

Botany Bay Forum

University of NSW (UNSW) – Morning Session

Speakers

Chairperson: Bruce Thom
Speaker 1: Rory Hume
Speaker 2: John Black
Speaker 3: Jim Colman
Speaker 4: Alberto Albani
Speaker 5: Jerzy Jankowski
Speaker 6: Noel Merrick

Chairperson: **Bruce Thom**

The Studies Unit at the University is now in a sort of reinvigorated mode and today's meeting, of course, is designed to continue the momentum that is now with the unit with the appointment of John Black. It's also a very opportune time because, in Government circles at the moment, there are major changes as to the way natural resources, in particular, are being managed and the opportunities that are being presented to universities and to groups, such as represented by the Botany Bay Studies Unit and similar groups in other universities, are there for the taking, and has been working with your Pro Vice Chancellor Research and John and from other universities in trying to provide the opportunity for universities to be closely linked to these new entities that are being created, these new catchment management authorities. There will be one for the metro Sydney area from Port Hacking to Pittwater, and the opportunities of groups like this to work with this emerging authority will be tremendous. I hope that from today's meeting we will be in a position to take to Government some ideas, some various thoughts that you find important and relevant for the betterment of the environment of Botany Bay.

It is now my great pleasure to introduce to you the Vice Chancellor of the UNSW, an old colleague of mine from Sydney University days, Professor Rory Hume.

First Speaker: **Rory Hume, Vice Chancellor**

Thank you Bruce, what a distinguished moderator for the morning. We are very pleased to have you here. On behalf of the University, I am very delighted to welcome you here. It is very appropriate that the University of New South Wales is hosting the launch of Botany Bay Moving Forward 2004 and I am very pleased that there are so many people here from State and Local Government and from the general community to take part in what I am sure will be a very productive days work.

The UNSW is, in one sense, in the heart of Botany Bay. We're part of the catchment. We're part of the area. We're part of the local political environment and there are many people at UNSW who care deeply about that environment and who care deeply about Botany Bay. As you know, UNSW has many strong initiatives related to environment and sustainability and we will continue to enhance those things. One of the strong desires among the campus that I find, and it certainly matches my own, is to enhance and to augment and build on the great strengths that we already have in environmental and sustainability issues. Concern about very local environments, such as Botany Bay, is extremely appropriate and well-aligned with our institutional direction. We do contribute to local community sustainability activities. We've got a good track record in that regard. We've had quite a major effect on the seaside aspects of our local environment and we already contribute to Botany Bay. We will continue to do so in the future.

The catchment area of Botany Bay is an iconic place for Australians of all origins and backgrounds. There are a number of very important historical features, and Norm mentioned some of them. I had the – 'pleasure's' not quite the right word - the illuminating experience of reading a book called 'Dancing with Strangers' by Ingrid Clendinan, which used as its basis all of the historic material that she could put together from the first two years of contact between the Europeans and the indigenous Australians in this area. A lot of it was about the traffic back and forth between the settlement at The Rocks and Botany Bay. Norm's words were very well aligned with the way that she - she certainly looked at the European invasion in a fairly cold light. The Europeans, who first came, of course, didn't particularly want to be here – but talking about the difficulties that developed as there was a pressure of population, really, on a fairly small but very important area of land, a very important hunting and gathering area.

We've been messing around and really destroying a part of our ecology for more than 200 years, and Norm's words about hoping that the next 200 years will be better than the last, I think, are very well founded. The poem was superb. Was it yours? Yes, well publish it, because it's very very good. Norm and I go back longer than - we were surprised to know that we met many many years ago at a strange circumstance, but I won't go into that.

I know the New South Wales Government is strongly behind protection of features in Botany Bay. There have been a number of studies and UNSW has contributed to them, but it is the site of first contact between Indigenous Australians and Europeans, or the people we call settlers, with a range of diverse and distinctive lifestyles. The place is extremely important to Indigenous Australians, as Norm has explained, but it is also from the point of view of the natural environment, a very important part, as Norm's poem illustrated, of the local ecology for fish, birds, animals, plants and we have a great responsibility to look after it. It has also, of course, become the centre for trade and tourism and industry and we have to work out ways to look after a very important piece of environment with all of those pressures on it.

To build on the information we have, to inform decision makers and policy makers, to bring together science and policy is what I believe that you are here to do, and I wish you well in doing it.

Two years ago, UNSW established the Botany Bay Studies Unit. Professor John Benzies assessing research need that one of the things we can do, education and research are the contribution that universities like ours make to public policy. The work of the last two years has culminated in today's workshop, which aims to bring people together to establish networks and to help shape research programs and policy priorities. David Ledlin who is here today and his group from the New South Wales Department of Infrastructure, Planning and Natural Resources, and the Sutherland Shire have worked to bring many of you here. The Shire worked hard to get the local community to know what was going on and contributed to efforts to publicise this event and we're very grateful to them for that.

Professor Alberto Albani from UNSW's Faculty of Science is currently sponsoring the Botany Bay Studies Unit and the Faculty of Science has just produced a new website. The new Dean, Mike Archer, is extremely committed to environmental and sustainability issues. I'm confident that he will add substantially to the good things that we already do.

I wish you a very enjoyable and productive day. I regret that I can't stay, because there are several conferences on and I have to dash to another to open it in a moment - not that I'm opening it, I'm welcoming, I guess. I'll open it too. I'm always happy to do so. I regret that I can't be with you but I do wish you well in what is a very important local issue but one which will have broader ramifications for how in Australia we behave and how people around the world behave related to the environment. Thanks very much.

Chairperson: **Bruce Thom**

Thank you very much, Vice Chancellor. Your words, I think, really do set the scene for today, along with Norm's poem, and I hope Norm's poem does get published, too.

The Botany Bay Studies Unit, from my point of view, has been reinvigorated by its new director, recently appointed, John Black, who, of course, has had a long association with UNSW, but still brings to the Botany Bay Studies Unit and the University and to the broader Sydney metro region, I might add, a wonderful cross-section of ideas and backgrounds. With his backgrounds in geography and engineering he must be very well equipped to handle a lot of the issues that confront the region. Without any further ado, John Black.

Second Speaker: John Black

Thank you very much Bruce, Vice Chancellor. Ladies and Gentlemen. If you have a passion for independent science, if you have a passion for the Botany Bay region, if you have a passion to try to develop better, longer-term, more sustainable outcomes, then please join the Botany Bay Studies Unit.

What are we at the University? We are no more than a loosely organised network of people who have research skills - relevant research skills - to tackle enormous challenging problems that speakers have already said to us this morning. I'll explain in more detail as the day goes on how that network is going to operate, but it is important to recognise, as the Vice Chancellor said, it was established two years ago and a number of people have had important influences into trying to shape a research agenda into multi-disciplinary aspects associated with Botany Bay. Our previous director, John Benzie, spent a lot of time, as did a colleague from Sydney University, Tony Underwood, who is here today, in assisting government shape research needs.

The person who is going to follow me who is also with the Botany Bay Studies Unit has helped shape the research agenda, will be Jim Colman. You will hear some of the specific ideas that Jim has. He's spent a lot of time researching in this area.

When we get on to the workshop, on the table you'll see what have been identified by the Botany Bay Unit as a number of research priorities. There's four of them. These didn't just happen overnight. There's a group of 24 stakeholders from Government, local community, NGOs - and their names are all listed on the table that you'll see when we get on to the workshops - and these people have considered over the time what their views of research priorities are. The purpose of today's workshop is to try and build on those ideas, to try and move forward and to try and shape up what that research agenda should be.

I'm delighted to see so many people here. Our original design was, perhaps, about 40 people. We are going to have difficulties in trying to manage the workshops and the reporting and some of you are going to come away a little bit frustrated, perhaps, at the end of the day, when you haven't had a chance to say everything you wished to. Don't worry about that, because we have a new website and on the website I'm committed to putting a report of this workshop posted, hopefully, by April and I want to give everyone an opportunity to add value and provide further input onto that draft report. So today is not the end of the story, it's just the start of a process.

Ladies and gentlemen, thank you for trying to co-operate and help shape the research agenda for the Botany Bay Studies Unit. I'm looking forward to talking to you individually as the day progresses and in the workshop environment, looking forward to hearing your views.

Chairperson: Bruce Thom

Thank you very very much John. I'd like to call on Jim Colman - John made reference to Jim. Jim's had the wonderful opportunity over the last few years of working in Botany Bay in a very intensive way, stimulated by the interest of SSROC and the Commonwealth Government support, working with the University, working with lots of stakeholders, conducting lots of meetings right across the Bay region and I had the pleasure of being involved even in this room some time back with Jim, who was trying to work very very hard to bring together the various ideas that had lead to the co-operation with this University. Jim, over to you.

Third Speaker: Jim Colman

Thank you Bruce and it's great to be here. I need to refer to a cup of coffee that I had back in December 2000 with Alberto, when I think the penny dropped, the seed was sown, the idea of getting a dedicated Studies Unit up somewhere in Sydney on an appropriate campus. As we have heard already, there's been a lot of progress and it's great to be here, John and Alberto.

I was also pleased to attend the Vice Chancellor's inaugural address last year when I listened very carefully. There were three words that he used that we need to keep in mind here today. I think he might have even repeated them a moment ago. An emphasis on inter-disciplinary research, bringing the social sciences together with the physical sciences. Second, involving the community, dealing with community issues, third, focusing all that work on a campus that is part of the Bay story.

Alberto asked me to produce a research overview. Thanks very much Alberto, that was a great invitation, but what you'll hear is something a little different.

I'd like to remind you what the current political context is for this workshop. Just before Christmas, the State Government announced an Upper House Committee of Inquiry into port infrastructure in New South Wales. That Committee of Inquiry is currently sitting. Just before Christmas the Premier announced that there was a *Ports Growth Plan*, a mysterious document which no-one could find until a fortnight or so passed and suddenly it fell off a truck. The third was the release of the environmental impact study for the expansion of Port Botany by the Sydney Ports Corporation. Next came the appointment of a Commission of Inquiry into the proposal for the expansion of Port Botany. Next came the winding up of the advisory committee which the Department of Planning set up last year to assist in developing a strategy for the Bay. The reports that the committee produced supported by quite a sizeable team of people in the department, are sitting on a desk somewhere in Macquarie Street and who knows what will happen to them.

The final point that I'd make in this context is that we are facing imminent Local Government elections. There are a lot of councils around this Bay with a huge interest in the future. Behind those councils are the communities. It's a pretty turbulent context that we're meeting in today, Bruce.

With those reminders, a few other points I think of relevance. Going back to 1998 when Sutherland Shire Council was instrumental in setting up the *State of the Bay Report* that was probably the first in recent years, to focus on the condition of this environment. The Botany Bay Program which I manage was launched in May 2000 and in December that year we had the first Botany Bay science forum. In July that year, as we've already heard, this University announced the establishment of the Studies Unit and so on and so on, culminating in today's meeting.

Questions about the relationship between science and government, bringing those two parties together. How can it be done? Most recently there was quite a chunk of scientific input into the work of the Department of Planning's strategy last year. One might well ask what has happened to it and what will happen to that work in the future? Overseas there are many precedents of great value and I think that the Studies Unit will benefit from connecting with some of those precedents. I'll mention just a couple. The Mersey Estuary in Britain, the Mersey Basin campaign, the Thames Estuary partnership, the Chesapeake Bay work in the US, the Massachusetts Bays program and, here in Australia, Moreton Bay. What is the secret, the missing ingredient in this Bay? I think the answer is a formal recognition, some kind of partnership agreement which links the science community with government and with the community at large. Science has the skills, government has the dollars. In a nutshell that's what it's all about. A partnership will be mutually beneficial. There'll be two way benefits flowing.

Here on this campus, the Studies Unit can be a vehicle for creating such a partnership, remembering that behind these successful precedents elsewhere you will always find a local University. In the Mersey, the University of Liverpool was one of the first institutions to put up its hand to help get the dimensions of the destruction of the Mersey River out into the open. University College London is a central agent in the Thames Estuary partnership. Likewise, in the States, the Urban Harbours Institute in Boston is a driving force in the Massachusetts Bay program. Moreton Bay – University of Queensland – and so on, and so on. There's a key role for a University. That doesn't mean a monopoly, of course, but it means a focus with all the robustness that a great institution like this can offer.

The matter of social responsibility within the science community is one that I'd like to just touch on briefly and because it may come up in the workshops. It's a contentious topic, but Bruntland in 1987 got to the core of the matter and I'll quote, "Scientists were the first to point out evidence of significant environmental risks and changes – this is globally – resulting from the growing intensity of human activities, identifying risks, assessing impacts, designing and implementing measures to deal with them." Here in the Bay, is there a collective responsibility within the science community? When individual players such as the Sydney Ports Corporation or Sydney Airport Corporation, make what, in their individual judgments, are rational decisions to benefit their futures, does science have a responsibility to look at the collective costs, the community costs, to society and the environment, or can science simply sit back and wait to be called? When a valued natural resource is threatened, do scientists have an ethical responsibility to put their knowledge on the table - the political table, that is - or should they wait passively for an invitation?

My hopes for the Botany Bay Studies Unit were spelled out in *The Tide is Turning*, which is the final report of the Botany Bay Program. Briefly to summarise, and John Black hinted at some of this already, to get a database established, a research library, a website. Second, to engage in bringing the disciplines together, and we're talking about the social sciences as well. On this campus is a very strong environmental presence in a number of faculties and departments, not the least being my old first degree place over the road in the old main building and now the red centre - architecture, planning, environmental work, landscape. To establish a focus for the sharing of knowledge and information around the community at large, and perhaps for running an annual or biennial State of the Bay event to keep people up to speed on what's happening - the progress and the pitfalls.

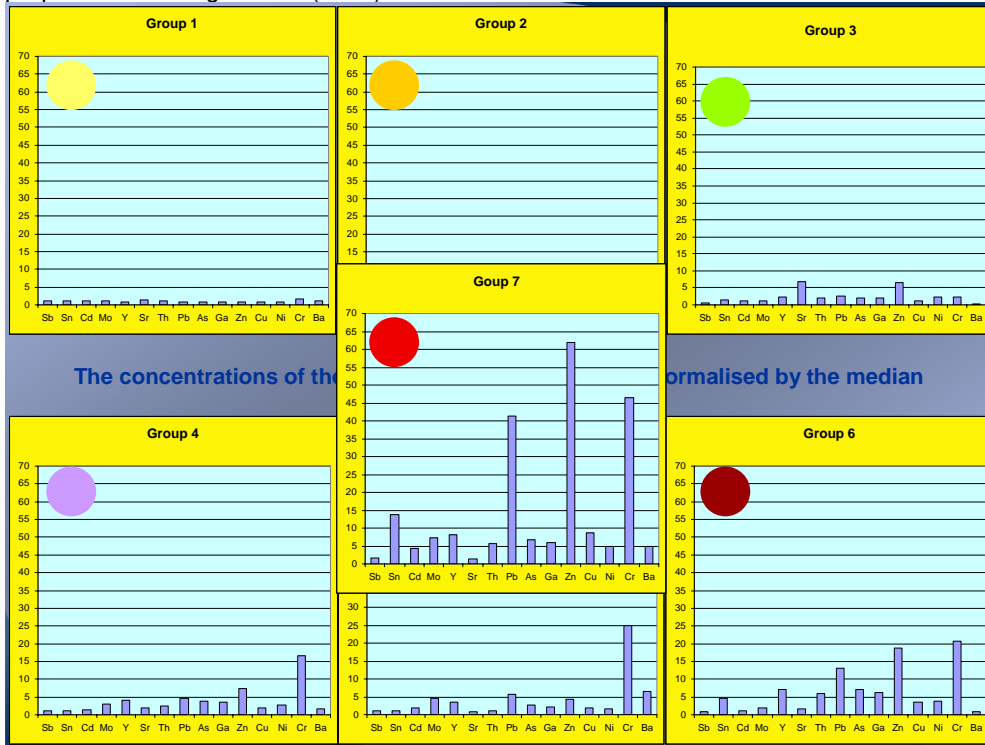
Community education is another area. We hear quite a bit these days about community science and if you want to get a really ding dong debate going amongst scientists, then you just put that on the table and away you go. Believe me, there are people out there – amateur scientists, fishermen, recreationalists – who know a hell of a lot about what's happening in the Bay. Their knowledge and information needs to be fed into the system. Liaison with all the Bay stakeholders is another role for the unit. Liaison with counterpart centres overseas, and I've mentioned a few.

Finally, chasing the dollars and the support. I have to admit that I'm not a great singer, but I'm just going to warn you about what's about to happen. From the current arrangements for managing the Bay and I acknowledge the huge influence of the Rolling Stones here - "I can't get no satisfaction" from the current arrangements for managing the Bay and if we don't get it right soon, well, "this could be the last time" we have a chance to build something great at UNSW. Let's go.

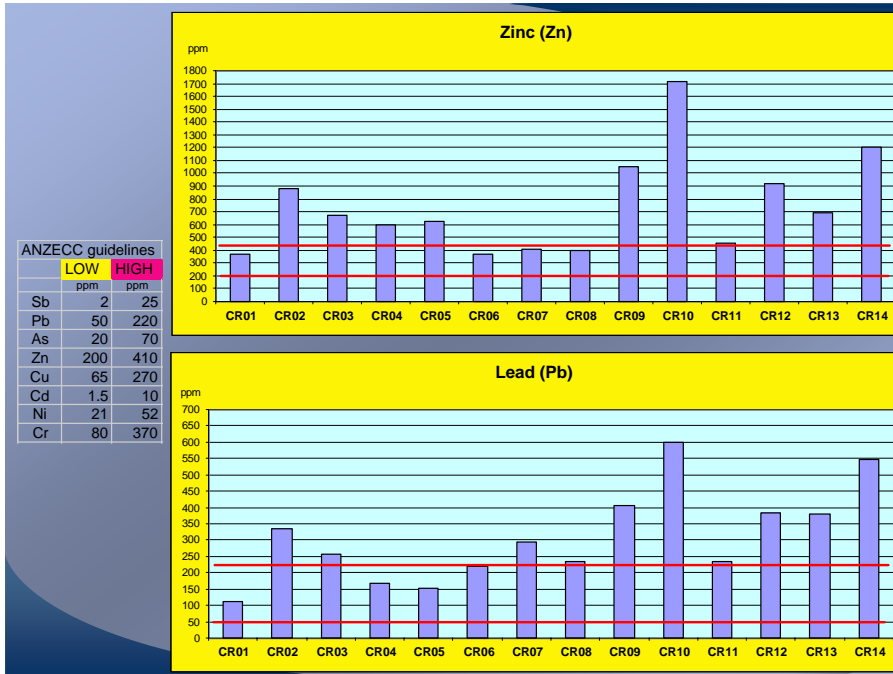
Chairperson: **Bruce Thom**

Ladies and gentlemen, I think we have to pay real tribute to Jim – not only his voice, I don't think he told the organisers that he was going to do that – but more importantly, and more seriously, his passion and his commitment to the Bay and the work that he's done over the past few years. I've had the privilege of working with Jim and seeing how he operates, how he networks, how he keeps things going and I'm sure he aint going to give up and I don't think any of us are going to give up and in the political mode, as I mentioned earlier - and it's very good to see Philip Sansom in the audience - the establishment of the new catchment

Let's go a little bit further. Let's look at the concentration of the various elements and we are looking only at the inorganic components, I have no data on the organic material. Don't worry about these different colours. It is reasonably homogenous. The only items I'd like to draw your attention to are the red colour and the dark whatever colour that is, purple, that stuff on the top. That is off Cooks River and is off the Georges River. Those are the items I'd like to illustrate to you and there are some of them that are present in the wetlands. Don't worry about all the details, it's not important. As you can see, the high quantity, let's say, of the different heavy metals, is relatively small. They are starting to be in group 6 which is that dark purple I was talking about. (Slide)



You may wonder why on earth, as a good scientist, I wouldn't enlarge the scale so that we can see something. I've done it on purpose, because the next group, which is this red group, shows that there are quite substantial changes. These are mainly in the samples that I collected from the Cooks River and, very quickly, we'll look at the sampling size – and this is only the beginning, there is a considerable amount of samples being collected in the next couple of months. What you can see is some interesting features. On the graphs there is the concentration. The two lines represent the low and high levels accepted by the ANZECC guidelines and you can see some of them are slightly higher than the maximum – as you can see for the copper. For the barium there is nothing because there are no guidelines available at the moment. There are anomalies that ought to be better looked at and investigated, particularly if that sediment is going to be disturbed due to dredging or similar activities. (Slide)



The last one is the basic ecology. I'm using a strange group of organisms of protozoans. They have a calcium carbonate shell. There are so many of them. There are a lot of different species. They allow us to look very carefully at their distribution. This is what they look like. They are quite pretty.

How is the work there? It is in progress and it is very very slow, I can assure you. For a good data set I need around about 100,000 pounds and I'm counting, but it takes a little bit of time. Where do we go from here? Those actually are the organisms that I used in the couple of sites on the Mediterranean Sea and repeating sampling after 20 years we were able to detect changes in the environmental conditions – either positive or negative changes – but they were quite indicative of changes in water quality.

Where do we go from here? First of all, finish the sampling. There are areas that I haven't looked at – Quibray Bay, Weeney Bay, Woollooware Bay. Those are the areas that are still under discussion. There are some more samples from within the Bay. Also, it is necessary to define the Bay environment from the lower Georges River environment and, therefore, when we are looking at the upstream end of the downstream end of the Georges River, this is the area that I'm planning to sample next - between the two bridges, Kogarah Bay and off Sylvania Waters area. That is the program and I hope I'll be able to complete it. Thank you.

Chairperson: **Bruce Thom**

One of the most difficult issues that the Bay faces is that associated with groundwater and our next two speakers will bring to us some of the really critical issues that the Bay faces with respect to its environmental future. I'd like to introduce to you Jerzy Jankowski and Noel Merrick to speak about the groundwater issues.

Fifth Speaker: **Jerzy Jankowski**

Thank you very much for the invitation to me for this workshop. I've worked with groundwater in the Botany Basin since 1989 – nearly 15 years – and my area of expertise is mostly water chemistry and contamination.

From my studies in the Botany Basin, northern part, north of Botany Bay, I find there is a lot of contamination, because the groundwater system is strongly heterogeneous. What does this mean? This means it's comprised of several different geological units, like silt, sand, clay and peat. There is a very close relationship between chemical composition of water and geological units. For example, if we had some clay and sand, we would have a high concentration of calcium and bicarbonate. If we have peat material, we would have a high concentration of metals.

What We Know

Botany Sands aquifer is heterogeneous geological unit comprising sand, clay, silt and peat and/or mixture of all of the above in different proportions

Close relation of hydrochemistry of trace elements and metals to geology, sedimentation and litho geochemistry in the Botany Sands aquifer (Ca & HCO₃ - shell material; SO₄, and metals - peat material)

Existence of more than 10 unlined landfills and many industrial sites in the Basin which have never been investigated with respect to water contamination

Release of toxic elements into groundwater and development of several leaching plumes across the Basin

We know that there are approximately 10, plus an unknown number, of unaligned municipal entities in the Basin and many industrial sites which never have been investigated, simply with respect to water quality, contamination or leachate bloom level. All these are a reason for different toxic elements from different leachate blooms across this Bay. We know very well that concentration of arsenic, selenium and chromium is very high in groundwater system and this groundwater later on is discharging into Botany Bay.

What We Don't Know

Background level of trace and metal concentrations in uncontaminated groundwaters in different lithostratigraphic units (As, Se, Zn, Cr, Cu)

Movement of shallow and deep leachate plumes from several unlined landfills and other contaminated sites and content of toxic elements within Moore Park and Randwick Racecourse

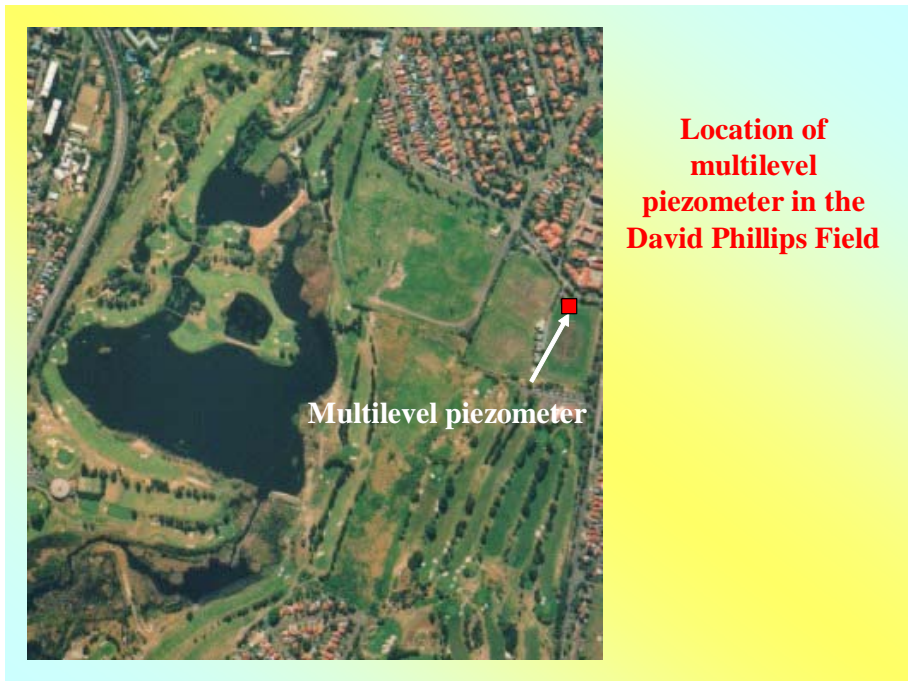
Impact of discharging groundwaters on water quality of ponds in Centennial Park and Lachlan Ponds

Release of toxic elements into Botany Bay from discharging groundwaters

Impact of discharging groundwaters on Botany Bay waters with respect to concentration of trace elements, metals and nutrients (organics from Orica site)

However, we don't know where this

concentration is present, how high this concentration is, if it is above or below water quality criteria and simply we don't know how many of these elements or what concentration is discharging into the Bay. We know that several leachate blooms from Randwick Racecourse which is producing a high concentration of nitrogen, nitrate and from Moore Park. We know that these discharging groundwaters later on are contaminating the surface water. This means ponds in Centennial Park and Chain of Ponds from Gardeners Road to Botany Bay. The critical issue is discharge of this groundwater into the Bay and the groundwater is carrying toxic matter, like arsenic, chromium, selenium, and others - as Alberto said - and evidence is from sediment.

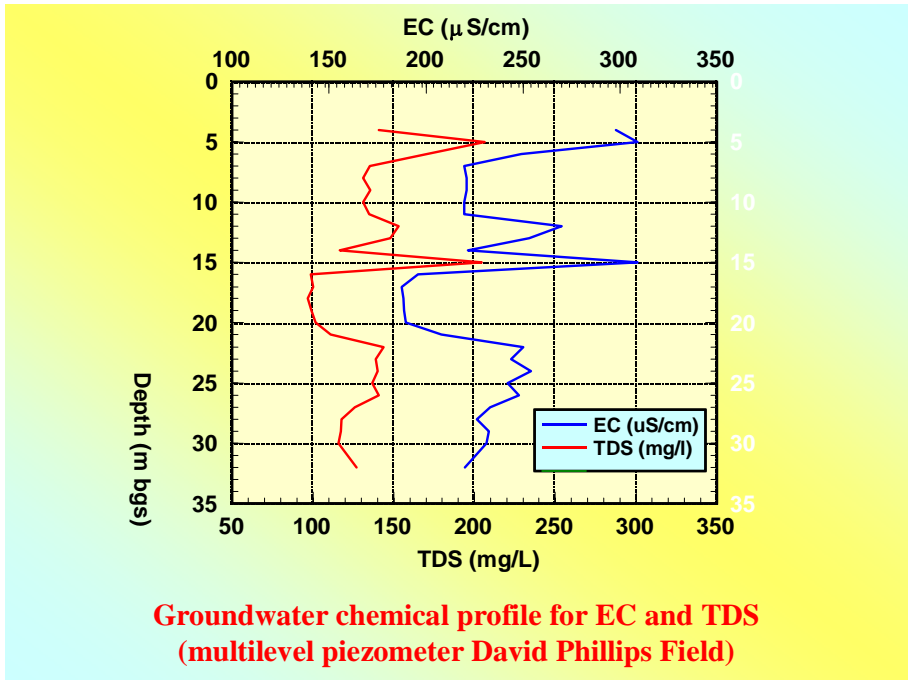


I will give you one example, and the example is from multi-level

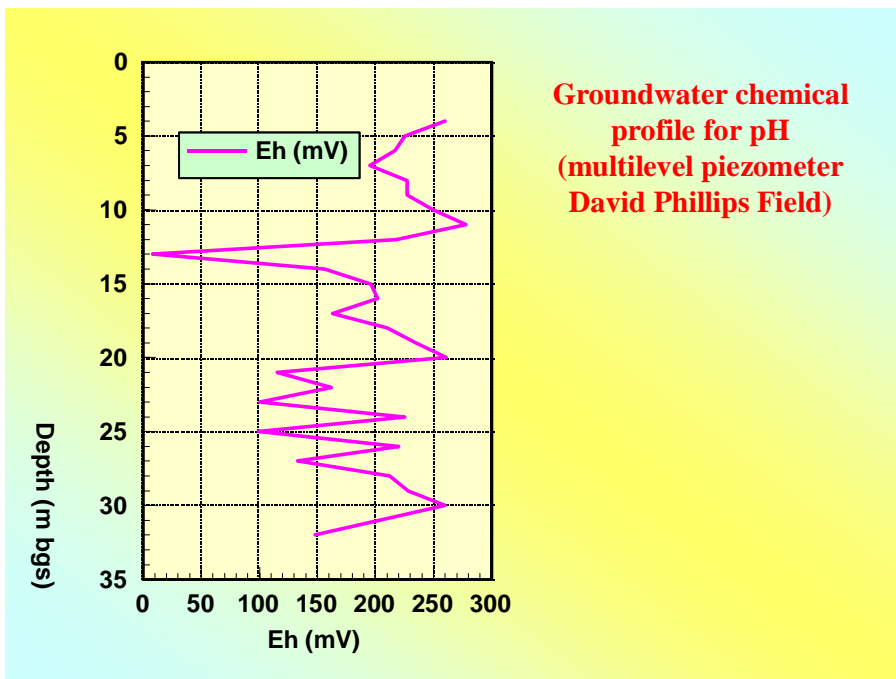
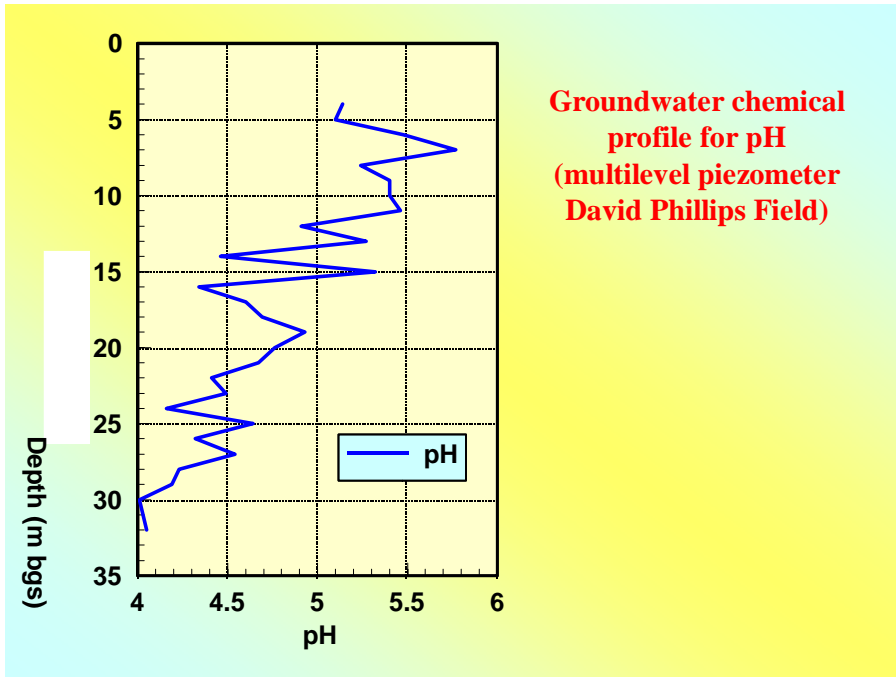
gasometer which is located at site A. It is up gradient from the municipal plant near site B, which is between this red point and the Pond no. 5 - it is down gradient. This multi-level gasometer has only one very detailed information about concentration of toxic matters across uncontaminated part of the Bay. You will be surprised.

With respect to electrical conductivity, you can see that it is very fresh water, but however there are some peaks and these peaks of concentration are associated with different

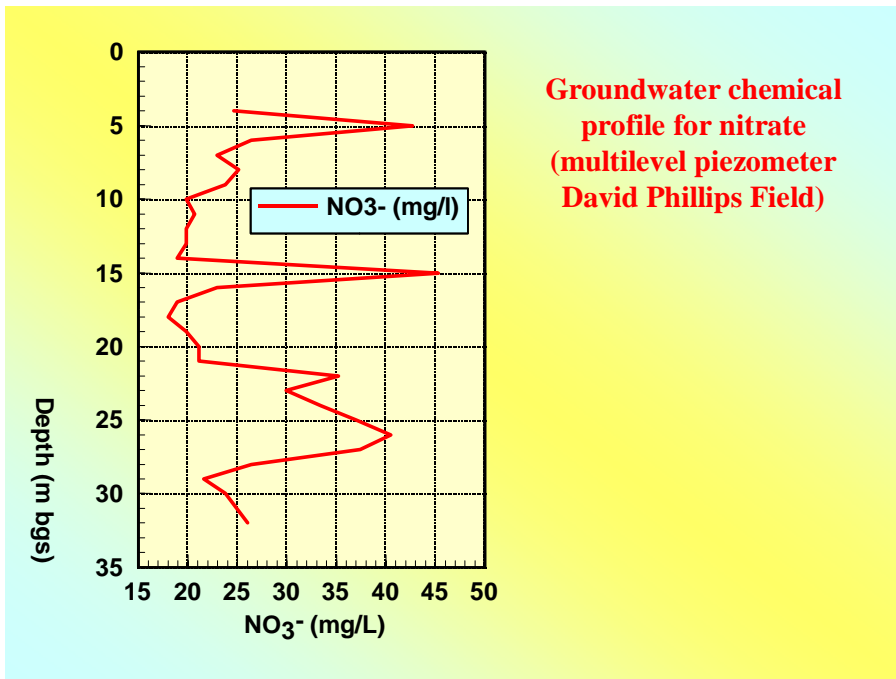
geological units.



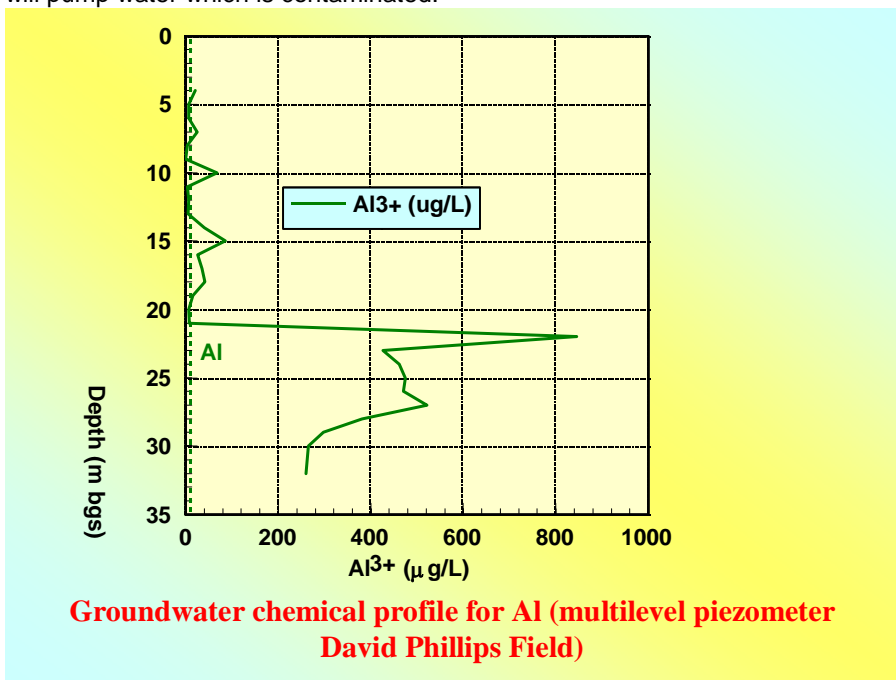
pH is significantly decreasing from the water level to approximately 32 metres below ground surface - six metres of bedrock - and water is extremely acidic.



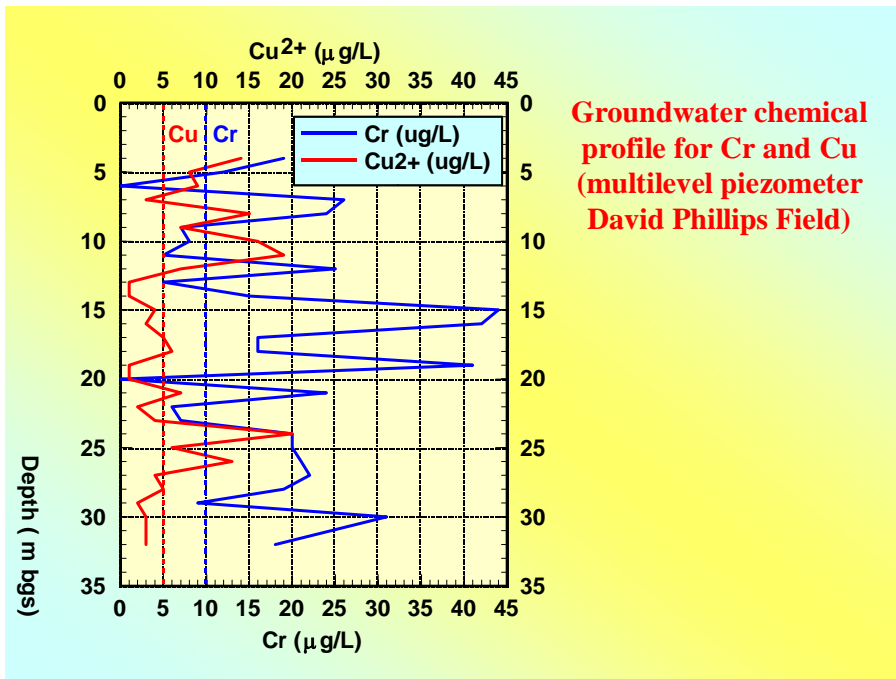
Water quality criteria for drinking water or irrigation is between 6 and 8 and we have here most below 6 and is approaching 4 and even below for the pH units. pH is showing very nice oxidised water and again variation only related to geological units. However, this is a surprise. Why? To have a natural environment high concentration of nitrate up to 50 milligrams per litre. You can think that maybe it is associated with geological units or maybe it is a leachate bloom coming from somewhere. We don't know. Maybe it is dispersed leachate bloom from Randwick Racecourse. It is only 2000 metres down gradient.



Next surprise – aluminium. Water quality criteria is 5 micrograms. We have more than 800 micrograms. If our well is located exactly between 20 and 25 metres or 20 and 30 metres, we will pump water which is contaminated.



However, it is naturally contaminated water - copper and chromium - and to have huge concentration of chromium in this natural system and chromium concentrations up to nearly 50 micrograms per litre and concentration up to 10 is for good water quality criteria. Arsenic and selenium in these waters are also elevated and well above water quality criteria.



What do we have to do? We have to investigate background chemical composition of groundwater and simply associate the distinct composition with different geological units. Never have any studies been done related to trace elements and minor elements, mostly heavy metals in the distinction between contaminated water and uncontaminated water because, if somebody were to collect the sample, and say it is contaminated water, but it is in a natural environment, there are not any contaminated sites around.

Specific Research Directions

1. Investigation on background chemical composition of groundwaters in the Botany Basin obtained from existing piezometers and wells in differing geological units (major, minor, traces and metals)
2. Distinction between contaminated and uncontaminated groundwater and the evaluation of fresh water resources
3. Assessment of degree of contamination across the Basin and movement of leaching plumes
4. Groundwater seepage into Botany Bay and chemical mass input to coastal waters
5. Impact of discharging groundwaters to Botany Bay water quality

Assessment of the degree of contamination in the basin. Very important seepage into the Bay and simply mask, chemical mask, input of toxic matters into the Bay and discharge of groundwater into the Bay.

Outcomes From The Projects

- 1. Determination of naturally occurring levels of contamination of the Basin (contaminated versus uncontaminated groundwaters)**
- 2. Delineation of contamination hot spots, leachate plumes, extent of migration and level of contamination.**
- 3. Assessment of volume of fresh water resources in the Basin.**
- 4. Determination of contamination in the Bay resulting from discharging groundwaters**
- 5. Why is remediation of contaminated groundwaters necessary: where, when and how???**
- 6. Establishing monitoring points where contamination exists, to assess the changes due to space and time**

What outcomes will you have from this project? The determination simply of these naturally occurring toxic elements and trace metals, the determination of hot spots and leachate blooms or extension of migration of these contaminated leachate blooms. Assessment of freshwater volume, which is simply available as drinking water or as irrigation water. Finally, what we have to remediate and when and how, because this site is not for remediation even if this site has very high concentration of heavy metals. Thank you.

Sixth Speaker: **Noel Merrick**

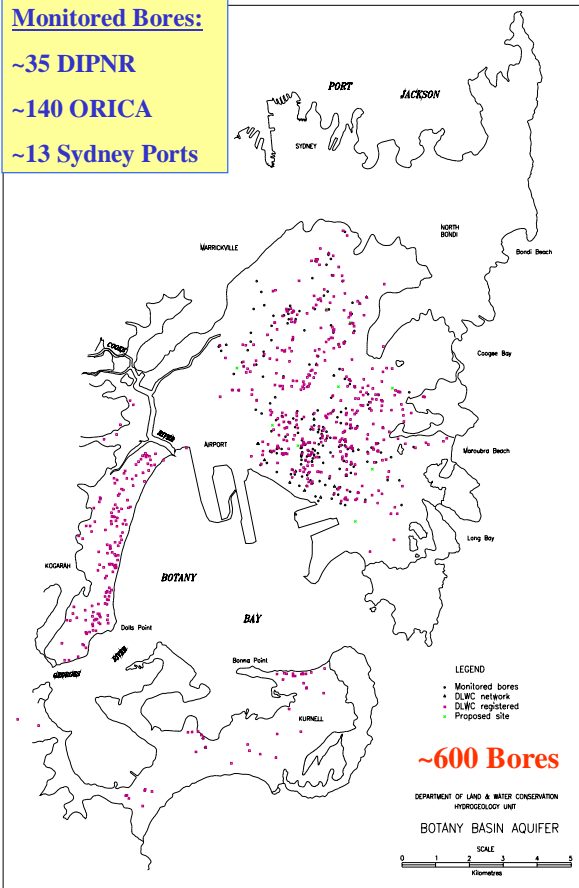
I'm from UTS. Thanks for the opportunity to represent an external University here. My connection with the area doesn't go back as far as Norm, but I can claim to have a connection that goes back to 1790, because my ancestor was one of those assisted immigrants who didn't want to come here in the first place.

I should say at the outset that the Botany aquifer is the only substantial aquifer in the Sydney Basin and that's been known for a long time. Groundwater has been used for more than a century for industrial purposes, for domestic use and for watering parks, golf courses, racecourses. Many other aquifers in New South Wales are suffering over-exploitation. Groundwater levels are going down. There are severe problems there. The Botany aquifer is not one of them. There is a state of dynamic equilibrium here and from a hydraulic point of view the aquifer is in good shape. It's the quality of the water that is the issue.

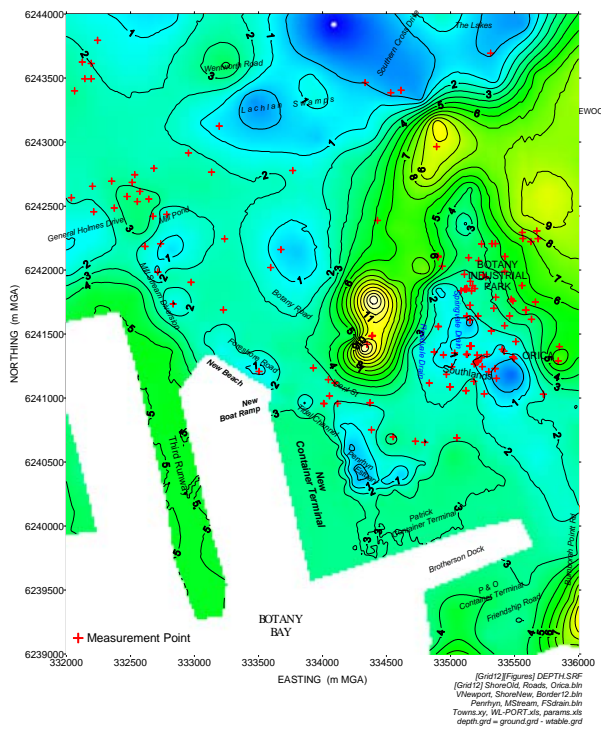
I plan to give you just a bit of a snap shot of the current status from a groundwater flow point of view. I'll put in a little bit of a comment towards the end on the contaminate blooms, but mostly stick to the hydraulics to show where the bores are, what's the rough depth to water table, a picture of the water table contours from which you can infer which way groundwater is flowing, what it looks like from a cross-section point of view, and what are the natural fluctuations in water level. That's important to place in context any impacts that might be caused by infrastructure projects.

Because the aquifer has a long history, there are literally hundreds and hundreds of bores that have been drilled here - about 600 all up that we know about. Most of those are lost, destroyed or vandalised. Not very many of them are being actively used for production any more. Particularly to the south there used to be a lot of groundwater production in the - when

I say south I mean the south part of the northern area where I've done all my work in the industrial area - there isn't a great deal of groundwater production from there anymore because of the quality problems. DIPNR are monitoring about 35 bores, Orica are monitoring about 140 and Sydney Ports 13.



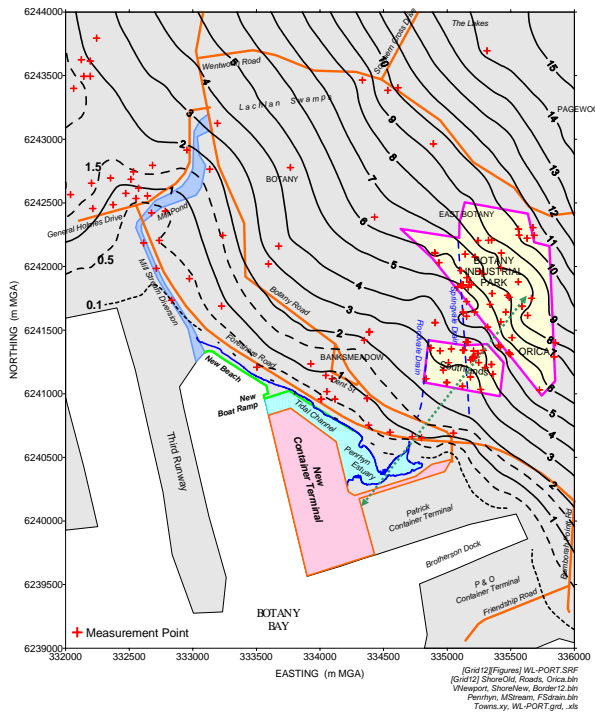
This is a partial map of the northern part of the Basin, just to give you a feel for how deep is it, the water table. The blue areas are around zero, 1 metre, so the water table is close to the surface in those areas and the green and yellow are the deepest areas. We've got a maximum depth there of the order of 11, 12 metres, but that's under sand dunes. Generally its a few metres down, but it can fluctuate substantially under natural conditions and I'll show that a little later.



Approximate depth to the water table (m)

N. Merrick, UTS

A map of the elevation of groundwater is much more important, being the depth of the water, because from this you can infer which way groundwater flows.

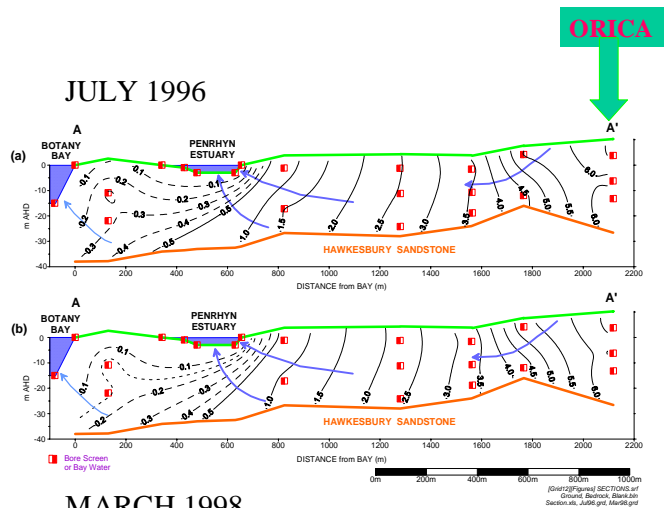


Water Table Elevations Measured in 2000-2002

N. Merrick, UTS

The simple rule is that - these are contours of groundwater level elevation, so groundwater flow is roughly perpendicular, normal, to those lines, so you can see that up in the northern part there is a strong groundwater flow almost westerly towards Alexandria Canal. There is substantial groundwater discharge to Alexandria Canal. Elsewhere you can see that the flow of water is south/south westerly with discharge to Botany Bay. There's an interesting area here, with this little closure. What's happening here is that we're getting groundwater outcropping, if you like, discharging where the Lachlan Lake system starts. As we come down the lake system - you can't see it at this scale - but there's a very strong interaction between the groundwater and the lakes, particularly because the lakes are dammed you have groundwater flowing into the lakes at the upper end, the more northern end of the dammed section, and you have the surface water flowing out into the aquifers near the dam wall. This interchange of water goes on all the way down to the Bay.

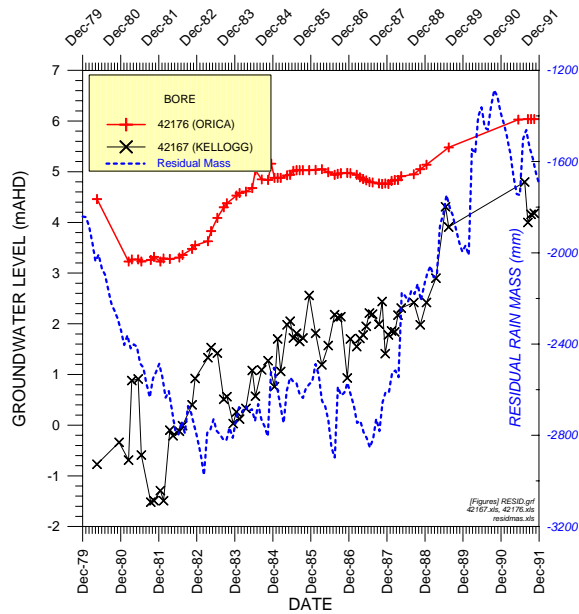
In cross-section, this is the lower part from the industrial area to the Penrhyn Estuary in the Bay and groundwater is essentially horizontal most of the time.



Cross Sections of Groundwater Flow on Line A-A'

You'll get vertical paths where recharge is occurring. What's interesting in this diagram is that most of the discharge along this line goes into the Penrhyn Estuary. It doesn't carry on underneath to go into Botany Bay. So the estuary will be capturing most of the groundwater flow in that section. That has ramifications when we consider contaminant plumes that are heading for that part of the Bay.

These are hydrographs, that is, variations with time of groundwater level at two sites.

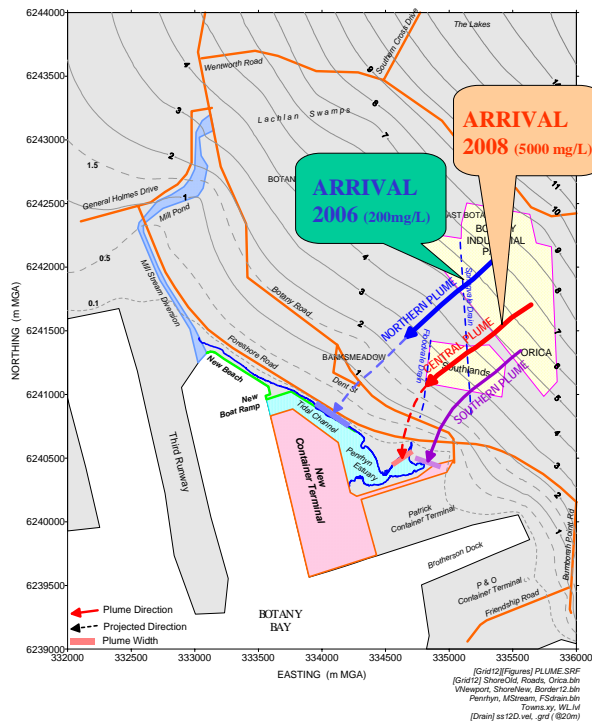


Water Table Variations over Time
- Correlation with Rainfall Variation

N. Merrick, UTS

The red one is on Orica land and the black one is on what used to be Kellogg's land. The point of the exercise is this is about a 10 year period. If you look at the red levels, 3 metres to 5 metres, you've got about a 2 metre variation. Some of that is due to a fairly heavy groundwater pumping in the 80s - much less pumping now - but most of it is natural. Most of it is due to rainfall. The dashed blue curve is a representation of the influence of rainfall. I won't go into the definition of it, but essentially we can say in this period conditions were very dry, we were in a drought in 1980, fairly stable climatic conditions from then on and then we went into a wet period in the late 80s and groundwater levels are coming up naturally because of this event. The black curve has gone from below sea level minus one and a half metres up to about four metres. We have got in the system a natural fluctuation of the order of several metres imposed on the water table.

Contaminant plumes. I'm sure everyone knows that these exist. The Orica site - we have three distinct plumes, northern, central and southern.



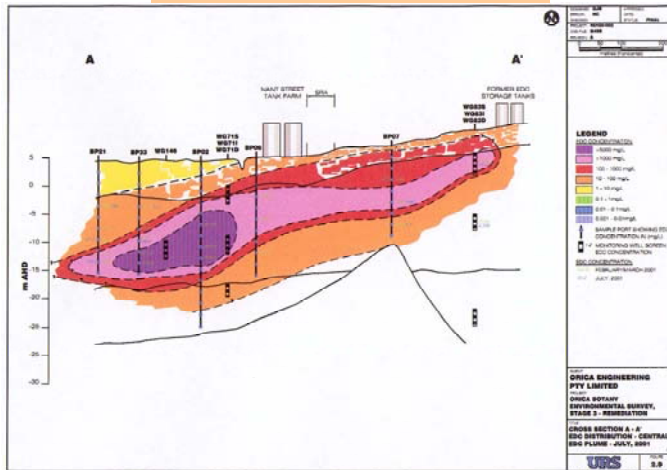
Contaminant Plumes

N. Merrick, UTS 9

The southern plume reached Penrhyn Estuary some years ago. The northern plume is expected to arrive about 2006, with concentrations of about 200 milligrams per litre of dichloroethanol. The main plume, though, the central one, which is expected to arrive about 2008 has pretty strong concentrations, 5000 milligrams per litre. These are just the axes of the plumes, the rough widths of the plumes are shown down here - a bit hard to see - a couple of hundred metres wide - and the solid parts are where we know they've been and the dashed parts are projections of where we think they will go.

In the cross-section of plume, the main plume looks a bit like this. This is the 5,000 milligram per litre material in the middle roughly around 15 metre depth mark and you can see that over time it has dropped down to the main aquifer. It is slowly moving sideways and also slowly moving downwards a little as well.

EDC PLUME at JULY 2001



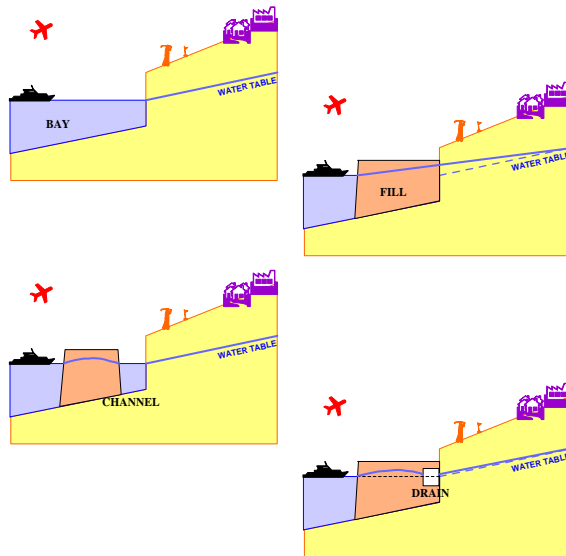
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Research themes. Impacts on the groundwater system of reclamation activities is an important one. There have been many changes in the shoreline over time and I'll show a little graph of that. Changes in groundwater pumping - what effect will they have? Will they cause subsidence, settlement of buildings, or will they cause water level rises that might have waterlogging effects and that sort of thing.

Infrastructure impacts. I've worked on all of these or the major infrastructure studies for the airport, the railway, the motorway and the current Port Botany expansion plan and also you might be aware that there is an EPA directive on Orca for pump and treat remediation and other forms of remediation, but the pump and treat is a hydraulic issue.

Just to show you what effect reclamation could have, with the natural system we have a water table that has a gradient towards the Bay.



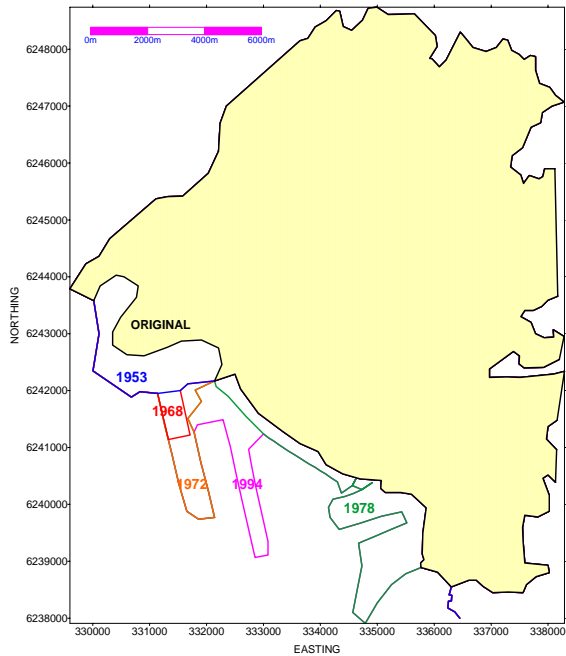
Expected Water Table Profiles
Following Reclamation, with
Mitigation Measures

N. Merrick, UTS

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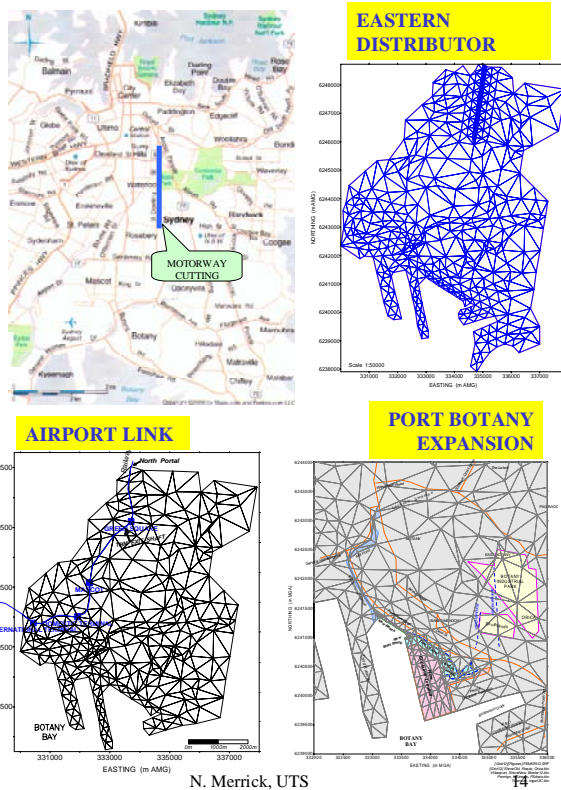
If we reclaim some of the Bay, the water table profile will then be flattened a little, because it has to reach the Bay at the zero point. That means that any land in this area would experience rises in water table. That's the simple principles. There are ways of mitigating that. If you preserve a channel in direct contact with the current foreshore, then the water table position is preserved, no water level rises inland, or if you do fill up to the current shoreline but have some kind of drainage you should be able to just about replicate the existing water table.

Just to show what reclamation has gone on in the past. This was the original shoreline.



The reclamation history of the northern shore of Botany Bay

This was Cooks River originally which got filled in when the airport was expanded and you can see the airport growth 1953, as planes got bigger 1968, 1972 the foreshore and creation of Port Botany 1978, third runway 1994 and now we have a plan for Port Botany expansion in this area. The hydraulic impacts in this area have been assessed by modelling. I don't want to go into that, just to show you that this is what the model designs look like to handle some of the major infrastructure. We don't know how much groundwater is pumped in detail. We know it's about 30 megalitres a day. That's about 20 swimming pools a day. We have very poor knowledge in the west and the south. There's really no routine on monitoring groundwater levels, except that being done by Orica. We don't have much of an idea on the importance of the vertical flow between different aquifer units. We don't have any idea on the importance of density on groundwater fluxes at the Bay and it's very important that the plumes that are heading towards the Bay, what effect will density mitigate that.



N. Merrick, UTS

To conclude with, research directions. I think the seawater/groundwater interaction is a critical thing, particularly with the groundwater plumes that are heading to the Bay. We really don't know what's going to happen when they hit. From a hydraulic point of view it's not so critical as the chemical point of view. What chemical reactions are going to go on? We don't have enough information on the lake groundwater interactions either and that's of importance for sustaining vegetation. Another research direction is the pump-and-treat exercise at Orica in just pumping out the right amount of water to minimise impacts. Thank you.

* Morning session cont'd on Session 2 Word Doc

End of Tape