CHANGES IN WATER USE AND MANAGEMENT OVER TIME, AND SIGNIFICANCE FOR AUSTRALIA AND SOUTH-EAST ASIA

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Abstract

Water has always played a significant role in the lives of people. In urbanised Rome, with its million people, sophisticated supply systems developed and then died with the empire, only to be rediscovered later. But it was the Industrial Revolution commencing in the eighteenth century that ushered in major paradigm shifts in use and attitudes towards water. Rapid and concentrated urbanisation brought problems of expanded demands for drinking supplies, waste management and disease. The strategy of using water from local streams, springs and village wells collapsed under the onslaughts of rising urban demands and pollution due to poor waste disposal practices. Expanding travel (railways, and steamships) aided the spread of disease.

In England, public health crises peaks, related to water-borne typhoid and the three major cholera outbreaks occurred in the late eighteenth and early nineteenth century respectively. Technological, engineering and institutional responses were successful in solving the public health problem. It is generally accepted that the putting of water into pipe networks both for a clean drinking supply, as well as using it as a transport medium for removal of human and other wastes, played a significant role in lowering death rates due to waterborne diseases such as cholera and typhoid towards the end of the nineteenth century. Today, similar principles apply. A recent World Bank report indicates that there can be upto 76% reduction in illness when major water and sanitation improvements occur in developing countries.

Water management, technology and thinking in Australia were relatively stable in the twentieth century up to the mid to late 1970s. Groundwater sources were investigated and developed for towns and agriculture. Dams were built, and pipe networks extended both for supply and waste water management. The management paradigms in Australia were essentially extensions of European strategies with the minor adaptions due to climate and hydrogeology.

During the 1970s and 1980s in Australia, it was realised increasingly that a knowledge of groundwater and hydrogeological processes were critical to pollution prevention, the development of sound waste management and the problems of salinity. Many millions of dollars have been both saved and generated as a consequence. This is especially in relation to domestic waste management and the disposal of aluminium refinery waste in New South Wales.

Major institutional changes in public sector water management are occurring in Australia. Upheveals and change have now reached all states in Australia with various approaches being followed. Market thinking, corporatisation, privatisation, internationalisation, downsizing and environmental pressures are all playing their role in this paradigm shift. One casualty of this turmoil is the progressive erosion of the public sector skillbase and this may become a serious issue should a public health crisis occur such as a water borne disease. Such crises have arisen over recent times.

A complete rethink of the urban water cycle is going on right now in Australia both at the State and Federal level. We are on the threshold of significant change in how we use and manage water, both as a supply and a waste transporter in Urban environments especially. Substantial replacement of the pipe system will be needed in 25 to 30 years time and this will cost billions of dollars.

The competition for water between irrigation needs and environmental requirements in Australia and overseas will continue to be an issue in rural areas. This will be especially heightened by the rising demand for irrigation produced food as the world's population grows

Rapid urbanisation and industrialisation in the emerging S.E. Asian countries are currently producing considerable demands for water management skills and infrastructure development. This trend is expected to grow. There are also severe water shortages in the Middle East to such an extent that wars may be fought over water issues. Environmental public health crises and shortages will help drive the trends.

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INTRODUCTION

There are considerable changes beginning to occur in water use and management all round the world. Furthermore, there are parts of the world where considerable shortages exist now, either for climatic (Middle East) or lack of development (Africa) reasons. These shortages are linked closely to public health and the economic well-being of the countries concerned.

Groundwater is playing an expanding role not only in water supply but also in environmental issues such as salinity and waste management.

Water is also joined to the issue of food security since almost one third of the world's food is derived from irrigation. Conflicts are beginning to emerge between the competing uses of water for irrigation, the environment and expanding urbanization. Some countries are focussing on a complete rethinking of the urban water cycle.

This paper addresses these issues from historic, present practice and future trend points of view. Some key principles established by past civilizations may well be worth "re-discovering" as we address these emerging needs.

HISTORICAL PATTERNS OF WATER USE AND PUBLIC HEALTH

Water has always played a significant role in the lives of people. As far back as 2000 BC the Minoan culture had piped water in-houses, Rosen (1993). The water supply system and its relationship to general public health are illustrated for some major civilizations over time in Fig. 1.

The Roman Empire (300BC-476AD) developed a very sophisticated water supp'y system which was not substantially improved upon until the latter part of the Nineteenth Century. The key principle developed by the Romans was to bring water a considerable distance from a clean source (often a groundwater fed spring or lake) to the population centre. This was by means of aqueducts (elevated pipe systems designed for water to flow under gravity. The water supply for Rome was served by some 10 of these major structures, constructed of stone, brick and mortar between 312BC and AD109. They had a total daily yield of about 1.1 million m^3 to service 1 million people (Gunliffe, 1978). By the commencement of Fourth Century AD, Rome had expanded its system to 14 aquaducts that supplied 11 public baths, 926 private baths and 2000 fountains, Dal Maso (1989). Greek ceramic pipe design was improved by the Romans and commonly used from the First Century BC. Ceramic pipes supplied the Skolastika public baths at Ephesus, Turkey during the first century. The Roman architect Vitruvius draw attention to the dangers of lead pipes for human health at about this time, Gunliffe (1978). Pipe supplies into private homes tended to be restricted to the wealthy. There is limited evidence that these practices in combination with the public baths provided some (but not complete) protection from water-borne epidemics eg typhoid, Rosen (1993).

Aquaducts were built throughout the Roman Empire including the Far East in modern day Turkey. Istanbul had an aquduct and pipe system that also involved a large underground storage facility unknown as the Basilica Cistern constructed using 7000 slaves between 123 AD-300 AD. Its capacity was 1 million m^3 (Akgül (1995)) that continued to supply water to Istanbul up to 1453 when the Ottoman Empire leaders conquered Turkey and preferred flowing water to the still water of the cistern.

	2000 - 1400 BC	1400 - 300 BC	300 - 0 - 476 BC AD	(133 ---650) AD ---1453	500 - 1500	1500 - 1700	1700 - 1850	1850 - 1940	1940-1980	1980 - 1995
Time Period	2000 - 1400 BC	1400 - 300 BC	300 - 0 - 476 BC AD	(133 ---650) AD ---1453	500 - 1500	1500 - 1700	1700 - 1850	1850 - 1940	1940-1980	1980 - 1995
Culture	Minoan	Greek	Roman (west)	Byzantine (Romaneast)	Middle Ages	Renaissance	Industrial Revolution	Colonies to Nations	Technology Revolution → Information Revolution →	
Supply System	Pipe Water to Houses Source ?	Spring water,River Some piped water to houses	Aqueducts, sewerage system, "Spring water from Distance"	Aqueducts cisterns and pipe system continues on to 1453	Local Springs / wells / rivers monasteries preserve pipe system Knowledge passed on to some towns 1290	1581 London 1st pipe system; Wood pipes, 1st water closets 1558-1600	Steel pipes 1810 Water closets → sewers → rivers (1780) Water supply sewerage pipe systems 1848 (UK) 1858 Australia	Sewerage system developed. septic tanks, pans replaced Hydrogeology starts 1855 Water supply extended (pipes) 1800 Sydney Tank Stream supply 1850 Groundwater - fed lakes 1888 - 1977 (Nepean - Shoalhaven) Dam Building period		
Public Health		Poor to reasonable	Reasonable to Good (rich)	Reasonable	Poor (some exceptions reasonable)	Poor but becoming understood (Science)	Very poor 100 yrs of Health crises (Europe)	Improves (especially after 1870 in UK) Very good (Developed countries) 3rd world urban crises emerging Medical (immunization) effective after 1900		

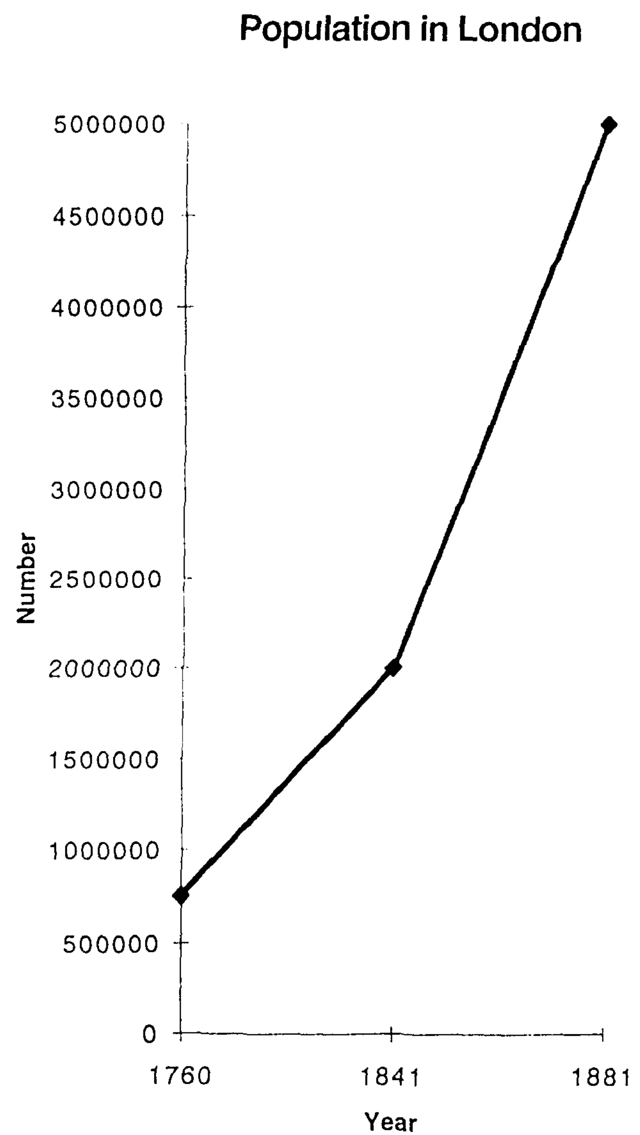
Fig. 1 Water supply system and public health for various cultures over time. Data based on Rosen (1994), Beasley (1988), Gunliffe (1978), Dal Maso (1984), Akgül (1995)

When the Roman Empire in the West (Europe) collapsed after 476 AD most of the water supply/public health knowledge was lost. However some elements were preserved by monastries through the Middle Ages (500-1500 AD), Rosen (1993) Some limited transfer of supply system knowledge occurred between monastries and towns in 1290. In the Western Roman Empire, supply knowledge was preserved in the Byzantine Empire and used up to 1453. Some of this information was utilised in parts of the Middle East eg. Egypt. Public health in the European Middle Ages was generally poor in towns as people drew from non protected wells, springs and rivers. The situation in the countryside, where most people resided, was less acute due to the reduced impact of poor waste management practice.

By 1581 London "rediscovered" pipe systems. These were of wood (Rosen, 1993) and transferred water from rivers to "watering points" in towns and near houses. During the period 1558–1600 (Queen Elizabeth I reign) the first water closets (a forerunner to modern toilets) were invented but not commonly used. Public health was still poor with the Great Plague of 1665 for example but it was becoming better understood due to the development of scientific approaches. However, it was the Industrial Revolution commencing in the Eighteenth Century that ushered in major paradigm shifts in use and attitudes towards water. Rapid and concentrated urbanisation brought problems of expanded demands for drinking supplies, industrial processes, waste management and disease. The strategy of using water from local streams, springs and village wells collapsed under the onslaughts of rising urban demands and pollution due to poor waste disposal practices.

There was a century of public health crises between 1770 and 1870, (Rosen (1993), with the spread of epidemics between countries being aided by steam powered ships and railways developed in the Industrial Revolution. In England, public health crises peaks, related to water-borne typhoid and the three major cholera outbreaks occurred in the late eighteenth and early nineteenth century respectively Fig 2.

Technological, engineering and institutional responses were successful in solving the problem. It is generally accepted that the Government controlled putting of water into pipe networks both for a clean drinking supply, as well as using it as a transport medium for removal of human and other wastes, played a significant role in lowering death rates due to waterborne disease such as cholera and typhoid. This was especially so across the boundary between the nineteenth and twentieth centuries. Medicine then contributed further to increases in lifespan and in reducing the impact of disease, Burnet and White (1972). Today similar principles apply. A recent World Bank report indicates that there can be up to a 76% reduction in illness when major water and sanitation improvements occur in developing countries, Seregeldin (1995), Table 1.



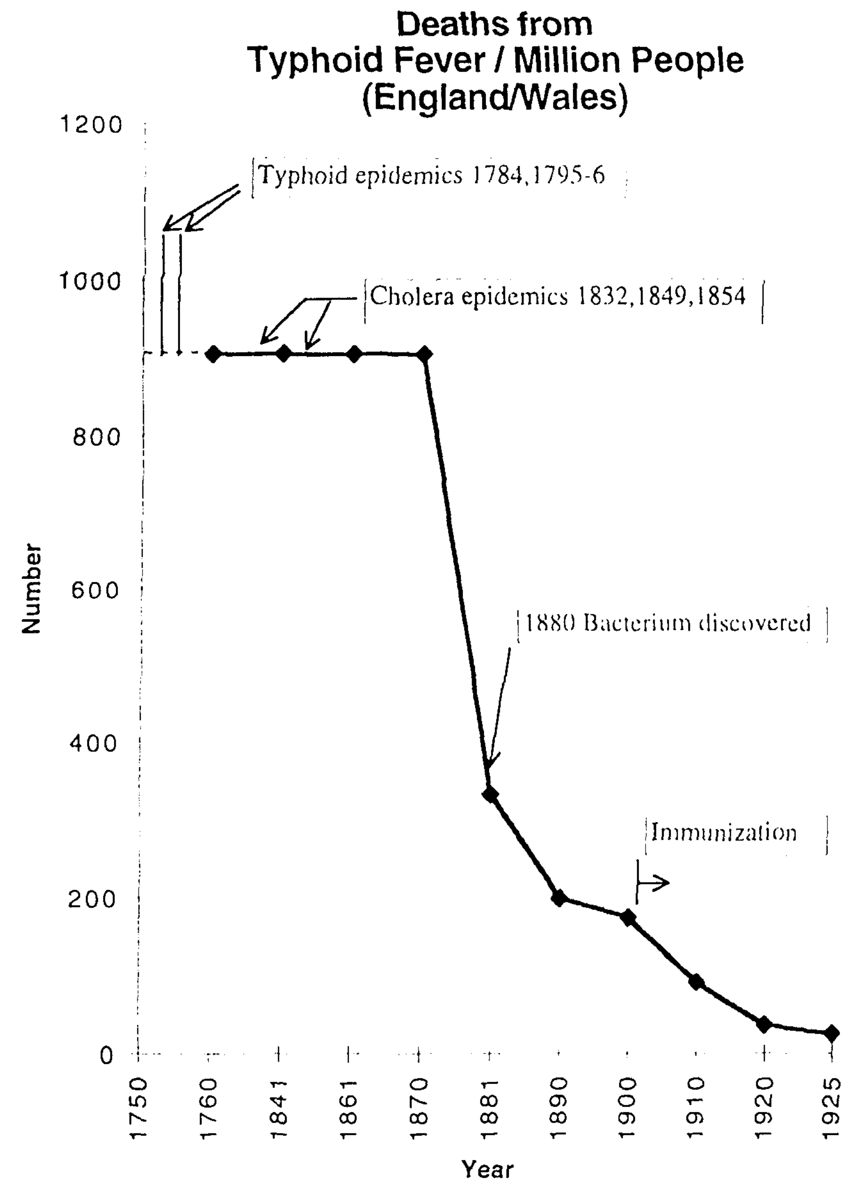


Fig.2 Population growth and death from water borne Typhoid Fever from 1760 in England. (Based on data in Rosen 1993)

Table 1 Effects of Improved Water and Sanitation on Illness

Disease	Millions of persons affected by illness	Median reduction contributed to improvement (%)
Diarrhoea	900*[1]	22
Guinea worm	4	76
Roundworm	900	28
Schistosomiasis	200	73

*[1] Number of episodes a year
Data after Serageldrin (1995) and World Bank (1992)

WATER USE PATTERNS IN AUSTRALIA

Sydney

The first settlers in Sydney draw water from the Tank Stream between 1788-1826 Beasley (1988). This stream was fed by a groundwater spring in Hawkesbury sandstone near Park Street and flowed four kilometers beside the present day. Pitt Street and on into Sydney Cove, Fig. 3.

The tank stream became polluted and a new supply was provided between 1826-1856 from Busby's Bore. Beasley (1988). Busby's Bore was a tunnel 4 km long and 1.5m high. *It brought water from the groundwater fed Centennial Park Lake (Lachlan Swamp)* located in the Botany Sands aquifer Beasley (1988). The tunnel emerged as a pipe above ground in the City's Hyde Park and water carts collected water for transport to use Fig. 4.

This supply lasted 30 years but was eventually insufficient for growing Sydney and water was pumped from other small groundwater fed lakes in the Lachlan Swamp Chain (Botany Sands Aquifer) to the south near Botany Bay. The Lachlan Swamp pumped waters extended the supply by a further 32 years until 1888. So for the first 100 years of Sydney's existence, groundwater was the major resource supply. In 1888 a major change of thinking occurred. Large dams were constructed at a considerable distance south and west from Sydney. Construction began with the Nepean Dam (1888) and ended with the Shoalhaven Scheme in 1977.

As the water supply expanded so did the piped sewerage system. This began in Sydney in 1858 and currently there is a 42,000 km pipe network linked to ocean outfalls. Pollett (1995). Only primary treatment is employed. The total value of the water and sewerage supply assets for Sydney is $12 billion, Pollett (199).

Other Australian Cities

Melbourne followed similar patterns developing from a river sources (Yarra) to dam/pipe supplies for drinking and sewerage. Melbourne didn't develop groundwater to any degree even thoagh good aquifers existed in a number of areas. At times, the piped water supply system failed and water was distributed by cart as in 1878.

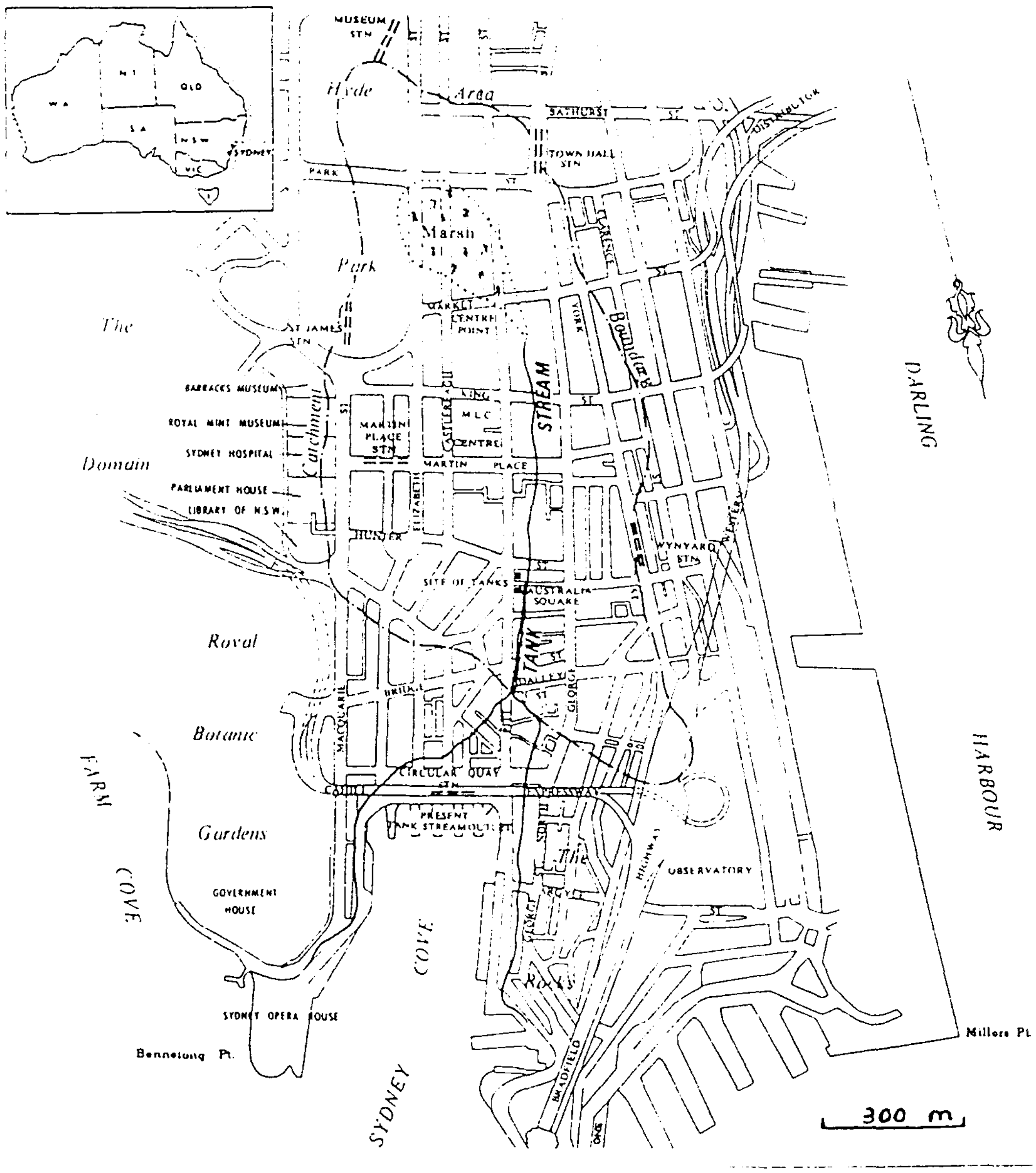


Fig.3 The course of the Tank Stream beneath present day Sydney streets. Data after Beasley (1988).

The other major cities varied in their supplies:

Brisbane	–	river
Adelaide	–	stream
Perth	–	groundwater and surface sources

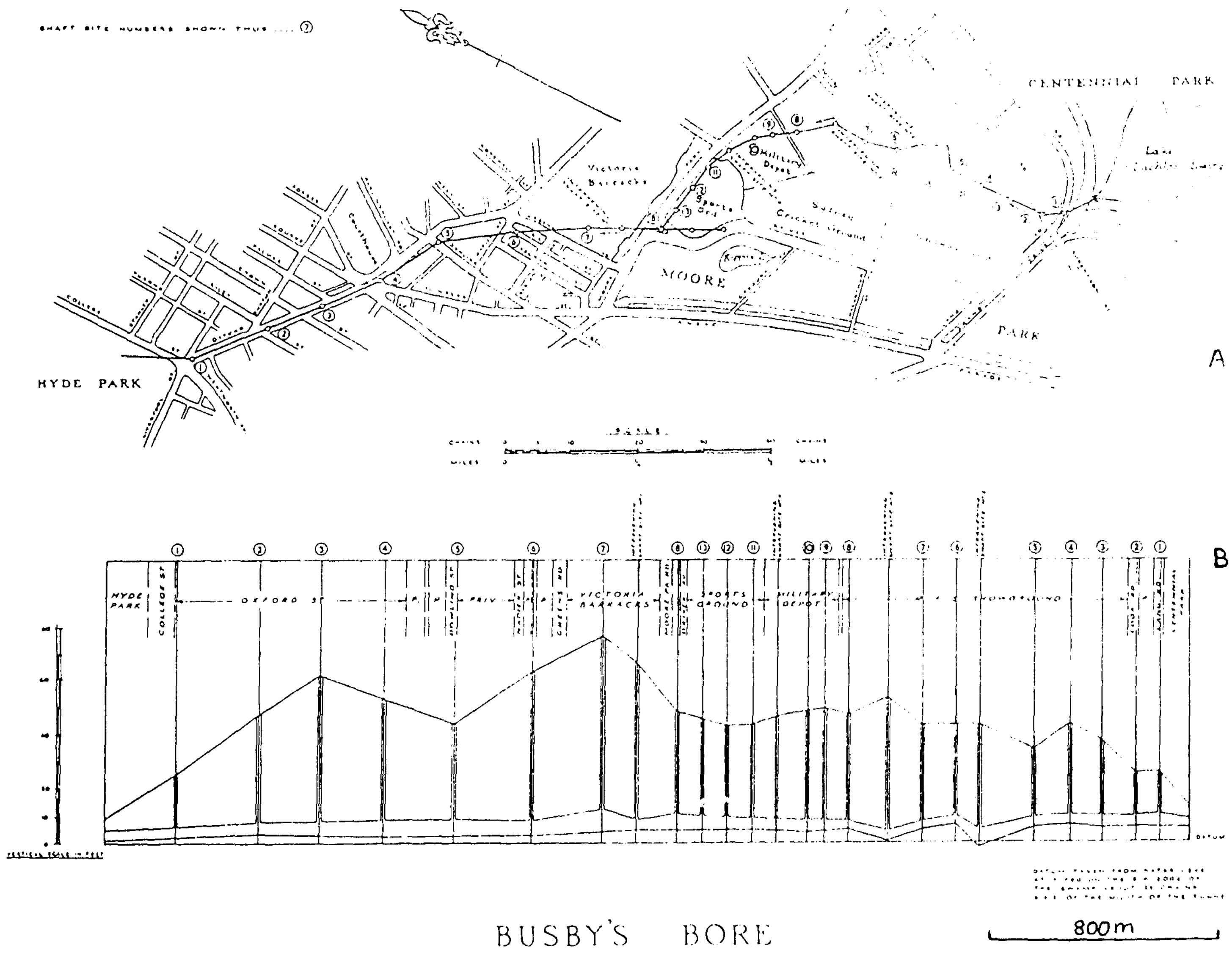


Fig. 4 Busby's Bore in Plan (A) and Section (B). Data modified from Beasley (1988).

HYDROGEOLOGY AND ENVIRONMENTAL PROBLEMS

Modern, scientifically based Hydrogeology began in 1855 when Darcy discovered "Darcy's Law" that describes mathematically the flow of water through a porous media, Freeze (1994).

In Australia up to the 1970s the major application of hydrogeological principles was to finding and developing water supplies as a resource, for country towns in the main. In some situations such as mines and underground tunnels, etc, groundwater removal was focussed on as a problem, eg the Yallourn open cut coalmine dewatering in Victoria.

Also during the 1970s there were the beginnings in a research sense of applying groundwater ideas to more general environmental problems such as domestic solid waste landfills, Knight et al (1978). This paralleled developments overseas especially in USA where landfills had been studied scientifically since the mid 1960s. Landfill studies developed further both in research and practice during the 1980s, Knight (1983), Knight and Beck (1987), Knight (1990). The study by Knight and Beck (1987) completed in 1985, introduced to Australia the concepts of a landfill being bioreactor, landfill stabilization over time and the importance of leachate recycling. Figs 5,6. Parallel independent understanding developed overseas, eg Lu et al (1985).

It was in the 1980s, that the role of groundwater in controlling both dryland and irrigation salinity processes was realised and considerable hydrogeological activity occurred in Australia over this period, especially in Victoria and Western Australian. Ghassemi et al (1995) provides a good overview of the Australian context of salinity and also reviews the international situation. The involvement of natural geological processes (i.e. not involving human intervention) in causing salinity were described by Knight et al (1989) Martin and Knight (1989).

In the mid the 1980's, principles of hydrochemistry and the interactions between groundwater, wastes and soil materials were applied to the disposal of fluoride bearing aluminium refinery wastes, Knight (1988) and Sullivan and Knight (1990). One important finding revealed the link between sodium fluoride (NaF) and changes (decrease) in clay permeability during the break through passage of a concentrated NaF solution, Fig 7.

The clay's high natural adsorptive capacity of the clay at Wallaroo (Fig 8) proved to be an important geological barrier to fluoride migration. Another was the formation of new sodium zeolite mineral that further reduced permeability, Knight (1988).

In addition, concepts of engineered chemically reactive treatment zones were developed, Knight (1984) for land disposal of aluminium refinery wastes. The design involved placing a zone of gypsum ($CaSO_4 2H_2O$), superphosphate or limestone treatment zones around the walls and on the bottom of disposal trenches Fig 9. The concept was that any mobilized fluoride bearing leachate would react and precipitate to form solid CaF_2 or fluorapatite. Materials to aid biodegradation of cyanide were suggested for a subsiduary treatment zone should the wastes contain that compound.

Later it was found that for granular fluoride wastes a satisfactory reaction effect could also be achieved to meet the environmental standards by mixing the waste with gypsum in a rotating drum prior to trench disposal, Knight (1990). This disposal system has been most satisfactory to this time enabling some 380,000 tonnes of aluminium to be produced per year since 1985 by the Tomago Aluminium smelter. Over the past 10 years there has been a $A3 billion gain in value due to the achievement of this appropriate waste management strategy.

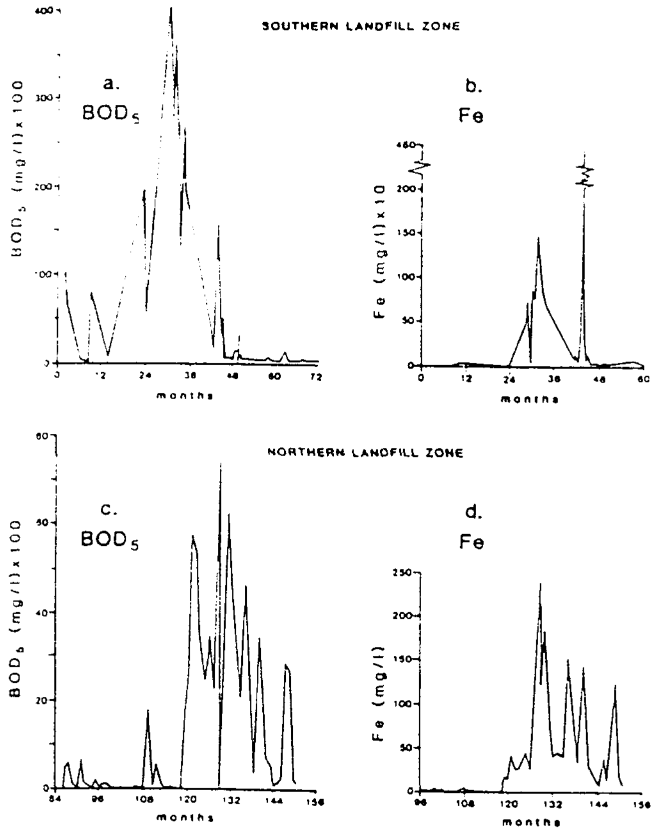


Fig 5 Stabilization of BOD_5 and Fe in the Lucas Heights Landfill, Sydney (after Knight and Beck 1987).

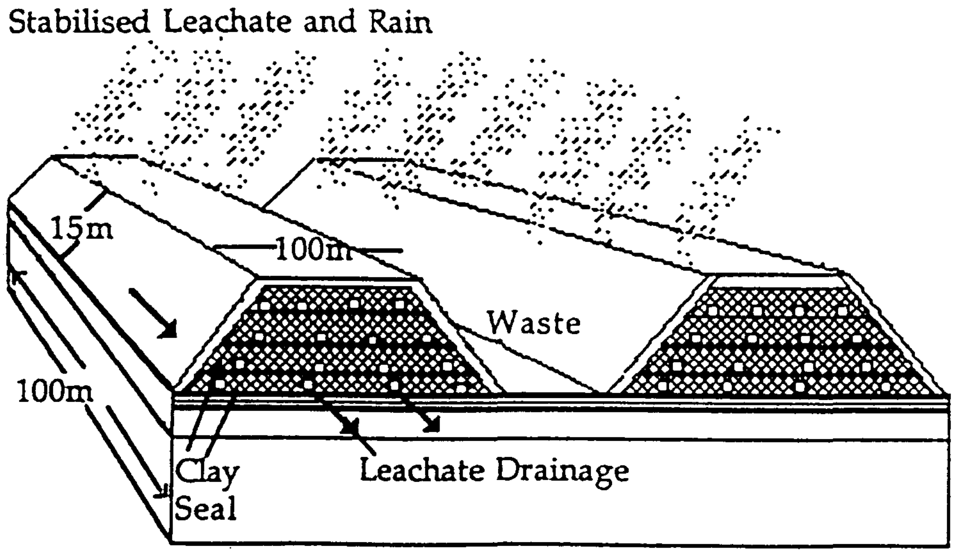


Fig 6 Leachate recycling and optimal domestic solid waste landfill design (After Knight, 1990).

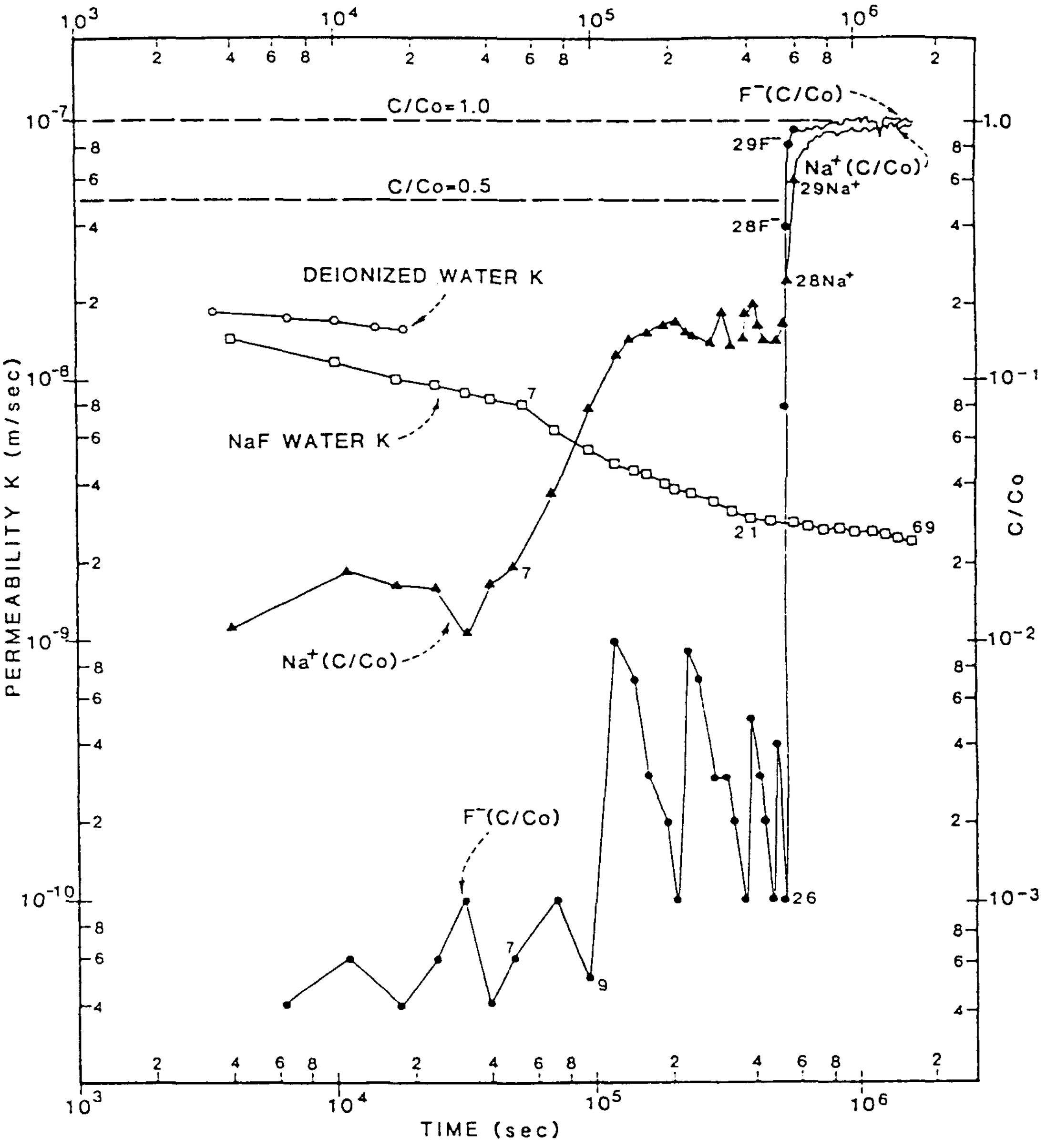


Fig. 7 Permeability and relative concentrations of sodium fluoride outflow with time (Data after Knight, 1988).

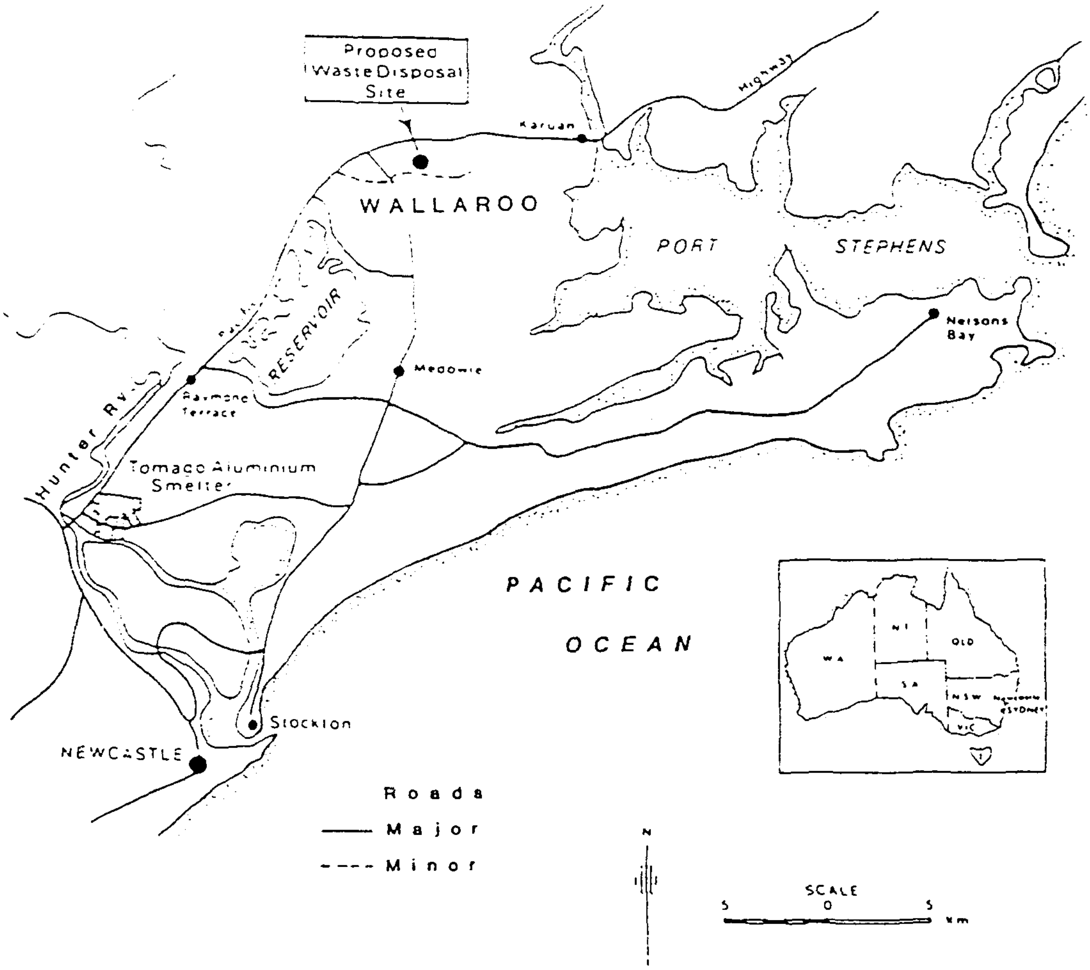


Fig. 8 Location map for the Wallaroo disposal of fluoride bearing wastes from the Tomago Aluminium smelter (After Knight, 1988).

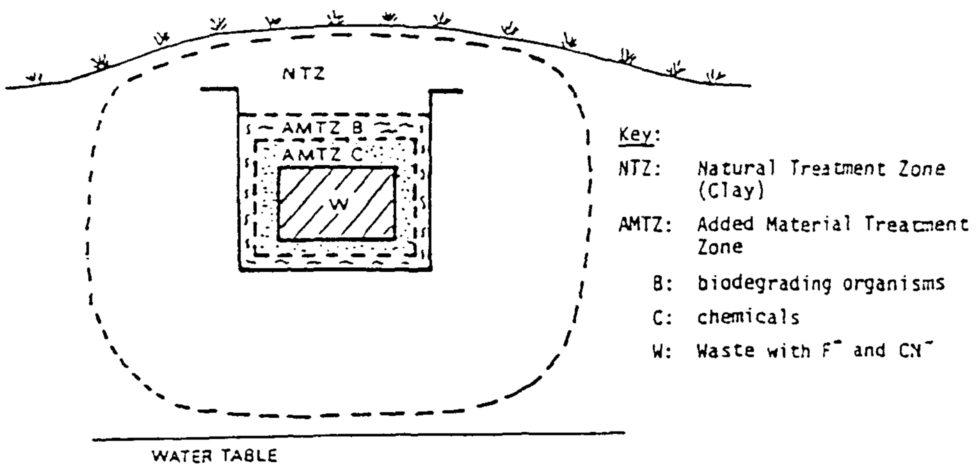


Fig 9 Schematic engineered chemical and natural treatment zones of gypsum, super phosphate or lime for trench disposal of fluoride and cyanide wastes. (After Knight 1984).

Engineered chemically reactive treatment zones of iron compounds are also being proposed currently for remediation of groundwater contaminated with chlorinated hydrocarbons, Pakow and Cherry, (1996).

Another trend in Hydrogeology is to apply technological instruments to field monitor continuous processes involved in the hydrological cycle. A recent example is the measurement of water use by trees. In Thailand the relationship between mango tree water use and soil moisture has been studied by Lertisirivorakul et al (1995), Fig. 10. This data shows that at flowering time, the mango tree begins using considerably more water than pre-flowering. This is an important finding for optimal fruit production.

SOME FUTURE WATER CRISIS

Many countries in South-East and South Asia, Africa, and the Middle East especially will be facing reductions in annual renewable water per capita as their population rise. Over the next 30 years the world's population will rise from 5.6 billion (in 1994) to 8 billion (Brown et al 1994, Serageldrin 1995). Reductions in annual renewable water per capita in South-east Asia are illustrated in Fig 11. Three countries with large populations that are most likely to be progressing towards potential problem situations are Thailand, Philippines and Indonesia. A country is defined as being in a state of water supply scarcity if its annual renewable supply per capita goes below 1.7 million m^3 Serageldrin (1995). Some 26 countries world-wide are in this state now with 9 being in the Middle-East, Serageldrin (1995).

Table 2 Renewable annual water supplies per capital for Thailand, Philippines, Indonesia and Australia.

Country	Population (million) years		Per capita water resources ($1000m^3$/year)	
	1991	2010	1991	2010
Thailand	57.5	71.2	1.9	1.5
Philippines	62.9	92.1	5.1	3.5
Indonesia	186.3	246.7	13.6	10.3
Australia	17.3	20.6	19.8	15.1

Data after EAAU (1994).

The water scarcity problems of the Middle East and parts of Africa are illustrated in Fig 12.

These generalised statistics do not consider the acute problems that occur in specific areas of individual countries. In North-East Thailand there are severe water shortages coupled to land and groundwater salinization. In Jakarta, Indonesia only 14% of homes have piped water and 35% buy water from vendors for up to $A6.90/1000 litres, Sergeldrin (1995). This may be compared with the $A0.65/1000 litres paid by householders in Sydney.

CHANGES IN WATER RESOURCE MANAGEMENT

In response to changing needs, eg. population growth, urbanisation, industrialization, and crises etc. the management of water resources has changed over time and is in the process of considerable change currently.

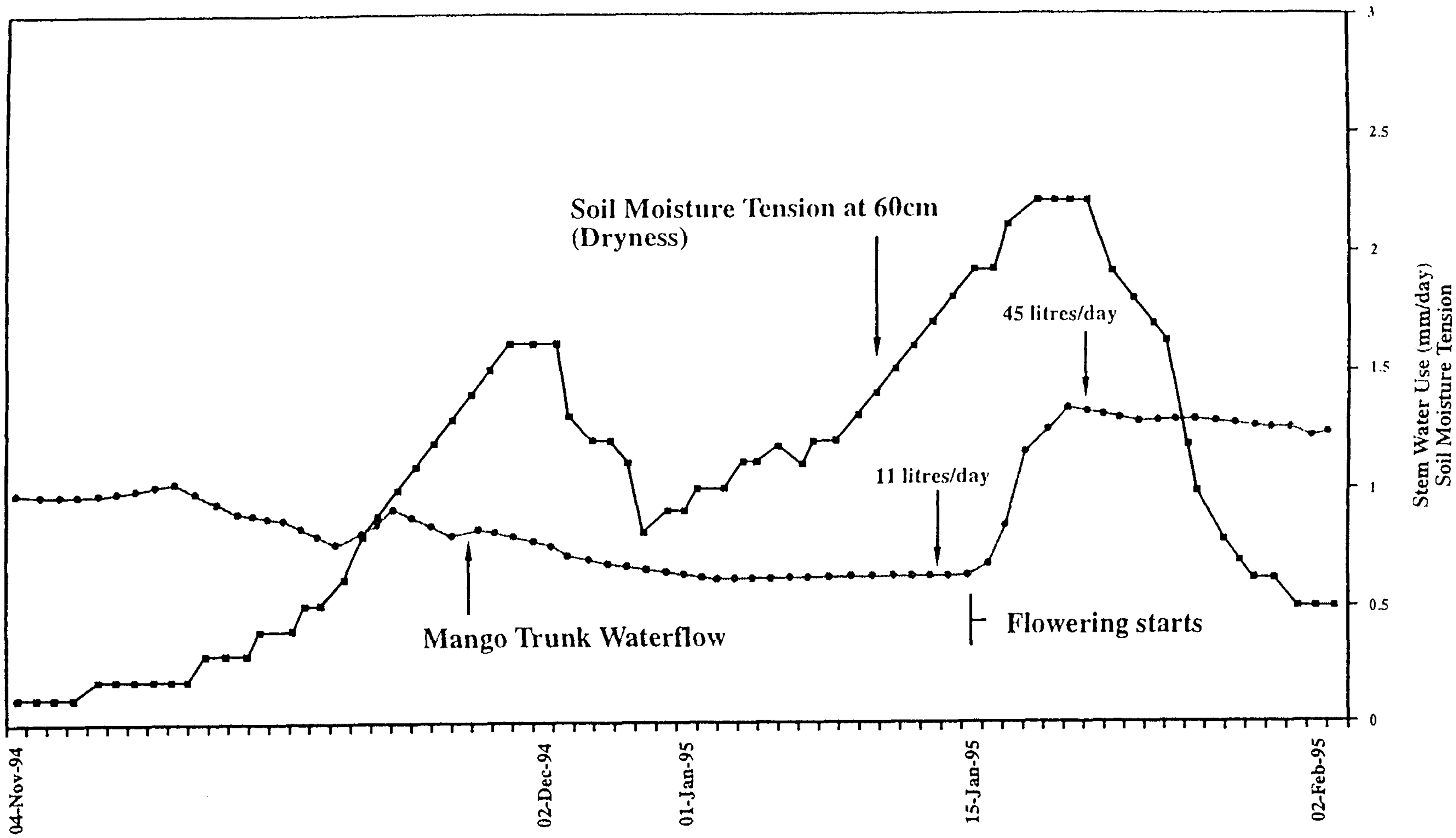
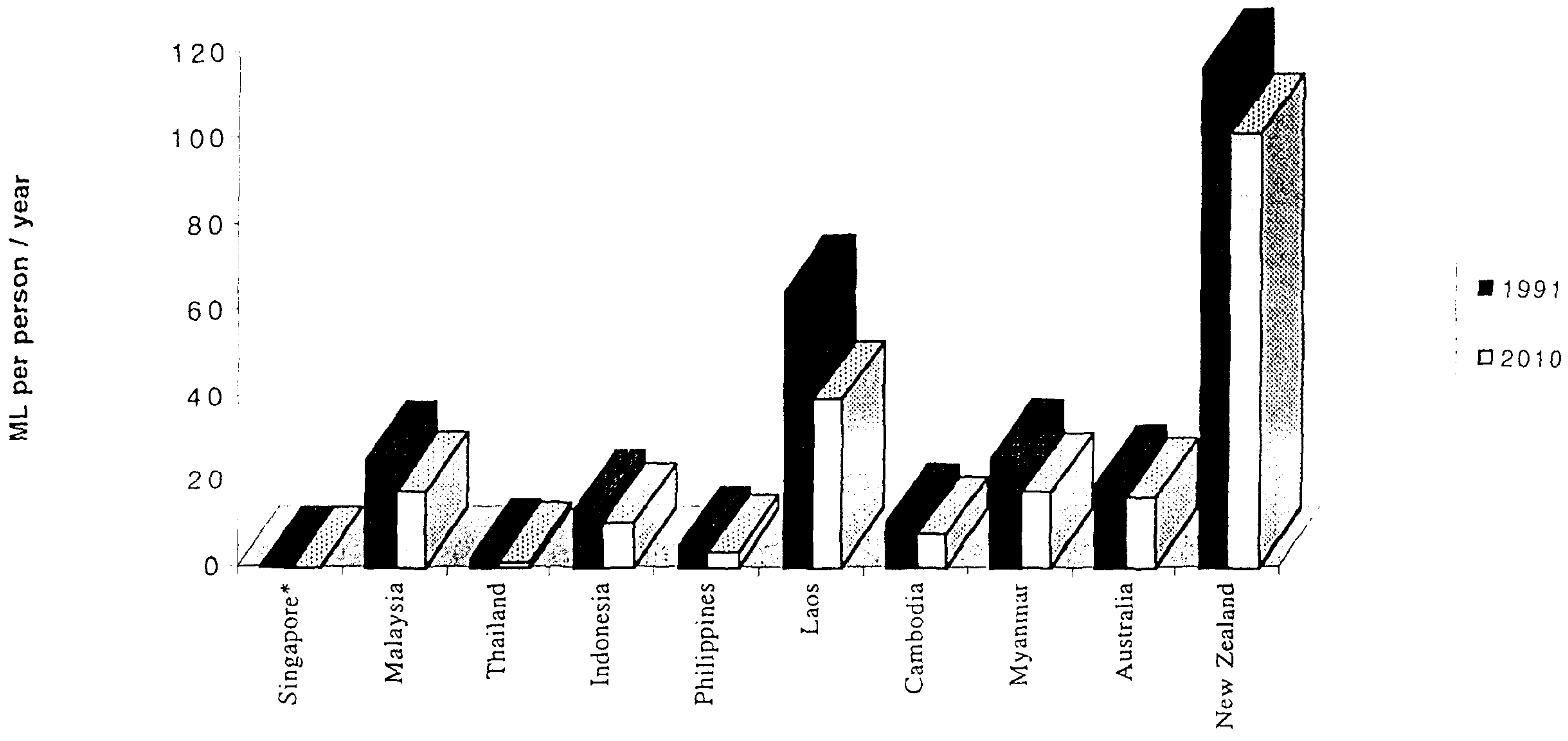


Fig. 10 Water use by a mango tree, Khon Kaen University, North-East Thailand November 4, 1994 - February 3, 1995. Data after Lertsirivorakul et al (1995).



Note: * Singapore imports most of its water supplies from Malaysia

Fig. 11 South-East Asia internal renewable water resources 1991–2010. Data after EAAU (a994).

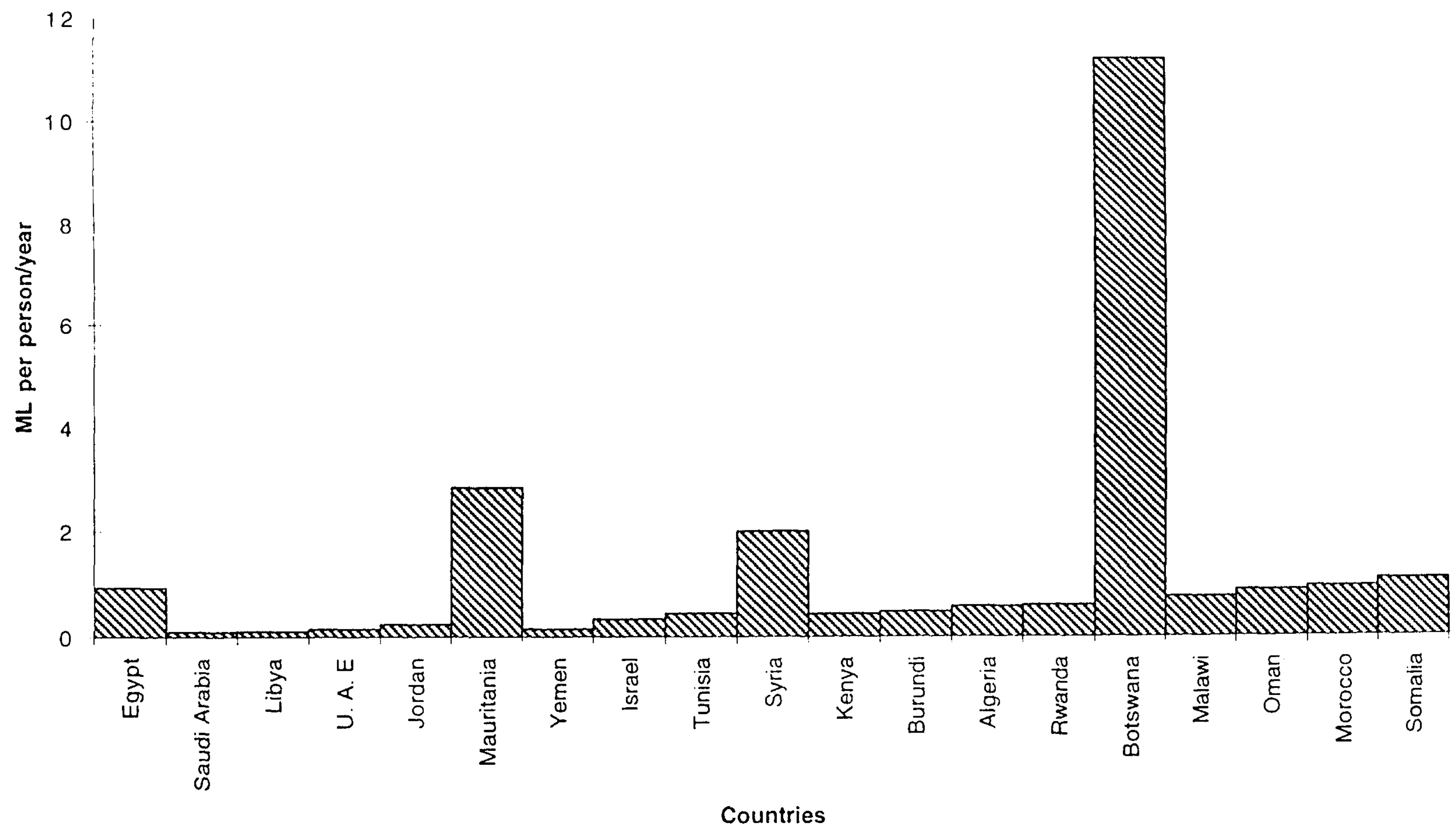


Fig. 12 Water availability in Middle East and Africa. Data after Kotwicki (1994).

Historical Patterns

Over the past centuries there have been identifiable patterns of water resource management. Figure 13 illustrates the major possible elements of: institutional control and delivery, private enterprise, and control by the individual (laissez faire) during the major cultural divisions recognized previously.

In the Minoan and Greek times (2000-300 BC) there was probably a mixture of institutional and individual water management with public health varying from poor to reasonable. Roman management became strongly controlled in an institutional sense for over 770 years (300BC- 476AD) and public health was probably reasonable to good especially for the rich who had pipe supplies to their homes. In the eastern Roman Empire and the subsequent Byzantine Empire this strong institutional control continued much longer up to 1453. In Europe, however water management fell back to individual control following the collapse of the Roman Empire in 476. This laissez fair approach continued for 1130 years up to about 1609 when in England, private enterprise took over both ownership and delivery of water. Water was seen as a tradeable commodity. A good example was the selling of Edinburgh's water supply to a company in 1818 for £30,000, Rosen (1993). This period of privatisation continued for 240 years up to about 1848/50.

Public health was generally very poor especially over the last 100 years of this period. Poor sanitation and burial practices existed over this time with disease transmission occurring via groundwater (well supplies) and streams. The following quotations by Bell (1994) relating to conditions at the time of the Great Plague in London in 1665 and later observation in 1845 by Engels and reported by Hoyles (1991) show that it would be very easy for the water borne epidemics of cholera and typhoid to occur in urban areas of England over the period 1770-1870.

Bell (1994) writing in (1924) made some insightful observations on in relation to disease transmission and water including groundwater below church grave yards:

"And London had learned nothing. Sanitary science had not been born. Foul streams like the Fleet, defiled from every overhanging house and neighbouring alley, were no better than open sewers, and in parishes aligned upon the banks of these pestilent watercourses - St. Bride's, St. Sepulchre's and St. Andrew's Holborn notably, and St. Giles's Cripplegate by the water-soaked moor- the Plague mark is most darkly drawn. Laystalls of rotting town refuse, the sweepings of streets, houses and middens, were piled high near inhabited quarters, poisoning the air. The dead were buried thickly in graveyards surrounding the City churches; the living drew from wells water for household use which had percolated through the graveyards. At St. Clement Danes, St. Bride's, Cripplegate (Crowder's Well) and many more City places, each of the parish wells now closed, but commemorated by surviving pump or lettered tablet, is a churchyard well."

(Data after Bell 1994, p.9)

Conditions had not much improved by 1845 when Engels described the Pauper grave at St. Bride in London at a time when cholera epidemics (water borne) were striking London:

"The poor are dumped into the earth like infected cattle. The pauper burial-ground of St. Brides, London, is a bare morass, in use as a cemetery since the time of Charles II, and filled with heaps of bones; every Wednesday the paupers are thrown into a

Time Period									
	2000 - 300 BC	300 - 476 BC - AD	(133--- 650) AD --- 1453	500 - 1500	1500 - 1700	1700 1850	1850-1940	1940 -1980	1980-1995
Culture									
	Minoan & Greek	Roman (west)	Byzantine (Roman East)	Middle Ages	Renaissance	Industrial Revolution	Colonies to Nations	Technology Revolution Information Revolution →	
Water Management									
Institutional Control	--? --? --? --	← 770 Yrs →	← 1220 Yrs →				← 145 Yrs → 1985 Commercialising		?
Institutional Delivery		← 770 Yrs →	← 1220 Yrs →				← →		?
Private Enterprise					1609 ← 240 Yrs →				1989/91
Individual (Laissez-faire)	← 1700 Yrs →		← 1130 Yrs → 1609						
Public Health									
	Poor to reasonable	Reasonable to Good(rich)	Reasonable	Poor (some exceptions reasonable)	Poor but becoming understood (Science)	Very poor 100 yrs of Health crises (Europe)	Improves (especially after 1870 in UK) Very good (Developed countries) 3rd world urban crises emerging Medical (immunization) effective after 1900		

Fig.13 Water management systems and public health during various cultural periods of history

ditch is loosely covered in, to be re-opened the next Wednesday, and filled with corpses as long as one more can be forced in. The putrefaction thus engendered contaminates the whole neighbourhood. In Manchester, the pauper burial-ground lies opposite to the Old Town, along the Irk: this, too, is a rough, desolate place. About two years ago a railroad was carried through it. If it had been a respectable cemetery, how the bourgeoisie and the clergy would have shrieked over the desecration ! But it was a pauper burial-ground, the resting-place of the outcast and superfluous, so no one concerned himself about the matter. It was not even thought worth while to convey the partially decayed bodies to the other side of the cemetery: they were heaped up just as it happened, and the piles were driven into newly-made graves, so that the water oozed out of the swampy ground, pregnant with putrefying matter, and filled the neighbourhood with the most revolting and injurious gases. The disgusting brutality which accompanied this work I cannot describe in further detail"

(Data after Hoyles 1991, p137-138)

Control of water supply and distribution in England was wrested from private companies by Government from 1850 onwards with the goal of improving public health. Since that time there has been about 130-134 years of Government control in the United Kingdom but in 1989 water distribution was privatised again.

In France by contrast, Government control and management of distribution appears to have begun in 1840 (eg Dijon town supply developed by Darcy, for the municipal council, Freeze 1994) and developed in parallel with private companies. Large companies have distributed water continuously in France since the late 1880's but resource ownership has not been privatised.

South-East Asia

In South-East Asia, Malaysia has developed a privatised water distribution system. In Thailand there is Government control over the water supply through a number of urban and regional authorities. The sewerage "system" of Bangkok is complex with at least four practices functioning in parallel;

- Individual management including canal/river disposal
- Inhouse systems of treatment (hotels)
- Small plants (housing estates)
- Septic tanks (individual houses)

Changes in Australia

For about 145 years from 1850, the management paradigms in Australia were essentially extensions of European strategies with minor adaptions to climate and hydrogeology.

Major institutional changes in public sector water management in Australia began in 1985 with a move to change the economic restructuring of the Hunter District Water Board. Upheavals and change have now reached all states in Australia with various approaches being used. The following list summarises the strategies for the period 1985-95.

- **New South Wales:** Corporatised numerous restructurings and commercialisation, some privatisation.
- **Australian Capital Territory:** Corporatised, strong international trading,
- **Victoria:** Privatised and corporatised.
- **South Australia:** Privatising (overseas buyer?),
- **Western Australia:** Major restructuring,
- **Queensland:** Major restructuring (some commercialisation).
- **Northern Territory:** No major change and
- **Tasmania:** No major change.

Market thinking, corporatisation, privatisation, internationalisation, downsizing and environmental pressures are all playing their role in this paradigm shift.

Commercialising the water industry seems to have some positive (good news) and negative (bad news) aspects. These can be summarised as follows;

The good news:

- Water as a precious resource attitude is developing slowly in Australia,
- Not wasting water is becoming popular (save money),
- More dams can be avoided/delayed for some time (retain land/environment),
- There is potential integration of surface water/groundwater/waste water management and
- The system can become more efficient and accountable.

The bad news:

- Loss of professional expertise (staff downsizing), occuring,
- Loss of corporate memory,
- Water price will rise considerably,
- Fewer big picture enterprises, eg. salinity research, will occur, and
- Can future Public Health crises be avoided/managed when there is considerable pressure to be commercially viable? Such crises have arisen over recent times.

THE URBAN WATER CYCLE IN THE YEARS AHEAD

Australia

A complete rethink of the urban water cycle is going on right now in Australia both at the State and Federal level. We are on the threshold of significant change in how we use and manage water, both as a supply and a waste transporter in urban environments especially. Substantial replacement of the pipe system will be needed in 25 to 30 years time and this will cost billions of dollars.

The Australian Science and Technology Council (ASTEC) has recently supported study on the future of the Urban Water Cycle in Australia, ASTEC (1995). An important part of the study was the application of foresighting techniques to try to predict possible scenarios. Four possible future scenarios that could describe what may happen in Australian cities over the next 50 years are considered to be appropriate.

It is not possible to predict exactly if one scenario will dominate events or whether elements of each will occur. The four scenarios are identified by the following titles:

- Slow Deterioration Scenario,
- Market World Scenario,
- Ecological Scenario and
- Public Health Crisis Scenario.

Slow Deterioration Scenario

This may be summarised as including the following;

- Public (Government) ownership maintained,
- Current once-through system continues with some repairs,
- Available water decreases – pipe losses increase, dams silt up,
- Sewer collapse and burst water mains, increasing groundwater pollution intensifies. Blue-green algae blooms more frequent, estuaries deteriorate,
- The billions of dollars required to replace the pipe system between 2020 or 2030 not available, and
- Eventual major crisis, system breakdown, only response available is radical.

Market World Scenario

The key ideas for this scenario are:

- *Full Privatisation*
  - Companies own/operate supply
  - Public ownership/company operation
  - Catchments sold, international trading

- *Little Regulation* – Free market

- *Centralised Wholesale Water "Spine"*
  - Supplied by dams, bores (public/private) recyclers, harvesters, sewer miners

- *Retailers draw water from Spine*
  - Strong demand management,
  - Smart electronic metering inhouse*[1],
  - Variable pricing (drought, (high), wet (low)

- *Improved Products*
  - Ultrasonic clothes washing/dishwashing machines, water factories, modular treatment systems

- *Public Health*
  - High quality by treatment (high cost)

- *Environment*
  - Managed by market mechanism
  - Tradeable waste permits, water allocation trading
  - Environment monitoring industry expands

Ecological Scenario

The main aspects of this future scenario are:

- Ecological crisis driven – food, climate, strong Greens Party
- Strong Legislation – ecological sustainable development
- Government ownership – full environmental costs, water prices rise
- Strong recycling – stormwater, greywater, sewage (no outfall) borehole injection/recovery, below ground storage*[2]
- Decentralising of the water system – urban village groupings, no new dams, small treatment units, new toilet designs
- Strong public education – redesign gardens, few lawns
- Developing countries take up socio-eco approaches to avoid crisis (export/import opportunities)

Public Health Crisis Scenario

- Epidemics – new diseases and pollutants
- Government control – strong regulations – strict standards
- Centralised water/wastewater treatment
- No recycling of water – environment sacrificed where conflict occurs
- Drinking water factories – tanker and bottle, home deliveries

South-East Asia and Other Areas

Rapid urbanisation and industrialisation in S.E. Asian countries are currently producing considerable demands for water management skills and infrastructure development. This trend is expected to grow and is part of a world-wide growth in cities, Fig. 14, Serageldrin (1995).

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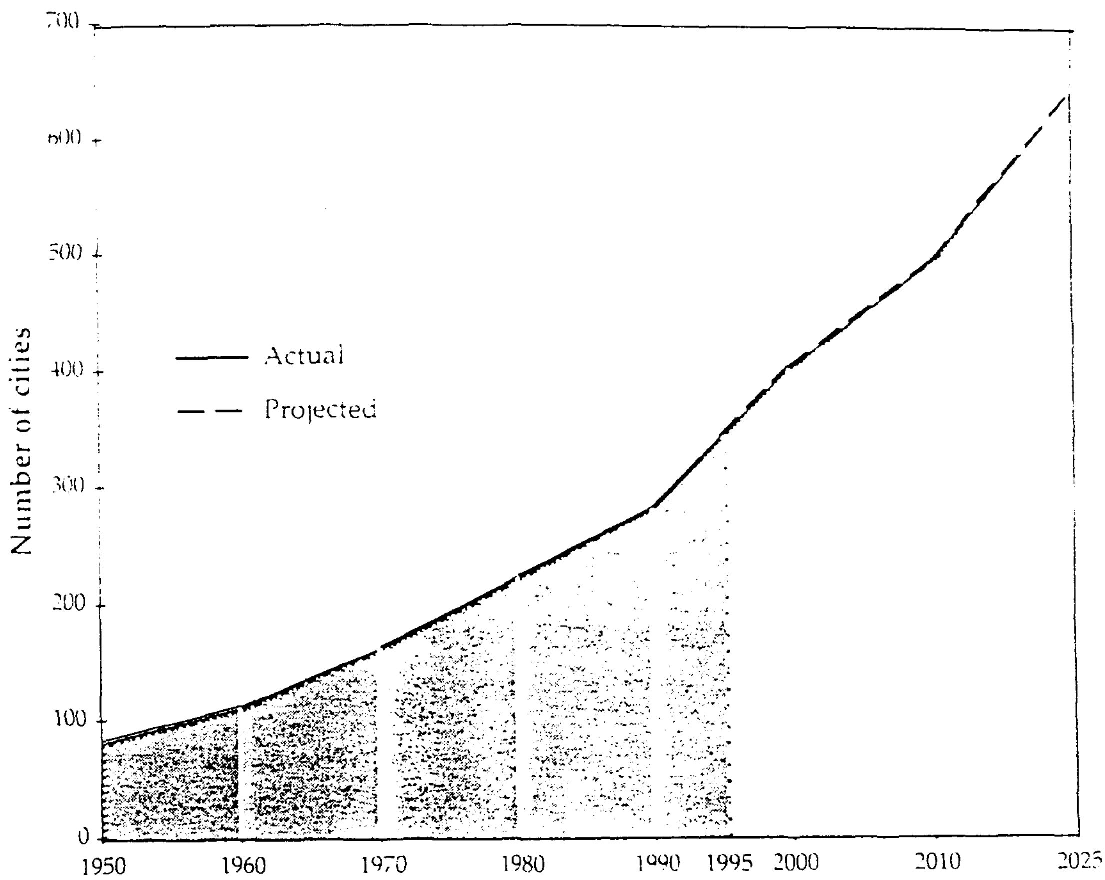
*1 Some trials with metering of household water facilities eg. showers has, and is being conducted, for an aboriginal community, Pholeros et al (1993), and in Canberra, Australia, C. Reynolds (1995 pers comm).

*2 The importance of groundwater resources and the value of subsurface space in general is beginning to be realised ownership and property rights to the space will probably need legal resolution.

Costs of water are expected to rise substantially (two to three times current costs). These trends are illustrated in Fig. 15 include two cities in S.E. Asia, Suryabaya (Indonesia) and Shenyang (China)



Source: World Bank data.

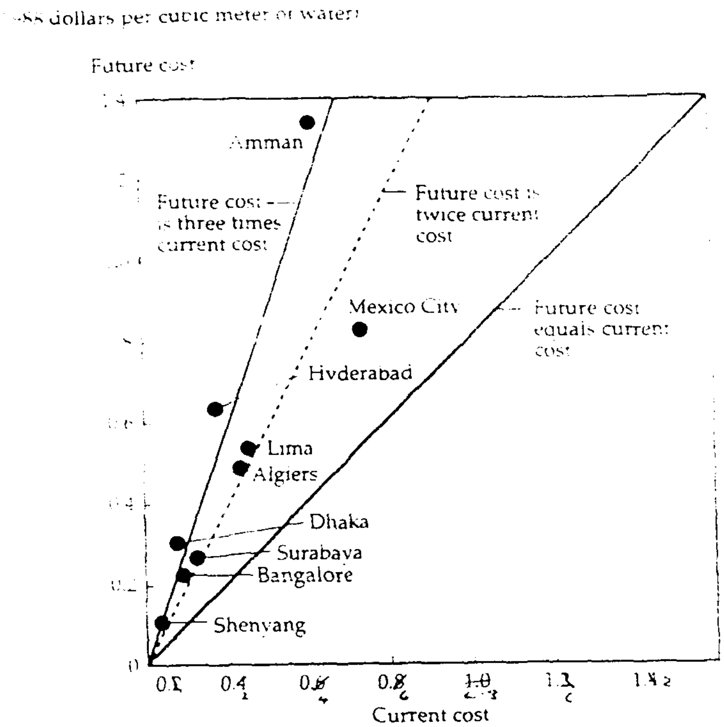
Fig. 14 Projected growth in the number of cities that have more than 1 million people, 1950-2025, Data after Serageldrin.

IRRIGATION, FOOD AND THE ENVIRONMENT

Food security is strongly linked to irrigation since some 30% of the world's food supply is produced using irrigation, Heiler (1994). With projected population growth over the next 20 years there must be an increase in food production of 2.5%/year. The most likely best estimate is 1% due to land degradation problems that develop as irrigation is expanded and limitations of avialable land and water. In South-East Asia, land degradation is a major and growing problem that will potentially conflict with the desire to expand irrigation, Fig. 16.

Another problem associated with irrigation is that of water use efficiency. Irrigation world wide is very inefficient in its use of water, Kotwicki (1994), Serageldrin (1995). The Food and Agricultural Organisation (FAO) estimates that only 45% of irrigation water is effectively used by a crop, Serageldrin (1995), Fig 17. The remainder is lost.

A common problem that is also emerging is the conflict between water required by the environment (river flow, wetland stability) and irrigation. Recently in New South Wales, excess water flows normally provided to farmers to irrigate crops have been returned to the rivers in order to prevent some nationally important wetlands drying up



Note: Cost excludes treatment and distribution. Current cost refers to cost at the time data were gathered. Future cost is a projection of cost under a new water development project.
Source: World Bank 1992.

Fig 15 Current cost and projected future costs of water supplied to some urban areas. Data after Serageldrin (1995).

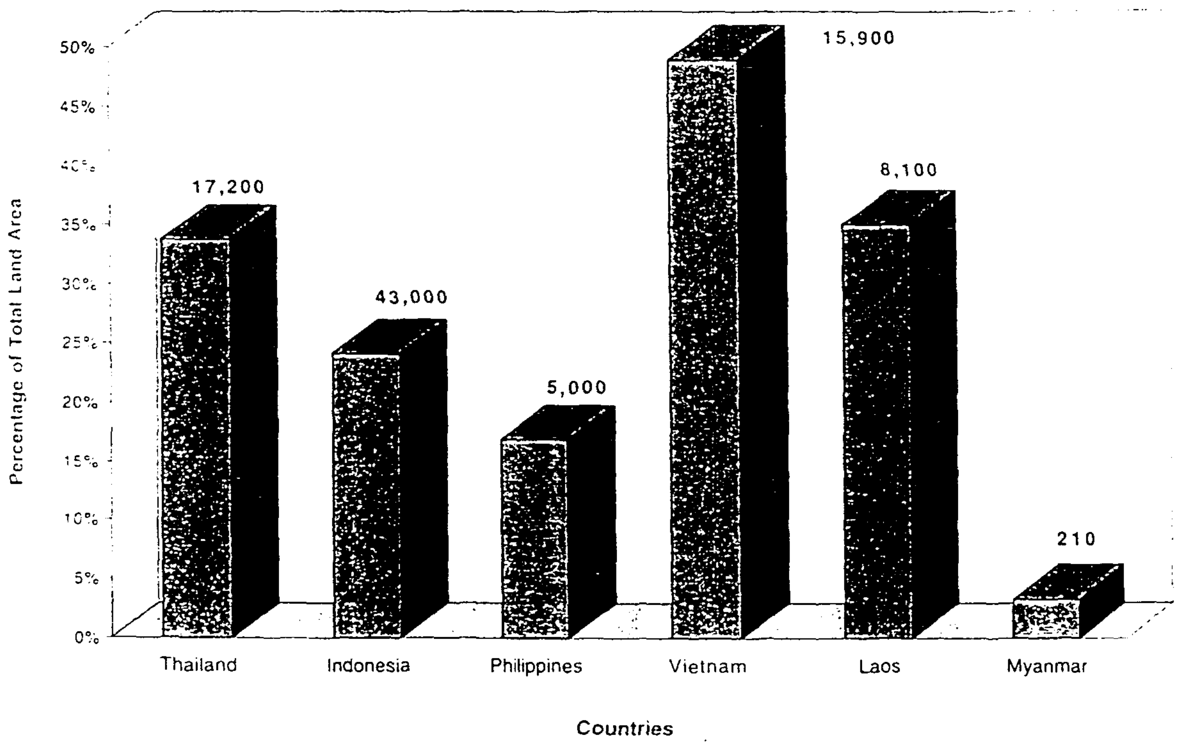


Fig 16 Percentage of total area and actual area of degraded land in some countries of South-East Asia in 1990 (Hectares x 1000)

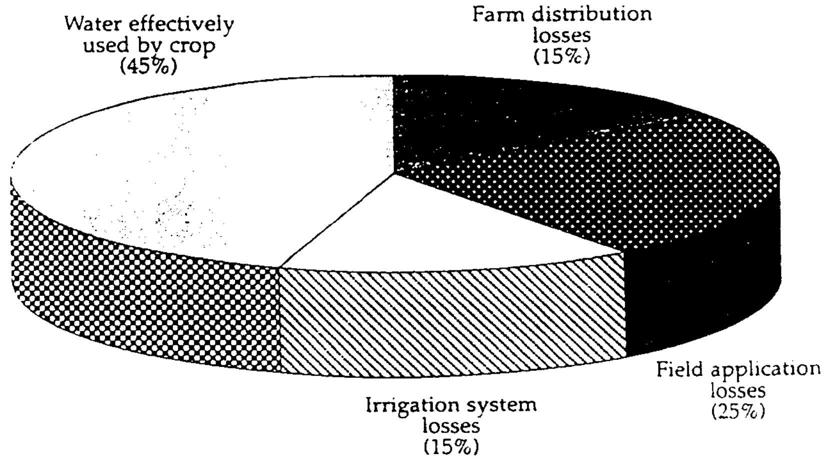


Fig. 17 Average losses of irrigation water. Data after Serageldrin (1995).

(Macquarie and Gwydir marshes). This action by the State Government has angered farmers.

Competition for water between irrigation to produce food and the environmental users is expected to heighten globally in the future.

The likely expansion of the environmental problems in South-East Asia and water in particular can be gauged from various recent market assessments, Franke (1995) and PTB (1995) for Indonesia, Fig. 18.

The market is expected to grow from 136 Billion DM (1995) to 370.5 Billion DM by 2010.

The Indonesian market sectors for environmental equipment and services in 1995 is estimated by PTBA (1995) to be:

• Water Treatment and Supply	$US 430 million
• Water Treatment	$US 180 million
• Waste Management (Municipal, Industrial and Toxic)	$US 240 million
• Air Pollution Control	$US 50 million
• Monitoring and Analytical Equipment	$US 40 million
• consultancy Services	$US 10 million

The total Indonesian market value is estimated at $US 973 Million.

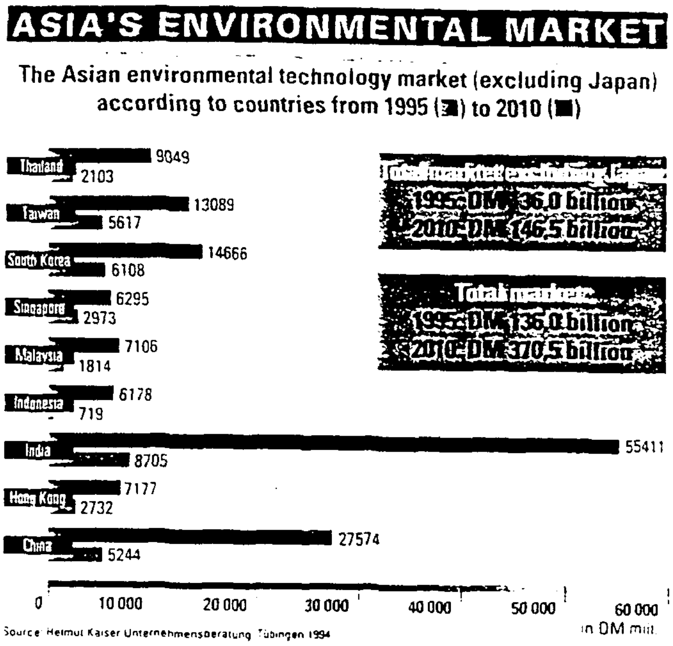


Fig 18 The estimated environmental technology market in Asia, 1995 and 2010. Values are in DM (1DM ≈ $1A), Data after Franke (1995).

CONCLUSIONS

Historically, water has always been important in the lives of people. The Romans especially, developed well organized water delivery systems that were not significantly improved on until the 19th Century. Improvements came after Public Health crises that were an unwanted consequence of the Individual Revolution in the late 18th and part of the 19th Centuries. Accelerated travel and growing urbanisation, (factors causing health crisis in the past such as epidemics) are again occurring at a growing rate.

Australian states have followed European ways of organising water and sewerage schemes in the past but they are now changing rapidly. One casualty of this change turmoil in the Government water agencies is the progressive erosion of the public sector skillbase and this may become a serious issue should a public health crisis occur such as a water borne disease. Such crises have arisen over recent times.

History teaches that useful knowledge can be lost overtime and that private company ownership and control of water may not be ideal from public health or environmental points of view. However, privatised delivery of water with adequate controls both on price and quality could be satisfactory. Worldwide, water supply costs are expected to rise sharply over the next 20 years.

There will be a growing demand for water by irrigation but the associated increase in potential land degradation and other environmental pressures are likely to cause a food crisis during the next 20 years. This issue will be especially important in South-East Asia with its reducing renewable water per capita. Thailand, Philippines and Indonesia are the most vulnerable. Water shortages in the Middle East are acute now and will become more so in the future. It is possible that wars could be fought over water in the region.

Programs of water conservation, improved management and public education are urgently needed in most countries including Australia and South-East Asia.

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