SA NUCLEAR FUEL CYCLE ROYAL COMMISSION

MR KEVIN SCARCE, Presiding Commissioner
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SPEAKERS:

MR NEIL POWER, Department of Environment, Water and Natural Resources
MR LLOYD SAMPSON, Department of Environment, Water and Natural Resources
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TRANSCRIPT OF PROCEEDINGS

ADELAIDE

10.02 AM, WEDNESDAY, 23 SEPTEMBER 2015

DAY FIVE

PROCEEDINGS RECORDED BY SPARK AND CANNON

COMMISSIONER: Good morning. We reconvene at 10 o'clock on the subject again of hydrogeology and I welcome Mr Neil Power and Mr Lloyd Sampson from the Department of Water, Environment and Natural Resources. This morning we will concentrate on hydrogeology. It is a subject of considerable importance to the Commission. We must understand our groundwater resources, how they're formed, where they're located, how they're managed, and as I said yesterday, we'll come back to this topic in later sessions, particularly those dealing with the expansion of exploration and mining and storage and disposal. Mr Jacobi.

MR JACOBI: Neil Power is the director of State Research Coordination and manages the State's government's involvement in Goyder Institute which is a partnership between the State government, the CSIRO and South Australia's universities which conduct research into water security to inform water management policy, and Mr Power is also the chair of the National Groundwater Working Group, a national policy advisory group to the Commonwealth and State government.

Lloyd Sampson is a principal hydrogeologist in the Science Monitoring and Knowledge branch of DEWNR. Lloyd has a background in geology and groundwater science. He has extensive experience in the assessment of mining petroleum developments and the understanding of mining petroleum exploration and production techniques, and we call both Mr Neil Power and Mr Lloyd Sampson to the Commission.

COMMISSIONER: Gentlemen, can I start with a question? Can you walk us through the sources of groundwater and then walk to where they're actually located in the State?

MR POWER: Thanks, Mr Commissioner. What I thought I might do initially, we'll just do a quick outline of what groundwater systems are in terms of definitions and then we can move into the type of aquifers in South Australia. Probably in terms of what an aquifer is, it's an underlying layer of water-bearing impermeable rock, rock fractures or unconsolidated materials such as gravel, sand or silt from which groundwater can be extracted using a water well.

So in it's simplest form what we've got is a porous material and water moves through the grains. You might have a sandstone or a sand, for example, where the water moves through the grains. In it's simplest form you've got an impermeable layer at the bottom such as bedrock and overlying that you've got the saturated area of water which we call groundwater, and where it's a watertable, ie, that it's atmospheric pressure, then that is the saturated zone or an unconfined aquifer, and overlying that is what we call the unsaturated zone where water seeps from the ground surface down to that watertable. That's the

most basic type of aquifer that we see here in South Australia and elsewhere.

The other type of aquifer is what we call a confined aquifer. I've just got a slide here which shows both an unconfined aquifer which is overlying a confined aquifer. Now, the difference here is that where you can have recharge to an unconfined aquifer down from the ground surface, in confined aquifers, because they've got these confining layers which are called aquitards, they're actually normally recharged in a localised area you can see there on the left which might be on the edge of hills, for example, or outcropping material. So if I look at the Adelaide Plains, the western side of the Mount Lofty Ranges, for example, is the recharge area for confined aquifers underlying the Adelaide Plains.

The other distinguishing feature of confined aquifers is they're under pressure and that's because you've got this depth of overlying sediment and other material above that's pressing down, and when you then drill into that combined aquifer the water rises up the bore and when it actually flows at the surface what we have in the Great Artesian Basin is called a flowing bore or it's artesian. If it only goes partially up to that, and you can see the confined well there over on the right-hand side, then it's subartesian, right, but it's under pressure.

Now, what that also means then is that where the watertable is above that artesian pressure level, which I've got there marked as potentiometric surface, then you can actually get water leaking from the unconfined aquifer into the confined aquifer, and there are examples of that in the south-east, but where the pressure level is above the watertable level then water will seep from the confined aquifer upwards into the unconfined.

So whatever the concept of gravity, you know, water moving from a point of higher elevation in a landscape to a lower elevation, we got the pressure systems you can actually get water moving vertically upwards or downwards between aquifers, and in this more complicated system you can actually have multiple layers of aquifers in a system. We generally called that a groundwater system. So it can be very simple or it can become quite complex where you've got multiple aquifer systems.

MR JACOBI: I think you picked up the topic of interactions between aquifers at different levels.

MR POWER: Yes.

MR JACOBI: Is there a conceptual way of approaching that issue, that is, are there particular ways or means by which there will be interactions between aquifers at different levels?

MR POWER: Normally you would identify whether those confining layers are - how leaky they are, as they're not always totally impermeable. They can be very low rates of leakage, but in most cases there is the potential for that, and then it depends very much on the difference between the pressure level and the watertable level, or the differences between different pressure levels in different confined aquifers. You can get movement of water from one confined aquifer to another aquifer as well where you might have multiple aquifer systems. So it's a combination of a pressure difference and how leaky what we call that aquitard or confining unit is.

MR JACOBI: You've identified a sedimentary aquifer type and we're familiar that there is a second kind called a fractured rock aquifer. I'm just wondering whether you could offer a brief explanation of that.

MR POWER: Yes, okay. Normally a fractured rock aquifer is associated with bedrock or mountainous-type areas or hillier-type areas where you've got harder rock types and you get fracturing in that rock type and you get fissures or joints in the rock mass, and within that, as shown here on the diagram - this is a conceptual diagram showing fractures within the rock and I've got a picture of an example. For example, you can just see that you're getting these types of - and that'll hold the groundwater. Now, the amount of groundwater it'll hold depends on how many of these types of little fractures you've got and how interconnected they are.

Often they can actually be just a small area then you get a small well from it, or if they're already connected when you put a well in and it intersects these fractures you'll get a high yield of water. So in South Australia in fact we've got predominantly two types. We've got these fractured rock aquifer systems associated with all the basement or rock-type areas and the higher ground, the higher elevated areas of the state, as such as shown in this plan here. We've got the fractured rock aquifer systems predominantly running through the Mount Lofty Ranges through to the Flinders Ranges, and then what's called the Gawler Craton, which is an area of high mineral prospectivity in South Australia, which is in that area south of Roxyby Downs through the Woomera prohibited zone area, and then extending right down through Eastern Eyre Peninsula.

The other major area is what's called the Musgrave Block just up in the APY lands where a lot of the Aboriginal communities are, and, in fact, a lot of the water supply service to the community has actually come from fractured rock aquifers, so they're generally the fractured rock aquifers are lower yielding because of the nature of the formations, and they're normally unconfined aquifers not under pressure, so that's the main provinces for those types of aquifers in South Australia.

MR JACOBI: I think you said that they're mainly unconfined aquifers, fractured rock. Is it possible to have a confined fractured rock aquifer?

MR POWER: Yes, and I'd say you can actually get some areas in a fractured rock aquifer that are (indistinct) so you can have also in sedimentary aquifers, particularly sandstone type formations which are more consolidated, you can have fractures within those and they provide higher (indistinct)

MR JACOBI: Perhaps if we can move to the slide that shows aquifers of a sedimentary kind, I think they're a couple along which shows the main sedimentary basis, perhaps as a comparator to the fractured rock and we could perhaps come back. I'm not sure the slide is working. We will refer to the paper copy then.

MR POWER: What we identified there is, in terms of South Australia - look, I'll start from the south-east and work upwards. In the lower south-east, what is called the Otway Basin, and that's an area where we've got two major ground water aquifers which also extend right through up to what's called Murray Basin, so they're actually extensive right through the south-east and they actually emanate from western Victoria. They are the main groundwater aquifers used in the south-east.

There's regional unconfined aquifer, which is mainly used for irrigation and some town water supplies, and includes the Blue Lake at Mount Gambier, for example, and it's a limestone aquifer, and it's underlined by a deeper aquifer, which is a confined aquifer, which provides emergency backup water supply for Mount Gambier, the water supply for places like Robe and Kingston. Progressively, in that Otway area water quality is very good, in the undefined aquifer, but it progressively becomes more saline as the aquifer system moves towards the River Murray along with the coast.

Similarly, the confined aquifer is of good water quality and it is more originally extensive in terms of good water quality right through into the upper south-east. Then you move up in that Murray area to what's called the Mallee area, and again those two aquifers are extensive area discharging into the River Murray, but they provide the water supply for irrigation in the townships at Pinnaroo and Lameroo, for example, and those types of systems. In terms of ground water in the state, extending up to the Mallee is probably one of the best groundwater systems of high quality water in South Australia, so it's a major groundwater province.

If I then move up towards Adelaide, we have the Mount Lofty Ranges, we have sedimentary basins within the Mount Lofty Ranges, like Piccadilly Valley, for example, it's an area where you've got a spread of sedimentary basins in the

valley floor sediment recharged by streams, for example. Then you've got the Willunga Basin and the Adelaide plains running through to the northern Adelaide plans, and again you've got unconfined aquifers overlaying confined aquifers there. Significant groundwater resources, the Willunga Basin supporting irrigation such as viticulture in particular.

In the Adelaide plains, it's used progressively for industrial purposes, Coca-Cola and the brewery, for example, they take groundwater for their products, and then in the northern Adelaide plains there's a major horticulture area. Now, both aquifers there are primarily used for what we call tertiary aquifers, or they are confined, they're both overlain by a hundred odd metres of sediments of different aquifer systems which are mainly brackish to saline, so in fact the good quality water in those aquifers is actually overlain by more poorer quality aquifers, and those ones are recharged, as I mentioned earlier, along the western side of the Mount Lofty Ranges.

That's quite a viable and good water quality resource in that area that is supporting industrial use and high quality horticulture, particularly in the northern Adelaide plains. If we move further north, that big resource which just got the label on there Lake Eyre, but it covers the Great Artesian Basin. The Great Artesian Basin is the largest ground basin in the southern hemisphere. It covers western Queensland right through up to the Gulf of Carpentaria, northwestern New South Wales and the south-west of the Northern Territory, and then an extensive area into South Australia.

It is recharged along the western side of the Great Dividing Range in Queensland, and there's some smaller amounts of recharge coming into South Australia from the western side along the Finke River and places like that. The major distinguishing features of the confined aquifer, it's quite hot, it can be up to a hundred degrees centigrade in parts, and it is under quite significant pressure, so if you drill a well into the Great Artesian Basin you could have water moving up extending 60 to 70 metres above ground level, it's under so much pressure.

It's viable, it's a major resource. We do need to manage it in a way to maintain the mound springs, which are listed under the Environment Protection and Biodiversity Conservation Act at the Commonwealth level, so they are quite unique environmental features of the Great Artesian Basin. That means that when we're managing that system we've got to manage it by pressure, targets in particular, to maintain the pressures at the mound springs so they maintain flow.

MR JACOBI: I'll come back, I think, in a moment to deal with that. We can come back to that issue later, but could you address the solidity of the basin?

MR POWER: Yes, the basin is 2000 to 3000 milligrams per litre or thereabouts, so it's just above potable, so, for example, Olympic Dam, when they take water from the Great Artesian Basin for Roxby Downs township it's desalinated. Again, the upper limit for drinking water is 1500 milligrams per litre, but once you get above 1000 then you can start to taste the salt in it, but from a potable level the upper limit is 1500 milligrams per litre. In terms of other major resources, there's the Arckaringa Basin, which is shown in blue there.

Again, two major aquifers in that system. We've got more limited knowledge of that system, but it is used for the water supply, for example, for paleovalley mine. Then if we go further to the west, we've got what's called the Otway Basin and the Nuclear Basin. Again, both high saline groundwater resources with limited knowledge, from our perspective, on those resources, mainly because of the high salinity in there for the very little use associated made with those have not been worth the effort to actually understand the capacity and size of those resources. Effectively, they cover the major groundwater resources in South Australia in terms of sedimentary basins.

MR SAMPSON: It's just worth noting in that northeastern part of the state that the basins are actually on top of each other, and you've got the Lake Eyre Basin. Underneath that is the GAB, underneath that is the Cooper Basin and the Arckaringa Basin, so they're not discrete things.

MR JACOBI: Picking up the issue before, I think, of interactivity, is there known to be much interactivity between the individual systems?

MR SAMPSON: It's been under investigation to try and work out the magnitude of it and also between aquifers and between the two systems, so not a great deal was known about how it will behave, assumptions are made in the modelling to try and work out what (indistinct) is, but it can be measured in the field.

MR POWER: Part of that reason is because it's been noted, the use of that resource, so it's been most departments in the terms of resource assessment has been what we call the prescribed areas in the state of better quality water areas, so it's where most of the irrigation typically occurs in South Australia.

MR JACOBI: Can I just come back to a number of general topics that I think have been picked up in the discussion so far. The first of it is salinity. Is there any general underlying identifier, does one more typically find saline water at particular depths?

MR POWER: We can move onto a couple of slides. So we've got a slide here is a best available groundwater, so this isn't necessarily the water near the

surface. If we look at the different aquifer systems in the area, what's the better quality so, again, looking at the south-east, good quality water in that south-east Otway Basin and Murray Basin up into the Mallee, and that's shaded in that blue area, used for both town water supply and irrigation, in particular. In the Mount Lofty Ranges, a good quality water through most of that area, again suitable for irrigation use. The Clare Valley and the Barossa Valley are similar, but they are, with increased utilisation of those resources, there's a threat of, as you take groundwater out, of being replaced by a more brackish groundwater on the margins of those systems.

As you mention, the Great Artesian Basin has shown up in the north-west area, 2000 to 3000 milligrams per litre. Then once you move out of those aquifer systems and there's some small lenses on Eyre Peninsula, which is used for Eyre Peninsula water supply, which are, again, good quality right down the bottom there near Port Lincoln, and there's another one just up on the west coast, which is a small lens of groundwater, shaded there in blue.

But then when you move out of those, we're starting to get into the areas of much higher salinity. That light brown area is 3000 to 14,000 milligrams per litre. Stock water use quality but, again, too brackish for drinking water or most irrigation activities. Then in the dark brown, 14,000 to 35,000. So once we're getting up to the 35,000, we're getting saltier seawater, for example. And the pink areas are, you know, highly brackish.

If we then move onto the next slide, which is just the surficial aquifers, so the first aquifer you'll intersect if you look at the system, again, it just shows that the aquifers overlying the Great Artesian Basin are basically brackish and you'll see the darker colours there, showing that's 3000 to 14,000, up to 35,000. So what it says to us is that our good quality groundwaters in the State are confined to those areas towards the southern part of the State with a higher rainfall, higher recharge rate, and the Great Artesian Basin, which is part of a much greater large system, which was recharged in largely western Queensland.

Actually, there's one other groundwater resource which we have skipped over. If we can just go back to a slide called Paleochannels and I think it's called Paleovalleys, and I think it's worthwhile just giving these up before we go any further.

MR JACOBI: I think that's a bit later.

MR POWER: Okay.

MR JACOBI: Can I just get you to pause just for a minute there. You mentioned something in terms of the fact that drawing water can draw more

saline water into an aquifer. I just wondered if you could explain the process.

MR POWER: Yes, in a lot of our areas, we've got good quality water which can either be surrounded or adjacent to them as other groundwater of higher salinity so as you start to take good quality water out, you've got to take out a rate so that you don't actually induce poor salinity water moving in to replace the better quality water. So we had instances in Barossa Valley where irrigation activity has occurred in the past and have actually used good quality water, but over time the quality has gone brackish above what is suitable for irrigation providers for example. So people have to actually discontinue use of that resource.

So where we manage water resources, groundwater resources in South Australia, we managed quantity, which is effectively managing water balance, but we also have a high on managing salinity, that we don't replace good quality water with the poorer quality water as we take it out. It's just largely due to the nature of the resources in South Australia.

MR JACOBI: There's one other aspect of interaction that I wanted to pick up, and that is this question of flows of water through groundwater systems. I was just wondering whether you can give the commission any insight into the movement of water through groundwater systems typically.

MR POWER: Okay. Can we just go back to the slide showing the confined and unconfined aquifers. Yes, that one will do. I'll just demonstrate here. So if we've got an area where recharge, for example, in the confined aquifer, there normally then will be a natural confined discharge area, for example, somewhere down the system. Now that could be where it approaches an area of lower elevation and then you might have wetlands or you might have groundwater (indistinct) natural vegetation and you get evapotranspiration losses through those systems. Or it may be connected into a stream that actually provides discharge from the groundwater system into the stream.

See, you'll have this movement of water under the pressure and you'll notice the pressure lines dropping, so it'll move from that point of higher pressure elevation through the aquifer system and out. If you're not taking water out, it's in a natural balance, so normally the amount of water that's coming in is equivalent to an amount of water which is coming out, and that's similar for both confined aquifers and unconfined aquifers, so the water table will be slightly higher here and then over down towards the discharge end will be lower so the water will move through.

In most cases, it moves very slowly, but where you look at the limestone groundwater systems in the south-east, for example, which are high porosity and permeability, the groundwater might move between one and five metres a

year, but a lot of other groundwater systems, it's a very slow rate.

MR JACOBI: Do we see different flows through fractured rock systems?

MR POWER: We do. Often, again, it's the degree of how well connected those fractures are as to how far that groundwater might move and the rate of that rate. Generally very slowly or it may well be that they're not well connected and the groundwater is effectively sitting there like water in a bathtub, for example, and not moving very far at all in that fracture system. But the big picture, regionally, it will move from the recharge area to the discharge area, generally slowly, largely driven by the change in the water table across the landscape or the pressure level, and how permeable, how porous the actual aqua material is.

MR JACOBI: I think that might lead us into the next question, which is an issue of lateral recharge, and I think we've got a slide, I think slide 10. I think you might have already explained the issue of the process for recharge, perhaps we can come to, and the characterisation of recharge rates in South Australia. I wonder if you can give an interpretation of that map.

MR POWER: Again, it shows that the areas in blue, which is the area of the higher recharge rate, which we see around Mount Gambier, in the Mount Lockyer Ranges, particularly on the Fleurieu Peninsula and in those areas, we'll have higher recharge rates, which can be anywhere between 50 to 100, or 120 millimetres per year. Then as you move away from those higher rainfall areas, you go into lower recharge rates. So the areas like in, say, yellow to brown, so you're looking in those areas of 10 to 20 millimetres or around five to 10.

So, again, the south-east, the Mount Lofty Ranges, Flinders Ranges, where you can get either higher rainfall or, actually, you can get good episodic storms, which actually provide a high intensity duration rainfall. Then as we move out of those, and similarly on the lower part of Eyre Peninsula, and recharge in that sense, it's actually dictated by your rainfall, by your vegetation cover, your soil types and your depth of your groundwater in particular. As you move further north in those areas in red we are very low-reach modern recharge rates.

So what it's saying is a lot of the groundwater in those systems has been laid down in much earlier times and that modern replenishment rates are quite low, typically less than one and up to five millimetres per year, which are very low. The area in white which is quite extensive there we've got limited data but I characterise them again as probably areas with low modern recharge. From a resource management perspective, with those low rates you'd effectively say that those systems are – any utilisation of those resources is going to be very dependent on how much water you've got in storage. We'll have that

discussion.

MR JACOBI: Do those averages include high-intensity events, that is uncharacteristic wet periods?

MR POWER: Yes. They're on average, long-term average.

MR JACOBI: I think it might have been picked up before, what you said about the Great Artesian Basin. That is that the recharge for some of the systems derives from rainfall outside South Australia itself.

MR POWER: That's correct. So most of the recharge of the Great Artesian Basin is in west Queensland, along the Brisbane flank of the Great Dividing Range. We believe there is some but very limited recharge around the Finke River type area in South Australia where you get a flood flow coming down the Finke River, crosses some of the GAB sediments near the surface, so a recharge event, but again they're few and far between. From a water management perspective you'd say that you can't rely on that.

MR JACOBI: I'm interested to understand what's the analytical basis for the data that's contained there and how is that measured?

MR POWER: We do have a number of analytical techniques which range from using things like what we call isotopes. So what you can have is measuring chloride in the rainfall and the chloride in the soil or in the groundwater itself and it gives you a way of actually, based on the concentration in the rainfall versus what's in the groundwater, some way of trying to estimate how rainfall has got into the aquifer. So there's methods like that. It can be just on the basis of what the rainfall is and what's the changes we're seeing in groundwater levels following rainfall events. So what normally happens when you get a rainfall event, the groundwater level would rise a little bit. In places like the south-east it might rise one or two metres. We can actually calculate then how much water is getting into the aquifer. So there has been a number of different techniques developed over the years. They're all reliant on point measurements. Then you've got to try and scale that up. So there's quite a bit of uncertainty in that science.

COMMISSIONER: Because of the uncertainty is it conservative estimates?

MR POWER: What we've found over the years – back in the 1960s and the 70s a lot of the groundwater people were probably optimistic in terms of their estimates and we tend now these days to go more towards the lower – when we're going those estimates, the lower range of them. That's a more conservative approach to what modern recharge actually is.

MR JACOBI: I think you wanted to pick up one more resource and there's a slide for it, slide 14, with respect to the paleovalleys. I think the question it leads to is can you explain the nature of that resource and perhaps its recharge also.

MR POWER: Okay. This is another significant groundwater resource and the reason I'm mentioning this is because there's a potential particularly for mine developments which might occur particularly in the northern and western parts of the state. These are old river channels, for example, which flowed back prior to when – in the old ancient landscape and you had old river channels which were full of sediment, sands for example, and groundwater was laid down in those systems. They've been subsequently covered by other modern material, geologically that is. So all of these systems can be down about 100-odd metres or so before you intersect them but they can hold, actually, quite substantial volumes of water, being old river channels and that type of thing. You can see there blue where they've been mapped in South Australia.

Generally, the water quality is brackish to saline but, again, with desalination techniques and the cost of that coming down these resources, particularly from a mining perspective, then become viable as water supply options for a mining development, for example. So in terms of an alternate supply which is outside of the sedimentary basins and the fractured rocks, as we spoke about earlier, if we can map these types of systems, that gives us an alternative source of water that is potentially available in this arid area, with some degree of treatment depending on the use you want to put it to.

MR JACOBI: Perhaps by comparison – I don't think we need to go to it – the slide we've seen before of the sedimentary basins, I just want to pick up the point you made. Are the sedimentary basins overlaying these paleovalleys or are they beneath them?

MR SAMPSON: Probably a bit of both. So they're not necessarily – some of them are superficial whereas others occur at depth. For example, up in the GAB, up around Oodnadatta area, they may be systems that are actually overlying.

COMMISSIONER: Are they recharged in the manner that you've explained to us?

MR SAMPSON: They would be from direct rainfall.

MR POWER: But very low recharges rates.

MR JACOBI: Picking up the topic in terms of how recharge was measured, perhaps we can go to the topic of the extent to which we've got monitoring

information with respect to groundwater resources in the state. We've got a slide for it, slide 15.

MR POWER: The Department of Environment, Water and Natural Resources actually runs a statewide monitoring network, both for groundwater levels and groundwater salinity. In terms of groundwater levels, this is a bigger picture slide just showing the whole state. We've got a separate slide covering the southern part of the state. In some cases we've got records running back up to 100 years but a lot of them are shorter than that, probably 1960s, 1970s onwards. At different times in the history the networks have been rationalised and some bores which were being monitored have been dropped out of the system, but at least it does give us a reasonable record of groundwater levels and seasonal cycles and groundwater levels and change. All of them pretty much focused, if you look at the map, around what we call prescribed areas, the areas which are being used for irrigation activity, town water supplies, that type of activity. Outside of those areas is very limited coverage.

So if we just go to the next slide. No, just go back one. So then we look at the areas like the south-east. You can see quite a dense network of monitoring through that area, again reflecting the high value of that groundwater resource to the state, similarly up to the Malley. The areas on the River Murray are more associated with salt interception schemes and that type of activity. So in the area of the Mount Lofty Ranges and those areas towards the southern part of the state, the Great Artesian Basin you see have long-term monitoring records. The red areas on places like Yorke Peninsula and Kangaroo Island in green are more associated with dry land salinity programs which were developed back particularly in the 1990s and more targeted to that type of monitoring. So the monitoring effort has been focused on those higher value water resources which are more commonly used and are actively managed through prescription processes which we'll talk about later.

MR JACOBI: I'm just interested to understand how far the data series goes back. Perhaps we can contrast the position between, say, the south-east and the areas that were shown in the north-east of the state.

MR SAMPSON: I think monitoring - Blue Lake, for example, has gone back to the late 1800s. It's been undertaken for a long time. Whereas up in the GAB a monitoring network has been recently established, but there's been some ad hoc monitoring going back to the 1980s, perhaps a little bit before then, and then in other parts of the State it would be varied depending on when people started being a bit concerned undertaking monitoring. About 1930 it would be for in some areas that monitoring has been undertaken.

MR POWER: So the length of the record varies around the State.

COMMISSIONER: In terms of the recharge for the Great Artesian Basin, are those records in Queensland go back further?

MR SAMPSON: I don't know. I'd have to check.

COMMISSIONER: No, that's fine. I just wondered whether - - -

MR SAMPSON: Yes. I don't know offhand.

MR POWER: The first wells were put back in the Great Artesian Basin in Queensland back in the late 1800s, but how firmly they monitored them, we'd have to check that for you.

MR JACOBI: I understand that the rationale for the monitoring is so as to manage extraction. I'm just interested to understand how that monitoring information is then fed into a management scheme or a management structure.

MR POWER: Actually I'll just use the south-east, for example. South-east is prescribed under the Natural Resources Management Act and that - parts of the south-east were progressively prescribed from the early 1980s and what then tended to happen is as you prescribe you would establish more active monitoring networks because you're going to start looking at developing a water management plan for the area and issue water licences for the use of that resource. So one of the critical things is to understand what's the status of the groundwater system with use. So what tended to happen is monitoring networks were improved when those management actions were taken.

Other areas the State people just took the initiative within government to actually start monitoring them at a basic level to start to understand the systems themselves and so it gets information from which they can assess the capacity of those resources. But I would say that the most monitoring ever associated with the establishment of formalised management arrangements for those particular resources was probably the summary point to make there. The other side then is the salinity.

MR JACOBI: I'll just pause you there. In practical terms, if one was to observe a depletion of a resource, the question then is what's done as part of the system to address that. And I'm interested both in a prescribed and in a non-prescribed.

MR POWER: Right, okay. I'll just talk about prescribed areas first. So a water allocation plan was - it's developed. We've said, "What's the status condition of the resource? How much water is set aside for environmental purposes. You can have dependent wetlands or you can have other ecological features, for example, effectively affected, and then - or how much water can

be actually allocated for some purposes. The monitoring data would then provide us a way of measuring over time are there adverse impacts occurring in terms of the rate of change of groundwater levels, or are there changes from a holding perspective. I'm tempted to say salinity network.

Where in time we've identified that there has been a decline in groundwater levels we've identified that is not what we call sustainable. It may result in water allocations being reduced, people's ability to take there has been cut back, and that's occurred in a number of places over time. That's probably the prime mechanism. The other way also is that the network and the information provides as a way of identifying the critical levels that we need to maintain to protect wetlands, for example, or to be placed on wetlands. So as a way of - and if you approach those levels you might say, "Do we need to again reduce use in a particular area close to that associated wetland area because it looks like it's having an adverse impact on that resource?"

So if you have a look at the resource as a whole or a part, or particular features in the resource that you might to protect, for example, so it's actively used that way. Normally the monitoring is reported through reports looked at annually. All the monitoring data is on our departmental groundwater database and that information is all available through the web, and then when they review the water allocation plan, which previously was five years but it was amended recently, in the last couple of years, to a ten-year cycle, then they would review all that data and see where they need to make adjustments to water allocations.

MR JACOBI: But I understand that if an area is not prescribed and so there aren't licences and there aren't extraction limits, I'm just interested, what happens in a non-prescribed area?

MR POWER: Most of the non-prescribed areas have low levels of use and therefore within that basis, most of these issues haven't arisen or be the basic so much. Where we've detected that there are problems occurring, the action would be to actually prescribe the resource to bring management direct to the manager. So, for example, the south-east, as I mentioned, a lot of that happened back in the late 1980s and 1990s. Mallee was around that era, but the Mount Lofty Ranges have been done in the last ten years.

MR JACOBI: Yes. The Mount Lofty Ranges was the last area to be prescribed, wasn't it?

MR POWER: That's right.

MR JACOBI: Are there any other areas currently looking at - - -

MR POWER: Central Adelaide Plains is now prescribed with a developing

water allocation plan for that. That's the last one, and as I mentioned before, that covers pretty much all the better quality water throughout the State.

MR JACOBI: Now, just to pick up on something you said in terms of the public availability of the information, we're looking at a series of point sources of measurements. Am I right in understanding that if I was interested to understand what was at any of those point sources, I could find that information out?

MR POWER: Yes.

MR SAMPSON: Well, it's got it online now, groundwater data web site. So-you can zoom in and select different networks and you can download a wide-read variety of information, including all the water level salinities, how the wells are struck, water chemistry information.

MR JACOBI: And does that have the depth of the datasets that we've been talking about in terms of - - -

MR SAMPSON: The historical datasets?

MR JACOBI: Yes.

MR SAMPSON: Everything you can find on our database is above the waterline, those wells.

MR JACOBI: Now, I think you just mentioned salinity, and I think we've addressed groundwater level monitoring. Perhaps we can deal with - I think we've got a slide that deals with this as well.

MR SAMPSON: Slide 17.

MR JACOBI: This shows the salinity stations. Can you explain the rationale for their establishment?

MR POWER: Again, it's very closely aligned with the areas that are prescribed and actively managed where the effort has gone in in terms of salinity monitoring, and as I mentioned, the nature of the resources in South Australia, whilst we're managing groundwater level we're often managing salinity, which can be the other major threat, and actually determining what a sustainable level will take from a resource is actually to make sure manage the salinity levels. So there is a more limited salinity monitoring network that's been established in those prescribed areas which are actively monitored.

Just go to the next five and again, similar to what we saw before, there's more

intensive effort in the south-east, for example, which is the high quality resource. So we don't need a network as extensive as the water level monitoring network, but we do need reasonable coverage just to manage that balance between groundwater levels and salinity. So there's a lot of water allocation plans, for example, when you're doing water transfers, salinity is one of the factors you need to take into account, ie, if we increased the amount of use of water particularly, will that act in increasing salinity level, and often that's the other criteria we need to take into account in doing those types of water transfer applications and assessments.

MR JACOBI: Well, aside from the issues of transfers, again, perhaps to take a practical approach, you would observe rising levels of salinity in a particular location. Is there a management response that's available for that?

MR POWER: A good case example is Padthaway where they have a rise in groundwater levels in the groundwater there which is used for viticulture and is quite critical in terms of the levels there. We went through a process of actually developing a computer water quality model to try and predict what salinities would be in the future and we use that to work with the community and they come up with strategies then to cut back their water allocations to change the amount of water they were taking out of the groundwater system to reduce the impact on salinity.

So there's been a couple of examples like that where salinity and rises in groundwater level and salinity levels have been a factor in actually reducing the water allocations and water use as a measured response.

MR JACOBI: To come back to, I think, the map that was shown previously at 17, I'm just interested in understanding again the rationale. I think the map accurately shows that there's not much monitoring of salinity in the western half of the state. Is there a reason for why there's not much monitoring in those areas?

MR POWER: Outside of the Aboriginal communities, right up to the Northern Territory border, there's virtually little to no use of the water resources in those areas. There's limited knowledge of them in terms of those resources as well, so effectively management hasn't gone into those areas, and the management emphasis has been focused on the prescribed areas. If you went through a process where you actually had increased use in those areas, then you would have to look at establishing monitoring networks there.

MR JACOBI: The specific area I had in mind was not only Eyre Peninsula but the area north of that.

MR POWER: That area we've been looking at between Port Augusta and

Roxby Downs, there's a large area in there, the Woomera prohibited zone. Again, there would be very limited use associated with that region, for example, so between Tarcoola and Roxby Downs, that area through there you've got that Woomera prohibited zone. Again, if that area becomes targeted for mining expansion, for example, then there would have to be increased monitoring established in that area to look at those impacts on resources associated with that development.

MR SAMPSON: Also too when monitoring fresh quality water resources, the salinity that's in those are areas that you were talking about before around that Port Augusta region the groundwater is more saline so it's in the order of stock quality, maybe industrial, and in other areas it actually exceeds industrial use, it's up around 60,000 parts, it's highly saline.

MR JACOBI: I understand the issue with respect to salinity, but I think the position is similar, with respect, if we go to slide 15. Again, I understand that the issue is broadly similar with respect to level monitoring - - -

MR SAMPSON: Yes, that's right.

MR JACOBI: - - - so it's dictated by the amount to which those resources are being extracted from. Is that right?

MR SAMPSON: Being utilised, yes.

MR JACOBI: I think this leads into where we spent quite some time yesterday in speaking to people with particular expertise in mineral geology, but what we don't know about the state, and I'm just interested to understand your perspectives on what we know that we don't understand well with respect to groundwater resources in South Australia.

MR POWER: It's often useful to have a look at slide 9. You've got a hard copy there of it. As Lloyd mentioned, we've got these different basins and some are underlying others. One of the areas there's probably a lack of knowledge is the northern part of the state, broadly, outside of the Great Artesian Basin. We've got quite a good knowledge base of the Great Artesian Basin both through state programs and through Commonwealth funded programs with the other states.

We've also done some work in recent times in the Arckaringa Basin associated with - it's got potential for coal seam gas and (indistinct) gas. There's been some additional work funded by the Commonwealth government in that area as well, but at this stage the overall understanding of those resources are more of a basic or rudimentary level, and in particular, as Lloyd mentioned, the interaction between the groundwater systems within those and the deeper

systems we have very limited knowledge of, and that's all been associated to the fact that we have no level of use for those resources.

We have put together for each of those areas in the north compiled existing information and put together reports in the last five years on those areas which identify what we do know, albeit of limited information, and we've published those. Also the Goyder Institute for Water Research has done some work using airborne geophysical data, and I've been interpreting that, that work that has been done by the mineral industry to identify ground mineral resources.

We've actually reinterpreted that data to find groundwater resources, and we've done some work in what we call that area up in the far north-west where the Aboriginal lands are, Aboriginal communities are, and we've also done some recent work with that technique on the Northern Eyre Peninsula, again, looking at potential areas where water might be used for mining developments. I would say overall we've got quite good knowledge of the prescribed areas, the southern part of the state, its groundwater resources, the Great Artesian Basin, but when we get outside of that we have much more limited knowledge and it's again been associated with the fact that there's been no (indistinct) use in the past, so all the management effort has gone into those other resources where there's been a higher level of use. Additional knowledge will probably come through associated developments, such as mining.

MR JACOBI: You talked about gathering information that's been gathered for other purposes, that is, taking it from the petroleum related use and using it for water related use. Putting that to one side, are there opportunities with the sorts of techniques we were discussing yesterday, electromagnetics and other programs that could be undertaken to provide us with more detailed information in those areas? Certainly, in terms of the shallow groundwater systems, like the paleovalleys.

MR POWER: We were able to map those better using these techniques, but they're not applicable to the deeper groundwater systems. For example, once you get below 100 to 150 metres then you've really got to start doing drilling programs and that type of stuff to actually get that information in more detail, and that has a higher cost associated with it. The last major effort, as I've mentioned, that we've just done is the Arckaringa Basin, which was funded by the regional assessment programs associated with the coal seam gas type activities looking at the potential of those areas. That was funded largely by the Commonwealth government, so outside of that type of work, yes.

MR JACOBI: Do you share that information around with other departments, or is the drilling specifically for water based activities?

MR POWER: Specifically, for water based drilling, all the geology findings

from those wells all goes into the state groundwater databases, and part of the state geological database, so it's all together.

MR JACOBI: So it's all shared.

MR POWER: Yes, some of that information is actually available via the web site.

MR SAMPSON: We work on the basis of open data, our rationale being to actually make that available for other people to utilise in the areas, to practice and utilise for the purposes they're to follow.

COMMISSIONER: Produced by mining companies, prospective mining companies.

MR SAMPSON: It largely forms a basis for their initial desktop studies, and it's from there that they can then go out and plan more detailed work.

COMMISSIONER: It might be time for me just to but in. I've been reading some of the submissions about some of the controversy of mound springs. Can you just draw to our attention what the issues of contention there are, and perhaps explain to me what mound springs is?

MR SAMPSON: Mound springs are essentially a discharge component of the Great Artesian Basin, and - - -

COMMISSIONER: Describe it for me because I haven't seen it.

MR SAMPSON: Basically, around the edge of the Great Artesian Basin, and I'll just refer for the moment to South Australia, so if you're looking around the Lake Eyre region, the Peaks and Denison, and up to Dalhousie.

COMMISSIONER: Probably Marree through Oondnadatta up through to - - -

MR SAMPSON: Yes, around that southern margin of GAB in South Australia. Actually, the GAB is artesian and the water makes its way to the surface, and where it's come out at those points, ecological communities have developed, and some of them are quite endemic to individual locations.

COMMISSIONER: So this is quite a large surface area.

MR SAMPSON: Yes. In some areas there are hundreds to thousands of springs in one location whereas in another they may be just a unique occurrence. They're derived from – some of the work we have done with (indistinct) from underlying structures. So the groundwater has made its way

up through either confining layers or abutting fractured rock to the surface and the springs have developed.

COMMISSIONER: Some of them rise because it's under pressure.

MR SAMPSON: Yes.

COMMISSIONER: Understood.

MR SAMPSON: So the existence of those springs is inherent on the Artesian pressure. So if the pressure drops then the springs will - - -

COMMISSIONER: How do you monitor that?

MR SAMPSON: We now have a monitoring network in the GAB for which we are monitoring changes in pressure. Some of those are located near the spring groups. So we are able to measure what happens in the GAB near those.

COMMISSIONER: So is that predictive measure for the springs or a lag?

MR SAMPSON: We're monitoring pressure at that point in time, so it changes - - -

MR POWER: Effectively a lag.

MR SAMPSON: Yes. I'll use BHP as an example. They've got their well fields in the GAB. They have predicted where their draw-down will extend to and the magnitude, including impact on springs, and then they undertake monitoring to see that their predictions from their modelling are true.

COMMISSIONER: You also monitor the springs as well or is that the responsibility - - -

MR SAMPSON: We don't usually monitor spring flows. We monitor the aquifer pressure near there.

COMMISSIONER: How are then sure that what has been modelled by companies becomes a reality?

MR SAMPSON: Through the monitoring of the aquifer pressure.

COMMISSIONER: So someone is checking - - -

MR POWER: And BHP actually does monitor spring flows as well that are associated with their well-diggers. So when they did their EIS, environment

assessment statement, they identified springs that they thought could be impacted by their extractions from the well fields and monitoring was set up. So they had to monitor spring flows and some of the (indistinct) of those springs in that area. That covered a fair area of the GAB spring complexes and that has been going on since the early 1980s, for example, and that now with the other pressure monitoring that both BHP do associated with their well fields and the monitoring that the department does gives us the combined information of that. Where in their environment impact assessments they looked at what the impact on the springs would be, then we monitor those and, through the annual reports, look at what the impacts are to see that they align with what the predictions were and to see that the things – that they aren't seeing things that shouldn't be occurring.

COMMISSIONER: So there is oversight of the monitoring of the mound spring - - -

MR POWER: Yes.

COMMISSIONER: If companies wanted to set up a mining activity there, then that process again would be modelled and there would be an EIS and that would come through the state government evaluation.

MR POWER: Yes, that would – obviously BHP and Olympic Dam is covered by Roxby Downs and indenture. Outside other mining developments would either come through under the Mining Act or could be declared significant development and come through the Planning Act and (indistinct) would be done in the same way.

COMMISSIONER: This may well be outside your knowledge, in which case tell me, but are there other impacts upon the springs other than extraction?

MR POWER: In terms of the mound springs?

COMMISSIONER: Yes.

MR POWER: So extraction from - - -

COMMISSIONER: Anything else that would cause it to change.

MR POWER: Yes. Well, you've got historically cattle access to the springs which have then caused degradation around the springs. So activity has actually (indistinct) the spring complexes occurred on some of the properties. Feral animals, camels in particular, cattle access, they've all – they go into the spring and trample them and that type of thing. That causes direct degradation. So there has been a history of those types of things. There has been introduced

species like palm trees and some other introduced vegetation that has come into some of the springs and that has caused problems over time. So land use activities are also another major impact on the springs. The other thing also to bear in mind is that the springs – because they're natural features, over time some decline, some new ones arise.

MR SAMPSON: If a spring builds up you get a mound growing. That gets to a height water pressure can't make it out the top any more, and they will flow will make its way out through another avenue.

MR JACOBI: I think perhaps we can, given that we've dealt very specifically with particular cases, step back and just deal with quite generally with the way that extraction is managed from a resource that's not in a prescribed area. I think we've already addressed the issue of EIS. I'm just wondering whether you could explain the role of – you mentioned numerical modelling as part of that exercise. What's the numeric modelling that's done and what is that used for?

MR POWER: The big picture in terms of outside the NRM prescribed areas, the National Resources Management Act, and Natural Resources Management Plan which evolved by National Resource Management boards but, again, through those avenues there's limited control of groundwater extraction in non-prescribed areas through those mechanisms. If you've got a major development such as mining, for example, that then initiates a whole process under the Mining Act or the Planning Act. That then, in terms of the context of whether they want a water supply or if it's an underground mine or open pit, there's an assessment process to look at what impacts that typically will have on the groundwater resource.

Now, associated with that, one of the key tools we have got is to develop a groundwater model. Normally the company would look at, if they're looking for a water supply for example, try and identify a resource where they can establish a supply. They would do field assessment work to get the available data in terms of drilling and testing wells to say how much water could be taken from the resource, how they would configure and design the well field and they'd often use – in all cases use a groundwater model to try and identify then what might be the long-term impact on the groundwater resource if they take certain volumes of water over particular periods of time. So that's a major assessment tool. It gives them some idea of how - - -

MR JACOBI: Is the modelling validated?

MR POWER: As best we can in terms of what we call pumping tests that they do when they test the wells, but there's obviously limited long-term monitoring data in a lot of these areas to actually do any other - - -

MR JACOBI: I'm interested in once the model has been done, I assume the activity is approved and it commences. Is it subsequently validated?

MR SAMPSON: Yes. So companies would be required to undertake monitoring. They'd have a monitoring network and they'd monitor their levels.

MR JACOBI: Is that a requirement of their licence?

MR SAMPSON: If you're in a prescribed area then to have a monitoring plan would be a condition of your water licence. Outside of there it's part of their PEPR, which is a mining - - -

COMMISSIONER: Explain what PEPR is.

MR SAMPSON: It's a program of environment – environment and rehabilitation program, something like that.

MR JACOBI: Under the Mining Act?

MR SAMPSON: Yes. So it's the second part of the mining development. So the monitoring plan will be part of that document and they will be required – in that monitoring plan they stipulate the wells that are being monitored, frequency in and parameters, and they will then compare that to their model, and if it's behaving differently to their model then they'll be required to update their model and show again what the extent of impacts will be.

MR JACOBI: Who are required to do it?

MR SAMPSON: Mining companies.

MR JACOBI: Where would the requirement come from? Is that a requirements that's inherent in the licences?

MR SAMPSON: Correct, yes.

MR JACOBI: In terms of the information that's gathered from the monitoring, is that information made publicly available?

MR SAMPSON: Through their annual reports, yes. So they have to report on their monitoring in their annul compliance reports.

MR JACOBI: What's the provision for public access to that information?

MR SAMPSON: That's through the Department of State Development's web

site, their Minerals web page. I think it's lodged pretty soon after it's submitted.

MR JACOBI: Yes. Can we deal with extraction? I think we've got a slide that deals with a different issue which is (indistinct) water, slide 19. I'm just wondering if you can give us an interpretation, particularly - I think it's another round PEPRs.

MR SAMPSON: Yes. So I'll start off with the three images on the right-hand side. They're some drawdown impacts that we predicted in the recent Olympic Dam proposed expansion. Okay. So they're looking at the Tenthill aquifer which is one of the major aquifers in there. So they're showing impacts resulting from their mine dewatering. Okay.

And we've got them to model out to a period of 500 years after their proposed closure, or they're what the EOS was going for. So what we can actually see in this instance here is a cone of depression, which is, you know, the impact on the water resource, has actually extended on the closure of mining. So if they were to stop mining because it's an open pit, what happens is you still get water flowing towards the pit, evaporates, and that's reached out to a stage of equilibrium. So that's how they keep drying up to - and they've modelled 500 years, that area. So there's a lot of uncertainty in modelling out that far because we know very little about changes in rainfall and other users, et cetera.

MR JACOBI: Perhaps by the schematic that appears on the left-hand side, could you give a broad description of the flows that explain or can be used to describe what mine dewatering is?

MR SAMPSON: Okay. So what mine dewatering - in essence, to operate a safe mine they have to extract all the groundwater from that site. So it can actually be interception of groundwater. So they would have some dewatering wells around their site. They would then pump out the groundwater and that will then result in a cone of depression in the water surface, or alternatively, what they can do is just have sumps within the pits. So if your rate of inflow is slow and it may just have in-pit sumps they'll just pump from. But using the image on the left, that's more what will happen on closure. So what we're seeing here is that water will flow back towards a pit and result in a pit lake forming.

MR JACOBI: And that's shown by the purple arrow, is that right, that - - -

MR SAMPSON: That's showing the direction of groundwater flow. So it's showing the - yes - - --

MR POWER: That's the regional groundwater flow in the aquifer, and then

you develop the mine pit and then you would get the groundwater as you dewater that. You get the pressure levels dropping down or the watertable, whatever it is, but then that - and that'll be dry while they're actually operating the pit or underground mine and then, as Lloyd was saying, once you get mind closure then you get partial recovery as the groundwater moves into the pit and you get - that will become an evaporation source.

So as Lloyd said, these are the pressure drawdowns that were modelled at 17 to 2050, and that area ,or the impact of that extends outwards to the mine operation and then once the mine operation stops then you'll get some - particularly for open pits in this type of activity, some imprint that stays there on the resource. If it's an underground mine, then often water levels will recover. We haven't got that open evaporation.

MR JACOBI: In terms of dewatering impacts, are they greater or worse when the mine is operating than they are when it's closed in terms of the impacts on other people that surround?

MR SAMPSON: It will vary. It depends on - some areas, the cone depression will - the size of it will decrease after they stop operating. In this instance here that we've shown, it will actually grow. Typically, it will reduce in size.

MR POWER: Only because of the amount of water that would be being pumped out will be greater than the amount that would be evaporated at the end of it, once you've got mine closure.

MR SAMPSON: The example here can be seen too is that that was a large pit. So hence the evaporative force would be quite high.

MR JACOBI: I think we'll change and deal with the third of the hydrogeological risks just as a broad introduction with respect to institute mining technique. I think we've got a slide that deals with this at 20. I think perhaps broadly if you can offer some explanation as to what is the in situ method and how that interacts with hydrogeology and encompassing the risks in that.

MR SAMPSON: Yes. So essentially, in situ recovery of uranium ore basically involves injecting an acid into the aquifer and pumping it out through nearby wells. I think we'll point these out. So we've got an acid being injected into the well there and by pumping on a nearby well, which is generally quite close, it might be only 10 to 50 metres away, you're actually drawing the acid through the aquifer which then extracts the uranium. That goes off to the plant. They strip out the uranium, regenerate the acid and then recycle back through the aquifer.

COMMISSIONER: When you say "acid", what - - -

MR SAMPSON: It's a sulphuric acid.

COMMISSIONER: Sulphuric acid.

MR SAMPSON: Yes. So it's low pH. Yes.

MR POWER: In a lot of the systems in United States they use an underlying submission, the majority in South Australia particularly tend to use an acidic solution and - so you'll have these bores - there's like an array of bores, bores where they inject the water and then a central one where they pull it out. So it's an array and then they have one - they will mine one area or they might have other arrays at the same time.

MR JACOBI: And the schematic shows monitoring works. I'm just interested to understand how the planned monitoring works is undertaken, why they're put where they're put.

MR SAMPSON: Yes. So obviously the risks associated with (indistinct) are the mining solution, extending laterally in the same aquifer, and then also potentially moving into an overlying aquifer or an underlying aquifer, and so - - -

MR JACOBI: That's what I meant, that concept of leakage you mentioned earlier in the discussion.

MR SAMPSON: Yes. So the example that we've seen here is there's actually a low permeable unit above and below the mining aquifer, hence the clays. So what we do have is monitoring wells in the overlying sand. We do have them in underlying aquifers, although we don't have any on this diagram. And then there's a perimeter around the mining area. They then construct lateral monitoring wells. They're monitored on a regular basis and - - -

MR JACOBI: What is monitored at those locations?

MR SAMPSON: Okay. So they monitor water levels and then there's three parameters that they monitor which enable them to detect that the monitoring solution has moved in that direction. That's typically pH sulphate and uranium. Yes. So they're monitored against those, yes, I think on a monthly basis, and that's for all wells. That's for overlying, underlying and lateral. They are required - - -

MR JACOBI: Monthly to you?

MR SAMPSON: No, not monthly. We get a quarterly report sent to us, but then there's an annual client's report which they always have to generate. That's publicly available.

COMMISSIONER: Publicly available through your web site.

MR SAMPSON: Through the Department of State Development's web site. Yes. DSD Minerals are the regulators for mining activities. So all those documents are made available through that web site.

MR JACOBI: Yes. I think just to pick up on that, what's the relationship between DSD and DEWNR when it comes to these particular objectives? What's DEWNR's responsibility?

MR POWER: We provide advice on the acceptability of the impacts on the groundwater resource, the form that might take. So when they're in assessment for a mine development process with EIS we'll provide that advice back to them and that will either become conditional as part of the mining development approval. In terms of the operational side of things, for example, (indistinct) it's an advisory role back to DSD to say that this is acceptable or something is happening here that we don't find acceptable, which they, as the regulator will take up. So the Department of State Development doesn't have a groundwater unit in its own right, so we provide that advisory role, both at a science technical level and also from a protecting, conserving the groundwater resource itself side of things.

The other, in terms of the uranium industry, of course, and the EPA also has a role in terms of water quality as well, so our role is advisory and also ensuring that we detect things that we don't think are acceptable and we could advise the Department of State Development as regulator.

MR JACOBI: I'm interested to understand that if, for example, an excursion was detected or there was something else that was not acceptable in terms of concentration, I'm interested to understand what sort of measures could be put in place, bearing in mind the technical (indistinct)

MR SAMPSON: Can I talk to that?

MR POWER: Yes, you can talk to that one.

MR SAMPSON: Yes, there's a number of possible solutions that could be used. One is to obviously cease operation and you could, you know, possibly extract more water from the wellfield, so increase your bleed, which will then encourage water to flow back towards the wellfields. You could install some barrier wells, for example, which would put some wells outside of the

monitoring wells and eject water and creating a higher pressure, which would push water back towards the operating wellfields. And I suppose you could then modify your injection and extraction regimes to move away from that area to encourage flow back towards the wellfields and try and get the parameters to an acceptable level.

MR POWER: So basically the engineering type approaches, either modifying to the volumes that they're actually circulating, which has an impact on their operations, which they would have to adjust for, or putting in, as Lloyd said, hydraulic barriers to stop (indistinct) away.

COMMISSIONER: Can I just understand, you mentioned the EPA has a responsibility as well; where does EPA's responsibility pick up some of these water issues? How do they work with you in this process?

MR POWER: Largely, they provide advice back to the Department of State Development and send them to us. Now, whilst our focus in the Department of State Development is around groundwater sustainability and perspective, the EPA is more around groundwater contamination and pollution, so that's the distinction. So they'll provide specific advice on those types of issues. They do have specific roles under the Radiation Act as well. I can't actually (indistinct)

COMMISSIONER: No, that's fine.

MR POWER: But perhaps a specific role there as well.

COMMISSIONER: My final question, I want to go back to the Mount Springs, and if you don't have this information, that's fine, but the operation now has been more than 20 years on. Have we noticed any change apart from natural change in the springs?

MR POWER: When the original EIS was done in 1985, that era, they went through in a process, identified some springs which had expired, some which were partly effective in terms of spring flows, and they established the original wellfield A. Over time, the initial extractions from that increased up to 15 megalitres a day and that was looking as though it couldn't be sustained in terms of the impact on mound springs. Some of the mound springs were looking like they would be impacted beyond what the EIS stated.

Now, in the immediate action at the time, it partly took this to actually modify the wellfield array and put in some new wells further to the north, but, again, they had limited success on pressing that issue. And also with their mine expansion, they then looked to actually establish wellfield B further away from the springs and reducing the amount of water coming out of wellfield A, and

that was to maintain those complexes.

We have seen some changes over time in some of the ecology of some of the springs. Again, it's a combination of whether it's the impact of groundwater extraction or land use activity impacts in particular springs, but, at this stage, we haven't seen major changes in springs outside of what was originally estimated.

MR SAMPSON: And that would be under the (indistinct) injection program, so they did see - - -

MR POWER: Yes, there was one - - -

MR SAMPSON: - - - a potential increased draw down in areas they weren't predicting, so they then implemented a program to inject the water back into the aquifer to maintain pressure near the springs, but that's been discontinued with the commencement of the wellfield.

COMMISSIONER: Gentlemen, thank you. I should mention in terms of in situ mining we will come back to this in much greater detail when we have the expansion of mining, which is a topic a few weeks ahead of us. Well, I thank you for your presentation and also for the work that went into this. It's been very useful in us understanding the groundwater and where it's located, how it's managed within the State. So we'll adjourn now until 1400.

ADJOURNED **[11.26 am]**

RESUMED **[2.01 pm]**

COMMISSIONER: We'll resume day three and I welcome Prof John Quiggin who was to be part of our first session on climate change but the technology was too much for us. John, you're very much welcome. Mr Jacobi.

MR JACOBI: I'll introduce Prof Quiggin again. He's an Australia Laureate Fellow of the School of Economics with the University of Queensland and has been since 2003. Prior to that he has held an academic position at a number of Australian universities – the ANU, University of Sydney, James Cook University as well as the in the United States the University of Maryland. He is a member of the Climate Change Authority. He is among the top 500 economists in the world according to the IDEAS RePEc and is best known for his work on utility theory. We call Prof Quiggin to the commission.

COMMISSIONER: Professor, if I can start – we will get to climate change but I'm interested in your submission for which I thank you. In that submission you talk about a time frame for establishing nuclear power. It may well start in

2016, should we so recommend it and it seems a power plant being constructed in 2030 to 2040 – I'd characterise this as a business as usual time scale. I'm just wondering whether you see anything that might be imminent that would change the motivation for the sort of time frame that you identify.

PROF QUIGGIN: Well, maybe jumping to a question that might come up later, of course certain kinds of policies, states could manage this on a much faster basis. France did so in the early 1970s. China, although they are, in fact, playing down nuclear a bit, China is capable of doing it. What you need are a set of characteristics, a very centrally controlled technocratic government, not too much democracy and local process, so certainly not too much concern about things like residents' objections and that kind of thing, not much concern about issues like competition policies.

So what France did was say, "We're going to pick a standardised design and we're going to put the plants here and here." The French technocratic elite was then at its peak, their whole rationale was from people like that, so they could do in the 1970s a very rapid transition to nuclear based on a single central decision taken with essentially very little debate. Obviously, of the countries proceeding with nuclear and having some success, China has done the same.

So if we could reproduce those conditions in Australia, make everything a federal system, not have any kind of environmental procedures, the kinds of things where we see a delay in coal projects, for example, and could have a centralised agreement between the major parties that we were going to pick a particular contractor, stick with it and push it through at great speed, we could go faster than that timetable I've suggested. But in the actual conditions we say that timetable, in my view, is highly optimistic, I think. I think the time I've allowed is far shorter than perhaps would be the case if we attempted to go nuclear.

COMMISSIONER: Do you see any external factors driving us down a potential to shorten the sort of time scale that you've identified?

PROF QUIGGIN: Honestly, I don't. I believe that there's a risk that we'll simply stay in the kind of policy paralysis we have at the present, but assuming we don't I think we'll go back to carbon pricing and we'll go down essentially a renewable (indistinct) perhaps already well-established industry. With popular acceptance – there's obviously a little bit of objection to wind but broad popular acceptance and essentially all we need is the price signal and some policy certainty and that's the path we'll take.

COMMISSIONER: We might go into some of the areas of your submission, but I'm interested in what your view is of the event that we expect in Paris at the end of the year and what signals you think the world might send from that

meeting and the consequent action that might come from that.

PROF QUIGGIN: I think the outlook is reasonably optimistic. I think if we go back to Copenhagen five years ago, on the one hand the expectations were too high, and on the other hand we had powerful parties – China most obviously but to some extent the US and India – all much more concerned with preserving their own freedom of action than with moving forward and much more concern about the economic impacts of the policy.

So I think we now see that the US and China in particular are both committed to doing things but we'll certainly have a bun fight about issues of whether it's legally binding and those things but I expect to see from the indicia of commitments we've seen so far a set of commitments which, while they're not on the optimal path to a degree of 450 parts per million solution, will keep us within reach of that path and I expect the path will be back again in five years and 10 years' time, gradually upping the ambition. I think under that scenario we can indeed reach 450 parts per million but we'll probably still be arguing about it right up till 2050 or thereabouts.

COMMISSIONER: So you think even with this gradual approach 450 parts per million by 2050 with zero emissions is within our scope?

PROF QUIGGIN: It is. It's not the optimal path. That's what economists have said about it. If we had all the information we needed to act 15 years ago we could have started then and we would have done it so much more cheaply, but the costs are still modest in terms of a growing world economy and I expect we'll achieve it, yes.

COMMISSIONER: If I could go back and then I'll ask Mr Jacobi to take over. So is the issue that concerns you with time frames social licence, predominantly?

PROF QUIGGIN: Well, it's a bunch of things. Social licence is part of it but I think that focuses too narrowly on the kind of what might be called the NIMBY objections of people who don't want nuclear power stations next door. Processes simply like setting up a regulatory framework are very complicated. If we look at – even assuming that there was general popular goodwill out there, we still have to have the procedure of selecting sites. That's something that hasn't been done in the Western world for many decades. All the existing power plants being built in the US are being built on brownfield sites next to existing nuclear power stations.

So we have to have a procedure of some kind to select locations and design procedures, finding the people to do it, setting up all the things that need to be thought about with a nuclear power station. That's inevitably going to take a

great deal of time, even assuming popular goodwill, which of course is a pretty heroic assumption.

COMMISSIONER: It is if the world doesn't accept a view about climate change and its impact.

PROF QUIGGIN: Well, I think even so. I think the majority view will be that renewables can do the job and should do the job. I think it will be hard to persuade a large proportion of the population that nuclear is superior to renewables but we won't see a substantial position. But, as I say, even in these US locations where there hasn't been any significant issue of social licence in the sense we're talking about it, there's still major regulatory complications, disputes about the price. So if there have been cost overruns then there are disputes from insure groups, of course, informed by concerns about nuclear, saying, "We shouldn't have to bear these costs," and disputes between parties, all of these things which are in broad terms under the heading of social licence, and led to very substantial delay.

So if we look at the US nuclear renaissance program they were starting in 2002, hoping to have plants online by 2012, and a lot of them instead will be lucky to get four plants online by 2020. That's without any significant element of protest. There hasn't, as far as I'm aware, been any public protests of any significance at the nuclear power plants that are under construction in the US. Obviously concerns have been expressed about the regulation process but there haven't been activist protestors. Nonetheless, a process that was supposed to take 10 years has taken 20.

COMMISSIONER: The commission has been to the UAE to have a look at their four build sites there. They're certainly a different democracy, as you point out.

PROF QUIGGIN: Yes.

COMMISSIONER: But they have developed a regulatory framework and despite, I think, what you allude to in one of your articles, they've managed to bring that expertise into the country to develop that and depending on who you read, they probably delivered their first reactor within 10 years.

PROF QUIGGIN: Yes. Honestly, I mean, UAE is another example, I guess, of the kind of jurisdiction that could do that kind of thing. As I say, I simply - even if we had popular goodwill, there's no way that - yes, there's no way, I think, in the Australian context that we could do the kind of things the UAE does.

COMMISSIONER: I accept it's a different environment, but I'm really talking

about trying to understand your approach, which appears to me to be a serial approach to the activities, and that's based upon largely, from what I can see, the US experience you had in terms of the challenges with the environment.

PROF QUIGGIN: There are some parallel elements. I have attempted, in drawing up the time scale, to do as much as I thought was feasible in parallel. It's largely based on the US because the US is the most favourable. If we look at France, for example, which historically was of course hugely successful, we have the phenomenon of negative learning by doing that. Successively as the conditions of 1970's France have disappeared, French nuclear power plants have become more and more expensive. The Flamanville plant is way overdue among other things, and this certainly is obviously going to be an issue in the Australian context. They went from a commitment to use foreign supply in the 1970s, an American supplier, because they were the cheapest and fastest, to having a French supply.

So the Australian context, for example, as an issue of social licence, it's very different. The obvious question, if a nuclear power plant were to be built in South Australia would be, is South Australia going to get any work out of this. The answer should be no. The answer should be, "No, we will hand over to the American firm that would construct the thing and they'll make their own commercial judgment with no pressure to use local suppliers. They will construct it in a way that is most efficient for them." I assume that's pretty much what's been done in the UAE, and so that kind of issue, I think, reflects the kinds of factors that I'm talking about in the delays in the process.

COMMISSIONER: I would have to say that the UA presents a different case from that, and there are several things that make no sense for a new country going into nuclear to construct, but there's a lot more that they can do, and I guess that will be part of the commission's work to try and establish what realistically can be done in a country where local communities and the local state gets benefit from it, and I should also make the point that Korea has just selected the green pit site. Again a different environment, but it certainly has occurred. I see also that you think the AP Westinghouse 1000 is the only technology we should consider.

PROF QUIGGIN: Yes.

COMMISSIONER: Could you just expand on it?

PROF QUIGGIN: So if we go back to the Swokowsi report, which was moderately enthusiastic about power there, one of the points he made was that we shouldn't do anything just at the moment, and obviously I take that not to mean literally the first, but that as a country with no experience in managing and dealing with this kind of technology, we want something with an

established track record, operation, a reasonable number of projects completed. If we also want a mature and modern technology, Generation III+, as opposed to the kind of obsolete technologies which are based on Generation II in the 20th century, we have fairly small number of possibilities, and in my view, the likelihood that any of those are going to be developed on a sufficient scale by the time we make a decision on times that we're talking about is quite small.

I don't see a CANDU or EPR going that way. I don't think in any conceivable context that a Russian supplier, for example, would be acceptable in Australia, and so that, I think, we can rule out, and I think the same is probably true of the Koreans. So in my view, if we want something which has by 2025 a reasonable number of plants in operation and assuming favourable conditions of nuclear are much more under construction, I think that's the only likely end.

COMMISSIONER: You dismiss the CANDU reactor?

PROF QUIGGIN: I can't see that there are going to be any significant number. There are none under construction right now, to the best of my knowledge. So I can't see how by 2025 we would have any scope. That would be an ideal case of Australia going for a first-of-a-kind technology.

MR JACOBI: I think just to come back to an issue we were discussing at the start, which was the nature of the French program in the 1970s, one of the issues which I want to give you an opportunity to comment on, whether there were any particular labour force characteristics that existed at that time in France in the 1970s and whether there's any relevant parallel to Australia now.

PROF QUIGGIN: Well, certainly, as I say, the - I don't know much about the construction work or the development but obviously the French École Nationale, they had a very technocratic process designed specifically to produce a technology (indistinct) after World War II and that was at its peak of success at that time, and while Australia obviously is not lacking expertise, at the same time I don't think we have anything comparable here.

MR JACOBI: Moving now to - I want to address the response or the likely transition pathways that might emerge in a broadsheet for 450 ppm. I'm interested to understand - first of all, putting to one side policy as a driver, the extent to which you think the economics of new technologies (indistinct) batteries might drive - how far they'll take us on a particular transition pathway.

PROF QUIGGIN: Well, if we look at with no change in current policy we are likely to see, I think, this isn't economically the most efficient route, but because of the penalties imposed on new buyers with (indistinct) solar and very high costs that come with electricity, I expect a significant uptake on the

solar-plus storage systems and that expectation is precisely why Tesla has chosen to launch the Powerwall in Australia ahead of the US which would be the obvious first market. So I think we'll see a significant movement in that direction, assuming that we've stabilised a renewable energy target and that we are past the kind of anti-NIMBYism that, you know, whilst characteristic of the recently departed leadership, I think we'll see a renewal.

There are a lot of new projects waiting to go ahead. So I think in the short term, we'll see significant growth in that direction. I think there's substantial capacity to expand renewables based on current conditions, the renewable energy target. By the time we reach the limits of renewable energy targets being (indistinct) see further cost reductions which would make renewables - certainly I think competitive with Newcom, for example, I don't expect to see any Newcom plants built, but obviously there's a problem of how rapidly we can shut down existing coal-fire powered plants and that does depend, I think, on (indistinct)

MR JACOBI: Particularly the coal (indistinct) constant and those policy (indistinct) I'm just interested to understand your view as to the extent to which expected reductions in costs in solar PV and batteries might drive us in terms of a pathway to emissions reduction on their own.

PROF QUIGGIN: I think the big difficulty is the existing coal-fired power stations. So they're obviously (indistinct) has been amitised. In the case of brown coal, the fuel has no other use. It's almost free. I think we do need policy there, but I think we're already - the economics is at a point where those technologies will be competitive with new coal and your gas. So I expect to see - I don't expect to see much new investment in coal even at the current policy settings, but I think to make the change fast enough we would need to see changes in policy, broadly speaking, in the direction of what we see that was prevailing a few years ago.

MR JACOBI: Assuming an end outcome or agreement that 450 ppm is the target at the two degree limit, do you have a view about how quickly existing coal plants need to be retired and about when you might need to start and what the very latest dates might need to be?

PROF QUIGGIN: Well, economically, the sooner the better. The sooner we act, that is, the optimal time path would be one which started - we had already started, so, yes, I think we missed an opportunity there.

MR JACOBI: We've touched on this before. Can I get you to unpack that a little bit - - -

PROF QUIGGIN: Sure.

MR JACOBI: - - - in terms of - you identified it would've been economically better if we had done it 15 years ago. Could you explain the rationale for that?

PROF QUIGGIN: Well, what we don't want to do then is have a rush - is delay things. Delayed things have accumulated a large - have used up most of our carbon budget and to forego relatively low-cost transition options, like gas, to need a large-scale upgrade of the grid. You could try and do this rapidly, you know, in 2030, with a requirement to very rapidly reduce to near zero because we've used up most of our carbon budget we'll certainly end up incurring substantially greater capital cost than if we take the process more gradually with the constraint being the capacity for any renewals, but that's obviously not a constraint that's binding at the moment. We've seen substantial cutbacks in the renewable sector. Simply by bringing back to where it was two or three years ago, we could substantially accelerate the process of transition.

MR JACOBI: To come back to time frames for retirements, and I understand your view about the optimality of retirement early, but do you have a view about the latest time frames for retirements in order to be consistent with that 450 ppm outcome?

PROF QUIGGIN: Yes, and that does inform my submission. In my view, there are different ways of doing it, but broadly speaking if we haven't substantially retired large sections of the coal fleet by 2030 I think there's no chance of meeting our targeted list. If we're on the current business as usual projects, although they may be a little pessimistic as to the scope for renewables to be substituted, we're way off target with those business as usual projections.

MR JACOBI: You said "large sections of the coal fleet". Are you able to give a broad idea in terms of the amount of generating capacity?

PROF QUIGGIN: I haven't got a number off the top of my head. Obviously, we want to start with brown coal because that's the most polluting, as well of course having substantial local costs. In terms of particular pollution, brown coal of course is a much more carbon intensive fuel than black coal. In terms of order you process, that would be the place we would like to start.

COMMISSIONER: Is it your view that renewables can just take up that in the generating capacity?

PROF QUIGGIN: Over a substantial period, yes. I've argued against the notion that there is a substantial so called base load demand which requires 24 hour availability of power. In my view, what we see, in fact, is a large portion of that demand is generated by the pricing structures designed to take up the

excess capacity of coal by power stations by encouraging people to use, for example, to heat their hot water late at night, solely in order that they can keep the coal mine and power stations running. In my view, we could simply add renewables for quite some time.

As we reach the final stages, we need more, we need to cope more with 1980s intermittence and the date of convariability. There are a range of possibilities. Obviously, the first thing to do would be change the pricing structures. If we are relying substantially on solar power, for example, we want to tell people to heat their hot water up in the day time and not at night time when there's excess power. Looking at pricing policies more generally as part of the story, we can look at storage, we can look at gas peaking, and, finally, we can look at expanding the (indistinct) so that we spread the load more generally.

There's a wide range of options to deal with the fact that we're talking about systems with very different supply characteristics to the one we have, but I think a crucial mistake made by many of the advocates of nuclear is to believe the system we had for coal has the ideal generating characteristics and therefore the most desirable technologies is one that replicates coal. The most desirable ones are spatial technologies like hydro and gas that can be turned on and off cheaply to meet demand, not either coal or nuclear which need to run continuously even when there isn't demand, and obviously, solar and wind, the problems with those are well known, but I think a conceptual mistake made very consistently in the advocacy of nuclear I've seen is to imagine that 24 hour availability without easy capacity to ramp down is a desirable characteristic rather than a limitation of a power source.

MR JACOBI: There were many, many things in the answer you've just given, and I hope we can pick up as we go along with the next quarter hour or so. The first is this issue of pricing structures.

PROF QUIGGIN: Yes.

MR JACOBI: I'm just interested to understand the sorts of pricing structures that you think we might expect to see develop in Australia over the course of the next 15 years with electricity.

PROF QUIGGIN: We have, of course, the technology now, but we've unfortunately not done a great job in terms of social licence of introducing time of day measuring, Victoria, in particular, unfortunately made a mess of it, but the obvious point is that our peak demand is in the late afternoon, but we don't have the pricing structure that reflects that. Indeed, solar is actually well suited, we have sensible pricing structures, solar panels on western houses rather than the north, but the pricing structures we have, have encouraged mislocation because essentially that would encourage you to optimise with

respect to generation rather than to matching demand, so it's an obvious shift which we could make overnight that would substantially increase the efficiency of rooftop solar PV as a technology of choice and, of course, (indistinct) that's the kind of thing to have in mind, in particular.

MR JACOBI: So the idea is to, in essence, diminish total output from the solar system but essentially deliver out at times of higher value?

PROF QUIGGIN: That's right.

MR JACOBI: We've heard some discussion of capacity based pricing from grids. Do you have a view with respect to that?

PROF QUIGGIN: Obviously, if we're going to have reserve capacity that's one way of financing it. As I say, it seems to me that correctly done this would favour gas and hydro rather than, if we did it correctly, all the (indistinct) capacity. In principle, unlikely a lot of jurisdictions, of course, the market is supposed to reward capacity. If we have a price to put up, $10,000 a megawatt hour, if you have power available at that time you can get what is in fact a capacity payment, so a lot of discussion of capacity payments is drawn from overseas systems which don't have any in principle capacity, so it's less clear that we need it here, and I think it's unlikely that it would be a major factor in relevant economics of coal and nuclear because what we're looking for (indistinct) capacity.

MR JACOBI: We've dealt briefly with base load, and I'm interested in understanding the extent to which the base load demand that does appear in load curves is a product of the pricing structure.

PROF QUIGGIN: In my view, almost entirely so I think there are special cases which are typically artifacts of special pricing deals, like having new power plants. We built a bunch of those in various jurisdictions in the 1980s all with special supply deals, but they're an isolated case and we've seeing the departure of most of the Australian (indistinct) plants from competition from China, but that's really largely separate from the typical cases being a dedicated power line and power station (indistinct) in Victoria. Leaving that aside, in my view, the great bulk of demand we see is an artifact of pricing in the sense that if we had pricing suitable to solar, for example, so power is expensive during the night, I think we would see hardly any demand at that time. We would see very few industrial processes bothering to incur the general extra costs of 24-hour operation if it weren't that they had access to cheap power at that time.

MR JACOBI: Do you see there being, aside from aluminium, other plants where they're energy intensive but there is a value with high capacity utilisation other than aluminium?

PROF QUIGGIN: I should say I'm not an expert on this, but I think the crucial edge of aluminium is the nature of the hotline process means that turning it off night is very expensive. As far as I'm aware, we don't have many other activities where that's the case. Typically, it's expensive to run a night shift, you know, typically unless you have the incentives provided by cheap power, I don't believe we would see many 24-hour industrial processes going on. They would have to be not only electricity intensive but also highly capital intensive, because otherwise you just use the electricity when it's available and, in fact, that happens later on at night which is, of course, what happens in the vast majority of the manufacturing sector, and of course retail and domestic demand, of course all those things drop to minimum levels in the morning hours.

MR JACOBI: You touched upon it earlier and you spoke about the installed battery, in-home storage technology - - -

PROF QUIGGIN: Yes.

MR JACOBI: - - - and you spoke about that interrelationship to the pricing structure we have in Australia. I'm just interested if you could explain your view as to how the Australian pricing structures favour the deployment of that sort of technology.

PROF QUIGGIN: Sure. In my view, we've seen further mistakes made in pricing policy in recent years, essentially designed to discriminate against solar rooftops, solar PV, so we're now looking at a situation where - - -

MR JACOBI: Sorry, can I just get you to - - -

PROF QUIGGIN: Sorry.

MR JACOBI: - - - go ahead and explain that in terms of - are you talking about the feed-in tariff prices?

PROF QUIGGIN: Yes, I am. So the feed-in tariff gave overly generous returns to solar feedback into the grid. In my view, the tariffs to replace them have over corrected that, so owners of solar PV are being penalised compared to other suppliers of electricity to the grid essentially because the regulators have taken views favourable to those support matters. The result is to provide a very strong incentive to home consumption, you can get less than the full price for putting electricity in the grid while you're paying the higher retail price for taking it out, and so you can pay three or four times as a new supplier and new installer of solar PVs (indistinct) being part of the existing (indistinct) tariffs are a huge incentive to consume your own generation, and so that, I

think, is higher in Australia than anywhere in the world, which we have some of the highest distribution charges anywhere in the world and some of the less favourable feed-in tariffs going. So that produces a very strong incentive for storage under carbon emissions.

MR JACOBI: We've touched on other pricing structures, capacity-based, time-based for use. How do you see there being an optimisation? You talked about there being this - it's gone from a situation of overpayment, in your view, to one of underpayment. What do you see is the optimal result?

PROF QUIGGIN: Well, in my view, if we moved to time-based pricing in general, we would have much more sensible incentives facing households in terms of the way they structured their demand. It's important to remember that although the regulators have come down very hard on solar PV, airconditioning is really the thing that's most distorted by the current pricing structures. We really don't pay any premium views in airconditioning when it's contributing most to peak demand. So all of those things would be much more efficiently done if we had time of day pricing.

And I think compared to capacity pricing, we're much closer to achieving it. We only really need a decent political push, some good sense in terms of the way metres are installed and paid for, and some degree of concern about the inevitable cases of - particularly cases who are hurt by changes in pricing structures. But even if we move to offshore pricing structures of time-based pricing, I think we would achieve a lot in that way.

MR JACOBI: I'm interested in the optimality of the pricing for the supply of electricity by essentially home owners that have solar PV systems. Do you have a view that they should, in essence, be generators that feed into the market and are priced accordingly as well, or do you have a view that there's some version of that as opposed to the fixed price that they get from retailers?

PROF QUIGGIN: So in my view, and I'm not an expert, but my understanding of the way that it's developed is that, in fact, solar PV suppliers, unlike remote generators, are taking load off the distribution grid when they feed back into it; that is, they're supplying power to nearby houses. If we look at the reasons for the huge increase in the cost of the grid, a large part has been upscaling the local part of the distribution network to cope with more peaking demand arising from airconditioning and greater demand for reliability associated with home computers and things of that kind. So it's my view that, in fact, the correct price for solar, the correct feed-in tariff would be above the pool price, allowing for a reduction in distribution cost rather than at or below it, which we're seeing in current determinations.

MR JACOBI: You mentioned gas, and I think we'll ultimately come back, I

think, to where we started to transition pathways, you mentioned gas in your answer in respect of the optimality of the peaking supplies. Prof Garnaut, when he gave evidence, expressed a view, his view that he had expressed I think back in 2012 at the time of his second report where gas would be very important, had been affected by recent experiences of increased gas prices in Australia, and future, and he expected maintenance of those prices at those levels. Do you see that being a factor in your analysis with respect to gas?

PROF QUIGGIN: Well, it's relevant. I think if I have the answers correct, the opening up of effectively Australia's world market has eliminated an artificial advantage of gas in Australia, but it's still my view that the supply characteristics of gas are ideal, and it's important to note again that existing policy, which is basically now only the renewable energy target, discriminates against gas.

So one of the options the Climate Change Authority is looking at is a low emissions target, which, among other things, or at least in principle, allow for nuclear, which would effectively treat the fossil fuel as not on the basis of whether they're renewable or not, that isn't really a concern, but on the basis of how emissions intensive they are. That would give gas a much lower requirement to offset itself than black or brown coal.

So we are seeing under current structures in which we're relying much more on the renewable energy target than on carbon price, we are, in fact, unfairly handicapping gas as a source. So if that were removed, either moved to a substantial carbon price, one which by redesigning the renewable energy target, gas as a transition fuel, as a peaking fuel, but I think proved again. The authority is looking at a bunch of different scenarios in procedural commission, but obviously I'm not speaking on behalf of the authority, but that's the kind of picture that we seem to be looking at.

MR JACOBI: I can understand how that would work with a market price carbon in terms of the fact that, in the end, gas's position would reflect its actual emissions output. How is it that a - perhaps to call it a low emissions energy target or clean energy target, could accommodate technologies with different greenhouse gas emissions - - -

PROF QUIGGIN: Well, yes, so essentially the current thing is buying it, if you're non-renewable and you have to buy a renewable certificate for each megawatt you generate, and perhaps (indistinct) if we said that the state - taking gas as the unit of that compound station, had to buy twice as many certificates and brown coal had to take three times as many certificates affecting carbon emissions, this wouldn't affect the carbon price for electricity.

So, in fact, in my commentary on the renewable energy target, I would make

the point that, in the absence of adequate carbon price, even the highest level it reached under previous government was still well below what's (indistinct) the renewable energy target acts (indistinct) carbon price. If for political or other reasons we wanted to use that as our instrument, we could refashion it so that the electricity sector, it effectively replicated the operation of carbon price.

MR JACOBI: You referred, I think, we discussed the modification of (indistinct) as a possible option. I noticed in a media release released by the Climate Change Authority that it's to report, I think, in May of next year on a range of possible transition pathways. I don't want to forecast what's going to be in the report, but I'm seeking the sorts of broad themes that need to be considered as part of that sort of analysis in your view.

PROF QUIGGIN: Yes, well, again, just speaking for myself, the obvious choices are essentially the kind of technique - a purely price-based policy, a purely renewable energy target policy with something like the existing scheme and without having been effective in the context of the non-covered sectors, more direct action types of policies, using that term literally, things like vehicle fuel emission targets, that's outside our sector, but, well, potentially not, of course, because electric vehicles are a major part of the potential story and could help to offset the - could help to manage things like time variation supply. So that's direct action in the ordinary sense of the term; of course, it's now used to include more to an option-based, subsidy-based scheme, which is another kind of price-based policy. Those are possibilities.

Buyouts for coal fired power stations I think are one of the elections, what we'd look at, more intensive promotion of energy efficiency than a range of possibilities we could look at on the assumption that (indistinct) a carbon price (indistinct) in the short run, and also because there are many limitations on price mechanisms, which although they don't appear in the simple textbook, once you start having a view of the policy, you see that they don't (indistinct) as quickly or as simply as you might hope.

MR JACOBI: I was actually interested in coming to this in terms of the – starting at, one, from a market price for carbon in terms of driving or shifting the cause in closures of particular plants and, on the other end, making payments. Is there a range of strategies that are sitting between?

PROF QUIGGIN: Well, there certainly are a range. I mean, depending on how we structure the electricity market, of course, we would see renewables with zero margin costs driving out other sources in the market. So if we wanted that goal we could certainly tweak the operation of the electricity market. The constant theme, unfortunately, is that not only has it been badly designed itself but even though the National Electricity Market virtually coincides with the summit, the design has paid no attention at all to greenhouse

gas issues and built nothing into their design that's in any way helpful to the operation of such a system. Undoubtedly, we could change the operation of the electricity market in a way that pushed competition in that direction.

MR JACOBI: Perhaps we can finish off. Do you have a view about the role that nuclear might play in other countries in terms of stepping outside Australia and the issues that we addressed with the Commissioner at the commencement about the extent to which you think nuclear might form a role and play a role in terms of delivering other countries' commitments?

PROF QUIGGIN: In general, my view has always been there should be more strategies. I think looking at the evidence 10 years ago you would have favoured, in the absence of deliberate changes to carbon perhaps from storage and nuclear power as two of those policy technologies, the evidence in the last 10 years has been very discouraging for (indistinct) from storage and quite discouraging for nuclear. So I think if we got some favourable suppliers on the cost side, if the Chinese and UAE plants go ahead and don't run into the kind of difficulties we've seen elsewhere, then jurisdictions could have the capacity to take the kind of top-down decision processes that those countries have. It would (indistinct)

I have to say that the current technological trends haven't been – even in countries like China, they haven't really been such as to favour nuclear. We've seen, compared to, say, 2010 before Fukushima, we've seen a scaling back of Chinese nuclear and a dramatic expansion of renewables. Of course, while (indistinct) experience in various ways, almost certainly it's going to imply a requirement for more expensive safety mechanisms which are in place that were considered acceptable in 2010. That of course adds to costs. That depends a lot on how you are going to (indistinct) operators.

It certainly is a possibility but I think, as I say, you need very specific conditions to have – if we look at nuclear as an economic option, we've only really seen one well established success in the 1970s, one potential success, China now. We may see some others but everywhere else either the economics has been bad or, as we've seen in the Soviet Union, the economics look good until you took account of the failure to put in the necessary safety procedures.

COMMISSIONER: Professor, thank you very much indeed and thanks for coming in on your holidays. It's much appreciated. Adjourned.

MATTER ADJOURNED AT 2.43 PM UNTIL
TUESDAY, 29 SEPTEMBER 2015