terms of all classifications?

MR JACOBI: Well, I am just interested in the extent of the contribution to that nuclear power generation makes to waste volumes as opposed to other activities?

DR NUTT: In terms of low-level waste generation it is probably – it is the biggest contributor. We have 100 – roughly 100 operating reactors that – the maintenance of the reactors, the clean up of the cooling systems all generate a lot of waste that has to be disposed of. There are smaller contributions from medical, industrial applications of radioactive materials that then become low-level waste. So by far in terms of volume it's the nuclear industry that

dominates a lot of the waste disposal. Another contributor in the US would be the defence cleanups that we have underway but those typically there are – there are defence sites that are operated by the Department of Energy, they do shift some materials to commercial low-level waste facilities but by and large it's the commercial industry. In terms of spent fuel it is the nuclear industry. We generate about 2,000 metric tonnes of spent fuel a year (indistinct) On a high level waste site it is again primarily the – the clean up of the high-level waste we have from the defence activities back in the Cold War that are generating the majority of high level waste that would have to be disposed of.

There is some very – fairly small amounts of high level waste from commercial generation that happened back in the seventies when we were considering reprocessing for commercial but the volume of that is pretty small. There is also spent fuels from the Department of Energy complex that – for research reactors, from former production reactors et cetera but in terms of radioactive materials across the board, it is the nuclear industry that is the primary generator.

MR JACOBI: Are there any broad rules of thumb that you can apply in terms of the amount of waste that is generated from the nuclear power plant by reference to the amount of energy, for example that's output?

DR NUTT: Well, from some calculations and an analysis we did a while ago, well back in 2010 and I believe is still relevant today, it is about making cubic metres per kilowatt hour of power and typically a - - -

MR JACOBI: So that is - - -

DR NUTT: - - - large - - -

MR JACOBI: Sorry, what class waste was the 19?

DR NUTT: Low-level waste. It 19 cubic metres of low-level waste; it's typically mostly what we would call class A low-level waste which is lower activity. There are some higher activities but we have a slightly different regulatory classification framework than what I was shown on the previous graph, on that first graph. Most of the waste is low activity waste. We do have about seven one hundredths of a cubic metre per kilowatt-hour of higher activity low-level waste. It has a little more stringent disposal requirements but it's a very little amount. The most active of the low-level waste is generated when we decommission power plants and you have to take the materials from inside the reactor core around the reactor vessel that tend to be a little more radioactive. That is about 11 cubic metres per plant and so when they decommission the plant; it's roughly about 11 cubic metres. In terms of spent fuel it's about three metric tonnes per kilowatt-hour of electricity generation.

For the US (indistinct) it's 2,000 metric tonnes per 100 reactors, so roughly about 20 tonnes a year.

MR JACOBI: I just want to come – sorry. I just want to come – stepping away from that to deal with the overarching framework that applies to the management of waste itself and the Commission has already heard a little bit about the joint convention of which Australia is a party but I am just interested for you to explain what you consider the key elements, or the two most important provisions within that convention which guide the way that disposal of waste must be managed around the world?

DR NUTT: Well, the two guide parameters that are looked at and there's a number of provisions in the joint convention but the two (indistinct) that we have is that – that I looked at are what is the - responsibility rests with the state in which it was generated. It does allow for management to be (indistinct) agreements between states, so as one state – one country, another country could work to an agreement where one might store or dispose of nuclear waste but in general it's up to the country in which it's generated. And the other one for me is the protection of the public not only today but in the future. So it's this inter-generational equity that people of today are gathering the benefits from nuclear electricity or nuclear energy and should deal with the problems of today and not pass the problems down, while allowing the future generation some flexibility to do what they feel is best for them.

MR JACOBI: Can I come from that, the Commission has heard quite a lot about the role that dry cask storage is now playing within the ability to manage waste and I am just interested to – perhaps for you to explain the background as to why it is that dry cask storage has come to assume such a particular role in the management of waste around the world?

DR NUTT: I think it is one way to temporarily manage the waste, dry storage is – there is a general consensus that it's indeed temporary, that the ultimate solution should be disposition of it in geologic repository. There may be – there is countries that are considering fuel cycles where you might reprocess and recycle materials back to the reactor but either way you are going to generate high-level waste that would need to be disposed of. Storage is an option, it allows the material to cool, it allows – it could increase flexibility in the system. In the US, in other countries we've gone more towards off site or dry storage as kind of a longer-term solution. Other countries are looking at entering wet storage and I think it's essentially up to the countries what they feel is best for them. We've gone towards entering dry storage at the reactor sites because all of the spent fuel pools for the US fleet are essentially full. In the nineties we did some work to re-rack the spent fuel pools to increase loading densities, managed to fill those pools up because there's (indistinct) disposition that way (indistinct) moved off to dry storage or essentially all of

our power plants in the fleet.

COMMISSIONER: Can I just pick up on the dry storage Dr Nutt? What sort of studies have been conducted in the US to look at the longevity of these dry storage casks and is there a view about – conservative view about how long they will last?

DR NUTT: I don't – no one has done a study to put a – what I'll call a line in the sand for how long they can last. Our regulatory framework allows storage up to 60 years, dry storage. We have studies underway within the Department of Energy's programme, the Electric Power Research Institute which is our utilities research arm. It's also investigating various aspects associated with extended storage. The Electric Power Research Institute runs a group called the Extend Storage Collaboration Project which is involved in - a number of countries are involved with it that are dealing with the same issues that we are. So there is a lot of work going on looking at extended storage and what it entails. There has been several gap analyses done to identify what the key issues are and the R&D's under way to try to resolve those, so that there is confidence in extended storage.

COMMISSIONER: I would assume some of your dry cask storage would be approaching 60 years now?

DR NUTT: No, not that long. Some of them have gone through licence renewals. The regulations allow you initially a 20-year licence on the facility then you have to go back to our regulator for renewal. Several have gone through the renewal process; several of them are coming up on it. One of the key issues with the renewals is the utilities and the power plants in the US have gone to higher and higher burn up on the fuel, essentially means they've ran it longer in the reactor cores. So there is some questions that are slowly being resolved about the long-term performance of the fuel during dry storage. There's questions that are being investigated regarding the performance of the canister or cask that it's stored in over time.

MR JACOBI: I am just interested – can I pick up from that and ask about the level of satisfaction that there is with the technique of dry storage? That is, to the extent to which it's now thought to be developed, or that there are still developmental changes that need to be made with that technique?

DR NUTT: I'm sorry could you repeat that?

MR JACOBI: I am just interested to pick up from the Commissioner's question and that is just to understand the extent to which, given the practical experience that has now occurred with dry storage, the extent to which there is satisfaction with the technique, or it's thought that there might need to be

changes with respect to the way that dry storage is conducted?

DR NUTT: I think there's general satisfaction with dry storage - - -

MS SARAEVA: (indistinct)

DR NUTT: Yes, it's passive. We moved in the US from loading what I call casks with bolted lid and cask – to welded canisters and that's reduced some of the inspection time for the maintenance, the surveillances that have to be done. We have got a very robust dry cask industry in the US that is actually doing work internationally now. A lot of the other countries that also move to dry – I know the Germans are using exclusively dry systems for storage. So there's – I think worldwide there is satisfaction in it being a fairly proven storage method.

MR JACOBI: Could I come just to the – some design features that need to be born in mind with respect to storage and disposal? I think you picked up just in an answer, the need for passivity with respect to the removal of heat, and I am just wondering perhaps whether you can pick up what you consider the important design features to be in storing and disposal of spent fuel?

DR NUTT: In regard to storage, it's mainly contained (indistinct) radioactive materials to ensure protection. That can be done, again, either wet or dry. The pool itself can provide the containment of the fuel within the fuel (indistinct) themselves. It can provide the shielding to the workers, to the public et cetera. So the dry storage, it's loaded in to the canisters when it's sufficiently cooled to be able to handle the heat that would be produced. They're dried, they're vaccuated, they are filled with an inert gas. They're entirely passive in that the cooling is all passive and the waste – the fuel itself is solid, it's not overheated. There's multiple barriers for – to the containment. There's the fuel itself, the cladding, the canister, cask it's put in to. There's fairly minimum human intervention that has to be involved.

MR JACOBI: Can I just pick up with respect to the issue of security as well? To what extent is security built in to – you mentioned the fact that dry cask storage might occur at a site away from a nuclear power plant and I am just interested to the extent to which security needs to be considered in siting and design?

DR NUTT: It has to be considered. It is our regulatory framework requires security considerations and it (indistinct) when a site is operating, get the entire security of the nuclear installation itself. When the site is decommissioned there's a security force that has to be involved along with it. The security requirements, I believe to decrease when you go from wet to dry. Entirely passive systems, big sealed canisters, protected by big concrete shield, so

there's – there's I guess, a little reduced security requirement for dry versus wet. If you go to an off site interim storage facility, the security requirements on that would – via a regulator would have to be met.

MR JACOBI: Can I come to the issue of disposal? We have heard in the course of receiving evidence from those involved in the finished projects, about the development of a safety case and I am just interested to understand the background to the origin of the idea, or the need for a safety case to be developed?

DR NUTT: I believe safety cases first kind of applied to anything nuclear. You have to demonstrate safety. It's kind of a fundamental tenet of nuclear to (indistinct) from day one of when our education started in nuclear. So it's typically for operating nuclear (indistinct) type facilities, it's pretty well defined on the type of safety assessments that have to be done. They're all engineered, all man made systems, they've all got the controls in a centre. When you get in to disposals, where I believe things get a little bit different because you are dealing with long timeframes, you're dealing with geologic systems, you are a large – sometimes large areas or footprints for the disposal facility and it leads to a little different type of safety case that one needs to consider to help build confidence in the safety of - the long term safety of the facility. Safety assessment is a key part of it. Sometimes you probably have to call for (indistinct) assessment or safety analysis. That is a key part of it. There is other arguments one would bring to bear in helping demonstrate to build confidence in the long terms safety of the facility. Natural analogues that people have investigated, all sorts of different things that people do to really build a case. But the safety case, the philosophy of the safety case is you begin it early in the development process and use it to inform your decision making as you proceed forward, identify the uncertainties, the critical uncertainties you have that one has, they key barriers that one has and focus the site characterisation and the research and development that the other way is to help resolve those issues to increase that confidence that one has in long term safety.

MR JACOBI: I am interested in the process of the development of a safety case. Is it something that's done in a single hit or is it something that one needs to constantly revise as one conducts the analysis?

DR NUTT: I believe one would want to revise it. As I said, when you're moving through a decision point to – for instance, if I had two or three sites that I was looking at, I would look at the safety cases and feed that in to the decision process by which I might select one, or how would I do my – evolve my site investigation programme and use the safety case. It is really intrative I believe, to be applied intrative for every decision point through the process.

MR JACOBI: You spoke of using natural analogues as part of the safety case.

I am just interested with respect to geological disposal, the extent to which it is necessary to use that concept; I think we have had explained to us is multiple lines of reasoning?

DR NUTT: Yes. I mean there is – for Yucca Mountain we did a very extensive natural analogue study that looked at gathering analogues worldwide that were – say if we're to process these, we were looking at relevant to the repository performance. One example that I had the pleasure to go visit was a uranium ore body in Mexico, outside of Chihuahua that had very similar characteristics as the repository environment at Yucca Mountain. So we were able to look at it, study it, track the migration of the uranium and its data products and use that to give us some – give us confidence that our predicted – long-term predicted models were giving representative results. There's others. People looked at long-term class, we looked at – since Yucca Mountain had large emplacement drifts, we had investigations in to some old caves in Europe where the art is still on the walls that we looked at to look at how caves can distribute water around them rather than drifting through the art and destroying it. So there's a variety of different ways you can use them to help build the confidence in the analytic tools you are using to assess performance and safety.

MR JACOBI: I am just interested in the extent to which I can pick up, and whether natural analogues are the whole or their not, the extent to which it's possible to validate the computer models that you're otherwise using to make these sorts of predictions?

DR NUTT: I'll say it's not possible to validate the long-term disposal models in the traditional sense. In that you can't do an experiment and then run the model and build the experiment for the repository itself. You can do a variety of techniques to again demonstrate your confidence in the models and their ability to reasonably predict or estimate exposures out in the future. We have spent a lot of time in Yucca Mountain licensing effort on that topic of demonstrating the validity of the models and the approaches we were doing. One of the keys in my opinion (indistinct) repository assessments is really explicitly quantifying the level of uncertainty that you have in the models, in the approach. I'm a proponent of the probabilistic performance assessment where you – in the assessment itself you capture the uncertainty and you propagate it through (indistinct) result.

MR JACOBI: Can I come to the Yucca Mountain process and I am just interested to understand the nature of the waste that it was proposed to be addressing this part of the Yucca Mountain repository and also to pick up any issues of the variability in the spent fuel that you needed to deal with?

DR NUTT: So when the nuclear waste policy was promulgated in 1982, it limited the capacity of the first repository to 70,000 metric tonnes. When the

Act was amended in 1987, it stopped our second repository programme but it maintained the 70,000 metric tonne limit on the Yucca Mountain site. In 1985, a decision was made by President Reagan to combine high-level waste from our nuclear defence work, with the civilian waste, so it was roughly about 60,000 metric tonnes of spent fuel and 7,000 or 10,000 metric tonnes of federal government managed, Department of Energy managed waste. That was a combination of spent fuel from production reactors and research reactors and high-level waste from the clean up of the reprocessing plants on the defence side. Commercial spent fuel is standard boiling water reactor, or pressurised water reactor fuel. It varies somewhat and just depending on the vendor that built the reactor and the model of the reactor, there is different numbers of pins, different pin dimensions but all in all it's pretty – for the purpose of disposal it's fairly homogenous.

On the defence side, the spent fuels that would be disposed of for coming out of the department side, there was quite a lot of variability in terms of the materials and in the safety assessment it would have been very difficult to quantify the performance of all that spent fuel. Some of it was aluminium clad; some of it was old reactor fuel. So there was a choice made to be very conservative and they simply assumed that when the waste package contains fuels degraded, that that material was immediately ready for – available for transport via groundwater pathway. The high-level waste class is – there's some (indistinct) but not significantly. The model that was put together to model the degradation of class waste form include that variability and uncertainty in it.

MR JACOBI: Do the differences in the origin of the fuel have implications in terms of canister design or other issues?

DR NUTT: There was a fairly standard design for high-level spent fuel from the commercial side and it's a 25 per cent (indistinct) reactor waste package for a 44 per cent boiling water reactor waste package. On the defence side, it was the waste package itself was a single canister, sealed canister with defence spent fuels in a larger canister with five canisters (indistinct) surround it.

MR JACOBI: I think we might have an image on slide 11. I think this is from the environmental impact statement.

DR NUTT: Yes. Yes, that would be – so in that one, the commercial spent fuel that's 90 per cent of the inventory or 60,000 metric tonnes, with the other 10 per cent being the Department of Energy managed materials spent fuel or (indistinct) waste but the (indistinct) of that is some of the variability in the spent fuel, some from test reactors, the end reactors, one of the old production reactors, different types of research reactors have been out.

MR JACOBI: In the process of the development of the facility, were there changes made with respect to either the canister systems or the facility design? I'm interested to understand how they evolved.

DR NUTT: Yes. The designs did evolve for the surface (indistinct) the subsurface repository. So (indistinct) in this large spent fuel handling pool. They're all wet pools where the fuel would've been received and what I call a reusable bolted transportation cask. The fuel would've been unloaded into the pool and then loaded into waste packages. They would've been evacuated, sealed and disposed of. The change in - I don't have it written down - a change in roughly about the 2000, 2002 time frame, where the project started looking at dry transfer systems and bringing in the fuel in a dry system, opening the cask up dry and transferring the fuel dry

And then there was a subsequent change in about 2005 where the idea moved to what we call transportation, aging and disposal canisters, a canister concept that would meet the transportation regulations, the storage regulations, the disposal regulation. They could be loaded at the reactor site, sealed, to never be opened again, brought to the repository, put inside a waste package and disposed of. A lot of those design changes from wet to dry and a dry standard to receiving canisters was somewhat due to the higher seismic loadings at the repository site, and that is somewhat seismically active, so there were some pretty large seismic ground forces that had to be managed, and it was to build more modular facilities, smaller facilities that could be deployed in phases, could adjust to funding levels, could adjust to changes in the schedule of arrivals.

So on the subsurface, there was probably more evolution. When Yucca Mountain was first being looked at, the investigators were looking in what they call the saturated zone, which is below the watertable. They started in roughly 1983 looking at potential benefits there could be by moving above the watertable in the unsaturated zone, and made a decision to do that by - you know, roughly about 1983 they were looking at something similar to like what you probably saw with Finland and Sweden where there were small canisters being put into a form and realised that by moving into the unsaturated zone allows one not to have to backfill the drifts for the tunnels immediately. You could put the larger canisters in a tunnel. You'd ventilate it so they can handle higher heat loads, and a design move to a large canister being placed on its side in the emplacement tunnels.

Waste package design (indistinct) originally kind of a corrosion, stainless-steel type material evolved into having to put some corrosion-resistant materials on it. In 1999, prior to doing the environmental impact statement for Yucca Mountain, in the site suitability evaluation that was done for the site recommendation there was a significant design alternative study that led to

some changes in the waste package design, the inclusion of a titanium drift shield to further isolate the waste from any water that may be drifting through the emplacement tunnels.

Some of this was driven by the urban performance assessment work that was being done where the results of the performance assessment would link into the ongoing design and would necessitate some changes to reduce risks and improve repository performance in regard to safety, and essentially settled on the design that went through the Nuclear Regulatory Commission's licencing review, which (indistinct) safety evaluation reports were just released last year. So the design does evolve. In my view, it should evolve, it will evolve. Its understanding of the repository environment proceeds.

MR JACOBI: We had an extensive discussion about the technical evolution. I'm interested to understand the extent to which the community around the facility was engaged during the process of this technical development.

DR NUTT: The community (indistinct) that period was really driven by the requirements in the Nuclear Waste Policy Act interacting with the affected state, affected units of local government, adjacent states. The Department had a number of hearings. The documents were all released. I'll use an example. From some documents issued with our site recommendation, from 1995 to 2001 there were 126 official hearings. There were 600 hours of meetings in 2001 alone. And they also offered tours of the site and there was a visitors' centre which people could visit in Las Vegas regarding the site. But most of the engagement and how the public was involved was prescribed per the Nuclear Waste Policy Act.

MR JACOBI: Can I take a step back? Prior to the particular site being selected and identified, I'm interested to understand how the siting process and how this particular site came to be identified.

DR NUTT: Well, prior to 1982 there were investigations looking at different sites for disposal of waste. There was a recommendation by our National Academy of Science in 1957 to proceed with geologic disposal. We started looking into it and investigating it. It was somewhat of a low level. They identified a site in Kansas (indistinct) ultimately proved that it wasn't going to work. Then after that, they promulgated the Waste Policy Act in 1982 that really laid out the process by which it would go for, and I believe one of the figures - what were the steps?

MR JACOBI: It's the rear slide, slide 12.

DR NUTT: Yes, from the state in the (indistinct)

MS SARAEVA: Slide 4.

MR JACOBI: Sorry.

DR NUTT: So it began in 1983 with the identification of nine potential repository sites that were investigated, and then to 1985, of that, five sites were nominated for further consideration and it moved through, essentially, into 1986 and 87 where three of those sites were identified as candidates for site characterisation. In 1987, from 1987 there was some political opposition and some of the states where the – one or two – all sites were located, began to see there was going to be an increased cost associated with site characterisation and congress amended the Waste Policy Act in 1987 that selected Yucca Mountain as the only site to characterise. So it did not select Yucca Mountain as the site that was going to be developed but it set up – of the three sites, characterised that one. That one in their view looked most suitable at that time, so between 1987 and 2002, the Department of Energy did site characterisation work and studies in design work for Yucca Mountain that ended with a site recommendation decision that was made by the Secretary of Energy essentially agreed to by the president. The Nuclear Waste Policy Act allowed the Governor of Nevada to disagree or veto, which he did and then it went to both our senate and our house and they overruled that veto. President Bush signed the site recommendation and the law.

From there the department progressed to submit the licence application to the Nuclear Regulatory Commission which was done in 2008 and then from there we had the (indistinct) no longer pursue it. So it was a fair step wise intrative process to try to get the site selection, the congress decision 1987 had some ramifications in Nevada. They were adamantly opposed and remain such throughout the entire development of the repository project and they are today.

COMMISSIONER: Would it be fair to characterise this process as top down?

DR NUTT: From 1987, yes. I believe personally, prior to 1987 it was a fairly comprehensive siting process to try to look at a variety of sites and a variety of locations to come up with a few. There was some top down focus on it but that really I think changed in 1987 when it was somewhat more of a political decision to pick Yucca, than a technical one.

MR JACOBI: I am just interested to pick up, you said before that a decision was made with respect to the Yucca site in 1987 and I am just interested to understand the extent to which there was any social consensus or any study of when a decision was made, that it was the suitable site about whether or not social considerations were taken in to account, as opposed to technical considerations.

DR NUTT: So the question was whether any studies done on the social consideration as opposed to technical considerations, I'm not aware of any that looked in to that. We could – we can look and see what was done but I personally am not aware of - - -

MS SARAEVA: (indistinct)

DR NUTT: Yes, I am not aware of anything where they actually looked at the social implications of what may have been done in 1987.

COMMISSIONER: Was there any – Dr Nutt was there any concept of recompensing the local community for having this facility on their – in their backyard for instance?

DR NUTT: I'm sorry; you broke up a little bit.

COMMISSIONER: I was just wondering whether there was any thought of recompensing the local community for having a facility on their site, on their land?

DR NUTT: There wasn't anything – so our Nuclear Waste Policy Act had guided what had to be done for the local community in terms of what we call a payment equal to taxes that was done. There was some tax that had to be given to the state to do their own studies but I don't believe there was anything that was required in terms of what I'll call benefits for hosting the repository. I know people had brought up the subject and some of the opposition in Nevada was – did not want to take any benefits; they didn't want to be seen as being bought. They were opposed and always opposed. That is part of the – I think the ongoing discussion that is happening in the United States with the recommendation by our (indistinct) Commission to follow consent the siting process. What does that entail? And we don't know right now.

MR JACOBI: You spoke of there being a number of public hearings that were conducted in the post 2000 period. I am just interested to understand what those public hearings related to? Were they hearings associated with the EIS, or were they related to other issues?

DR NUTT: They were mainly related to the environmental impact statement. Our laws – our National Environmental Protection Act requires the development of an environmental impact statement and it involves public comments on the environmental impact statement, public (indistinct) on the draft, consideration of those for the final public hearings and consideration of comments made to hearings. There were also hearings that were held around the site recommendation decision that was going to be made by the department. So in a sense, I think that the department held more than they were required to

by the law, so they did try to have – get to as many people that could be affected. They weren't just in the repository location; they were around the country and some of the cities that might be affected by transportation.

MR JACOBI: I just want to move to some of the work that has been done since the Blue Ribbon Commission and that is I am interested to pick up on the concept of execution strategy analysis that has been done. And I am just interested to understand perhaps first the backdrop to why it is thought to be important to study timeframes and how timeframes are fixed and whether there have been any particular difficulties associated with fixing timeframes for these large projects?

MS SARAEVA: So when the Blue Ribbon Commission worked out where (indistinct) experiences of siting different waste management facilities in the United States (indistinct) it came to the conclusion that the practice of having some rigid outlines was not (indistinct) because like (indistinct) siting and implementing such a facility is very complex issue. Now I don't (indistinct) also has components to it like (indistinct) funding and that so if they're very rigid (indistinct) and not – and then not (indistinct) so stakeholders (indistinct) extent to lose trust. So that is why the Blue Ribbon Commission recommended that rather than having a rigid and (indistinct) they should be (indistinct) adaptive approach (indistinct) like several (indistinct) they're re-examined and (indistinct) is going.

MR JACOBI: I am just interested, and if one isn't to fix lock associated with particular decisions being made, whether you have any views as to what tool you might use for the purposes of managing an overall process?

MS SARAEVA: Well, definitely some tools available that can help reach the (indistinct) estimate some timeframes and some (indistinct) direction. Under nuclear – and it is cheaper for (indistinct) nuclear fuels storage and transportation (indistinct) are developing tools for education strategy analysis (indistinct) ESA, so ESA allows us to see different ways of implementing future projects, assess a big picture. So (indistinct) take from the start to the success and it also depends how you define success. So what (indistinct) take you to implement a project and try different ways how you can gear it and we use – in our approach we use a variety of subject matter experts on the topic which (indistinct) different (indistinct) cost and (indistinct) use a tool which is (indistinct) and that takes into account models of (indistinct) but uncertainties and risks because sometimes we tend to be optimistic about how soon we can accomplish one or another (indistinct) and the duration sometimes do not include potential (indistinct). So there is two (indistinct) software that allows us to assess the performance of project (indistinct) impact of uncertainties and risks.

COMMISSIONER: Thank you very much for spending some time with us – our morning, your afternoon. We very much appreciate the work that you put in to this. It has been very helpful for us to understand the development of Yucca Mountain and what is happening subsequent to that and we very much appreciate your participation.

DR NUTT: You're welcome. If you have any follow up questions, or any additional information you are looking for, please let us know.

COMMISSIONER: I think we would like to follow up the model and we will do that out of the hearing but thank you again. We will now adjourn until 11.00. We will move across to the subject of nuclear non-proliferation.

ADJOURNED **[10.03 am]**