

Conclusion: A new solution

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By the 1860s Australian cities were generally facing four problems with their water supplies:

- They had poor supplies of potable water, resulting in infections from water-borne contagions.
- They were unsanitary and had increasing difficulties, including threats to health, in dealing with the disposal of human and other wastes of urbanisation.
- They suffered periodically from poor drainage of stormwater.
- They experienced crises due to a lack of convenient supplies of water to fight fires.

While all four were important, the health of their population was the prime consideration in securing new water supplies. The mid-century recognition in England, documented by the sanitation reformer Edwin Chadwick, that many health problems were directly related to the lack of secure supplies of potable water (Flinn 1965) was followed by pressure in Australian colonies to develop such supplies (Dingle, this volume, Chapter 1).

Potable water

From settlement, Colonial administrations had tried to secure reliable supplies of potable water by exploiting sources 'beyond' the urban boundary, but growth of each colony was such that often the urban area quickly grew beyond the area reserved and supplies were compromised. Households harvested and stored rainfall from roofs in tanks and occasionally from surface runoff in underground cisterns. These supplies often failed in long summers or drought periods. In addition, it became increasingly apparent that underground cisterns provided poor-quality water because of infiltration of runoff and due to seepage of sewage effluent into the cistern (Lloyd *et al.* 1992). 'New' sources periodically had to be sought from further afield to provide the secure supplies of potable water.

As the cities grew, the demand for the reticulation of secure supplies of potable water increased. Underlying the development of these supplies was the assumption that the demand for water could always be met by seeking/developing new supplies. The initial assumption, in 1878, for demand in Newcastle, which was similar to Sydney and advised by the same engineers, was that personal consumption of 20 gallons (91 litres) per head per day was sufficient to meet the demands for consumption, food preparation and personal

hygiene (33.2kL pa) but that this might rise to 50 to 80 gallons per head per day to meet the needs of manufacturing and garden watering (Lloyd *et al.* 1992). In Melbourne the estimated demand was originally 40 gallons per capita per day but reduced to 30 gallons per head per day before construction began (Dingle and Doyle 2003).

While potable water was needed for health reasons, the supply seemed reliable and generous enough to allow households to use water of a standard fit for domestic consumption for sanitation, to water gardens and for other uses. The seemingly adequate supply also meant that domestic bathing and laundry practices changed, with consequent dramatic increases in the discharge of wastewater from households. Households were no longer able to rely on the use of cess pits and drainage sumps to dispose of wastewater and 'excess' wastewater drained onto the street and into the general surface drainage system that was already inadequate to cope with stormwater runoff. The result was an increase in noisome flows of wastewater and sewage onto the city streets.

By 1880 the issue of managing waste disposal assumed greater proportion as urban populations grew. The worldwide popularity of Edwin Chadwick's ideas for improving urban sanitation and the development and increasing take-up of water closets exacerbated the sanitation problems in Sydney and Newcastle but also offered the idea for its solution in the form of the development of a piped sewerage system.

There was a neat symmetry in this. The supply of water met all the needs of households for potable water and there appeared to be water enough to provide the medium for the transport of wastes. This was seen as an elegant solution and in the original Chadwick proposal offered the first environmental solution to the management of human body wastes because it proposed to collect them and transport them to be used as fertiliser on nearby farmlands — a solution that, as Dingle points out in Chapter 1, was experimented with in Sydney and Adelaide but only seriously adopted in Australia by Melbourne.

The virtuous circle that was ultimately taken in most Australian cities was to develop a reticulated water supply and later a piped sewerage system to remove sewage. This solution was made more financially attractive for water authorities with the banning of rainwater tanks and the preferment of waste-management technologies that relied on water transport to the exclusion of technologies that did not. The attractions of water-based sewerage systems were so compelling that a networked sewerage system was developed to transport wastewater, human excreta and other wastes. This seemingly felicitous solution to the problem of sanitation ultimately led to a large environmental problem in the form of discharges of sewage to the ocean. Property owners were required to connect to the public water supply and later to the sewerage system on public-health grounds. Water consumption rose as households took advantage

of the apparently abundant supplies for their flush toilets and for personal hygiene.

Stormwater drainage

Stormwater runoff became more problematic as the cities grew and more of their area was covered with impervious surfaces. The volumes of water were so great that it was infeasible to manage the runoff by using the sewerage system, so separate stormwater drainage systems were developed. They, too, drained directly into rivers, harbours, bays and oceans that abutted the cities and became significant sources of pollution of those waters.

The early decision to develop separate systems for sewerage and stormwater drainage meant that wastewater flows could avoid the peaking problems associated with storms — problems that would only be exacerbated as development of the cities led to the increasing coverage of drainage catchments by impervious surfaces. Although sufficient water falls as rain in the urban areas to meet their water requirements, this approach to stormwater management means that, even today, stormwater is discarded and treated as a ‘problem’. How much of this is a consequence of the fact that surface drainage, as distinct from sewerage, was the responsibility of local government whereas in many cities sewerage was the responsibility of the water-supply authority has been little explored. It is interesting to note that in the recent drought some thought has been given to the possibility of redirecting stormwater, on occasion, to ensure that the sewers were properly flushed — the combined effect of water restrictions and water-saving behaviour having reduced sewage flows so that the systems had a tendency to block.

Twenty-first-century outcomes

The net effect of these nineteenth-century ‘solutions’ in the first decade of the twenty-first century is:

1. The per-capita consumption of water is now three times the level the original systems were designed to provide.
2. Stresses in the ecosystems from which water is abstracted to supply the cities.
3. Extreme stresses on the ecosystems into which wastewaters are discharged.
4. Stormwater runoff systems that are the major sources of pollution of the rivers, bays and harbours on which the cities are built.

The combined effect of rapid increase in population and massive increase in per-capita consumption meant that the demand for water soon outstripped supplies but the attraction and seeming felicity of the ‘scientific’ approach to water management fostered the engineering systems needed to increase supply — usually in the form of more dams which impounded the water in ecosystems

further from the cities for transport to them. There was a comforting belief that there were always additional supplies available and all that was required was application of engineering skills to deliver them to the cities.

By the mid twentieth century, most Australian cities had exploited all the water resources available in their near hinterlands. Their supplies were in precarious balance with demand. Although they had originally been conceived of as 'health authorities', with a remit to protect the public health, water authorities had seen opportunities to avail themselves of the financial rewards arising out of increased consumption. The gradual acceptance by their residents of the commodification of water and their passive acceptance of increased use of water-using services and equipment increased consumption and brought with it increased financial rewards to the water authorities. The water authorities were remarkably efficient at harvesting, storing and transporting the available surface water resources, although system losses due to evaporation and leakages became increasingly important as they reached the limits of the 'natural supply'. As the population grew and was accompanied by increasing levels of per-capita consumption, the water authorities increasingly found themselves with few reserves to cope with vagaries in supply. By the end of the twentieth century the situation became critical, in part because the apparent reduction in long-run rainfall over dam catchments meant that reservoirs were operating with small reserves.

The response has been to seek ways of increasing supply and, as a temporary measure, to introduce water restrictions aimed particularly at reducing water consumption on uses outside the dwelling. Generally, water restrictions have had some success in reducing demand but the scale of reduction has not been large, with the notable exception of Brisbane where the Queensland Water Commission in 2007 restricted water consumption to 140 litres per person per day and managed to improve on the target within a very short period (although there is some expectation that once the new desalination plants, water recycling, new dams and water grid come into operation consumption will increase (QWC 2008) — possibly with encouragement of the water authorities to increase revenue). These measures have not allayed anxieties but the current drought has brought underlying problems in the management of national water resources into high relief and led the Commonwealth Government to initiate national water-policy reform.

Features of the demand and supply of urban water

Two aspects of the water system need to be borne in mind:

1. The demand for water has some seasonal variation, with summer demand being higher than winter, but the pattern of consumption is fairly constant

year on year for conventional housing and especially throughout the year for higher-density forms of housing (Troy *et al.* 2005).

2. The supply of water through the water catchments is highly variable, depending as it does on rainfall. This was less of a concern when the storage was large enough to allow for several years of consumption, but is now because the increase in population, together with the increase in per-capita consumption, produces a high and relatively constant demand while rainfall over the catchments in the larger cities appears to have declined.

Attitudes to personal hygiene and cleanliness practices had been changing since the Middle Ages (Vigarello 1988). Moreover, cultural and behavioural norms in domestic water use changed considerably in the developed world during the nineteenth century, all adding considerably to increased per-capita water use. This meant that people used flush toilets and flushed them with each use more often compared with earlier toilet practices. They also washed themselves more frequently. At first, this was by bathing, but this was replaced by the increasing popularity of showering, which led to greatly increased domestic water consumption (Shove 2002; Shove 2003 — this is a discussion of UK experience but accords well with Australian experience; see Davison, Chapter 3 of this volume) and wastewater generation. To some degree the popularity of showering is related to the pleasure of the act — especially once heated water was more readily available — as much as it was to notions of personal hygiene (Gilg and Barr 2006; Hand *et al.* 2003; Allon and Safoulis 2006; Safoulis 2006). As Davison, Chapter 3, shows, cultural and behavioural norms in domestic water use in Australia changed considerably over the last 150 years, all adding considerably to increased per-capita water use, especially in the cities.

A recent survey of Sydney households' attitudes (Troy and Randolph 2006) revealed their strong determination to maintain their level and nature of shower use. It also revealed considerable reluctance to reduce toilet flushing. These responses suggest that programs designed to reduce consumption from both activities may encounter strong passive resistance.

So we now have a paradox that water-supply systems, once determined by considerations of health and primary hygiene, are more driven by calculations of lifestyle that may well be counterproductive. For example, increased showering is claimed to have been accompanied by an increase in skin diseases (Shumack 2006).

Contemporary water consumption also both helps create the demand for, and is a consequence of, the form of development of the city. The traditional separate house in its own garden was (and remains) a strong expression of the felt needs of households for a degree of independence (Gaynor 2006). It may also create the possibility of a high level of food self-sufficiency.

Traditional housing not only provided the opportunity for a high level of domestic production (Mullins 1981a, 1981b and 1992) but it also 'explains' why it was such an effective cornerstone of the conservative philosophy expressed by Menzies in the 1940s and 1950s (Brett 1992) who successfully built on the desire of households for a home of their own with a small garden to gain and retain office nationally and to shape the policies which guided the massive growth of Australian cities in the 1950s and 1960s. Freestone (2000) documents how the garden-city movement shaped the nature of Australian cities, although Hall (2007) also documents the disappearance of gardens in the contemporary city.

This form of accommodation not only provided the opportunity for a high level of domestic production, it also 'explains' why the separate house and garden shaped the policies which guided the massive growth of Australian cities in the 1950s and 1960s. Paradoxically, this suburbanisation is seen by some as entrenching the resistance to reform of water-consumption practices.

The widespread take-up by households since the 1940s of washing machines (Davison, Chapter 3) led to increased water consumption. In earlier periods, washing clothes was a tedious affair. The advent of new machines offered to take some of the labour out of the washing task. The higher level of workforce participation by women and the increasing degree of consumerism since the 1940s was accompanied by a significant fall in the cost of clothing and manchester items in household budgets, which in turn meant that people were able to change their clothing and manchester items more often and meant that there were more clothes to wash. The ability of machines to wash clothing whenever it was convenient significantly increased water consumption. This take-up of water-using services and appliances that have been an integral part of Australian cities may now be seen also as entrenching resistance to reform of water-consumption practices.

Water consumption in the kitchen has also increased, although it remains a small proportion of internal household consumption. External consumption of water also increased with the increasing popularity of swimming pools and more recently of spas. Garden usage is also important, but in some cities it is less significant than might be assumed. In Sydney, for example, most households rely heavily on rainfall to maintain their gardens (Troy and Randolph 2006).

The point is not to lament these changes, but simply to appreciate their cumulative effects on values and expectations as well as on levels of consumption. And then to ask how such interdependencies might be untangled in the least obstructive, most efficient ways.

Development of water supply: The case of Sydney

Water services are provided by a government corporation and monopoly supplier (Sydney Water Corporation). It has a strong engineering culture overlain by a strong economic approach to water-management issues. In the face of occasional criticism, it has developed a strong defensive institutional culture.

From its origins as a colony, Sydney has for the last two centuries responded by projecting the demand without any fundamental review of the services it provides and then setting out to provide the supply. Sydney Water Corporation's response to the increasing demand for water has been to follow the traditional 'project and provide' approach to water services.

It is now clear that Sydney cannot simply continue to harvest waters from sources outside its immediate region to meet what appears to be an unquenchable demand without serious environmental consequences and without failures in supply. This is acknowledged in the Metropolitan Water Plan, which was developed in part to meet the increased demand for water from a predicted increase in Sydney's population of around one million over the next 25 years. The Plan implicitly assumes an ever-increasing supply to meet demand.

The focus on increasing supply of water in the 'traditional' way will eventually prove problematic and unmanageable because of the environmental stresses associated with the approach and, not least, on cost grounds. A more fruitful way of continuing to meet reasonable demands for potable water from Sydney Water Corporation's *existing* storage facilities such as Warragamba Dam lies in encouraging residents to reduce their water consumption and to accept greater responsibility for security of their own supply and wastewater management in a manner that reduces the demand for potable water, improves the sustainability of the city and simultaneously enables the government to meet new environmental targets.

There is an urgent need for a major change in the way demand for water should be managed at the level of the individual household, together with new measures to reduce the consumption of potable water in the home. Such an approach is built on the assumption that initiatives need to be taken to minimise the environmental stresses that accompany the present consumption of water and the management of wastewater flows (Guy *et al.* 2001). It also assumes that we cannot simply turn to a new system and ignore the path-dependency effects of the water-supply and sewerage systems in place, a point made strongly by Dingle in Chapter 1. A new approach would need to be phased in as part of a new water-demand management model which would lead to less reliance on the traditional reticulation system and reduce the per-capita consumption of potable water supplied by Sydney Water Corporation.

Over the past six years we have had a plethora of national conferences and summits on water services. Much of the focus of these meetings has been on 'reform', which is code for privatisation of aspects of the services. The conferences have usually been built on the assumption that the present institutional structure of the urban water 'industry' is given, that the present engineering solutions are only to be made more efficient, that pricing is an acceptable, indeed major, tool for moderating demand (the shape of which is essentially taken as given) along with exploration of the privatisation of aspects of the water services to improve 'efficiency' but that there should be a vigorous search for 'new' sources. The program of the Sixth Annual 'Australian Water Summit' scheduled for March 2008, for example, provides a typical illustration of this constrained approach. These new sources tend to be ways of extracting more from existing dams by exploiting waters that were previously thought to be not worth using or were too costly to treat. Given the fact that all 'natural' sources are now fully exploited and in such a manner that there is little spare capacity to allow for the variation in rainfall and therefore of runoff from the dam catchments, the currently favoured solutions are to develop recycling plants (in the ACT these are coyly called 'water purification plants') and desalination plants.

We do not dwell here on the proposals to build desalination plants (although Peter Spearritt in Chapter 2 does document some of the consideration of such solutions to water supply in Southeast Queensland) which are now under construction in most major cities except to point out that desalination plants are not only expensive in environmental terms but they cannot easily be run efficiently in low-flow conditions (*SMH* 2007). The residents of Sydney are now being advised that the desalination plants now under construction will cost all households in Sydney an estimated \$110 per year which, together with other measures the Sydney water corporation proposes, would increase water bills by \$275 per year which is equivalent to an increase of 33 per cent in the average water bill (*SMH* 2007).

The present approach to water supply is to search for some 'new' source, with no review of the existing shape of the demand.

Reduction in demand for potable water

An alternative approach would be to explore the history of the way the consumption of water has changed to gain insights into possible avenues to reduce consumption. Davison's brief history here provides some valuable clues. In her exploration of the cultural determinants of water use, Lesley Head (Chapter 4) provides further evidence of ways in which consumption of potable water might be reshaped and reduced.

The problem of recycled water

One of the ways in which water corporations seek to increase supply is to sponsor the use of recycled sewage.

There is popular resistance to the human consumption of recycled water (Peter Spearritt Chapter 2; *Sydney Morning Herald* 2005b) because of anxieties about the efficiency of systems to eliminate the bacteria, protozoa and viruses commonly found in sewage, as well as the many biologically active molecules, such as drugs taken to control fertility, infection, hypertension, cholesterol, depression, and so on. The presence in sewage of preservatives added to food and beverages to which a significant minority, of people have allergic reactions is a further problem. A question also arises as to whether recycling systems can be maintained to produce high-quality water.

There is also increasing evidence that the engineering systems, including reverse osmosis, do not eliminate pharmaceutical drugs to a safe level, which may lead to increased health risks. Watkinson *et al.* (2007) report that 92 per cent of antibiotics are removed from treated sewage. A leading infectious-diseases physician and microbiologist, Professor Collignon, makes the point that this is only log 1 reduction, whereas for viruses and so on log 6 reductions are needed for microbiological safety (Collignon 2008).

One of the worrying features of the consideration over the use of recycled sewage in the potable-water supply is that this is being introduced without the benefit of community consultation. The community rejection of the proposal to use recycled sewage in the Toowoomba water supply has led water authorities to proceed to develop such approaches to water without public plebiscite. Water-recycling plants are in operation, under construction or in advanced planning stages in Brisbane, Canberra and Sydney, for which there has been little or no independent research to explore the long-run health risks of such projects and no public discussion of them. The high energy consumption required to produce such water is rarely considered by the water authorities to be a serious problem.

The major preoccupation in the original development of urban water supplies was the supply of potable water to secure the health of the community. This was often reflected in the motto of the water supplier such as for Newcastle which proudly stated (in Latin) that it was 'For the Public Health' (Lloyd *et al.* 1992). Public-health concerns were also the rationale for making it compulsory for property owners to pay for the connection to the water supply and later to the sewerage system.

This single-mindedness was remarkably successful. The health of the community was improved dramatically.

Because only a small proportion of the water now consumed needs to be of potable quality, a significant proportion of the revenue of water authorities recently has been more related to consumption not primarily related to health needs. For a complex variety of reasons, water authorities have not been enthusiastic about pursuing strategies designed to reduce the reliance on the use of potable water for uses and activities that do not need such high-quality water. They have sometimes argued that it is too costly to develop dual-flow water systems or to develop methods to capture rainfall as alternative supplies. They have generally been more enthusiastic about the use of manufactured water from recycling or recycling sewage to provide supply and have tended to ignore the objections of the risks to community health raised by those opposed to the human consumption of recycled sewage.

Here we have a perverse situation. The original requirement to pay for water supplied to the property was justified on health grounds, yet those who now object on grounds of the risk to health by the forced consumption of recycled sewage are nonetheless required to pay for a service they regard as compromised.

While it should not be ignored, the large-scale recycling of wastewater for human consumption need not be part of a comprehensive solution to better urban water-conservation practice. If recycling wastewater for human use proves politically difficult, then there are alternatives.

Making the transition to sustainability

Few aspects of our approach to the development and management of cities have lasted 150 years. We no longer have the same building regulations. We have consigned the miasmatic theory of disease transmission that existed in Chadwick's time to the dustbin of history. We live and work in our cities in very different ways now than we did then, and we communicate with one another in ways that were unimaginable then. The way we consume energy and the forms of energy we consume today are very different from then. The governance of our cities is different now and we pay for a whole range of services in ways that were inconceivable then. Our concern for the environment demands a very different approach to the way we use natural resources now.

We accept that we live in a state of flux. Paradoxically, the path dependencies we have created in the water services we provide and the way we provide them is reflected not only in the technologies we use in consuming water services; it is also reflected in the cultures of the institutional and administrative arrangements we have devised for the management of water. This institutional culture has fed and been created by the 'predict and provide' approach which is taken. The preoccupation with pricing regimes as solutions to moderate demand does little to generate new thinking in approaches to water services. The present so-called crisis or 'water problem' may be an apposite time to review sanitation

services and to develop a new approach that recognises our fundamental need for potable water to maintain our health standards and our need to manage human body wastes in a felicitous manner but one which minimises the use of water.

Even if it is acknowledged that present uses of water cannot be sustained and that the current approach to the water crisis by searching for ways of increasing supply is ultimately self-defeating, it would be impossible to arrange for a rapid transition from the way water services are currently provided. The 150 years of development of the water-supply and sewerage systems have shaped, and been shaped by, the development that has occurred in Australian cities. This creates a significant degree of path dependency in the way in which services are provided and must be taken into account in trying to find ways of continuing to provide a supply of potable water. A similar situation exists in relation to the provision of waste-management services.

While it is conceivable that alternative approaches to the provision of water-supply and waste-management services could lead to significant reductions in the consumption of water, any transition from the way these services are currently delivered must be pursued taking into account the rate of growth of the urban areas served and the rate of obsolescence of the existing reticulated services.

Currently, the additions to the built environment run at about 1–1.5 per cent per year, depending on the stage in the building cycle. By mandating all new developments to install rainwater tanks, greywater-recycling systems and dry-composting toilets would reduce the demand for potable water by up to 70 per cent per dwelling. By identifying areas where it would make sense to retrofit developments with such things, the rate of change of a new approach to water services could be doubled. Pursuing such a program for a decade would mean that after 10 years, 30 per cent of the urban development would be using 70 per cent less water per dwelling. Such savings would continue to be obtained as the older parts of the cities were progressively modernised. Similar savings could be achieved in all non-residential developments in the city. This would mean that the path-dependency effects of the present systems were recognised and taken into account as the city renewed itself. In the longer term, this would lead to a continuing and substantial reduction in demand for the publicly provided supply of potable water.

This suggests that changing the existing services may take some time and that several strategies may be pursued simultaneously.

The first would focus on an aggressive pursuit of efficiencies in the consumption and supply of water services in the existing urban development.

The second would be to require new additions to the urban stock to provide for the capture of rainwater runoff at the time of construction. Water so harvested could then be used to substitute for potable water supplied through the present reticulation system. Many current proposals include a requirement to plumb tanks to toilets and washing machines.

The third would focus on the development of a retrofit program to gradually change over the existing development, with the rate of change being dependent on the rate of obsolescence of the services.

This approach would minimise the problem of stranded assets, identified by Dovers in Chapter 5, which would be created if the rate of change to new systems was too rapid. The actual rate of change would be decided for different areas within the city following a detailed analysis of the water consumption in those areas and the efficacy of introducing new waste-management services and the costs of doing so. It would, of course, also explore the savings to be obtained from reducing water supplies and consumption and of reducing the management and treatment of waste flows.

Dovers also points out the need to explore changes in the institutional and regulatory arrangements currently employed in the management of water services generally. This seems to be the most difficult phase in developing a new approach to the solution of our water-services problem. Water authorities are simply loath to take a new approach. They take refuge behind economic arguments that pricing structures can lead to reduced consumption but seem not to accept either the issues of rights of access to potable water or the equity aspects of the pricing regimes they favour. They also discount alternative approaches to supply, such as encouraging use of rainwater tanks or stormwater harvesting, on the grounds that they still have an obligation to provide water services in dry periods, arguing that the risk to services is too great. This leads them into arguments supporting the use of manufactured water in which the risks to health and to environmental stresses are heavily discounted. Their proposals also seek to avoid allowing the public any say in the decision-making.

An equitable pricing regime

A regulatory and retrofit strategy would need to be buttressed by a pricing policy which ensured that water was supplied to households at a minimum guaranteed volume per person per year at an equitable price. This might sensibly be seen as an inalienable environmental right for all residents. In this way, lower-income households and lower-consumption households would not be penalised. In Chapter 8, Godden explores issues of water rights, including the notion of environmental rights in water. The point here is that if the guaranteed level was close to the original design levels for most city services (approximately 30kl per person per year) and was the level needed to sustain life and provide

for basic levels of personal hygiene, any consumption above that level could be considered as discretionary and priced to reflect that situation.

The price charged for consumption volumes above the minimum guaranteed volume could then be set at a rapidly escalating rate to ensure that those who used more than the minimum paid significantly more for water. This would mean that those with high external consumption would pay significantly more.

Such changes in the pricing regime would need to be accompanied by changes in the bill structure so that the 'fixed' charges component of water bills would be reduced to a minimum administrative charge or eliminated. This would ensure that a user-pays pricing system was properly directed at the higher water consumers. Such an approach would reduce the pressure in the current systems which effectively allow high consumers to impose financial costs or environmental consequences on others.

Constructing such a pricing regime would have the beneficial effect of relating water price to consumption in a way that was most likely to affect behaviour. It would also provide an incentive for the installation of water-harvesting facilities and lead to greater household water independence.

Present water consumption patterns

A recent ABS report revealed that in 2001, 25 per cent of water consumption in NSW was for outdoor or external purposes (Table C1). This was approximately the same as the proportion used in the bathroom (26 per cent) and for toilets (23 per cent). Kitchens and laundry uses accounted for the remaining 26 per cent. One of the paradoxes facing water managers is that although they have been successful in providing a reliable supply of drinking water, little of it is actually drunk (approx 1 per cent). The volume of potable water actually consumed, used in food preparation or cleaning cooking equipment and utensils, cutlery and crockery is about 10 per cent of household consumption.

Table C1: Average annual per-capita water consumption by location of use in 2001 (kL)

	NSW	VIC	QLD	SA	WA	ACT
Bathroom	26.3	26.5	26.0	18.5	22.4	18.7
Toilet	23.2	19.4	16.4	16.0	14.5	16.4
Laundry	16.2	15.3	13.7	16.0	18.5	11.7
Kitchen	10.0	5.1	12.3	12.3	10.6	5.8
Outdoor	25.3	35.7	69.0	62	66.0	64.4
Total	101	102	137	123	132	117

Derived from Tables 9.6 and 9.7 in ABS 2004

No regional breakdown of this consumption within NSW is offered in the ABS report (2004), but given that the great proportion of this consumption is accounted for by households in Sydney, the NSW figure can reasonably be taken

as a close proxy for the Sydney Metropolitan Area at that time. Recent research shows that water restrictions on garden watering and car washing, the main targets of these restrictions, at best impacted on a minority of Sydney residents; namely, those who had gardens and bothered to water them, or those who regularly washed their cars at home. These turned out to be minority pursuits across households in Sydney, even before the introduction of restrictions.

The other key fact to note here about water consumption, as evidenced in several recent studies (IPART 2004a; Troy *et al.* 2005; Eardley *et al.* 2005), is that the size of household is a key determinant of domestic water consumption. A number of studies indicate that on a per-capita basis Sydney households in different forms of accommodation have, for all practical purposes, similar annual demand for water, at approximately 100kL (IPART 2004a & b; ABS 2004; Troy *et al.* 2005). Research also indicates that there were considerable economies of scale in domestic water consumption in Sydney. This implies that, per-capita water consumption is not dependent on the residential built form. Falling household size is likely to be accompanied by an increase in average per-capita consumption.

Given that the current restrictions on external water use have probably reduced such use as far as is possible, then it is only by reducing the consumption of potable water *inside* the home that real gains in winding back the growing demand for water services in Sydney can be made.

Whatever the cause of the increasing inability of the water-supply system to meet current demand, whether it is due to growth in demand exceeding the supply, the need to maintain environmental flows, reduced runoff in the dam catchments due to long-run climatic cycles or to global climate change, there is an urgent need to re-examine Australian cities' water-services systems. This is needed to make the cities more water independent without at the same time creating unacceptable stresses on the regions from which water is abstracted or of creating environmental stresses in the water bodies around them into which wastewaters are discharged.

City water corporations have undertaken major exercises in demand management which significantly reduced consumption, most of which has been achieved mostly through improved efficiency in commercial and industrial activities. Mandatory restrictions on domestic water consumption, with severe penalties for those breaking the restrictions, have also been used to reduce consumption. The totality of these measures, however, remains insufficient to be able to rely on dams as the major supply.

A variety of alternative sources of water have been proposed in each city. In Sydney these include increased extraction from the Shoalhaven River south of Sydney (a river which is already stressed), large-scale recycling, extraction from aquifers in the Sydney region and building a major desalination plant. All

proposals also imply continuation of the nineteenth-century solution to meet the demand for water by increasing supply. Before adopting any of these 'solutions' it would be apposite to review the nineteenth-century decision-making to try to understand how Sydney has reached the current crisis and to explore alternative methods of providing essential water services. The same could be said of other large cities such as Brisbane where a significant proportion of the consumption of water is used for cooling water flows in power stations and where the basic demands for water have not been reviewed. The draft water plan for SE Queensland (QWC 2008) nonetheless proposes five desalination plants and recycling of sewage (without public consultation) to maintain water services. In the case of the desalination plants, little consideration appears to have been given to the increase in greenhouse gases and therefore increased climate change pressures to which their operation would lead.

Many of the proposals to increase supply by exploiting wastewater flows assume that the waste streams are available to be sold. However, in Chapter 7 Gray and Gardner advance a compelling argument that waste may be seen as belonging to those who create it. This raises several considerations, including whether or not those discharging body wastes can object to their wastes being sold to others without their approval or of being used in recycling systems without their approval.

The development of reticulated water supply and sewerage systems in Australian cities in the late nineteenth century led to improved personal hygiene and improved sanitation, which was reflected in dramatic improvements in the health of communities. This success has coloured the approaches to water supply and management ever since and has raised community expectations that the present water-services systems can continue to do so. Unfortunately, they cannot.

Rather than simply increasing supply, a different strategy is now required to significantly reduce consumption of potable water. The strategy must acknowledge that the need to supply potable water for drinking and basic health reasons remains but that for other purposes individual and community expectations have to change. The question is: how can this be achieved at the same time as the use of potable water for purposes and activities that do not need to use water of drinking quality is reduced in an equitable manner? The current 'drought' provides the need for short-term measures to begin the process of re-educating people, of changing their patterns of consumption, of reshaping some of their behaviour and attitudes. The increasing acceptance of the reality of climate change and, with it, the increased variability in rainfall provides opportunities to change expectations and cultural norms that affect the patterns of consumption in potentially a more profound way.

Two basic approaches suggest themselves:

1. Measures to reduce consumption of potable water and encourage consumers to accept some responsibility for their consumption by making use of locally available water resources.

Two possible sources suggest themselves:

A. Rainwater tanks

Rainwater tanks were, until the 1890s, the most common supply for most city households. They were made illegal in many cities (for example, Sydney and Newcastle) to ensure the financial viability for the then developing water-supply authorities and until recently were not allowed to be plumbed into the interior of dwellings. They were also banned because of alleged health risks. Whatever the justification for the position taken then, the current situation is that it is now possible to discard the first rainfall to flush the roof clean, ensuring that contamination of the tank water by bird and animal droppings is negligible. The second health argument was that tank water had high levels of lead in it. This was alleged to be from the lead flashing used in roofing and from the lead paints used. Neither has been allowed for many years, so this cannot be a major source of contamination now. While it is possible that lead may be above acceptable limits in tanks harvesting water from older housing, the use of 'first-flush bypass' systems greatly reduces the risk of pollution from lead and other heavy metals. The banning of lead additives in petrol also eliminated the possibility of lead being 'washed' into storage tanks through rainfall.

B. Recycling and storage of treated of greywater

Greywater cannot be stored for long before it becomes a nuisance and even a health risk. It is possible to treat the greywater on site for on-site uses such as toilet flushing, laundry and gardening. Apart from the use for gardening, this means that greywater should be treated and stored. The 'production' of greywater is slightly more than that used for toilet flushing so that the volume to be stored should be sufficient to maintain toilet flushing for a few days. Demand for garden watering may not be as consistent as that for toilet flushing so that the tank for storing treated greywater may need to be large enough to hold water for both activities.

2. Employment of technologies that enable the community to maintain sanitation objectives and meet its ambitions of comfort and convenience without consumption of potable water.

Currently about a quarter of the per-capita average annual consumption of potable water is used to clear the toilet basin but this is not sufficient to transport the approximately 500 kilos of urine, faeces and paper 'produced' per capita annually (note that this is about twice the amount estimated to have been

‘produced’ at the time of the Chadwick report on sanitation. One of the problems was that while the Chadwickian solution to sanitation was based on water-borne transportation of wastes it assumed a relatively low flow of water. The sewers themselves had relatively high gradients.

Changes in water-using behaviour increased the wastewater flows, which had two consequences.

The first was that with higher flows the sewerage lines could be laid at lower gradients, leading to significant economies in the construction and operation of sewerage systems. One consequence of this approach is that currently the sewers need water in addition to that required to flush toilets to transport wastes to the treatment plants. This means that there is a tendency for sewerage-system managers to be less enthusiastic about measures to reduce ‘wastewater’ discharges to the sewer. The problem of dwellings ‘producing’ less sewage and wastewater flows on average thus lead to tendencies for sewers to ‘block’. This has necessitated the release of potable water directly to the sewers to ensure that the system functions. Examples of this ‘problem’ may be seen in holiday and retirement areas that have rapidly expanded or where only small proportions of the dwellings serviced by a sewerage system are occupied at one time.

The second was that sewage treatment plants are required to treat ever-increasing volumes of water to increasing standards to minimise the environmental stresses from the urine, faeces and other wastes discharged to the sewer. The fact that approximately 40 per cent of the potable water delivered to dwellings (some of it being bathroom and laundry discharge) is now used to transport toilet wastes should itself cause questions to be raised about the efficacy of the present approach to sanitation services.

Other waste-management systems

The preference for water-borne sewerage systems meant that little encouragement has been given to other methods of managing human body wastes. There is a wide variety of approaches to provision of waterless or dry-composting toilets, with many systems developed in Sweden and the United States. Some of these separate the urine flow and many require low-powered air venting of the composting chamber. A number of similar systems using different ways of managing or recovering the compost have been developed in Australia. The system developed for medium density housing in Melbourne (GHD 2003) shows that such systems could be developed for urban areas and achieve very significant savings in water use. Using such a system would mean a saving of about 19 per cent water in Melbourne. Use of dry-composting toilets would mean that the recycled greywater would be available to maintain gardens and for laundry use. The use of dry-composting toilets would not only reduce water consumption but would enable the recovery of the composted material for use as garden or

farm fertiliser. Use of a dry-composting system that enabled separate collection of urine flows would not only simplify the composting process but would provide a supply for processing to higher-grade 'natural' fertiliser or, suitably diluted, could be used in house gardens. It is important to acknowledge that today's dry-composting toilets are very different from the earlier manual systems for removal of sewage.

Households are under minimal pressure to reduce their consumption or to desist from discharging difficult or dangerous material to the sewage stream which complicates or makes difficult the operation of sewage treatment systems. Moreover, the structure of water pricing gives households little incentive to reduce their consumption.

Providing a subsidy and/or mandating the installation of low- or no-water toilets in all new developments would quickly reduce consumption of potable water substantially.

Local-area water management

Other ways of indirectly reducing demand for potable water include developing local-area harvesting of stormwater runoff for use in public parks and gardens. This will become more important as climate change proceeds because it will be even more important to encourage and support the growth of trees and shrubs to help manage the production of CO₂ emissions. More energetic encouragement of the use of greywater for the maintenance of trees and shrubs around dwellings would have a similar effect.

Separating the water-supply services from the sanitation services would lead to significant reductions in water consumption and sewage flows. The new approach would require dwellings to install a rainwater tank, a greywater-recycling system and a storage tank for the treated greywater. These components would increase the cost of dwellings but there would be significant savings in the dwellings' plumbing and in their water-supply system.

Installation of a new waste-management system would lead to significant reductions in sewage flows, which would lead to economies in the development and operation of the sewerage system. Reduction in the sewage discharge from dwellings would lead to smaller volumes requiring to be treated at sewage treatment plants and, in turn, smaller volumes to be discharged into receiving ecosystems.

The installation of dry-composting toilets would greatly reduce the need for sewerage services, as well as reducing water consumption. Such toilets would be cheaper to install than the present water-based flushing systems; moreover they would greatly reduce the environmental stresses currently experienced in the water bodies into which sewage is discharged.

The significant savings in the water-supply, sewerage and stormwater-management systems could be used to subsidise the installation of the new approach to water services. The reduction in the volume of potable water supplied by the water-supply network would leave more water to be applied to maintain environmental flows and to provide a more secure supply in dry periods.

Securing a similar degree of water independence for households in multi-unit developments would, in principle, be no different from those in traditional housing, although the collection of rainwater and the processing and storage of recycled water would present slightly different challenges.

As discussed above, water authorities were originally created as public-health agencies and they have been successful in that mission. Water consumption is now more a result of the commodification of water and changes in behaviour. One consequence of the need to encourage more local responsibility for water services is that the health standards of the community would need to be protected. Local water storage and waste management would need to be regulated and compliance with the regulations checked regularly to ensure that the water supply was of a high standard. Checking the quality of household and other supplies could become part of the obligations of the meter readers who visit consumers monthly to record their consumption.

Industrial and commercial development

A similar approach to the water supplied to new and existing industrial and commercial undertakings would also reduce the demand on potable water supplies and lead to similar economies in the water-supply, sewerage and stormwater-management systems.

Households, industry, commerce and public facilities would use significantly less potable water, which in turn would mean that the construction of new storage and large-scale treatment plants could be delayed, possibly indefinitely. There would be less need for high-volume reticulation of water-supply systems or for sewerage system and treatment plants. A major benefit would be that households and industrial and commercial undertakings would become more responsible for managing their own affairs.

An additional benefit would be that the stormwater runoff problem would be reduced, which in turn would reduce the pollution load in the rivers, harbours and bays on which Australian cities are built. The water-supply system would also be less vulnerable to attack or other disruption.

The reduced stormwater runoff could also be captured for treatment and recycling for industrial use, as well as for irrigation of public parks and gardens. It could also be used to maintain the environmental flows in rivers and other water bodies. Capturing and treating the reduced stormwater runoff would lead

to reduction in the environmental stresses currently experienced by coastal and river waters into which untreated stormwater currently drains.

The nature of the water-supply services would change from one focused on large-scale catchment management to a much more localised set of catchments operated in a quasi-cascade form. Using the water resources on each block for the developments on them would not only ensure that residents and businesses became more aware of, and responsible for, their own supply as much as possible, it would also ensure that the provision of local water services for parks and public gardens made better use of the local drainage flows, including stormwater runoff. In this way, the present problem of the pollution of the cities' bays, rivers and harbours would be greatly reduced.

Institutional arrangements

The adoption of the approach outlined here would require changes to existing institutional arrangements. The first step would be to revise the regulations governing installation of rainwater tanks, waterless toilets or greywater treatment and recycling systems. Such institutional revision would also enable households to refrain from connecting to the sewerage system.

The present health regulations governing rainwater tanks, dry-composting toilets and greywater-recycling systems would need to be reviewed. Clearly, health objectives need to be secured but innovations in these technologies need to be recognised and improvements acknowledged in revised regulations controlling the installation and management of such systems. The powers of local government authorities would need to be revised to enable them to approve developments using modern water services and sanitation facilities.

City water corporations might sensibly be able to revert to their original role as a 'health authorities'. This would resolve the conundrum created by the enthusiastic adoption of the Chadwickian approach to the supply of potable water and the provision of sanitation services.

Conclusion

The point has been reached where it would be timely to reconsider the water services supplied to dwellings in Australian cities. It would also be timely to reconsider the ways in which waste-management services are provided. The situation facing all cities in Australia is that the water used to maintain their sewerage systems now accounts for almost half the water consumed inside the dwelling. This is putting the cart before the horse. The failure to reconsider the present water-supply and waste-management systems is leading to a moral panic in desperate searches for 'new' sources of water. All the options for these 'new' sources of water are expensive and environmentally damaging. The cities would be better served if more attention was paid first to ways of reshaping the demand

for potable water and secondly reconsidering the ways in which wastes are managed.

Chadwick had, through his work on the Poor Law Commission, insisted on evidence in challenging the conventional wisdom of his time. His empirical research and that of others was based on the assumption that there was an inexhaustible supply of water. It was also based on the understanding that households consumed small volumes of water for all their wants. Nor did he or any of his colleagues understand that the great increases in the urban populations, partly as a result of the effectiveness of his reforms of sanitation, would lead to the burgeoning cities that followed.

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