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 confined 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 Roxby 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 (pause) 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 SAMPSON: Yes, and artesian so you can actually get some aquifers, some areas which have fractured rock aquifers that are artesian in pressure, yes.

MR POWER: 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 RATES OF FLOWS.

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 basins, perhaps as a comparator to the fractured rock and we could perhaps come back. I'm not sure the slide is working.

MR POWER: 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 the 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 there, 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, the southeast and 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 sediments 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 the 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 water 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 salinity 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 the Prominent Hill mine. Then if we go further to the west, we've got what's called the Officer Basin and the Eucla 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 that 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 them is salinity. Is there any general underlying identifier, does one more typically find saline water at particular depths?

MR POWER: We can move on to 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 as salty as 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 getting 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 like 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 supporting 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 aquifer material is.

MR JACOBI: I think that might lead us into the next question, which is an issue of actual natural 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 Lofty 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 its salinity 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 surficial 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 annual 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 Mallee. 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 once - 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 need 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 in management to actively manage it. 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 on different networks and you can download a wide variety of information, including all the water level salinities, how the wells constructed, water chemistry information.

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

MR SAMPSON: 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 we 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 slide 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 our 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 came 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 the value of it is less, 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 POWER: 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. We'll 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 understanding it's got potential for coal seam gas and shale 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 a lot of 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 good 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?

MR POWER: 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.

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

MR SAMPSON: So it's all shared.

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

MR POWER: 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.

MR POWER: 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 THE Arckaringa Basin 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.

MR POWER: 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 ecologies 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 the Roxby Downs 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 to actually influence 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 from time to 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 - - -

MR POWER: Explain what PEPR is.

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

MR POWER: 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 mine dewatering, slide 19. I'm just wondering if you can give us an interpretation, particularly - I think it's another of our 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 the end - 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 mine 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 2017 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: Normally 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 in situ 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 alkaline solution, 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 ISL mining 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 POWERS: 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, ISL again 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 specifics.

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 talk about their specific role there.

COMMISSIONER: No, that's fine.

COMMISSIONER: My final question, I want to go back to the Mound 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 Topale 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]