Attention: Jeanette Radcliffe

We wish to make a submission to the current inquiry into the construction of a dam at Traveston to provide additional supplies for urban water consumption in Brisbane.

The attached written submission relates in large measure to research carried out in Sydney, however, the argument applies with equal force to Brisbane and indeed to most of our coastal cities. That is, although the detailed figures of consumption for Sydney will vary from those in Brisbane, particularly in relation to garden water consumption, the internal levels of consumption in Brisbane will be close enough to those in Sydney to indicate the directions that solutions to Brisbane's demand for water should be met.

The research we have carried out in Sydney suggests that the solution to the 'urban water problem' should not be to simply to continue the traditional approach which has been to predict growth in demand and then undertake engineering works to increase the supply to meet the demand. We take the view that it is more important to understand the drivers of demand and then to try to re-shape them to reduce the demand and therefore the need for provide water. Other researchers have come to a similar view, moreover, the evidence emerging from studies of the efficacy of water restrictions support this view.

As we make clear a large part of the demand for water in our cities, including Brisbane, are a consequence of the technological solutions that were adopted in the nineteenth century to meet demand for potable water and our need for sanitary services to manage human body wastes. It is timely for us to reconsider those solutions and to adopt different approaches.

We have presented simple illustrations of the possible approaches to the on-site consumption of potable water. We are aware that there are many innovations that may be employed to reduce the demand for potable water to flush toilets for example and they should perhaps be encouraged, especially in the older existing areas of development. We believe, however, that encouraging households to accept some responsibility for their own water supplies would have profound beneficial effects on the consumption of publicly provided potable water supplies.

A vigorous program to require all new developments to provide for some of their own water and to manage, on site, their own grey water would lead to a dramatic reduction in demand for water. This would be beneficial for the eco-systems from which water is extracted for urban use, those into which waste waters have traditionally been discharged and on those on which the city is built.

All of these approaches could be taken while requiring public water authorities to supply water as an 'inviolable environmental right' to all residents in the city. This right should be set at the volume of water required to meet the demand for potable water for drinking, food preparation and cooking and for the minimal demands for hygiene. In Sydney we have argued that this should be about 20kL per person per year and provided free or at a very low price. We take the view that such a level of and inviolable environmental right would be appropriate for Brisbane. We further argue that consumption above this volume should be priced at a high and increasing rate to encourage parsimony in water use.

We suggest that a decision to construct a dam at Traveston will not only destroy a valuable eco-system but that it is premature. Moreover, construction of such a dam will take some years before demand can be increased whereas adoption of the approach suggested in the submission would begin to reduce demand with each new development and all existing dwellings retrofitted with devices to reduce consumption.

It should hardly need to be pointed out that construction of a dam at Traveston can, at best, only delay the need for a more sustainable approach to the demand for water and sanitary services.

Yours sincerely,
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A New Approach to the Domestic Water Supply Problem

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A New Approach to the Domestic Water Supply Problem

Abstract

The current crisis in provision of urban water supplies has its origin in the technological choices made in the nineteenth century when Australian cities developed their water services systems. This paper builds on recent research into domestic water consumption in Sydney to argue that the issue is not one of shortage of water, as it is popularly presented, but is more related to the choices made in that city about the way sanitary services are provided and the ways in which socio-cultural values and behaviour have led to increases in consumption. The paper asserts that the current approach to urban water services cannot be sustained without increased stresses in the eco-systems from which water is abstracted to supply Sydney, in the eco-systems into which waster flows are currently discharged and on the eco-system on which the city is built. It offers a schematic solution to provide water services in a way which is sustainable and capable of bring progressively introduced.

Introduction

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 Sydney's water services systems. This is needed to make the city more water independent without at the same time creating unacceptable stresses on the regions from which water is abstracted for consumption in Sydney or of creating environmental stresses in the water bodies around Sydney into which waste waters are discharged.

Sydney Water Corporation has undertaken a major exercise in demand management (Turner et al 2005) which has led to significant reduction in consumption most of which has been achieved through improved efficiency in commercial and industrial activities.. Mandatory restrictions on domestic water consumption with severe penalties for those breaking the restrictions were also introduced in 2003 (Sydney Water Corporation 2003) to reduce demand. The government has also introduced higher charges for higher volume consumers to reduce demand. Moreover, the NSW Building Sustainability Index (BASIX) building code system, introduced by the Department of Planning in 2005 which applies to all new residential development and housing subject to major renovation, includes measures designed to reduce consumption of water from the reticulated system at the level of the individual dwelling. The totality of these measures, however, remains insufficient to be able to rely on Warragamba Dam as the major supply.

A variety of alternative sources of water have been proposed. These include increased extraction from the Shoalhaven River to the south of Sydney, large scale recycling, extraction from aquifers in the Sydney region and proposals to build a major desalination plant. All of these proposals imply continuation of the nineteenth century solution to meet the demand for water, that is, to simply increase supply.

Before adopting any of these 'solutions' to Sydney's water problem it would be more apposite to review the nineteenth century decision making to try to understand how Sydney has reached the current state of crisis and to explore alternative methods of providing essential water services.

History

By the 1860s, in common with other cities, Sydney was experiencing problems with its water supplies (Dingle and Rasmussen (1991), Lloyd et al (1992), Melosi (2000), Dingle and Doyle (2003)). Not surprisingly, it sought to solve them in similar ways. At that time Sydney faced four major difficulties:

1. It had poor supplies of potable water, resulting in infections from water bourne contagions,

2. It was unsanitary and with increasing difficulties, including threats to health, of dealing with the disposal of human and other wastes of urbanisation,

3. It suffered periodically from poor drainage of storm-water,

4. It experienced crises due to lack of convenient supplies of water to fight fires.

While all four difficulties noted above were important during the city's development period the health of the population was the prime consideration in securing new water supplies. The mid century recognition in England that many health problems were directly related to the lack of secure supplies of potable water was followed by pressure in Australian colonies to develop such supplies.

From the time of settlement, the Colonial administration had tried to secure reliable supplies of potable water by exploiting sources 'beyond' the urban boundary, but the growth of Sydney was such that the urban area quickly grew beyond the area reserved and supplies were compromised that meant that 'new' sources periodically had to be sought from further afield. But there was an important assumption underlying the development of these supplies: the demand for water could always be met by seeking/developing new supplies. The initial assumption 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) but 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). While potable water was needed for health reasons, the supply of water seemed reliable and generous enough to allow households to use water for sanitation, to water gardens and for other uses. The convenient and seemingly adequate supply of water also meant that domestic bathing and laundry practices changed with consequent dramatic increases in the discharge of waste water from households.

By 1880 the issue of managing waste disposal assumed greater proportion as the size of Sydney's population grew. The world-wide popularity of Edwin Chadwicks' sanitary ideas (Melosi 2000) and the development and increasing take-up of water closets exacerbated the problems 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 was only seriously adopted in Australia by Melbourne with its Werribee Sewage Farm.

The virtuous circle that was ultimately developed in most Australian cities was to develop a reticulated water supply and then later to develop a piped sewerage system to remove sewage. This solution was made more financially attractive for the water authorities with the banning of rainwater tanks and the preferment of waste management technologies that relied on water transport to the exclusion of other technologies that did not. But it became a vicious cycle.

Property owners found themselves being required to connect to the public water supply and 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.

The use of cess pits and pan systems to cart away human excreta were increasingly problematic and as households adopted modern water closets, discharges to drains and water ways increased with attendant increased risk to public health. Rather than pursue other technologies for the management of human wastes the attractions of water based sewerage systems were so compelling that a networked sewerage system was developed to transport waste water, 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.

Storm-water runoff became more problematic as the city grew and more of its area was covered with impervious surfaces. The volumes of water were so great that it was infeasible to try to manage the runoff by using the sewerage system so a separate storm-water drainage system was developed. This, too, drained directly into rivers, the harbour and the ocean. Although sufficient water falls as rain in the Sydney metropolitan area to meet all its water requirements, this approach to storm water management means that even today, storm-water is discarded and treated as a ‘problem’.

The net effect of these nineteenth century ‘solutions’ 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 eco-systems from which water is abstracted to supply Sydney.

3. Extreme stresses on the eco-systems into which waste waters are discharged.

4. A storm-water runoff system that is the major source of pollution of the rivers and harbours on which it is 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 and one after another cities invested in increased supplies – usually in the form of more dams which impounded the water in eco-systems 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

The early decision to develop separate systems for sewerage and storm-water drainage meant that waste water flows could avoid the peaking problems associated with storms – problems that would only be exacerbated as development of the cities occurred by the increasing coverage of drainage catchments by impervious surfaces.

By mid twentieth century Sydney, like most Australian cities, had exploited all the water resources available in its near hinterlands. The increased consumption of water that had been encouraged by water authorities that had long since been less concerned with their original public health remit and were more exercised by the financial rewards of commodification of water was reflected in the increase in water using facilities and equipment.

The continuing increase in urban populations and the dramatic increase in per capita consumption strained the supplies of water. By the end of the twentieth century the situation facing most of the major urban centres became critical because of the apparent reduction in long run rainfall over dam catchments meant that reservoirs were operating with small reserves. The shortage in supply has been exacerbated by a severe drought that has affected large regions of the country.

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. 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. Although the reform initially focused on rural water uses it has been broadened to embracing water issues affecting urban areas.

Features of demand and supply

Two aspects of the water system need to be borne in mind. Firstly, the demand for water does have 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). Secondly, the supply of water through the water catchments is highly variable depending as it does on rainfall. This was not a concern when the storage was large enough to allow for several years of consumption, but it is now a problem because the increase in population together with the increase in per capita consumption now produces a high and relatively constant demand while rainfall over the catchments appears to have declined.

Moreover, cultural and behavioural norms in domestic water use have shifted considerably during the intervening century, all adding considerably to increased *per capita* water use. Changing attitudes to personal hygiene meant that people used flush toilets and flushed them with each use 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 and waste water 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 & Barr 2006, Hand *et al* 2003, Allon and Safoulis 2006). A recent survey of Sydney households' attitudes (Troy and Randolph 2006) revealed their strong determination to maintain their level and nature of shower use and considerable reluctance to reduce toilet flushing suggesting that programs designed to reduce consumption from both activities may encounter strong passive resistance. That is, much contemporary water consumption practice is life style and fashion driven and only tangentially related to concerns for hygiene, although paradoxically, the increase in showering has been accompanied by an increase in skin diseases (Shumack 2007). Contemporary consumption is also a consequence of the form of development of the city. The traditional form of a separate house in its own garden was (and probably remains) a strong expression of the felt needs of households for a degree of independence (Gaynor 2006). This form of accommodation not only provided the opportunity for a high level of domestic production (Mullins 1981a &1981b) it also ‘explains’ why it was such an effective cornerstone of the conservative philosophy expressed by Menzies in the 1940s and 1950s (Menzies 1943) and 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 general and Sydney in particular in the 1950s and 1960s.

Changes in attitudes to ‘dirt’ also led to increased water consumption. This is particularly obvious in relation to clothes washing. Even where occupations and activities do not lead to heavily soiled clothing (especially given the shift away from manual work to office and service work), strong expectations have developed that people will wear fresh clothes every day – often changing clothes more than once daily. This inevitably increases the consumption of water for clothes washing. Water consumption in the kitchen has also increased although it remains a small proportion of total 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 because most Sydney households rely heavily on rainfall to maintain their gardens, it is less significant than might be assumed (Troy and Randolph, 2006), and in any event has been reduced by the current water restrictions.

Development of supply – Sydney

Water services in Sydney are provided by the Sydney Water Corporation which is a government corporation and is a monopoly supplier. Until recently it set regulations and prices for its services. It has a strong engineering culture overlain by a strong economistic approach to water management issues. In the face of occasional criticism it has developed a strong defensive institutional culture.

Sydney Water’s response to the increasing demand for water has been to follow the traditional ‘project and provide’ approach to water services. That is, the city 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. It is clear, however, 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 (DIPNR 2004), which was been developed in part to meet the increased demand for water from a predicted increase in Sydney’s population of around 1m over the next 25 years. The Plan, however, while proposing major initiatives to meet this growing demand by both increasing the supply of water as well as assuming a further reduction in demand, is in essence, still based on developing a major infrastructure program which is focused on securing new supplies for Sydney's growth areas, particularly those in Western Sydney. So despite a new focus on restricting demand growth through water demand management policies, not least through an active publicity campaign in the media, the traditional 19th century response to Sydney's water crises in terms of assuming an ever increasing supply remains the cornerstone of water planning for the city.

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. Instead, we contend that a more fruitful way of continuing to meet reasonable demands for potable water from Sydney Water's *existing* storage facilities such as Warragamba Dam lies in encouraging residents to accept greater responsibility for security of their own water supply and waste water management in a manner that improves the sustainability of the city and simultaneously enables the government to meet new environmental targets. The proposal is for a major change in the way demand for water should be managed at the level of the individual household, together with the introduction of new measures to reduce the consumption of potable water in the home. The proposal 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 waste water flows (Guy et al 2001). It is also built on the assumption that we cannot simply turn to a new system while ignoring the water supply and sewerage systems in place, but instead need to phase in a new water demand management approach which will lead to less reliance on the traditional reticulation system and which will result in a reduction in the per capita consumption of potable water.

Present Water Consumption Patterns

A recent ABS report revealed that in 2001, 25% of water consumption in NSW was for outdoor or external purposes (Table 1). This was approximately the same as the proportion used in the bathroom (26%) and for toilets (23%). Kitchens and laundry uses accounted for the remaining 26%. No regional 'breakdown' of this consumption within NSW is offered in the ABS report, 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. It is highly likely that these proportions have changed a little since the introduction of water restrictions in 2004, although no comparable date is currently available. Research by the authors referred to above showed that, water restrictions on garden watering and car washing, the main targets of these restrictions, at best only 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 (Randolph and Troy 2006)). Both these turned out to be minority pursuits across households in Sydney as a whole, even before the introduction of restrictions.

The other key fact to note here about domestic water consumption, as evidenced in several recent studies (IPART 2004a, Troy et al 2005a, Eardley et al 2005), is that the size of household is a key determinant of domestic water consumption. The IPART study also indicated that there are some economies of scale involved. Two person households consume 67% percent more water than a single person house while a three person household only uses 23% more water than a two person household. 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, ABS 2004a, Troy et al 2005a). This implies that, *per capita* water consumption is not dependent on the residential built form, although these studies and other research have confirmed a relationship with income and socio-economic status (Eardley, at al, 2005; Troy, et al, 2007 forthcoming). Falling household size is likely to be accompanied by an increase in average per capita consumption.

It is only by reducing the consumption of potable water *inside* the home that the next real gains in winding back the growing demand for water services in Sydney can be made. This represents the next big task for Sydney water demand management policy makers and will require a fundamental shift in attitudes to water use in the home that may impact on personal comfort and amenity. The final sections of the paper discuss options for developing appropriate policies and how they might be made effective.

Table 1 about here

A New Approach to the supply of water in Sydney

As the above discussion has indicated, the present water restrictions designed to reduce total water consumption by reducing garden watering may lead to smaller savings in total water consumption than generally thought. A small proportion of households have a high level of consumption which may be due to heavy watering of gardens, but they are too few in number to provide a substantial across the board reduction in total water consumption. This does not mean such reductions should not be sought, but it implies that other strategies are required to ensure demand for total water consumption is reduced.

The *Metropolitan Water Plan of 2004: Meeting the Challenges - Securing Sydney's Water Future* (DIPNR 2004) says that 'all new houses built in Sydney must reduce their mains water consumption by 40% compared with the current average for similar sized homes'(DIPNR 2004, 6). This level of saving can be achieved only by installation of water efficient fixtures by installing a rainwater tank and/or connecting to a local recycled water system.

Sydney Water's demand management policies and programs achieved a saving of 20% in total water consumption between 1991 and 2004 although much of this was due to savings in the business and industrial sectors (Turner *et al* 2005). The Metropolitan Water Plan indicates that best international practice in demand management has achieved water consumption savings of only 10% except in exceptional circumstances. This suggests that it will be difficult to achieve savings of more than 10% under current demand management programs. The Plan's target of a reduction in consumption is 40%. Assuming this reduction target is to apply across the board, and given that total domestic external consumption was 25% in 2001, it is clear that even if **all** external domestic consumption was eliminated there would be a 15% shortfall in the consumption reduction target for the domestic sector. Assuming that the 10% reduction in consumption under the current demand management programs is feasible, then continued savings of at least a further 5% would need to be obtained from other sources. The obvious target is to seek further reduction in internal consumption through the current demand management programs or to seek alternative ways of meeting the demand while reducing reliance on the reticulated supply of potable water. The savings reported in the Metropolitan Water Plan 2004 of another 10% against the 10-year average in the year following the introduction of mandatory water restrictions suggests that it will be hard to maintain high levels of reduction in consumption.

Sydney's water supply and sewerage services were developed on the notion that a supply of high quality potable water could be found to meet all the demands of modern society. 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. The volume of water actually consumed, used in food preparation or cleaning or cooking equipment and utensils, cutlery and crockery is about 10% of total household consumption. Moreover, Sydney Water has adopted a 'once only use' of water to support life, meet sanitation objectives, enable the pursuit of notions of cleanliness, and meet needs for recreational uses. The development of Sydney's reticulated water supply and sewerage systems in the late nineteenth century led to improved personal hygiene which was reflected in dramatic improvements in the health of communities. This success has coloured the approaches to water supply and management ever since.

Background to Current Problems

Sydney Water has been too successful in delivering water of a quality, quantity and reliability exceeding its original undertaking. Its performance has raised community expectations that it can continue to do so. Unfortunately it can not. A different strategy is now required to significantly reduce the consumption potable quality water. The strategy must acknowledge that the need to supply potable water for drinking and basic health reasons remains. 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?

Two basic approaches suggest themselves:

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

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

A Case in Point: the Flush Toilet

The nineteenth century invention of the water closet as a technology for managing human body wastes was predicated on a reliable, plenteous supply of water. That is manifestly not the case now. When the water closet was developed other technologies were available for the management of human body wastes but the adoption of water borne waste disposal together with regulations requiring households to be connected to the sewerage networks meant that they were not used except in areas of water shortages or where it was infeasible to develop a water borne waste disposal system. Water authorities have introduced measures, including more efficient designs and installation of 'dual flush' toilets, to reduce the water used in toilets. These measures have led to small reductions in water consumption.

We note that one of the arguments used by water authorities to resist reductions in waste water flows is that the flow is needed to clear the sewer lines. The sewers having been designed on the assumption of high flows have low hydraulic gradients and need flows in addition to the water used to flush the toilets to transport the wastes to the treatment plant. Currently 23kL 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 0.5 kL of urine and about 70 kilos of faeces and paper 'produced' per capita annually. One consequence of this is that sewage treatment plants are required to treat ever increasing volumes of water to increasing standard to minimise the environmental stresses from the urine and faeces. The odd thing here is that the urine is quite valuable and much of it could be recovered at source if a different approach was taken to sanitary management.

A variety of waterless toilets including composting toilets, especially dry composting toilets, are now available the installation of which could save as much as 23% of present consumption. Providing a subsidy and/or mandating the installation of dry composting toilets in all new developments would quickly substantially reduce water consumption.

Reducing the Supply Obligation

A major reduction in water consumption could be achieved by reducing reliance on the reticulated supply of potable water for domestic consumption for discretionary activities and uses that do not need to use potable water. One approach would be to reign in the consumption by returning to volumes of potable water delivered to households to quantities closer to the original 'design' consumption for the water supply system.

How might this be achieved? As only 10% of total consumption is used in the kitchen for drinking, food preparation and cleaning utensils, this suggests that only 10% of the water used by households needs to be supplied at the highest quality. If we allow that some of the bathroom consumption should also be of the highest standard, e.g. the bathroom hand basin and the shower/bath, we might settle on a need to supply potable water up to 20% of present total consumption: say, 10% for kitchen use and 10% for bathroom use. This should become the supply obligation of Sydney Water. It may be appropriate to see this level of consumption (20Kl per person per year) as an inalienable environmental right to potable water for all residents.

Under the present supply system, households are under minimal pressure to reduce their consumption. They are also under little pressure to desist from discharging difficult or dangerous material to the sewage stream which complicates or makes difficult the operation of sewage treatment systems. The low price of water also means that they are under little economic pressure to reduce their consumption.

Historically water was provided to dwellings and it was paid for by a rate on value of the property. Properties were required to pay for water services whether they used them or not. The tariff structure typically had two elements to it:

1. a base charge assessed on property valuation, and

2. an 'excess' water charge calculated on the volume used once the basic allocation was used. The system did not discourage consumption and was highly regressive.

This system was replaced generally by 'user pays' tariffs in the 1980s. In some cases the introduction of user charges greatly reduced water consumption especially among the high volume users such as major industry consumers.

The tendency among decision makers is to argue for increase in pricing to moderate demand, but there are significant equity issues in this approach. Moreover, there is a case for arguing that households should not be allowed to impose financial costs or environmental consequences on others which is one outcome of present management of waste water.

The problem is how to devise a water supply and waste management system which encourages people to accept responsibility for their own behaviour while pursuing the public health objectives that were central to the remit of public water authorities and do so without penalising or excluding low income households from the benefits of a high quality, low cost water supply and waste management system. The challenge is to develop such a system and simultaneously reduce total consumption by 80%. The most obvious way to make households responsible for much of their own consumption would be to make use of local water resources.

Two possible sources suggest themselves:

1. Rainwater tanks

Rainwater tanks were, until the 1890s, the most common supply for most city households. They were made illegal initially to ensure the financial viability for the then developing water supply authorities. 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. It is also possible to ensure that birds and vermin cannot gain access to the water tank. The use of lead in flashings and roof paints has now been eliminated as has the use of lead additives in petrol which means that potential health hazard of lead ingestion from these sources no longer exists. Moreover, heating rainwater for use in showers meets current health standards (Coombes et al 2006). Widespread installation of rainwater tanks can lead to "considerable reduction in operating costs and greenhouse gas emissions of regional water supplies" (Coombes 2006).

What size rainwater tank would be needed to meet household demand? The BASIX system already requires savings of 'up to 40% of the potable water consumption of the current average of a similar sized home'. Much of this can be achieved to meet the license provisions by installation of dual flush toilets, efficient shower heads and taps as well as development of gardens using native plants and mulching. BASIX does not require the plumbing of the rainwater tank to provide a supply to facilities that do not require water to be of potable quality nor is there any monitoring to ensure that households achieve the level of savings sought in the license provisions. That is, the BASIX system only goes part of the way and is unlikely to reach the consumption reduction target unless the regulatory framework is strengthened to ensure that the rainwater tank is plumbed into the dwelling. The system proposed here differs from BASIX in that it proposes to continue to treat and recycle grey water so that its end uses for laundry, toilet flushing or gardening would enable a much greater reduction in consumption of potable water.

If collected rainwater was reserved for use in the bathroom by plumbing the rainwater tank into the bath, shower and hand-basin, using the figures for NSW (ABS 2004a) as a guide, it would need to be able to supply, on average, 16 kL per person per year (26kL – 10kL from the potable water supply), equivalent to 1.3kL per person per month. Assuming the average size of households is that for Western Sydney, i.e. 3.05 persons, this would equal 4kL per month

A roof area of 140 square metres would yield 56kL if the tank it fed stored 60% of the 668mm rainfall falling in the worst drought year (1994). Assuming relatively equal distribution of rainfall throughout the year, this would require a 4.7kL storage tank to meet all the needs of the average Western Sydney suburbs household (Sydney Water recommends a minimum size tank of 5kl). Increasing the storage to 10kL, would allow for the contingency of unequal rainfall or of a larger than average sized household. A larger rainwater storage tank would simply give households a greater security of supply. Rainfall in non-drought years would be more than sufficient to meet the bathroom consumption of the average household.

2 Recycling and storage of treated of grey water

As noted above, modern rainfall collection systems allow the first flush of rain falling to be discarded to ensure that the water stored is of the highest quality. This discarded water could be diverted to a recycled water treatment system and then stored in a recycled water tank for use as recycled water.

In most years the rainfall available for collection would greatly exceed the storage capacity of the average tank. The 'surplus' water could also be redirected to the 'recycled water tank'. Rainwater runoff in excess of the combined capacity of the primary rainwater tank and the recycled water tank would be discharged to the storm-water drainage system. The recycled water tank would be used to store the bathroom and laundry consumption water once it had passed through a grey water treatment system.

Assuming that the bathroom consumption was stored the volume available to be treated for recycling would be 33.5 kL per capita per year. Laundry consumption is approximately 16.2kL per capita per year which would, in turn, be recycled assuming a net recovery of 80% of the laundry water. To improve the ‘recyclability’ of washing machine water it might be necessary to introduce regulatory changes to phase out the use of inefficient appliances and the use of high phosphate detergents and other cleaning agents which make it more difficult to treat effluents to recyclable quality. While top loading washing machines use more water they are generally faster and more flexible in their use than front loading machines. If the washing machines in a dwelling are supplied with water from water harvested from the roof or with water recycled within the household there may be no need to change the ‘mix’ of washing machines.

Assuming no change in the ‘mix’ of ‘top’ loading and ‘front’ loading washing machines would mean a reduction of 3.4kL per person per year. That is, the volume available for toilet flushing would be 30.1 kL per person per year which is in excess of the 23.2kL per person per year used in toilet flushing. Toilet flushing water, i.e. ‘black water’, would be discharged to the sewerage system.

Assuming that the average size of households is that for Western Sydney suburbs and that their use of the toilet is the same each month the size of recycled water tank to meet the total demand for toilet flushing would be 5.9kL. To store all the recycled water for the average household from the kitchen, bathroom and net laundry use, the tank would need to be 7.7kL capacity. This would mean that 1.8kL of water was available each month for external uses. A tank of 10kL capacity would enable 4.1kL of water to be used per month for external use or provide additional security in supply of water for toilet flushing.

The water ‘supply’ and waste disposal system for a house would then have the following components:

1. A connection to the reticulated water supply for use in the kitchen and bathroom hand basin

2. A 10kL rainwater storage tank plumbed into the bath, shower and bathroom basin

3. A grey-water recycling treatment system for each house

4. A dry composting toilet for all new developments

5. A recycled storage water tank of 10kL capacity plumbed into the toilet and laundry with a upper level ‘take off’ for garden watering

6. A connection to the sewerage system for ‘black water’ waste

7. A connection to the storm-water management system for surplus treated grey water and for excess rainfall.

The present system has three of these components viz 1, 6 and 7. The new system would require dwellings to install and maintain the dry composting toilet, two tanks and the grey water recycling system to Sydney Water standards. These components would increase the cost of dwellings but there would be significant savings in the water supply system, the sewerage system and the storm-water management systems that could be used to subsidise their installation. 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.

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. Collection of rainwater, including that stored in the recycled water tank, would significantly reduce the storm-water runoff peaking problem. By careful use of appropriate detergents and cleaning agents households would be responsible for the efficiency of their own recycling of grey water. That is, household behaviour would directly affect the volume and quality of the recycled water supply available for their own laundry and other uses.

Securing a similar degree of water independence for households in multi-unit developments would, in principle, be no different although the collection of rainwater and the processing and storage of recycled water would present slightly different challenges. It would be just as feasible to incorporate rainwater collection and storage facilities in new developments. The collection and treatment of recycled grey water would also present options under existing technology for new developments. Retrofitting existing multi-unit developments with rainwater tanks and grey water treatment and storage capacity might be harder to achieve than in traditional houses although on equity grounds it would be important to attempt to do so and there are already storage systems in use that could be adapted for many existing developments. Taking 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 storm-water management systems.

Sensitivity of assumptions

Consumption

The estimates of consumption for the different uses within the household are averages reported in ABS 2004a. More detailed micro-metering measures are needed to improve on these estimates. It is clear that several of the internal consumption measures reported could be reduced if households adopted different usage patterns. The adoption of dual flush toilets has led to some reduction in toilet consumption and as they become the norm this consumption is likely to be further reduced. The use of high efficiency shower heads could also lead to reductions in bathroom consumption although the cultural and fashion factors influencing shower consumption would need to change to achieve significant reductions. Lower consumption appliances are already being more widely installed in new housing, so that as these appliances become the norm the average consumption for these uses will fall.

This means that the average consumption estimates used above are at the higher end of the predicted consumption, thus providing a greater ‘safety’ margin in the estimated tank capacities. Should bathroom efficiency of use increase faster than toilet flushing or laundry usage it is possible that the ‘system’ as proposed might be inadequate in extended drought periods. Lower bathroom consumption would mean that less water was available for recycling and that a smaller tank would be needed for rainwater storage. This would allow more of the rainwater to be redirected to the recycled water tank. The balance between the two storage tanks would need to be worked out with more precise estimates of the consumption for different uses within the dwelling.

The illustrative model of the appropriate sized storage tanks is based on the average size of households in houses. It may be more appropriate to design the tank capacities having regard to the distribution of size of households. The ABS Census in 2001 (ABS 2003) indicates that 61% of households in houses are less than or equal to three persons (the estimate used in the illustrative model was 3.05). Increasing the estimated household size to 5 would mean that 94% of houses with the system described would be able to meet their demand for water. The larger sized households tend also to live in larger houses which presumably have larger roof areas and therefore would be able to collect more water. We note that 94% of semi-detached dwellings housed four or fewer people per dwelling which means that a high proportion of households in such dwellings could also potentially collect sufficient rainwater to be water independent.

The volume of water used in gardens is heavily dependent on gardening practices. Households in Sydney’s coastal strip can more readily rely on summer rainfall to maintain gardens especially if the gardens are mulched and contain regionally appropriate native plants. In the system proposed a small volume of water would be available to help maintain gardens, the amount could be increased by the amount of any efficiency in internal consumption. To ensure that the recycling storage tank always held sufficient water for toilet flushing the ‘off-take’ for garden watering would have to be set at a level which retained the required volume.

Supply -Roof Area

There are no precise figures for the roof area of the stock of houses in Sydney. The average floor area of new separate houses (excluding the very large houses with more than 250 square metres floor area) increased significantly from 135 square metres in 1981 to 151 square metres in 1992 (Troy 1996:182). The average floor area of more modern houses is more than 150 square metres. The floor area is not the same as the roof area (in most cases the roof area is significantly greater because of the overhanging eaves that most houses have) so we cannot assume that the roof area has increased at the same rate although it is probable that roofs, including carport roofs, increased at a greater rate.

The roof area of 140 square metres assumed in this estimation is at the lower end of the distribution of roof area for the newer separate houses. This means that the roof area for a very large proportion of separate houses in the Sydney Metropolitan Area is large enough to provide a greater degree of security of supply than assumed in this estimation.

Rainfall capture

We have assumed 60 percent capture of rainfall for the bathroom supply. Modern systems can collect a greater proportion although we believe that basing estimated storage at a low proportion gives a margin of safety which allows for good capture in heavy storms that might exceed the capacity of the delivery system. Currently almost 6% of houses have rainwater tanks largely in response to Sydney Water and local government authority subsidies and encouragement. Unfortunately, many of these tanks are smaller that the size needed to effectively reduce the consumption of reticulated potable water.

Grey-water treatment system

The capacity of the treatment system would have to be large enough to process a day’s consumption. There are several systems on the market employing different approaches to the treatment and management of grey-water - each produces water of high standard (the water is generally of potable water standard but for aesthetic and health reasons we do not propose that the water should be used for human consumption). It should be noted that about 5% of houses already use grey water on their gardens although this is not generally treated.

Pricing strategy and regulatory framework

To achieve a high level of compliance it would be necessary to construct a pricing strategy and regulatory framework that increased the probability of reducing consumption. The price of the mandated maximum volume of potable water to be delivered to each dwelling might be set at the current level. Consumption above that level would be priced at a rapidly increasing rate to discourage excess consumption and to encourage efficient use of on-site water.

Sydney Water would be required to ensure that the rainwater collection system and storage, the grey-water treatment system and the recycled water storage system were appropriately plumbed into the dwelling’s reticulation, sewerage and storm-water disposal systems. To ensure compliance and maintenance of the systems in a healthy condition the systems would need to be regularly inspected. These inspections could be made part of the regular reading of water meters. It might be appropriate to charge an annual ‘connection and inspection’ fee to cover the cost of these services.

Reducing Waste water flows to minimise pollution of receiving waters

The storm-water drainage system and the sewerage networks and sewage treatment systems would be redesigned and modified so that as much use as possible was made of local storm-water and recycled treated sewage for irrigating local parks and playing fields as well as for commercial and industrial uses.

This would be accompanied by a greater effort to ensure that the design and construction of developments was pursued to ensure that the runoff characteristics of catchments were as close as possible to their ‘natural’ profile prior to development. The cost of development would undoubtedly increase. At present a rainwater storage tank plus a grey water treatment system and a treated water storage tank and associated plumbing would cost $10,000-15,000. These costs could be expected to fall if volume production took place. There are significant off-setting benefits including reduced consumption of potable water which should also be taken into account. One immediate benefit would be a significant reduction in the need for investment in a major recycled water reticulation system. The reduced complexity and lower flows in the sewerage system would also lead to significant reduction in investment in the sewerage system.

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 as well as 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 storm water runoff problem would be reduced which in turn would reduce the pollution load in Sydney Harbour, Botany Bay and the Hawkesbury River systems. The water supply system would also be less vulnerable to attack or other disruption.

The benefits of the approach outlined include reducing the flow of sewage which means that the sewerage systems would be able to treat the lower volumes to a higher standard making it available for industrial use and for irrigation of parks and large public spaces. This would also minimize the discharge through outfall sewers with consequent reduction in environmental stress to the near ocean or river waters into which such flows are currently discharged.

The reduced storm-water 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 storm-water runoff would lead to reduction in the environmental stresses currently experienced by near coastal and river waters into which untreated stormwater currently drains.

This approach would require a different approach to the management both of sewerage systems and to storm-water drainage systems. Instead of the large scale drainage to a small number of points, the systems would ideally be managed as a series of systems on the sub-catchments that make up the city.

A significant benefit of this approach is that the city as a whole would be less vulnerable to break downs in the system and consumers would be made more directly responsible for the environmental health of the water catchments as well as to the security of their supply.

The need for progressive introduction of the new program

The current rate of additions to the stock of housing is between 1 and 1.5% per year depending on the stage of the building cycle. By requiring all new housing, whether on green-field or redevelopment sites, to reduce their consumption of potable water supplied by water authorities the reduction in supply of potable water from central sources would begin to decline. The BASIX system now in NSW takes a useful first step in this direction in requiring greatly improved consumption standards in all new house construction but, as argued above, needs to be more definite and to aim for a higher level of savings to be effective.

An important element of the strategy, on equity grounds, would be to ensure that requiring all new dwellings to meet objectives to reduce consumption of potable water would be accompanied by programs to retrofit existing developments to meet the same objectives. In this manner the rate of reduction in consumption could be significantly increased.

To ensure wide support for the policy of reduction in water consumption, an integrated strategy would also need to develop programs, pricing strategies and regulatory frameworks to apply to new and existing industrial and commercial undertakings. That is, it would be essential to develop a transition program to ensure that the burden of achieving a significant reduction in demand for potable water was not borne only by the new additions to housing stock or to new industrial and commercial undertakings. New development whether on green-field sites or redevelopment, including significant renovation and extensions, could be required to comply with reduced consumption targets and the levels of water independence. Programs to retrofit existing areas of urban development could be progressively introduced to ensure that eventually all areas of the city met the new reduced consumption targets. Such programs might be a mixture of phased introduction of regulations and price rises as well as subsidies, where appropriate, to enable dwellings and industrial and commercial undertakings to operate at the new reduced consumption levels.

Some forms of housing and commercial and industrial building lend themselves more easily to retrofitting than others. Areas in which there are concentrations of the dwellings and buildings more easily retrofitted should become the targets for programs designed to increase the rate at which consumption is reduced. An energetic, targeted campaign could over a decade lead to a significant reduction in the demand for potable water supplied from central sources. If a retrofitting program was of the same scale as the new development additions to stock we could expect that in a decade 20-30% of households would consume approximately 80% less potable water than they otherwise would - assuming no change in behaviour. A more rapid rate of reduction could be achieved by a larger retrofitting program. Additional reductions in consumption due to changes in behaviour could be expected as households became more aware that their own behaviour directly affected both consumption and the efficiency of waste water treatment.

The net effect of such a strategy would inevitably mean that all housing, new and old, as well as commercial and industrial undertakings would become more water independent.

Separately managing black and grey water waste streams from dwellings and industrial and commercial operations would leave open options for the later adoption of alternative approaches or technology for the management of either waste water stream. This is particularly important for black water flows.

An Equitable Pricing Regime

The regulatory and retrofit strategy would need to be buttressed by a pricing policy which ensured that water was supplied to households at the minimum guaranteed volume per person at an equitable price. In this way lower income households and lower consumption households would not be penalised. Nor would there be any discrimination between old and new building stock.

The price charged for consumption volumes above the minimum guaranteed volume should 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.

Under present pricing strategies rainwater collection and grey water recycling treatment and storage systems are uneconomic. Adopting an escalating rate for potable water consumed above the minimum guaranteed volume would rapidly change the economics of rainwater tank and grey water recycling systems and storage making such systems attractive. The pricing regime for water introduced in 2005 (Sydney Morning Herald 2005a) partially acknowledged the importance of this argument but, because the price increase is a simple two step tariff and does not come into full effect until water consumption exceeds the average, a very large proportion of households will be unaffected and will not be pressured to accept their responsibility to collect and store rainwater and to recycle grey water.

Financial problems that might develop for households and commercial and industrial undertakings that are in transition from the present system to a new system relying on greater independence of water services, particularly through retrofitting, might need to be addressed by creating new mechanisms to allow such consumers to pay for the new services over a specified period. These could include allowing the services to be paid off by a deferred charge calculated for each account to be added to their annual water service charges. Sydney Water currently offers a subsidy of up to $650 for the installation of a rainwater tank. This could be increased for the installation of a recycled grey water treatment and storage system. It might also be appropriate to develop greater subsidies for the retrofitting of existing dwellings. The offset to the net costs of rainwater and recycled grey water treatment and storage systems or deferred charges outlined above would be the savings from reduced consumption of potable water supplied by the water authority.

It would be appropriate to subsidise the installation of dry composting toilets because, like rainwater tanks, they would significantly reduce the demand for water supplies and lead to reduction in the cost of sewerage systems.

The water utilities and government should work out a suitable subsidy component to encourage consumers to move towards more sustainable water usage. One possibility would be the hypothecation for a specified period of all or a part of the revenue derived from Sydney Water's activities, currently paid to State Government as an addition to general revenue. Supporting the transition to sustainable water uses would indicate the need to take water conservation seriously and provide a major impetus to the transition process.

No human consumption of recycled water

Given that there is popular resistance to the human consumption of recycled water (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 etc and the presence in the sewage of preservatives added to food and beverages to which a significant, if minority, of people have allergic reactions and whether those systems can be maintained. The strategy proposed here has a significant advantage because it does not entertain the idea of human consumption of recycled water.

The black-water and storm-water drainage systems should be organised to facilitate the drainage to local points within each sub catchment and the water treated for recycling so that it is available for industrial and commercial use and for irrigation of parks gardens and playing fields. Water surplus to these requirements should be used to maintain environmental flows in the rivers and bays of the Metropolitan region. These local treatment plants could be progressively developed but initially would focus on areas of new development and areas of intensive redevelopment.

Proposed Water services system for Sydney

The proposed system for each house is outlined in Figure 1. It illustrates the way the water supplied to, collected, stored and used for the various activities in a dwelling could be arranged. The Figure also indicates the average per capita savings that could be achieved by pursuing various options for development ranging from simple installation of a rain water tank through to the installation of a grey water recycling system to the installation of a dry composting toilet.

Major advantages of the proposed system are:

- Households are made more responsible to reduce their consumption of potable water.
- Warragamba Dam would be able to meet the demand for water without further investment.
- The program could be phased in.
- No consumption of recycled black water

- Storm-water runoff would be reduced thus reducing pollution loads on Sydney Harbour, Botany Bay and the Hawkesbury River system.

- Pressures on Government investment in water and sewerage infrastructure would be reduced.

Institutional Arrangements and Powers

The adoption of the approach outlined here would require changes to existing institutional arrangements and powers. The first step would be to revise the powers of Sydney Water to prevent it from banning the installation of dry composting toilets or grey water 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 grey-water 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 their installation.

The powers of Local Government Authorities would need to be revised to enable them to approve developments using modern water services and sanitation facilities.

While adoption of the proposed system would lead to significant savings in potable water consumption these would be small in the early years but would become increasingly substantial. Transition from the present system to a new arrangement would take some time and the rate of transition would necessarily take cognizance of the rate of obsolescence of the existing system. The urban planning and development control systems would need to be adjusted to cope with problems of transition.

A Strong Educational Campaign

The proposed system would include a continuation and expansion of Sydney Water’s campaign to educate people to the need to use non-potable water for laundry, bathroom and toilet consumption. Such a campaign might also include educating people to make less use of high salt and/or phosphate detergents and a variety of toiletry and cleaning products. The campaign should also continue the attempt to educate the community to better ways of maintaining gardens while consuming less water.

Figure 1 about here

Acknowledgments

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Table 1: 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	23.4
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	5.9
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 2004a

Figure 1: Schematic proposal for Sydney