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BOTANY SANDS AQUIFER, SYDNEY NSW

Aquifer:
A layer of soil or rock with relatively higher porosity and permeability than surrounding layers. This enables usable quantities of water to be extracted from it.

Permeability:
Permeability is a measure of how well connected the pores in soil and rock are. Generally groundwater flows through gaps between particles of soil and rock. How well it flows depends on how many gaps there are (porosity) and how well connected the gaps are (permeability).

Porosity:
The volume of "space" between particles of soil or rock as a percentage of the total volume of the soil or rock.

What is the Botany Sands Aquifer?

The Botany Sands Aquifer is a large volume of underground water present in the sandy ground surrounding Botany Bay which runs from Centennial Park to the Botany Wetlands and into Botany Bay. It covers an area of approximately 141 square kilometres. The average groundwater salinity is around 500mg/L. It is estimated that the aquifer can sustainably supply 22,500ML/yr of groundwater. Currently only approximately 6,000ML/yr is allocated for use.

The Botany Aquifer is like a sandy sponge which holds water beneath the ground and was once Sydney's main water source. The aquifer is recharged by rainwater percolating through sand and sandstone strata which act as natural filters to remove solid litter, silt and harmful nutrients. The water holding capacity of the sand aquifer is enormous and has been estimated to contain up to 300 litres of water per cubic metre of sand.

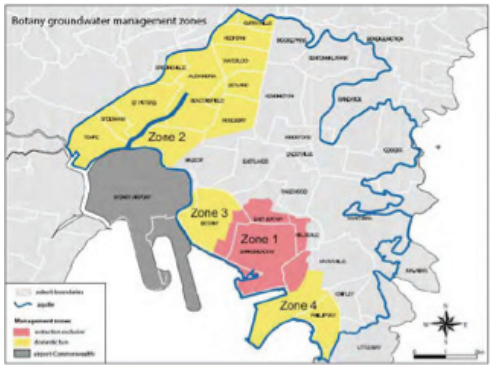

FIGURE 1: EXTENT OF THE BOTANY SANDS AQUIFER

The groundwater supports natural pond systems along its flow path, as well as receiving water from the ponds into the aquifer as recharge at other points. Ponds that are in part supported by the groundwater include those in Centennial Park,The Royal Randwick Racecourse and ponds within golf courses including Eastlakes and Mill Pond.

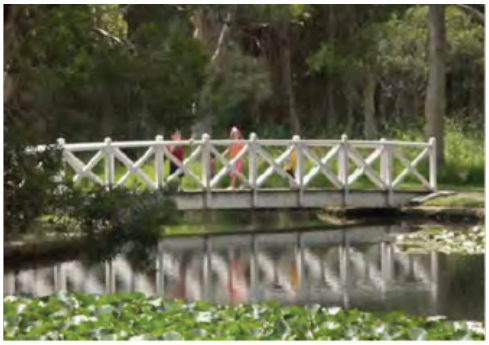

FIGURE 2: AN EXAMPLE POND THAT IS SUPPORTED BY GROUNDWATER – EASTLAKES.

The natural ponds supported aboriginal communities in the Botany Bay area. The ponds that exist today have been altered from the natural ponds that existed prior to European settlement. It was reported that the ponds may have dried out in the 1830s. Certainly in May 2006 they were very low.

The ponds get their water from stormwater and groundwater. The level of the ponds depends on the amount of rainfall (stormwater), evaporation, and the amount of water that is taken from groundwater.

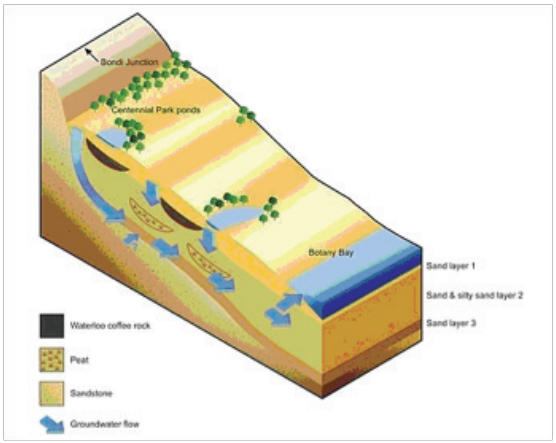

FIGURE 3: EXAMPLE CROSS SECTION OF THE BOTANY SANDS AQUIFER

Going further

Given that the aquifer is mainly sand, how might it have formed?

A source of water for Sydney

When Lieutenant James Cook explored Botany Bay in April 1770, he and Sir Joseph Banks observed aboriginal "huts" on the northern shoreline of the bay and heathlands ascending to high sandy ridges beyond. With European settlement in 1788, it was not long before industry arrived in Botany with Simeon Lord establishing his wool factory adjacent to ponds north of Botany Bay in 1815. Other industries followed, mostly toxic to waterways.

Going further:

Research the history of Aboriginal interactions with this area. How would have they depended on the aquifer before white settlement. What evidence is there to support your findings? What barriers may you find? Determine how you could tell this story to others.

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What is a DNAPL?
A dense, non-aqueous phase liquid (or DNAPL), is a liquid that is heavier than water and does not readily dissolve in water. DNAPL contaminants can be difficult to manage in groundwater, as they move downward through the ground based on gravity and where the permeability is greatest. This makes it difficult to predict their movement and therefore to find them when looking to clean them up. Once in the ground, they form a long term source of contamination, as they slowly dissolve into the passing groundwater.

Sydney's insatiable thirst for water soon outstripped the Tank Stream in Sydney Town's heart. This waterway became polluted and undrinkable. Lachlan Macquarie ordered construction of a tunneled pipeline from Lachlan Swamps, Paddington (Centennial Park), with a standpipe near Hyde Park – Busby's Bore. This water supply sufficed until population growth once more forced a further solution.

Busby's Bore delivered 1.5 million litres of stormwater and groundwater to Sydney every day supplying 20,000 people. Approximately 28 bores and shafts connected into a 3.6km long tunnel that ran from Centennial Park area to the growing city Sydney.

FIGURE 1: EXTENT OF THE BOTANY SANDS AQUIFER

Busby's Bore still provides up to 490 million litres of water to the Royal Botanic Garden Sydney each year. Sydney Municipal Council built a pumping station near Engine Pond, at Botany, pumping water to Sydney. This solution sufficed until large dams and reservoirs were built in the 1890s to meet the water needs of Sydney's increasing population.

More information on Busby's Bore
http://www.sydneywater.com.au/Publications Factsheets/BusbysBore.pdf

http://www.cityofsydney.nsw.gov.au/waterexhibition/WaterSupplySewerage/BusbyBore.html

Going further

How does the water use of early Sydney-siders compare with todays water use?
How does it compare to your families water use?
What might you have to change to use the same amount of water as Sydney's first settlers?

Contamination of the Botany Sands Aquifer

Botany and its surrounding suburbs have been heavily used by industry for at least 100 years. This was largely before any environmental protection controls were in place and at that time basic measures to prevent pollution were not considered to be necessary. Groundwater managers are now dealing with this legacy in Australia and around the world.

A range of industries operated in the Botany area such as tanneries, metal platers, service stations and depots, landfills, dry cleaners and wool scourers. As a result, chemicals such as chlorinated hydrocarbons and other solvents, petroleum hydrocarbons (such as petrol and diesel), and some heavy metals such as chromium, nickel, lead and arsenic, may have contaminated the aquifer. A well publicized example (but not the only source of contamination) is the Orica Botany Bay chemical plant.

Orica Botany – an example of groundwater contamination

Orica commenced chemical manufacturing at the Botany site in 1944. In the late 1970s and 1980s, Orica identified the presences of chlorinated hydrocarbons in groundwater beneath the site.

Chlorinated hydrocarbon (CHC) is a generic term given to chemical compounds containing chlorine, carbon and hydrogen. The term can be used to describe pesticides such as lindane and DDT, industrial chemicals such as polychlorinated biphenyls (PCB), chlorine waste products such as dioxins and furans, and dry-cleaning products such as perchloroethylene.

It is suspected that the CHC that contaminated groundwater came from a series of sources in including the manufacturing plants, storage of tanks and drums and leaks from the plant's effluent treatment system. Some of the contaminants are heavier than water, and dissolve very slowly in water. These contaminants are collectively called Dense, Non-Aqueous Phase Liquids or DNAPLs.

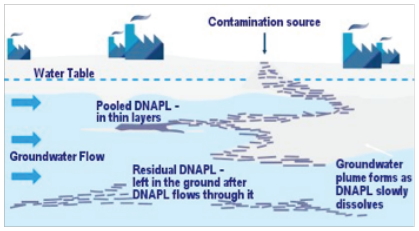

FIGURE 5: DNAPL FORM A COMPLEX SOURCE OF CONTAMINATION (SOURCE: ORICA)

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Managed Aquifer Recharge (MAR)
The basic concept of MAR is to capture additional surface water and use the aquifer as the storage for that water. The water can be put into the aquifer by pumping it in through bores, or by allowing it to infiltrate through ponds. It is then pumped back out for later use.

Where contamination from the Orica site affects groundwater, it limits the use to which that groundwater can be safely used. The salinity of the groundwater in the Botany Sands Aquifer is generally around 500mg/L of dissolved solids. Under natural conditions, this would mean the water could be used for a wide range of things including drinking water. With the addition of contaminants, the overall salinity may not change, but the contaminants may represent an unacceptable risk to human or environmental health. The groundwater also flows out to Botany Bay, and may affect environmental values where it discharges.

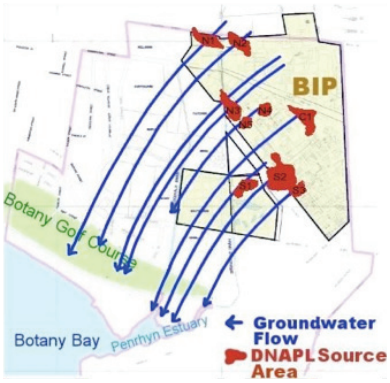

FIGURE 6: DISSOLVED CONTAMINATION MOVES THROUGH THE AQUIFER, AFFECTING ITS QUALITY AND POTENTIALLY AFFECTING ENVIRONMENTAL VALUES WHERE IT DISCHARGES (SOURCE: ORICA).

More information on the Orica site and its clean-up can be found at:
http://www.oricabotanytransformation.com/

Going further

There are many examples where human activity has resulted in contamination of groundwater. This may have been as a result of ignorance, carelessness or competing values and priorities. Research other examples whereby human activities have resulted in such a legacy in groundwater.

Use your findings to debate the responsibility of people in ensuring that the practices of today don't leave the problems for future generations.

Approach to contaminant management in the Botany Sands aquifer

NSW has a robust contaminated land management approach. Whilst only a small proportion of the Botany Sands aquifer area is known to be contaminated, the legacy of past activities could have affected the groundwater in other locations. Because of this, the NSW Government has taken a precautionary approach to ensure public health is not put at risk from exposure to potentially contaminated groundwater.

The Government has divided the area into four management zones: the pre-existing Orica exclusion area (Zone 1) and three other management zones (Zones 2 to 4) – Figure 7.

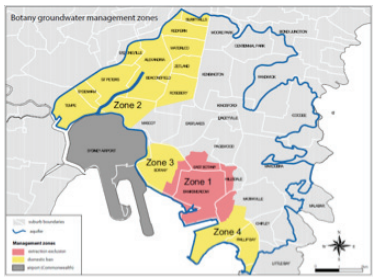

FIGURE 7: MANAGEMENT ZONES FOR THE BOTANY SANDS AQUIFER

Zone 1 reflects the Groundwater Extraction Exclusion zone related to the contamination from the Orica site. All use of groundwater is banned in this area. Industrial users must monitor and report water quality annually.

In Zones 2 to 4, the use of groundwater for drinking water, watering gardens, washing windows and cars, bathing, or to fill swimming pools is banned and industrial users of groundwater must test water quality annually and report it to the Government. This will help gain a better understanding of the extent and nature of any contamination in the area.

An embargo on any new licenses (that is, no new licences would be issued) was declared in 2003 for an initial area covering the most likely areas that could be affected by contamination. This was extended to cover the entire Botany Sands Aquifer in 2007. However existing users outside the four zones illustrated in Figure 7 can continue using groundwater.

More information on the Orica site and its clean-up can be found at:
http://www.water.nsw.gov.au/Water-management/Water-quality/Groundwater/Botany-Sand-Beds-aquifer/Botany-Sands-Aquifer/default.aspx

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Opportunities for the future – Managed Aquifer Recharge

The shallow, unconfined nature of the groundwater in the Botany Sands means that there is the opportunity to put extra surface water into the aquifer, using the aquifer as a storage. This is called Managed Aquifer Recharge.

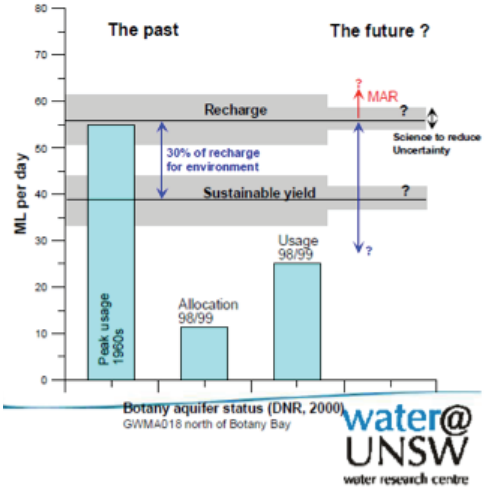

FIGURE 8: POTENTIAL TO PUT MORE WATER INTO THE AQUIFER, USING IT AS A STORAGE, SO MORE WATER CAN BE TAKEN OUT.

The pond systems of Centennial Park currently RECHARGE the groundwater systems. Over the years, stormwater has been directed into these ponds, which has effectively increased the amount of recharge. There is an opportunity to use this process to make more water available from the aquifer.

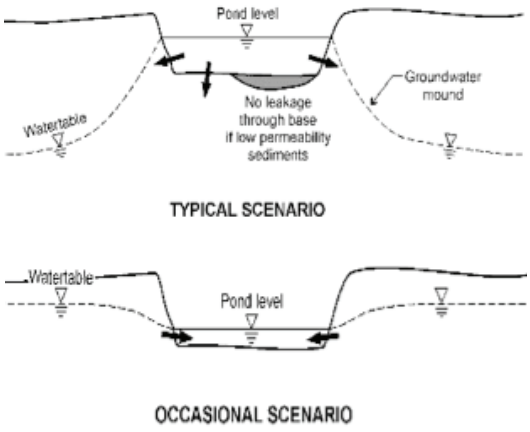

FIGURE 9: CENTENNIAL LAKES – WHAT CURRENTLY HAPPENS. THERE IS THE POTENTIAL TO INCREASE RECHARGE (TOP FIGURE) BY PUTTING MORE WATER INTO THE LAKES AT KEY TIMES (SOURCE: UNSW).

Making a decision – what is the best source of water to use for Managed Aquifer Recharge?

Different sources of water can be used to recharge the aquifer. They have different strengths and limitations? Stormwater provides high volumes in short periods. It has lower overall reliability, and requires significant infrastructure to capture it for infiltration. Generally, however, it does not require much treatment. In fact where it is infiltrated, the aquifer can act as a "filter" for the water.

Treated sewerage is more reliable, and systems can be built to provide an almost constant input to the aquifer. This provides a reliable source, but requires a very high level of treatment to reach an acceptable standard. Also, there are social issues with the use of treated sewerage!

More information on Managed Aquifer Recharge and the Botany Sands Aquifer can be found at:
https://www.connectedwaters.unsw.edu.au/technical/research/projects/projects_mar.html

Going further

Using recycled wastewater represents a potential source of water for MAR schemes. How would you feel about drinking treated wastewater (that is safe to drink) straight from the wastewater treatment plant?
How would you feel about drinking the same water if it had first been pumped into the ground as part a MAR scheme and pumped out again? Explain your concerns.

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An insatiable need for more information...

As with any water resource management process, there is always a need for an appropriate level of information to make the best decisions. Ongoing research is vital to enable the challenges of groundwater resource management to be met. This includes greater understanding of the ground and in particular, how groundwater and other contaminants move through it, and also of the broader acceptability of the options to manage, such as MAR.

FIGURE 10: GROUNDWATER QUALITY AND THE PROPERTIES OF THE HOW THE GROUND TRANSMITS WATER AND CONTAMINANTS ARE KEY INFORMATION NEEDS (SOURCE: UNSW).

Summary – Botany Sands Aquifer

The Botany Sands Aquifer was a significant source of water for Sydney in the 1800s. Contamination of the aquifer has had a significant impact on the usability of the aquifer. Management of the contamination recognises that it can't all be cleaned up, and that restrictions on use into the future are a part of the overall management framework. There is an opportunity, where the aquifer is not affected by contamination, to use Managed Aquifer Recharge to provide additional water storage for use.

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