COMMISSIONER: Good morning. We'll reconvene at 1100. Topic 10, nuclear accidents, and in particular, Fukushima Daiichi. Counsel.

MR DOYLE: The Commission's terms of reference require an inquiry into the feasibility and viability of establishing and operating a nuclear power reactor in South Australia. During yesterday's session, the Commission heard evidence about the risks involved in the normal operation and shutdown of a nuclear reactor and the ways in which advances in technology and regulation have sought to mitigate those risks. However, any contemporary consideration of those risk requires attention to be given to the accident which occurred at the Fukushima Daiichi plant as a consequence of the tsunami which followed the Great East Japan Earthquake of 11 March 2011. That's the focus of today's public session.

The lessons to be learned from the Fukushima accident extend well beyond specific reactor design which made the emergency cooling system vulnerable to an external event, interfering both with normal power and the emergency generators. These lessons can be gleaned from a number of comprehensive studies of the Fukushima accident, including the UNSCEAR report on the effects of atomic radiation published in 2013, and the recently published and exhaustive report of the Director General of the IAEA which draws on five detailed technical volumes prepared by a range of international experts.

The focus of this public session is not to traverse each and every detail of that extensive literature, but to identify those observations and lessons which are of critical importance in considering the extent to which the various design, operational, cultural and institutional risks which played a role in the Fukushima accident might be managed were the generation of electricity from nuclear power to be pursued in this State.

The first witness today is Dr Stephen Solomon. Dr Solomon is the chief radiation health scientist and head of Radiation Health Services Branch at ARPANSA, the Australian Radiation Protection and Nuclear Safety Agency. He has a PhD in nuclear physics and over 35 years of experience in health physics and radiation protection. Dr Solomon was the leader of the expert group which evaluated radiation pathways and exposure to the public and the environment following the Fukushima Daiichi accident in 2011 for the United Nations Scientific Committee on the Effects of Atomic Radiation, UNSCEAR.

COMMISSIONER: Dr Solomon, thank you very much for joining us today. As we've heard, the Commission is interested to understand what happened at Fukushima, why, the consequences, and the subsequent action taken throughout the world in responding to the reports about the accident. So perhaps we can just start today with an understanding of what happened and then the progression of events and then we'll move on to the report that you were instrumental in working with in the UNSCEAR report.

DR SOLOMON: Okay. So thank you for the opportunity to provide evidence, and I will give my evidence speaking through the UNSCEAR work as context. So the Fukushima Daiichi nuclear accident occurred 11 March 2011. It was initiated by an earthquake magnitude 9 off the coast of northern Japan. That triggered a massive tsunami, and I guess we all saw the TV images of that. That really led to the deaths of more than 20,000 individuals, severe damage to the infrastructure along the coast there, and one of the flow-ons from that was that it knocked out the electricity infrastructure in that part of Japan and that triggered, I guess, the events that led to the accident at the nuclear reactor at the Fukushima Daiichi plant.

Now, just to look at that in more detail, the earthquake, as I said, did actually shut off the electricity grid and the reactors in that whole area basically shut down, as they are designed to do, and that was certainly the case with Fukushima Daiichi. The tsunami, when it arrived some while later, basically overwhelmed the seawall protection at that plant. It flooded the basements of the Fukushima Daiichi reactor and basically flooded the diesel power generators and it flooded the DC batteries and it took out a lot of the electrical infrastructure in the basement.

COMMISSIONER: So all of the backup generators and batteries were in the basement of the plant.

DR SOLOMON: Yes. Now, that had been identified in some previous assessments as being something that probably wasn't good design. Similar reactors actually had undertaken design changes. This particular reactor, a change had not taken place. So, yes, all the generation was in the basement and when they were flooded basically lost the - so lost the AC power. They lost all the DC power.

COMMISSIONER: The primary cooling, was that pretty much at sea level so the primary cooling was - - -

DR SOLOMON: The reactor vessels and the containment weren't flooded per se. It was really the fact that the halls with those - that DC generation infrastructure was in the basement.

COMMISSIONER: But the primary cooling, which is seawater cooling?

DR SOLOMON: Well, the primary cooling, all those - I mean, the primary cooling requires electrical power to drive the pumps and to drive many of the valves. When that power basically is running on batteries for some hours, when those batteries failed they lost their ability to pump water out. There is some measure of being able to maintain some passive cooling, but they require the pumps to be operating. That led to basically an increase - so a loss of the core cooling, basically an increase in the temperature of the cores, and that led to, I guess, the cooling water in the cores basically boiling. That basically produced hydrogen which basically leaked from the primary containment vessels into the secondary containment.

That hydrogen generation eventually led to a series of hydrogen explosions. They weren't nuclear explosions. They were hydrogen explosions. And so the radioactive material that had leaked from the primary reactor vessel into the secondary was basically disbursed into the environment, both into the atmosphere and, I guess, into the water and into the marine environment. So certainly the understanding now is that three of those reactor cores, due to lack of cooling, had really melted within the first day or two.

COMMISSIONER: Within the first - - -

DR SOLOMON: Well, I guess the first two days. I think the first core melt was really within the first 24 hours. I think it's now assessed that unit 2, the core melt was on about 14 March. So we're talking about within the first three days.

MR DOYLE: And how did the hydrogen explosions that resulted from the build-up of hydrogen relate to the core melts in those reactors?

DR SOLOMON: I'm not a nuclear engineer, but my understanding is that as the cores melted and the temperatures increased basically there was interaction between the water and the zirconium in the actual core and basically that triggers the production of hydrogen, and while the integrity of the primary vessels was generally sort of maintained, there was leakage into the secondary containment both of the hydrogen and fission triggers the production of hydrogen, and while the integrity of the primary vessels was generally sort of maintained, there was leakage into the secondary containment both of the hydrogen and fission products, and when the hydrogen explosions occurred that material then was disbursed to the environment. There were issues with the electrical power in terms of maintaining the valves.

There are meant to be processes for venting those secondary containment vessels. Because of the lack of power, they were trying to do that manually. That didn't work. I mean, they did try very hard to bring this under control and I guess that the - the end point was that the cores did melt and there were releases to the environment.

COMMISSIONER: So we're seeing here the result of the hydrogen explosions?

DR SOLOMON: Yes. So we're talking reactors - the explosions were in 1 and 4 and 2, 3, I guess is the way it worked. So, yes, we're looking at the results, and certainly - I mean, the critical issue with this, the releases to the environment weren't in the first day or so as per Chernobyl. These releases were over a period of nearly two weeks and beyond, and in fact releases into the marine environment are still ongoing at low levels. So this is really quite a complex series of events and certainly the releases are quite complex. So certainly a significant level of damage to the infrastructure there, but notwithstanding that, the primary containment basically was preserved. So notwithstanding the hydrogen explosions, there's no indicate that the primary pressure vessels were damaged significantly.

COMMISSIONER: Perhaps we could now move on to the report that looked at this particular activity, the report that you were involved with, and you might just give us a bit of background with UNSCEAR and - - -

DR SOLOMON: Yes. I mean, UNSCEAR is, okay, United Nations Scientific Committee on the Effect of Atomic Radiation. Basically its membership is basically 27 member states, including Australia. It was formed in 1955. Australia was one of the original members. Its remit is to undertake a scientific evaluation of data and information on levels and effects, exposure to ionising radiation. UNSCEAR basically - its assessment and its reports underpins the radiation protection framework. So in May 2011, so after the actual accident, UNSCEAR, at its meeting, agreed that it would undertake an assessment of the levels and exposures arising from the Fukushima accident.

So it initiated that study, and a team of about 80 or so scientists were put together. The work was split into a number of different areas, some areas looking at what data was available, looking at the source term and modelling, looking at the dose assessment to public, looking at exposures to workers, looking at the health effects. I was responsible for leading the team that did the assessment of exposures to public and to the environment, and I had a team of about 26 more people sort of around the world, and we spent three years or so working on assessing information that was available to assess, as I say, the doses and the potential health impacts from that particular accident.

COMMISSIONER: So this is an independent committee of the United Nations?

DR SOLOMON: Yes. It sits under the UN environment program. It is supported by funding from member states. So it's totally independent in terms of its assessments. Its remit is scientific. It does not play into the policy space, and so you will find the UNSCEAR report does not make assessments about the actual accident and the cause of the accident, or makes assessments about policy or radiation protection changes. That's for others to do. UNSCEAR just looks at the science.

MR DOYLE: And therefore it's quite separate from IAEA.

DR SOLOMON: It is quite separate. So it's a UN body, but basically its remit is about the science, not about promoting nuclear energy or nuclear safety. The IEA's recommendations are based on the scientific data that UNSCEAR collects. So it underpins our knowledge about radiation effects and radiation principles, but, as I say, it's really a scientific-based organisation, totally independent.

MR DOYLE: And your role at ARPANSA is of course quite separate from the role that you played in the UNSCEAR report, or were you involved in your capacity as an ARPANSA representative?

DR SOLOMON: ARPANSA is the Australian radiation regulator. We are responsible for protecting the Australian public and the environment from radiation. What we did at UNSCEAR was basically part and parcel of what we would do as part of our normal work. At the time we undertook it, Carl-Magnus Larsson, the CEO of ARPANSA, was in fact the chair of UNSCEAR, and so what we did - UNSCEAR was basically Australia's support in terms of the international community and trying to understand this. So it was based on my knowledge and experience, but basically it was done as part of an ARPANSA Australian government employee.

MR DOYLE: We're going to come in a moment, Dr Solomon, to the methodology that UNSCEAR adopted and then the ultimate conclusions it drew about exposures to radiation, but could we start with an overview of the quantum, for lack of a better word, of a radioactive material that was generated by the Fukushima accident?

DR SOLOMON: Yes.

MR DOYLE: And I think we have a slide that deals with that issue.

DR SOLOMON: Okay.

MR DOYLE: What were the conclusions that you were able to draw and how did you go about estimating those matters?

DR SOLOMON: Yes. Can I just say the report itself is available on the web? It was published in April 2014. So all this information is available in detail. But in terms of UNSCEAR's approach, one of the first things that UNSCEAR had to do was to understand the nature of the event, understand what was released into the environment. The measure of radioactivity is in this table, which is the becquerel, which is basically a unit of radioactivity. It basically reflects one disintegration per second and it's basically a measure of the quantity of radioactivity, and it needs to be differentiated from measures of radiation dose, which I'll get to later on, which is really about how the radiation arising from radioactivity interacts with the human body and a radiation dose is received. So this is a measure of quantity of radioactivity, and so, as I say, it's a measure of how much radiation is being given off.

So the reactor has, you know, a significant quantity of radioactive material in it. I guess we're talking in inventories at the time of shutdown of 6,000 petabecquerels of iodine-131. Peta is 10^{15}, so it's a big number, and the release to the environment was of the order 10^{500}. The exact quantity released to the environment is really difficult to establish, because there was very little monitoring around the vicinity of the reactor that would enable you to actually establish what actually came out. About half the release went out to sea, so it wasn't measured at all. It's estimated that about 2 to 10% of the iodine-131 in the inventory was released and about 1 to 4% of the caesium-137.

Iodine-131 and caesium-137 are given here because they are the principal radioisotopes of interest in terms of this dose assessment. Iodine-131, at seven days half-life, is short lived. It's important in terms of uptake into the thyroid. It's important in those first few weeks of inhalation, particularly exposure to children. Caesium-137 is basically longer lived and basically it provides ongoing, long-term exposure to gamma. So that's why they're there in this particular table.

So, as I say, the assessment is quite difficult, and there are still assessments ongoing trying to backtrack from measurements in the field using dispersion modelling, using complex models of wind fields on the day to try to work back to what was released from the reactor. There's also some modelling of the actual reactor accident itself, but that's why there was a range quoted, because there is no single definitive number, but, as I say, a few per cent of core inventories were released over the course of weeks.

MR DOYLE: Yes, and you've already mentioned that that is a factor that distinguished it from Chernobyl, the time frame of the release, but are you able to say whether, from a percentage release perspective, it was comparable to Chernobyl?

DR SOLOMON: It’s estimated that this release was, I guess a factor of five to 10 lower than what was released in Chernobyl, so this is an event that obviously the impacts were not as – the releases were not as great at Chernobyl and that’s partly reflected. Look at the figure there in terms of the map or where the contamination was. The contamination was really limited, the bulk of it within a couple of hundred kilometres from the reactor accident itself. So yes, there was – there were releases detectable further afield but they were much lower. So this was a smaller release. It was still a significant event, in terms of its impact on the environment and on people but as I say, the amount of radioactivity release was lower than Chernobyl, five to 10.

MR DOYLE: All right. Well, we might now work through the methodology that was adopted in trying to reach an ultimate conclusion about exposure levels. Am I right that there was somewhat limited source data about the time release of the radioactive materials?

DR SOLOMON: Yes. That is correct. I mean the challenge for UNSCEAR in trying to understand the impact on people was understanding what came out of the reactor as a function of time because that affects where people were. These two graphs here show, I guess, two estimates of the releases and partly – so the red curve shows what UNSCEAR use for its assessment in terms of what went in to the later modelling. The blue curve is a French estimate that basically using similar data and sort of similar approaches, comes up with I guess a different assessment of what was released. At the end of the day, at this point in time, no particular model, or no particular sort of data is assessed as being better than any other one and so what this shows is that there is a high level of uncertainty in terms of our understanding about what was released and when. So UNSCEAR made its judgment about which source term and it took a source term that was produced by experts in Japan and it was basically published in the open literature and based on UNSCEAR judged to be good science and a good estimate.

So as I say, this shows then that there were a range of releases over a period of – really over a period of only three weeks. Most of it occurred over the first week or so and the release on the 15th, is probably the one that contributed to the most significant levels of contamination. If you look at the previous figure that showed that there was sort of areas of red out to the north west, that was an event that occurred on the 15 March when the wind blew it out to the north west and there was a rain event that basically led to wet the position and deposition of the contamination in those north west areas. So this information here was used as input in to the atmospheric modelling to try to get a better understanding about what levels of radioactivity were at particular locations and particular times in the absence of actual radiation measurements. I'll talk a little bit about the radiation measurements further in.

MR DOYLE: Mm.

DR SOLOMON: So UNSCEAR basically – an assessment of the source term, made an assessment of what that source term was and its function of time and that basically provides the input in to the subsequent calculations.

MR DOYLE: And so I wonder if you can then explain the concept of different exposure pathways and why it was critical for you to consider the different pathways in modelling the impacts on human health.

DR SOLOMON: Yes. When you have a radiation release as occurred at the Fukushima accident, there was a number of pathways giving lead to exposure to people. There was a significant quantity that was released in to the air and that basically lead to exposures either from inhalation, where people were actually in the plume. It can also lead to exposures from external pathway once it’s – whether people are standing in the plume, or once it deposits on the ground, it can lead to exposure to people externally from that – what’s on the ground. Once it’s deposited on the ground, it can go in to the food chain; it can go in to food and go in to water. It can pass in to dairy products, in to the cow, pass in to milk. So there is an ingestion pathway there. So UNSCEAR in its assessment had to basically consider all the potential significant pathways for exposure to people and take the available data in terms of what was available for measurement data and from the modelling, to make assessments of exposure to people from those particular exposure pathways.

MR DOYLE: And did the different exposure pathways then lead you to different techniques of modelling and measurement that were relevant to your overall conclusions?

DR SOLOMON: Yes. And I suppose in terms of the way the processes were done, I actually had a series of teams working on the different pathways. And so certainly one pathway, the external pathway is an exposure pathway, a significant one where it basically occurs both in the short term and in the longer term. So it basically radioactivity is deposited on the ground and the radiation from that basically exposes people in the course of their normal activities. To model that, one needs to understand effectively what was basically deposited on the ground. One needs to understand what was in the actual air at the time the plume went through. And you need to understand where people were. For the inhalation pathway, similarly you need to understand what was the radioactivity in the air and the ingestion pathway you need to understand what was in the food. And so – and there’s large data sets. Certainly for the food, there was a food agricultural organisation database that was established with IEA that basically had many tens of thousands of measurement points for that. On the face of that input data, UNSCEAR took that data and basically used a whole lot of exposure models. These are the models that go from how much radioactivity is on the ground? What’s the radiation that comes from that? And what’s received by the individual? What’s the radiation dose to those individuals? And these are models that were used that grew out of what was done at Chernobyl, so there’s – so these models are well established. To simplify the assessment, it’s quite complex.

UNSCEAR restricted itself to looking at three age groups, so young infants, children, adults which are the groups. Looked at basically it's a measure called effective dose, which is basically a measure of - it's the measure of whole body dose. It basically – it has a whole lot of other factors in it but basically it's a measure of the overall dose received by an individual, as opposed to absorb dose to particular organs and UNSCEAR looked at the actual dose received to the thyroid, red bone marrow and female breast. One of the issues here being that in trying to assess the health risks associated with these exposures, you really have to work from the exposure or the doses to particular organs to make that assessment. So basically UNSCEAR looked at assessing these particular end points for these particular groups and undertook that assessment for the settlement averages for the evacuees. So we didn't do individual assessments, we looked at averages across the population groups. We looked at the district from the prefecture average doses for non-evacuees and we did that assessment for first year after the accident. Doses to year 10 and doses to year 80. So three definite points on that.

MR DOYLE: Why do you look at different age ranges for these purposes?

DR SOLOMON: We looked at different age ranges because there are different sensitivities in different age groups. I mean certainly children are much more sensitive to exposure to radioiodine. Radioiodine is basically when ingested or inhaled in to the body, it is taken up in to the thyroid gland and basically there – if – post Chernobyl the Chernobyl experience was that there were a large – you know, many thousands of children who had thyroid cancer arising from intakes of radioiodine. That pathway was milk. So certainly children are very sensitive to radio – I guess radiation induced thyroid cancers and that's against very low incidents of thyroid cancer in children. So certainly assessing the children and their uptake of radioiodine and the doses to the thyroid was certainly a very important factor in terms of the assessment.

MR DOYLE: With the different behavioural assumptions about the different age groups?

DR SOLOMON: There are different factors that go into the calculation in terms of the uptake, in terms of the metabolic processes, in terms of the dose that's delivered. So certainly they would be taken into account. In terms of the behavioural data, I guess not a lot of information available about individual behaviour. So basically assumptions are made about whether people are indoors or outdoors and the times on that, the quantities of food. So there were some age-specific data there but it's more in general terms.

MR DOYLE: You mentioned a moment ago that the modelling was done and differentiated not only by age group but by location and activity. So I think we've come now to the difficulties and the challenges that were encountered in making geographical measurements. I wonder if you might address that topic.

DR SOLOMON: As part of the modelling one needs to understand what the radioactivity was in particular areas at particular times. As I indicated, the earthquake really damaged a significant portion of the infrastructure and that was both in terms of the radiation monitoring networks that were in place. It also damaged roads and other infrastructure. So movement was actually difficult. So the a body of information in those first few weeks is limited. There is some data from some fixed monitoring stations in the area. There were monitoring stations around the remit of the reactor, the gates. There's some data from those. The top left shows some monitoring stations at a distance from Fukushima but you can see there were various peaks at particular times reflecting when the wind was blowing in that direction and when there were release of some of the reactor.

UNSCEAR collected data from the Japanese government. It collected data from other member states and there was a significant body of data that was provided by the Japanese government. It was quality checked and it was analysed. At the end of the day the amount of data that was relevant to the assessment was limited. In June the Japanese government undertook measurements in soil in the vicinity of the reactor. They did 2200 soil sample measurements based on a two-kilometre grid. The plot to the left-hand side shows just the general shape and form of that. So that data set was actually very important for us. It basically underpinned our assessment of what the radioactivity was at a particular location. So we could basically fold that in with our understanding of where the populations were to make an assessment about the doses at particular locations within the Fukushima prefecture.

The other data set that was used was again some months after the actual accident. There were airborne radiation surveys undertaken across Japan and they were basically where large volume radiation detectors were flown at low altitude, something like a 200-metre grid, across the whole area. That was being analysed to assess levels of particular radionuclides as a function of location.

COMMISSIONER: Could you explain the colours?

DR SOLOMON: The colours there basically reflect the levels of contamination. I guess that's not clear on that but the red levels would be levels of contamination that were many megabecquerels per metre squared.

COMMISSIONER: High levels of - - -

DR SOLOMON: High levels. That’s correct. So once we get down to the brown levels we're talking below thousand becquerels per metre squared which is low level where the additional dose rates would be at levels of background or below. In those red areas you are talking about dose rates there of many microsieverts per hour. So the red areas are the areas of higher contamination and the areas of higher dose rate to individuals. Obviously the areas closer to Fukushima where the evacuees were is where the highest doses would have been received. So this is the measurement data and, as I say, the measurement data – there's very little measurement data about the concentrations of radioiodine in the air in the first few weeks when the plumes were up there. Because of that the assessment for inhalation, both for the evacuees and for the non-evacuees had to be really based – had to use some of the modelling data from the – that was produced by the WMO, I guess and that probably speaks to the next slide which is – this is an example of some of the modelling that was done. This one is a bit more readable. My apologies for the quality of the previous slide. So this shows some of the product from that atmospheric transport dispersion modelling that was undertaken by the WMO. This actually shows the time integrated iodine 131 concentration predicted in one particular model and it basically shows, I guess that – I guess the – this is over a period of time, so you know the actual dispersion was really over many directions and certainly there were events that basically led to radioactivity over the mainland and there were events where basically there were obviously exposures to particular individuals, whether that was the evacuees at the time of the evacuation or the non-evacuees.

So the atmospheric transport modelling was used to supplement the measurement data in the absence of measurement data. And the issue with this data is that it carries a significant uncertainty. This is based on the – I guess the measured wind fields or predicted wind fields across Japan over the weeks following the accident. It’s based on the source term that I spoke about earlier on and basically this was undertaken by a number of different international meteorological organisations as part of the WMO network and there was significant variability for the values at particular locations and time between those that says well, individual – like there’s a high uncertainty in what the real values were. So this data then was used as input in to the actual dose assessment. Used in combination with the actual measurement data.

MR DOYLE: All right. Well then in order to relate that modelling to the effects on cohorts of people affected, obviously you needed to understand the movements of people during the relevant periods. I wonder if you could start with giving the Commission a brief overview of the protective measures that were implemented following the accident and then how that impacted on the methodology for selecting groups of people to analyse.

DR SOLOMON: Okay. So in the – I guess the first day following the initial accident there were a number of evacuations that were undertaken as protective measures in the close proximity to the reactor. As I say, there was very little data about the levels of radioactivity in the environment but there were – in the first week, 78,000 people were evacuated from the – out to about 20 kilometres from the reactor and subsequently in early April there were about another 10,000 people that were evacuated out to the north west on the basis of measured levels of radioactivity. So there were protective measures undertaken. As I say the two particular groups here, one where they were evacuated precaution – as a precautionary measure on the understanding of what the plant condition was. In those first few days, a lot of lack of clarity about what was happening and so people were evacuated on the basis that there was really uncertainty about what the reactors were going to do and what the actual plant condition was. Subsequently to that, a month or so on when there were actually measurements there, people were evacuated on the basis of the radiation monitoring information. But we're talking here about, as I say, about 90,000 people evacuated. So this was the – a significant protective measure. In addition to the evacuations there was significant restrictions of food and water and milk in those early weeks. And I have to say that these protective measures were quite important in terms of the impacts in terms of actual doses received by individuals.

For the evacuated groups, in doing the dose assessment for those groups UNSCEAR used information that was I guess produced by the National Institute of Radiological Science in Japan. They undertook a survey of the evacuees to work out what patterns, in terms of the movements of those individuals in those early days. And they established a set of 18 scenarios. Twelve of those, which were for the precautionary evacuated individuals and another six that were for the (indistinct) evacuated. So these were basically, I guess a set of scenarios that basically placed the groups in particular areas at particular times. So that provided the basis for doing the assessment for the evacuees. So you take that information about where they were at a particular time and location, you combine that with the results from the modelling and the atmospheric modelling about what the doses were in the air and on the ground at those times and you can make an assessment about the doses received by those groups during those particular scenarios.

So this was – and in addition to that, since the doses were received over the course of a year, you took the - UNSCEAR summed the doses received during, before and during the evacuation with the doses received when people were actually at the point where they were evacuated to, to assess the full year's exposure. So - - -

MR DOYLE: All right.

DR SOLOMON: Is that clear? Is that clear, or is that - - -

MR DOYLE: Yes, it is. And we'll turn now to some of the conclusions that were reached using that methodology.

DR SOLOMON: Yes.

MR DOYLE: We were conscious that the UNSCEAR report is a very detailed document with a vast amount of conclusions and data. You mentioned 18 evacuation groups. I think we've got the capacity to summarise that cohort in to two broader groups - - -

DR SOLOMON: Yes.

MR DOYLE: - - - and bearing in mind, we don't intend to deal with each and every finding in the report, I wonder if you could pick out what the key conclusions are in relation to evacuees, the two groups that you've separated there during that first year.

DR SOLOMON: Yes. I think the important element in this, as I say, there are two groups and if you look at the effective doses received, in the first year, the critical point is that both for the precautionary evacuated settlements and the (indistinct) evacuated settlements, the average doses for those groups were below 10 millisieverts. So the – and for the infants they're basically from around 10 to maximum 13 millisieverts. What does that say? That the evacuee doses in that first year were basically relatively low, 10 millisieverts or less. These are average doses for those settlements but there will be a little bit of variability around that. But typically the numbers are low. When one looks at the absorbed dose to the thyroid and I guess the critical group here is the infants, one year olds to children. Again, there's some variability in terms of the different scenarios but the upper level, there is 80 milligrays to the thyroid for infants as being the upper level.

What's the context of that? That's a factor of 10 times lower than the Chernobyl, some of the maximum Chernobyl assessments. Background exposure to thyroid is of the order two milligrays per year to – and I guess if we put the context for the effective dose as well, the background radiation exposure in Japan is of the – the average is in the order 2.4 millisieverts per year. But in terms of variability, I mean I guess background globally varies less than one to a bit over 10 millisieverts per year, depending on location. So the effective doses are within that sort of range of variability of background and as such basically are not considered to be high. The absorbed dose to the thyroid, I guess below 100 milligrays which is the – what's the right measure – I'll put that in context, the level of protective measures in the IEA recommendations is 100 milligray for giving potassium iodide so these numbers are below the threshold for the international standard for giving potassium iodide in an emergency situation. So these certainly elevated levels and I'll talk more about the potential health impacts of those further in.

MR DOYLE: All right. Well, wonder if we could then come to groups who weren't evacuated and the conclusions of the UNSCEAR report in relation to – that were further afield from the accident.

DR SOLOMON: Yes. Now so there's three groups here, the Fukushima prefecture was dealt as one group and I guess if you look at the average effective dose in the first year, it's – for the adults it's less than five, for children it's up to about seven and a half millisieverts. These are, I guess district average numbers. So they reflect – the assessment was done at a high resolution than that within a district and we averaged it across the district. So there is some variability across it. But typically those numbers are below – less than 10 millisieverts in the first year. Thyroid doses in that Fukushima prefecture are up to – for the one year old up to about 50 milligrays. It has to be said that significant portion of that, about two thirds of that particular thyroid dose arises from the ingestion pathways. There's significant uncertainty there about – there's a sense that the UNSCEAR assessment may be too conservative in terms of its assumptions about the ingestion of contaminated foodstuffs. So having said that, certainly the – for the non-evacuees, the highest thyroid average dose is assessed up to about 50 milligrays. Now just as another measure here, for the evacuees, if the protective measures had not been undertaken, people hadn't bee moved, then it's predicted that thyroid doses up to perhaps 700 milligrays would have been received by individuals close in to the reactor. So those protective measures really did afford a level of protection of about a factor of 10.

MR DOYLE: Just ask you to – you've mentioned that the thyroid might normally expect by background radiation to be exposed to absorption in the order of two milligrays per year.

DR SOLOMON: That's correct.

MR DOYLE: Is there any consensus on – and I know safety is a very relative concept but is there any international consensus on the level at which it begins to pose a very serious risk to the health of your child?

DR SOLOMON: I guess what I perhaps will do is when we get in to the health effects in general; I'll speak a little bit more to that. Is there a consensus? There is a body of information, particularly post Chernobyl about the levels of risk from exposure to radioiodine and I guess, that – our understanding is quite good at the high levels of exposure. Our understanding about health effects at low levels of exposure, and this is considered getting down towards low level of exposure, our understanding about the actual absolute levels of risk here are not so well understood. It's more difficult to quantify. So as I say, I'll speak in more detail of that when I – later on.

COMMISSIONER: The other groups?

DR SOLOMON: The other groups. My apologies. Just to go back on that please, the previous slide. So the group prefectures were those prefectures that are basically around Fukushima prefecture, so – and you can see there that the case of the effective doses, the doses were about a third lower overall, so – and group four is the rest of Japan and the effective doses there are not much more above – just above background really, make a small (indistinct) part. And that's true in terms of there was – so there was some exposure to the surrounding prefectures but those levels were lower than was in the Fukushima prefecture. And the overall assessment of the exposure to Japan was low. I should just say, at this point the UNSCEAR's assessment of the impact on outside of Japan, the levels of exposure are even smaller, we're talking here about really a fraction of a millisievert in that first year. So the impact on Australia was minimal and the impact in terms of surrounding countries and the rest of the world, arising from this accident was very low, which is quite different from Chernobyl.

COMMISSIONER: Yes.

DR SOLOMON: Chernobyl had significant impacts on other countries.

MR DOYLE: You mentioned earlier that not only looked at exposure and effective doses for one year, you looked at lifetime impact.

DR SOLOMON: Yes.

MR DOYLE: Can you explain the conclusions of the report in relation to those longer time frames?

DR SOLOMON: Certainly. UNSCEAR did the assessment for year 10 and up to age 80, and its estimates basically show that the doses at year 10 are about double the doses received in the first year, and out to age 80 is basically about a factor of three, the first year doses. Why are these sort of levels lower? It reflects the decay of the radioactivity in the environment. Caesium has a half-life of about 30 years. Certainly the iodine was really gone in the first months or so, and so this just reflects that the radioactivity diminishes in the environment and the doses received in time reduce.

To put that in context then, so if we're saying that the doses to adults, or doses to infants, up to age 80 is sort of less than 20 millisieverts, the group averages - to put that in context, the expected exposure from natural background over that time period accumulatively is about 170 milligrays.

MR DOYLE: You said milligrays.

DR SOLOMON: So millisieverts.

MR DOYLE: Yes.

DR SOLOMON: Okay. So we're saying here that the first year - so for group 2, Fukushima prefecture, infant exposure, additional 20 millisieverts sitting on top of 170 millisieverts. So the additional lifetime dose is small relative to the background dose. Now, one thing I should say is UNSCEAR assess these doses taking any account of remediation, because at the time we had data up to the end of 2012. So the assessment basically was published early in 2014, but basically we use - as the assessment took time, we basically took data. At that time there was very little information about remediation and the effect of remediation. So UNSCEAR took the conservative approach which was to say we did not account of remediation.

COMMISSIONER: So having been to Fukushima, I saw some of the remediation work. You'd expect the longer term levels to be less after remediation?

DR SOLOMON: That is the expectation, yes. Having said that, the behaviour in the environment was based on the Chernobyl experience. That is mostly a rural environment. There's data in the IEA Fukushima study that speaks about the effect of remediation and, I guess, the changes in the environment of the radioactivity with time, and so one can see differences in terms of rural environments, urban environments and forest. So it's not quite so definitive, but the expectation is the real numbers, as we get better information in the future, will be lower.

MR DOYLE: All right. Well, I think we'll turn now from conclusions about dose levels to the inferred risks to human health, and I wonder if you could explain the basic approach, bearing in mind it's obviously a complex topic. Perhaps if we start at a general level.

DR SOLOMON: Okay. So I think in terms of health effects here, there are two principal sources of health effects. One is a concern with radiation, one which are deterministic effects, acute effects, which are threshold-based and normally would kick in about doses of the order 100 millisievert or 100 milligrays to particular organs, and so these are acute affects such as severe tissue effects, radiation poisoning. So these are effects that are threshold and obviously high enough levels of radiation exposure will lead to death.

The other type of health effect are stochastic. They are basically effects that really are - such as induction of cancer, potentially hereditary effects, where the risk associated with that particular health effect is really related to the level of exposure. It's a probabilistic effect, and so for radiation protection purposes, one uses the linear no-threshold hypotheses and so obviously one has - the higher the radiation exposure, the higher the radiation risk, and so I used - I spoke before of a 10%-per-sievert number. That basically reflects a stochastic risk, potential induction of cancer.

One of the things here is that UNSCEAR basically - linear no-threshold hypothesis is basically a radiation protection approach. UNSCEAR doesn't do radiation protection. It basically undertakes its assessments based on the size, and so the size in terms of what happens at low doses is really less clear. There is good data on health effects related to exposure to radiation above about 100 millisieverts or so, milligrays. Below that the fourth - there's evidence for particular age groups and for particular organs, but it is less clear. So UNSCEAR based its health assessment on, I guess, projected health risks that was undertaken by WHO in a previous assessment, but it did recognise it did have to make some assessments about the potential impacts at these low levels.

So one of things it basically says here is that when risk is small, or may only be inferred on the face of existing knowledge and risk models, or the number exposed is small - it's used the phrase "no discernible increase" - to express the idea that currently available methods would most not likely be able to demonstrate an increase in the health statistics. So what that says is that the levels of exposure assessed here by UNSCEAR are around the 10s of millisievert. The likelihood is it is going to be unlikely to be able to see a measurable increase above the baseline rates in terms of these particular diseases that's attributable to the actual radiation exposure.

But having said that, it isn't possible to rule out the possibility of future excess cancers, and so, as I say, this phrase, "no discernible increase", best reflects, I guess, some of the uncertainties there about our understanding about exposures at low doses, and I think next week Carl-Magnus Larsson will speak to you a little bit more about our understanding of that. It is quite a complex subject. So in terms of this assessment here - we can perhaps move to the next slide. Yes. In terms of identifications, if one looks at the solid tumours on the induction there, the baseline risk in the Japanese population was about 35%.

If one basically looks at doses in the range of 1 to 10 millisieverts, the attributable risk over a lifetime that arises from an exposure of that magnitude is something in the order of .01 to .1% against a baseline risk of 35%. Future studies really will have - in terms of the number of people involved here, the impact on health just would not be discernible. This is the assessment.

MR DOYLE: So just to be clear, the column relating to dose areas, the hypothetical, incremental dose of someone exposed to the accident and the attributable risk is the additional attributable risk over and above the baseline.

DR SOLOMON: That's correct. That is the way this is to be interpreted. And similarly, the risk to children. So it's the additional dose of 1 to 20 millisieverts in that first year, and that's the range of doses that were assessed. The attributable risk for solid cancers, solid tumours, is very small. So the relative risk to an individual is low, in fact very low, in terms of the impacts in terms of these levels of radiation, and really, it is unlikely that you will see a discernible increase. So in the future, if they do epidemiological studies with this group basically it is unlikely that you will see a statistically significant increase on the basis of these particular doses and our understanding of health effects arising from doses of that magnitude.

MR DOYLE: Well, perhaps we'll turn to the specific context of thyroid cancer in children and you might summarise the effect of this low.

DR SOLOMON: Yes. Now, if you look at - children, as I said earlier on, are much more - the baseline rate of thyroid cancer in children is low, but their sensitivity to thyroid cancer from radiation exposure is high at a young age. So if we're talking doses in the order of 50 milligrays, then the attributable risk from that is about .15% based on our current understanding of risk factors, against a baseline risk of about .5%, so we're talking about a 30% increase there at that particular level. And so the issue here is this is a very rare form of cancer, and so whether it will be detectable in the community in terms of studies is indeterminate, I think is the word to be used here. So there is a medium level of risk.

You would be aware that there are significant health screening programs underway in Japan at this time, and in fact they are looking at doing screening of all of the exposed children in the Fukushima prefecture to be able to establish whether there's any increase in terms of the thyroid. So UNSCEAR's assessment was that the information on the dose distribution uncertainty is such that it's not possible for the Committee to draw a firm conclusion as to whether a potential increase in terms of thyroid cancer would be discernible amongst exposed higher thyroid doses in infants in childhood.

What that's saying is that the doses are such that they're not high enough to be definitive in this particular circumstance as to whether we will see levels of increased thyroid cancer in this particular group. There are uncertainties in terms of doses assessed and there are uncertainties in terms of, I guess, the risks associated with those exposures. So it's really indeterminate at this point in time, and I think certainly there is significant concern in Japan, the parents of the children, and so there are obviously intensive studies that are being undertaken and health programs that are being undertaken to establish a better understanding of this. So it's borderline.

COMMISSIONER: Does UNSCEAR have an ongoing role in monitoring the results of those pieces of work in Japan?

DR SOLOMON: Yes, is the answer. UNSCEAR has initiated the Fukushima follow-up program, and the intent is that it will, on an annual basis, access the scientific literature associated with the accident and publish a report to the General Assembly on the basis of its assessment. It has one underway at the moment. I mean, there are assessments being made of the IEA Fukushima report, for example. There are assessments being made of all the published literature. So UNSCEAR will undertake assessments into the futures, and when there is an adequate level of additional information available it will undertake a follow-up assessment. I mean, it did that with Chernobyl. Okay. So the answer is yes.

COMMISSIONER: Any idea of sort of time frames for that?

DR SOLOMON: I would want to see the outcomes from these follow-up screening surveys. We publish on annual basis a follow-up report in terms of what's out there in terms of what the literature is saying. That would be basically in the form of a summary of all the public literature. The intent is there to see whether there is any new information that basically would give cause for concern about the assessment made by UNSCEAR. So is there anything that contradicts or basically allows us to better assess the levels? And what there is adequate and sufficient additional information available, as I say, we'd undertake that.

So expect an annual review of the literature, and I expect in line with Chernobyl, probably at least ten years before that assessment would be done, I suspect. It depends upon whether there is anything that comes out with the new science that basically gives UNSCEAR cause to think that its assessment is not correct. I think at this point in time there's nothing that's showing up that basically would rise to give - the assessment is basically not a sound assessment.

MR DOYLE: Just before we leave this topic and move on to the analysis of the impact on workers, in the context of thyroid cancer in children, do you know whether there was any significant administration of non-radioactive iodine tablets in the population, and if so, does your analysis assume anything about that, or does it assume no use of those tablets?

DR SOLOMON: Work backwards here. The assessment does not take account of any potential administration of iodine prophylaxis. So basically it assumes that there was no administration of potassium iodide, and potassium iodide is - I guess it blocks the uptake of radioiodine in the thyroid. So it potentially does reduce the dose, but all these UNSCEAR numbers were calculated with no allocation of potassium iodide prophylaxis. That was on the basis that the data available to UNSCEAR at the time of its assessment was very sketchy in terms of which particular individuals and which group has got potassium iodide.

Potassium iodide was distributed to particular municipalities and to districts. At the time we did the assessment there was very little information about which individuals received it. So on the basis of lack of really detailed information, UNSCEAR took the more conservative approach, which was to not - - -

COMMISSIONER: Assume.

DR SOLOMON: Assume not.

MR DOYLE: Well, turning then to emergency workers, what were the key conclusions that you were able to reach about their exposures.

DR SOLOMON: So UNSCEAR did quite a detailed assessment of the exposure to workers on the basis of the information provided by the operator TEPCO and it did its own assessments on many of those internal exposures just to check the integrity. Over the course of the accident and the remediation or dealing with the effects of the accident, there were about 25,000 workers who were exposed to average levels of about 10 millisieverts and effective doses of less than 100 millisieverts. It's possible to infer that there's a small increase of cancer risk to that group, but it's unlikely that you'll see a discernible increase of excess cancers in that particular group.

There were a small number - I think in this case, 173 - with effective doses above 100 millisieverts, 140. They will potentially have an increased cancer risk. 100 millisieverts is sort of the level at which the epidemiological data starts to be more sound in terms of - - -

MR DOYLE: Predictive then.

DR SOLOMON: Predictive, yes. So there certainly is a risk to those individual workers. Again, it's unlikely that you'll see a measurable increase in the statistics, but there is an increase in individual risk. There were about 2,000 workers who inhaled radioiodine because they were sort of involved with the operation in the early weeks. Above 100 milligrays one can infer a small increase to thyroid risk in that particular group. Again, it's unlikely that you're going to see a discernible increase in the statistics.

There was a small group, about - it says 12 here - where they absorbed doses to the thyroid were significant. These are the guys who were doing things close in to the - in terms of those early days, trying to return the reactors to some level of safety, and things were really quite difficult in those early days. So these workers received doses of the order 2 to 12 grays. Now, these are significant doses. I spoke earlier about deterministic effects. These are above the threshold for deterministic effects here. So there is a low risk of hyperthyroidism, a risk of thyroid cancer is enhanced. There, to date, were no deterministic effects in this group, but, I mean, certainly these doses are significant. So again, in terms of when you do studies on this, there are not enough individual workers involved here to be able to make a definitive study on this, but there is certainly an increased risk to the workers.

COMMISSIONER: I noticed yesterday that there was a report in the press where I understand the government accepted that one worker had cancer caused by this particular accident. Did you see that report?

DR SOLOMON: I saw that report. My interpretation of that report is to say that the decision by the government was based on legal issues. That is, I guess accepting a responsibility on the basis of their- they feel is a legal responsibility not on a scientific basis. My reading – my understanding of that particular individual, the dose received by that individual was low, like 15 millisieverts. At that level it would not be possible to attribute the – I guess a particular leukaemia to being induced by particular radiation exposure. So I think certainly the – it is not possible to attribute that particular leukaemia to exposure in the course of their work at Fukushima because of the level of the actual exposure and the level of risk. And the decision by the government is really based on a separate process in terms of accepting a legal liability.

MR DOYLE: Okay. All right. Well, allowing for all those complexities and the uncertainty what in your judgment are the broad conclusions we can draw about the health outcomes due to radiation.

DR SOLOMON: So on the basis of the UNSCEAR assessment of the doses and its understanding of the risks, I guess this summarises what the expected health outcomes are due to radiation here. So no observed deterministic effects, and there's not likely to be any in to the future. So unlike Chernobyl where there were severe – there were 29 or so fire fighters who basically received severe – died basically, exposure to radiation. So this did not happen at Fukushima. So no deterministic effects. For the cancer rates, the – it's not expected to be discernible increases generally though the models, various models do imply that the risk to some individuals have increased by small amounts. But as I say, that won't be – it is unlikely that will be discernible in the health statistics. Thyroid cancers, I guess there's uncertainties in the actual dose distribution in terms of the doses assessment, particularly talking here in terms of the infants and children and that certainly I think that does imply further follow up is required; which is why the Japanese government and the Fukushima prefecture government has very intensive programmes underway to study, or to screen and to sort of do follow up in terms of the exposure to those groups.

Heritable effects, so genetic effects will not be discernable. Birth defects there's no impact in terms of these level of exposures and for workers no discernible increases although risks will increase to individuals. And some of those individuals, there is a follow up is actually warranted under the – for those most exposed individuals. So these conclusions really only apply to the radiation effects and I think one can observe that there was certainly a large indirect impact on the populations in Fukushima prefecture and in Japan, in terms of both the social and mental well-being. Certainly there is evidence to show that the health of the evacuees who still haven't returned to their original homes is impacted by the actual – their conditions. That can be changes to their actual social patterns, their behaviour, their diet and that impacts on their health and well-being. So I think those impacts are much more difficult to define. They're not related to the radiation per se but they are related to the accident and the protective measures arising from it. There's some lessons learnt there in terms of how one deals with not only the protective measures during the accident but how you return people's normality in terms of the follow up and that health impacts are more broader than just the radiation effects.

MR DOYLE: Dr Solomon, we haven't explored today, but I know that the UNSCEAR report has considered non-human environmental impacts. I wonder if you could just give us a very short overview of the assessment that was made on the impact of non-human life?

DR SOLOMON: Sure. Separate to the assessment on people, workers and public, I mean UNSCEAR did undertake an assessment of the impacts on non-human biota in terms of on the environment and that has different end points and so it's not just a matter of whether it affects the – has an effect on people, it's actually whether it affects an environment directly. UNSCEAR's assessment using sort of current methodologies was that there was the possibility of some effects on some parts of the wildlife but those will be very localised and in general, the impact on the broader wildlife and non-human biota is basically insignificant. But potentially there will be small pockets of particular non-human biota, wildlife where it may be detectable effects but nothing so significant that will impact on those particular species on a broader sense.

MR DOYLE: And just finally, summarising the findings of the report, has there been any modelling or predictions as to predicted levels of exposure in the future?

DR SOLOMON: One of the things – in presenting this information to the public, UNSCEAR has looked at how it could communicate its understanding about what the radiation levels will be in to the future and what the actual effects on the people will be. In the report UNSCEAR does have information where it enables an assessment to be made of radiation levels in to the future as a functional location and what this particular animation shows is the projected contour boundaries for the exposure of one millisievert per year in to the future. Now as I said earlier on, UNSCEAR did not take account of remediation in terms of assessments, so this is what happens just in terms of radioactive decay and in terms of those physiochemical processes where the caesium moves in to the soil and basically the levels diminish. What it shows is that with no changes at all, the radiation levels, basically it's only a very small area around the accident site itself where the – basically the additional levels of exposure above a millisievert per year. So without any protective measures at all, the radiation levels in this area will have diminished significantly in to the future. That's probably not the public perception in terms of what the situation is.

So one of the challenges here is in terms of how one communicates both to the public, the radiation levels and the health impacts of those levels, to provide a level of reassurance in terms of the impacts on individuals and I guess to try to move to some really to support the process of that return to normality. And this is something to give consideration to in terms of any strategy in terms of protective measures. It's not just how you undertake those protective measures but how you undertake to switch them off and this is challenging. So the purpose of this particular animation, as I say, is to show that the radiation levels in this area will diminish significantly over a period of the next 30 years. And already it's really only a small area that basically where the levels are above a millisievert per year.

MR DOYLE: Okay. I wonder if we can conclude our discussion with any comments you have about the implications of this analysis for Australia, or the implications more generally from the Fukushima accident that you want to share with the Commission?

DR SOLOMON: Okay. So look at the implications, the impacts on Australia. ARPANSA undertook an assessment of various pathways, the source of exposure to Australian citizens arising from Fukushima and we looked at levels in food, we looked at levels in seafood, we looked at – we measured on cars, we basically did - our assessment was that the overall impact on Australia was minimal in terms of the levels of exposure in Australia and that's consistent with the experience of other countries overseas.

COMMISSIONER: When you say “minimal”?

DR SOLOMON: Well - - -

COMMISSIONER: Can you be more definitive?

DR SOLOMON: So the levels of radioactivity detected in food were basically in general insignificant, so by minimal, I mean, certainly the levels of exposure were below levels of background.

COMMISSIONER: Below levels of background.

DR SOLOMON: There was one detection of radioiodine in Darwin. That was a very, very sensitive instrument and the levels of exposure are a small fraction of normal background radiation. So the levels were very, very low and health impacts were very small. So certainly no radiological concern to Australia. The other element for us is that really Australia does not have nuclear power. We have a research reactor at ANSTO. We receive nuclear powered warships to Australian ports a number of times per year. We have a radiation detection framework in place that allows for the planning of those visits and puts in place a framework for undertaking protective measures in the event of an accident.

In fact, we use this particular radiation detection series number 7, which is an ARPANSA document that's part of, I guess, our radiation detection series. It's produced at the radiation health committee. We actually used many of the processes in this document to support our provision of advice to government and to public during Fukushima. So the trigger levels in here in terms of food, in terms of establishing protective boundaries in Japan for our citizens in Japan, basically we use this document. So this document is really quite important. It's based on international guidance from the ICRP and the IAEA. So it's consistent with international practice although it has to be said we are looking to revise that over the coming years in line with changes to international practice to reflect lessons learned from Fukushima.

COMMISSIONER: What do you expect will change as a result of Fukushima?

DR SOLOMON: What will change – two things, principally. One, the actual trigger levels probably won't change but the approach by which you approach this will change. Implementing protective measures is much more complex than just having a trigger level safety shelter or evacuation. The planning for protective measures needs to take consideration of both the benefits associated with the production of the radiation and the detriments associated with those protective measures. You need to consider that in a broad range in terms of both evacuation, shelter in place, potassium iodide relocation. All of those particular elements needs to be done in a much more consistent way.

So there's much more emphasis on optimisation in terms of the international guidance now and the intent is that we will look to basically establishing guidance that takes account of that. Part of that will be establishing, I guess, reference levels that provide the boundary in terms of what's acceptable in terms of radiation risk. That's something that has to be worked through over the coming months years in terms of deciding what is an acceptable reference level in terms of those protective measures. That's a discussion to be had with government and other stakeholders, including the public. That becomes very important in terms of future planning in terms of establishing planning zones, in terms of emergency planning for any facility.

The other lesson out of that was the return to normality. Moving from the emergency phase to the recovery phase is very challenging and it's something this document doesn't speak to and it's something that future guidance needs to address. So that basically one ensures that process is undertaken effectively and in a timely way to minimise the impacts on the public.

The other points in terms of the lessons learned here is in terms of the accident itself. I'd be saying that in terms of when one looks at the root causes for the accident itself, yes, there was an accident and, yes, there was a tsunami and an earthquake but, yes, there were issues in terms of some of the safety elements around that particular reactor. Obviously a strong independent regulator – obviously strength reduces the likelihood of some of those particular issues. So I think that's a lesson to be learned here and I think that's something that the IAEA has factored into its guidance. Certainly a strong safety culture is also important. I think here having an effective radiation protection framework is important to deal with any emergencies if they arise.

Out of all of that, I think in terms of looking at the broader issues in terms of the health impacts beyond the radiation impacts it's important to have strong stakeholder communication, strong stakeholder engagement in terms of both the planning and in terms of the response in terms of any future emergencies. We're taking those on board. So thank you.

COMMISSIONER: Dr Solomon, thank you very much for your evidence. We'll now adjourn until 1430 when we'll have Mr Caruso from – he's a special coordinator, Nuclear Safety Action Team, International Atomic Energy Agency. Thank you, Dr Solomon.

ADJOURNED **[12.26 pm]**