CHAPTER
14
FUTURE MANAGEMENT

14.1 INTRODUCTION

The Perth Urban Water Balance (Cargeeg *et al* 1987) identified the maintenance of groundwater levels as being the 'fundamental issue in managing the unconfined groundwater system'. This study also predicted the currently observed declines based on continued below average rainfall, increased groundwater extraction and continued urban development. The predicted decline in net vertical flux under these conditions was estimated at 20mm yr^{-1}, about half of the currently observed decline (Chapter 13). The degradation or complete elimination of wetlands is probably the single most obvious feature of a groundwater system under stress. The best (and simplest) solution would be a persistent period of increased rainfall. The Perth Urban Water Balance models suggested that a decade of 'average' rain (about 869mm annually) would result in a water table rise in the Perry Lakes area of less than 0.5m. In order for Perry Lakes and Camel Lake to be rejuvenated a rise of at least 1.5m is required. If Perry Lakes (and possibly even Camel Lake as well) are to be rejuvenated, complementary management strategies will have to be implemented. These become even more important if the current low rainfall trends continue and may at best provide only partial solutions. Again the Perth Urban Water Balance models predict that with below average rainfall, even a 50% reduction in domestic bore extraction coupled with a 30% reduction in local authority and potable water extraction would result in a rise of well less than 1m at Perry Lakes over 10 years. These models assumed reductions over the entire Perth metropolitan area.

14.2 REDUCING GROUNDWATER EXTRACTION

14.2.1 Modelling

Management strategies, particularly where they involve expensive infrastructure (such as waste water recycling) or major changes in social behaviour or preference (such as three minute showers and shifts from European to native gardens) must be based on sound science and predictive modelling. Mathematical models allow planners and water managers to understand and make informed decisions about water resources. More importantly they allow the consequences of proposed actions (such as engineered solutions) or theoretical changes (such as climate change) to be analysed and predicted (Anderson & Woessner 1992). A principal objective would be to differentiate natural and anthropologic cause and effect. Modelling and water balance studies of the Perry Lakes sector could provide insights and allow analysis of significant questions pertinent to the ultimate management of Perry Lakes (Turner & Rich 1999). These include:

Climate Change

- If rainfall and groundwater extraction within the Perry Lakes sector persist at their present rates, what are the long term trends and predicted levels for groundwater at Perry Lakes?
- What average annual increase in rainfall (and associated recharge) would be required to cause a natural rise in the water table? How much would be required to ensure lake basins remain flooded over most summers?

Bores & Groundwater Extraction

- To what extent are public and private bores in the Perry Lakes Sector contributing to the regional decline in groundwater levels?
- In particular what is the effect of the high level of groundwater extraction occurring within Perry Lakes Reserve? If pumping just within the reserve was reduced (or ceased) what effect (if any) would this have on lake levels?
- What would be the effect on groundwater levels if the bore usage in the Perry Lakes Sector was reduced by 10%, 30%, 50% etc under differing rainfall regimes?

Conservation & Public Education

- What is an 'optimum' water level regime for Perry Lakes consistent with its multi-purpose role as a wildlife reserve and recreation amenity? What combination of hydrological and/or engineered strategies could be used to achieve this outcome?
- If a reduction in bore usage was predicted to bring about a substantial groundwater rise, would the state government consider proclaiming the Perry Lakes sector to be a groundwater management zone, banning new bores and limiting the use of existing bores? If so what would be the effect?
- Would a comprehensive public education program achieve the same ends?

14.2.2 Bore Licensing

Water law in Australia operates on the premise that groundwater, as a common resource belongs to the crown and is only available to private users under rights or license given by a managing authority (Banyard 1989). Western Australia operates on a system of 'Proclaimed' areas (where bore licenses are required) and 'Non proclaimed' areas where anyone has the common law right to sink a private bore and extract groundwater with no license, and no requirement to notify any government authority. Landowners are free to take water for any purpose and in such quantities as they see fit (Cargeeg *et al* 1987).

Within the Perth metropolitan area there are a number of proclaimed areas such as Gwelup, Jandakot, Mirrabooka, Swan and Wanneroo (where groundwater is drawn for public supplies) however the bulk of the area is non proclaimed. The number of bores within this area is unknown but is estimated (1998) to be well over 130,000 (Water and Rivers Commission 1998b).

Society has for some time been moving towards a 'user pays' principle. There is a justification for applying this to groundwater management such that all users, both direct and indirect, shoulder a portion of management costs. There is also the view that groundwater is a grossly undervalued resource and that free access leads to over exploitation and wasteful irrigation practices. Given that there is a limit to the amount of groundwater which can be extracted and that such extraction is already contributing to significant environmental damage to some wetlands, licensing would have the principal benefit of controlling the further expansion of domestic extraction and (if bores were metered) controlling extraction in some areas.

Licensing users would require that all the Perth metropolitan area be proclaimed. Pope (1989) and Banyard (1989) have explored the considerable policy difficulties in setting up groundwater license and usage pricing policy and the logistical problems of bore metering. Possibly the simplest solution would be to proclaim the entire area but with licensing and monitoring only in those areas such as Wembley and Floreat where extraction is clearly contributing to environmental damage. Within these areas all bores would be registered and a permit required for any new or replacement bores. There is an argument that a blanket 'usage fee' might simply encourage continued high usage. Probably the best option would be to metre all bores in these areas and apply a nominal yearly license fee plus incremental water usage fees. This might include an initial 'free' allocation. This would allow total extraction to be measured (thereby allowing meaningful management and modelling) and actively encourage reduced usage and water efficient gardens. This would apply to both domestic and public users such as local councils. The policy objective would be to reduce usage, not raise revenue. There would be a general ban on new bore construction but there is no reason why licenses could not be transferable so that if a resident decommissioned a bore someone else could then acquire the license and construct one.

Historically the general connection between urbanisation and water table rise is one of the principal reasons private domestic bores have been allowed to proliferate unchecked in Perth. Water Corporation and its predecessor have actively encouraged bores as an convenient means of taking pressure off treated domestic water supplies. Currently garden irrigation consumes 47% of all treated domestic water, rising to 70% in summer months (Water Corporation 2002a). Bore licensing and extraction regulation is a contentious issue. If the current rainfall trends persist however it could form part of a management strategy for endangered wetlands such as Perry Lakes.

To date there has been not only a reluctance towards additional regulation but continued active encouragement of private groundwater exploitation. Following another year of below average rainfall in 2002, Water Corporation began offering a $500 rebate on domestic bore construction. Their on line maps continued to show the Perry Lakes sector as being suitable for bore construction.

Many of the ideas presented here are not new. Recommendations in the Perth Urban Water Balance Study (Cargeeg *et al* 1987) included:

- Proclaiming all of metropolitan Perth as a Groundwater Area
  (Recommendation 2)
- Licensing of all non domestic bores along with groundwater allocations
  (Recommendation 2)
- Implementing specific management strategies to reduce abstraction and increased recharge in the inner western suburbs around Wembley and Floreat
  (Recommendation 7)
- Determine the need for local management strategies in risk areas
  (Recommendation 8)

Sadly (or perhaps predictably) these recommendations have been largely ignored. It is worth noting again the comments of Sadler *et al* (1988). History shows that timely decisions on difficult resource management problems are difficult to achieve and action is often precipitated only after the problem reaches crisis proportions.

14.2.3 Public Education

Any scheme to supplement water to Perry Lakes must be accompanied by public education to cut profligate water use and water waste. Perth has a Mediterranean climate but continues to indulge in European style temperate gardens and huge amounts of lawn. Despite increasing water restrictions and other warnings, the average resident continues to undervalue water. Attempts by water utilities at demand management have largely failed. The preferred option has been to reduce pressure on the reticulated domestic supply by actively encouraging the use of bore water. During the 1977-79 drought, there was a 50% increase in the number of private bores (Water Authority of Western Australia 1995). This document also notes that education is seen as the most cost effective and publicly acceptable water management tool, however it can be argued that in 'special case' areas such as Perry Lakes public education pertinent to the local area and problems has been lacking.

Demand for water in Perth continues to increase. There has been a 20% rise in domestic (treated) water use per capita over the past two decades, accounted for mostly by water used outside the home on lawns and gardens . The average household consumes 920 litres per day with gardens (47%), showers (16%), laundry (13%) and toilets (10%) being the biggest users (Water Corporation 2002a). Promoting Mediterranean gardens, reducing or eliminating lawns and mandating water efficient appliances such as dual flush toilets, high efficiency shower roses, more efficient washing machines is a start. In some ways we perhaps need to go back to the ethos which still prevails in many parts of rural Australia where water is truly considered a precious commodity. Water wise and water wasting consumers should be rewarded and penalised respectively with appropriate domestic water pricing policies which have as their overriding priority water conservation.

14.2.4 Better Urban Design

Modifications to urban design, both existing and future, could have significant impacts on groundwater levels. The overriding consideration should be towards enhancing widespread groundwater recharge and limiting groundwater extraction. Block sizes should be reduced, limiting lawn and garden area and all water caught on impervious shedding surfaces should be routed directly into the soil as recharge. Roof drains should go directly to soak wells located below the grass root zone. Driveways and paths should be constructed to channel water off into adjacent soil rather than into streets and gutters and ultimately wetlands. Similarly storm drain networks should where ever possible terminate in infiltration basins rather than wetlands. Ultimately the aim should be twofold:

- reduce direct inputs to wetlands (which forces them to become recharge lakes)
- allow the groundwater system around wetlands to rise through increased recharge and reduced abstraction

All waste water from sewage treatment plants should be recycled via a second reticulation system to domestic users for toilet flushing and (careful!) garden use, and to high usage commercial users for industrial purposes. Urban design needs to promote higher density housing with less or no lawn, smaller gardens and drought tolerant plants.

14.2.5 Limiting Urban Expansion

Western Australia has the highest rate of growth in Australia, and Perth is the focus of that growth with over 70% of the total state population (Graetz *et al* 1998). The Swan Coastal Plain, bounded by the ocean and the Darling Range offers absolutely no constraint to north-south expansion. Perth is and shows every indication of continuing to be a low density city. Only 20% of urban housing is classed as medium density. Suburbs are 80% detached housing, one per allotment surrounded by a garden (Graetz *et al* 1998). The state population is expected to rise from 1.8 million to 3 million by 2029, when Perth's population will reach 2 million. As long as this 'Los Angeles' style of expansion continues, Perth will increasingly place inordinate demands on its groundwater. The style and extent of Perth's expansion needs to be reigned in but to date 'planning' seems aimed simply at accommodating accelerating low density urban sprawl.

14.3 ENGINEERED SOLUTIONS

14.3.1 Diversion from Herdsman Lake

Herdsman Lake was drained for agricultural purposes in 1924 by constructing a tunnelled drain to the ocean. This drain still operates. Water volumes drained for 1998 are summarised in Table 14.1:

Table 14.1 Water Volumes to Herdsman Drain 1998

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Daily m^3/s	0.140	0.121	0.128	0.134	0.170	0.341	0.433	0.498	0.519	0.287	0.207	0.188
Daily m^3	12100	10450	11060	11580	14690	29460	37410	43030	44840	24800	17890	16240

Data from Water Corporation WA (1999)

Total water drained for 1998 was approximately 8,340,000m^3 while the total water used to maintain East Lake over 1996/97 was about 180 000m^3. It is believed that a similar proposal along with some engineering and planning was put to the Perth City Council in the 1960's. The proposal involved a purpose built gravity drain, with the final section utilising the existing storm drains into West Lake.

Perry Lakes would become an artificial groundwater recharge area. A small proportion of surplus Herdsman Lake water would be directed into the lakes both summer and winter, effectively creating a local, permanent groundwater mound. Water would be constantly entering the lakes. Water losses would comprise evapotranspiration and seepage through the lake bottoms. Computer modelling would be able to predict the extent of this local mound and the amount of imported water required to maintain it. There is even a possibility that local levels might rise sufficiently to create winter inundation at Camel Lake. There is equally the possibility that the former South Lake (now the children's play area adjacent to the toilet block) might also re-flood, allowing a third lake to be created effectively re-establishing the lake system which existed in the 1950's (Chapter 2).

The maximum water requirement would be in summer when the water table is below the lake bottoms and evapotranspirative losses are greatest. There would be significant on going seepage losses maintaining a local groundwater mound. Under current summer level maintenance maximum seepage losses are about 100mm per day. Possible daily requirements taking into account seepage and evaporation are summarised in Table 14.2. These proposed levels would ensure a minimum of about 30cm depth over the entire basin floor.

Table 14.2 Possible Daily Water Requirements

	Stage	Wetted Area	Volume	Daily Losses m^3
East Lake	3.9m AHD	70350m^2	50400m^3	7035m^3
West Lake	3.8m AHD	63200m^2	44550m^3	6320m^3
Total				13355m^3

These estimates suggest that over the summer, there would be sufficient water available from Herdsman Lake to maintain an artificial recharge program at Perry Lakes. During summer any shortfall could be supplied from tertiary treated sewage (refer below).

Importing water whether natural or recycled risks upsetting the nutrient balance in wetlands. In Swan Coastal Plain wetlands, nutrients entering a lake tend to accumulate, largely in the sediments. Under certain water chemistry conditions, this nutrient reservoir can be released back into the water column, leading to algal blooms. Water quality data for Herdsman Lake (Table 14.3) shows nitrogen and phosphorous levels in the Herdsman drain.

Table 14.3 Nitrogen & Phosphorous Levels, Herdsman Drain

	May 97	Jun 97	Jul 97	Aug 97	Sep 97	May 98	Jun 98	Jul 98	Sep 98	Oct 98
Total N (mg/l)	4.20	3.30	4.08	3.42	4.76	3.64	4.22	3.30	3.37	3.84
Total P (mg/l)	0.35	0.14	0.09	0.07	0.08	0.08	0.23	0.06	0.09	0.05

Data from Water Corporation WA 1999

Compared to other Swan Coastal Plain wetlands, these levels are on the high side (Davis *et al* 1993). The proposed water quality objectives to ensure aquatic ecosystem integrity at Herdsman Lake (Clarke *et al* 1990) recommended total N<2.0mg/l and total P<0.10mg/l. Nutrient stripping might be required to keep nutrient levels within acceptable limits. Certainly tertiary treated waste water would require nutrient stripping.

14.3.2 Treated Waste Water

Tertiary treated sewage re-use is a proven technology, common in arid regions where sewage and grey water is utilised for irrigation or artificial recharge to aquifers (Wright & Parsons 1994). The water is rendered useable by treating it for pathogenic organisms, nutrients and trace metals (Asano 1994). Tertiary treated water has high initial infrastructure costs and on going treatment costs but with the advantage that once operating it provides a constant and assured water supply (Water Authority of Western Australia 1995).

The Subiaco waste water treatment plant is located 1.2km from East Lake (Figure 1.1). Output from this facility represents a huge resource which currently is disposed of by ocean outfall. Total output from the Subiaco plant is about 19,800 megalitres (19.8 million m^3) per year. Only a small portion of this would be required to maintain summer levels in both East and West Lakes (East Lake top up summer 1996/97 was 180,000 m^3). Viewed from an engineering perspective much of the pipe work is already in place. The rising main which feeds water from the Perry East flood remediation pumping station (Figure 5.1a) could be used to gravity feed waste water back into East Lake. The single biggest problem which would have to be overcome is excess nutrient levels in the water. Current nutrient load from the plant is around 450kg phosphorous and 1300kg nitrogen per day (Water Corporation 2001). Waste water typically contains phosphorous and nitrogen in the range 2.3 to 9.0 and 6.1 to 44.2 mg l^{-1} (Scatena & Williamson 1999). Waste water is currently treated to the point where it is already widely used in country towns throughout Western Australia for park irrigation (Water Corporation 2000). In this application some nutrient load is seen as an advantage, reducing the need for artificial fertilisers. A pilot project is under way to use waste water to irrigate McGillivray playing fields (Figure 1.1). This will reduce groundwater extraction by about 350,000 m^3 per year (Water Corporation 2002b). There is no reason why this could not be extended to include Perry Lakes Reserve where current lawn irrigation consumes about 430,000 m^3 of groundwater per year. Removal of nutrient is technically feasible (Scatena & Williamson 1999) and has been considered by Water Corporation for other waste water reuse projects including groundwater recharge and remediation of salt water intrusion in the Cottesloe and Mosman Park area (Water Corporation 2000). Possibly the biggest initial impediment is cost. Water Corporation would prefer to recoup some of the costs of tertiary treatment by selling water to industrial users. This is feasible for water from the Woodman Point waste water plant which can be used by industry in Kwinana. The Subiaco water however would be used only for wetland conservation purposes and would require financial assistance in order to be viable.

14.3.3 Groundwater Recharge

Groundwater recharge is a proven technology and one which has been considered as a technique to take some pressure off Perth's groundwater supplies (Peters 1998, Scatena & Williamson 1999, Bekele 2001). Scatena & Williamson (1999) have identified areas, including Perry Lakes, within the Perth metropolitan area in which physical characteristics of the unconfined aquifer are likely to be suitable for artificial recharge. Modelling would be required to ascertain if recharge of waste water would raise groundwater levels sufficiently to flood the lakes to the required level. Based on cost and engineering complexity, piping waste water directly into the lakes remains the simplest option. In this case the lakes would become permanent infiltration basins. Schemes such as this are at odds with the recommendations in Section 14.2 which advocate reduced direct inputs to wetlands but in the end it can be argued that a wetland (operating permanently as a recharge lake) is better than no wetland at all.

14.3.4 Dual Water Supplies

Dual water supplies are a feature of many cities in arid climates. The Los Angeles area has over 1000 reuse areas where about a million m^3 per day are used for agricultural and landscape irrigation, groundwater recharge and industrial reuse (Water Corporation 2000). Typically dual water supplies have two reticulation systems carrying potable and non potable recycled water. The recycled water is used for toilet flushing and garden irrigation. In the Wembley-Floreat area a dual supply would provide maximum benefit as a substitute for domestic bores. The single biggest impediment to schemes of this sort is that the cost of reused water is often similar to the mean cost for potable water and so few authorities are willing to subsidise waste water reuse projects (N. Martyn, e-mail posted to 'WaterForum' January 4, 2001).

14.4 CONCLUSIONS

The Perth Metropolitan Area and satellite developments will continue to grow on current predictions to at least 2030. In the absence of any definitive policy to limit expansion on the Perth Coastal Plain, urban sprawl will continue and with it an increasing demand for water. This coupled with the likelihood of continued low rainfall will place an ever increasing pressure on easily extracted groundwater. It appears inevitable that overall groundwater levels will decline. Perry Lakes and other wetland systems will be threatened with total extinction. The elaborate engineered solutions which may save Perry Lakes are not a panacea which can easily be applied elsewhere. Most of our wetlands are water table 'windows'. Under pre urban episodes of climate change they expanded and contracted or disappeared altogether in response to small changes in water table levels.

Urbanisation and its seemingly insatiable demand for water and climate change are now placing all wetlands under threat.

One of the important values that society places on wetlands is their ability to convey a sense of the natural environment as it was before urbanisation. Public attitude towards wetlands (and indeed the environment generally) has changed remarkably over the past few decades. Up to the 1960's wetlands were systematically drained, filled (often with rubbish) and developed. These destructive activities are now at variance with the views of the vast majority of the population who see wetlands and urban bushland as important and essential components of the urban landscape. This is reflected in the extensive legislation which exists to protect them. Unfortunately the threat is not now from bulldozers and developers but collectively from all of us. Urbanisation and an insatiable demand for water will continue to place wetlands under threat. Only a huge paradigm shift in our collective attitudes to water conservation, a major reversal to a wetter climate or innovative technical solutions (importing water from the Ord River or desalinisation, for example) which reduce our dependence on groundwater, will save Perth's wetlands.

Many of the recommendations made in the Perth Urban Water Balance, if implemented when first published in 1987 might now be having a significant effect on reducing groundwater abstraction. They would have been politically unpopular then, as now, and it appears that in the longer term wetlands will ultimately be sacrificed as the price of political expediency. For Perry Lakes it may already be too late and engineered solutions may be the only hope (in the short term at least) for preserving Joseph Perry's swamps.