WATER SENSITIVE URBAN DESIGN

SUSTAINABLE DRAINAGE SYSTEMS

FOR URBAN AREAS

GROUNDWATER MANAGEMENT

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Do We Need to Manage Groundwater?

Worldwide, groundwater is recognized as a major water resource. It underpins the availability and reliability of water supplies to many major cities (eg Los Angeles, London, Paris, Beijing, Bangkok, and Perth).

Poor management of groundwater resources is also a major problem in a number of cities as is exemplified by land subsidence around Bangkok and Venice to name but two locations.

In Australia, Perth is the only city in which groundwater is fully integrated into the water supply capacity and drainage system. Elsewhere, poor management of groundwater has given rise to substantial and expensive salinity issues due to rising water tables with accompanying salinity problems. Examples of this are to be found in the western suburbs of Sydney, around Adelaide and around regional centres such as Wagga Wagga in NSW and Shepparton in Victoria.

The consequences of not managing groundwater can be that a valuable resource is overlooked or is not exploited to its greatest benefit, or that the resource balance may be disturbed by the consequences of urban development causing costly problems in infrastructure and soil damage.

From a statutory viewpoint, groundwater management is mandatory in every state, but only in Victoria has a specific protection policy been introduced. The problem is that management is only driven on a project by project basis with urban development being largely exempt.

Groundwater Roles in Urban Design

Groundwater can provide both as a water source as well as a recipient of urban drainage. It can also act as a heat sink or energy source.

With limits having now been reached on engineered water storages for most of our major cities but, with an increasing population and water demand, it is inevitable in our climate that the use of groundwater either directly or as a second grade water source must be considered. Groundwater around our cities is often only a second grade water due to salinity, but it is available for use. The economics of the use is dependent mostly upon natural salinity (and chemistry) and on the occurrence of adequate permeability at an economic depth.

Thus, for the City of Perth, with the Bassendean Sands immediately underlying most of the urban area as a high quality unconfined aquifer, it is normal practice to use this source for garden watering during the long hot summers. At the same time, the aquifer readily accepts roof runoff to shallow sockage pits; acts to accept and to polish septic tank effluent and receives the majority of road runoff via infiltration swales and small wetlands.

The consequences of this use of the aquifer in Perth is a reduced demand for reticulated water, a reduced cost in stormwater drainage, and a reduced cost in necessary sewerage provision.

This same approach is used on Long Island NY (USA) where infiltration of stormwater into shallow glacial outwash sands and gravels recharge the deep Magothy Beds which provide the whole water supply to over 10M people. Again, around the southern counties which fringe Los Angeles and around the Bay area of San Francisco, groundwater infiltration basins treat and recharge the hill wash sands and gravel which provide both storage and distribution of water resources to another 10M people at small engineering costs. Such systems are common throughout the US.

Even the City of London recycles its wastewater via the controlled infiltration of sewage effluents into the Chalks of the South Downs. This water is then picked up at depth to contribute to the cities water supply.

A series of drier than average years during the 1970s, 1980s and 1990s in the UK demonstrated that reliance upon surface waters for potable supply was misplaced. During this period many engineered artificial recharge projects have been implemented. These and similar projects in the US and elsewhere have provided a solid basis in aquifer storage and recovery (ASR) technology development and improvement.

It is apparent then that managed integration of groundwater into urban design and drainage can pay substantial dividends for the cmmunity. These may be in reduced capital costs of services, in reduced operating costs and/or in improved system reliability.

Integrating Groundwater into Urban Design in Australia

To talk about Perth is to talk about history, groundwater is already integrated into both primary and secondary water supply and provides for much urban drainage.

Adelaide, suffers from extremely intense local summer water shortages from its "Hills Water Supply System". This system is backed up by pumped water from Morgan on the Murray River, but this water is of extremely variable quality, being not infrequently in excess of 1000mg/L TDS.

To offset the problem of water resources restriction on garden watering in a hot dry city, the concept of ASR has been introduced where hydrogeological conditions are favourable.

The fundamentals of the system include collecting runoff from "low pollution" sources (roof runoff, infrequently used car parks) and, after first flush sedimentation, creating infiltration basins or galleries which allow the water to pass into underlying aquifers or in some cases artificial aquifers (gravel dams) for later recovery and use in garden watering.

Several such systems have been installed in the Adelaide area (St Elizabeth Church and Parfitt Square Project) [Argue et al 1996]), but the most ambitious and most effective is the Andrews Farm Estate system. Located on the margins of the North Adelaide Plain area near Elizabeth this system involves roof and road runoff being directed to sedimentation basins and then to wetlands before being infiltrated into a shallow aquifer containing marginal quality irrigation water. More recently tertiary treated sewage effluent has been added, with the result being that the housing development and each house is now self sufficient in garden water supply obtained through both individual and communal pump back systems.

Opportunities to undertake a similar approach exists in some areas around Melbourne, though much of the Melbourne area is underlain by heavy clay soils or by very shallow water tables. In this case it is necessary or at least desirable to reduce the existing water table level to create storage within the aquifers in advance of recharge projects by encouraging groundwater use for garden or horticultural water supply. It will then be necessary to engineer recharge facilities using storm water and/or tertiary treated sewage effluents.

To the west and north west of Melbourne the shallow aquifers are fractured basalts which commonly contain brackish to saline and occasionally industrially contaminated water at depth varying from 5-8m.

The waters in the basalt aquifers is of a quality that is very limiting on use, but it could be used for some subsurface irrigation of playing fields; to maintain wetland feature water levels, for industrial and municipal washdown and for maintaining ecological flows in streams.

These aquifers are overlain at the surface by heavy smectite clays 0.5 to 1.5m thick. Recharging these aquifers could prove difficult, but has been done locally where roof runoff has been run direct into drilled boreholes after filtration.

Water can be subsequently recovered from the same bore holes and, while somewhat affected by the natural aquifer salinity over time, it has proven highly suitable for garden watering and grass irrigation at some locations.

Similar opportunities exist around the bayside suburbs of Melbourne to the north of Beaumaris. The Capital Golf Course, more by good luck than good management, has established a substantial ASR system which could serve their irrigation requirements well. Opportunities also exist in some areas around Frankston and Cranbourne where highly permeable dune sands underlie urban developments.

Opportunities for integrating groundwater into urban development and drainage around Sydney and Brisbane is extremely limited by the topography and geology of these cities, though real opportunities exist around Canberra and Darwin and many regional centres around NSW and Queensland have already implemented schemes (eg Mackay Qld).

Alice Springs a city totally dependent upon groundwater for its water supply has developed some very serious problems of rising water tables and salinity problems in the Town and Farm Basins which underlie the urban area of the city. This problem derives from poorly planned and in efficient water transfers between alternative aquifer sources.

Problems in Groundwater Recharge in Urban Areas

Recharging aquifers with waters that accumulate at the surface sounds simple, but is in practice fraught with difficulties. These can be summarized as:

- clogging of the infiltration interfaces where recharge occurs due to suspended solids in the runoff;
- contamination of the groundwater by contaminants in solution including hydrocarbons, pesticides, heavy metals and pathogens or by chemical reactions within the aquifer (eg sulphide oxidation);
- loss of permeability due to the impact of surface water chemistry on groundwaters in the aquifer and cation exchange on clays (eg Myrtleford, Victoria).

Some of these problems are easily managed by infiltration basin scouring and indeed clogging, especially with some organic materials, has proven beneficial in adsorbing potentially contaminating intractable organics (some hydrocarbons and halogenated organic compounds) (Strom and Hancock 1979).

Other problems require specific site engineering. In particular, it is necessary to understand the geochemical equilibria that apply within the aquifer and especially the aquifer mineralogy (clay types, exchangeable cations, presence of sulphides, carbonates, etc.).

A further source of problem are the incorporation of unrealistic water quality standards and the lack of recognition of natural attenuation capacity in statutory groundwater protection policies. These issues are necessarily argued on a site by site basis, but the process gives rise to substantial costs in implementing ASR projects.

In practice, there are a wide variety of scientifically proven approaches to engineering reliable recharge systems. It is necessary however that the hydrogeology and chemistry of the recharge waters, the aquifer and the aquifer mineralogy are well known in advance.

Experience in recharging surface waters and effluent is available worldwide with massive schemes exist in the EU and in the US, many of which have been operational for over 80 years (eg Hamburg and Berlin, Germany; Nassau and Suffolk County Long Island, New York, USA).

Conclusion

Any new urban development should, in our opinion be required to consider sustainability in their design and this should in particular be demanded in terms of the stormwater and sewerage effluents they will produce.

Not all developments will be able to integrate groundwater and ASR into their designs, but they must consider their potential for crating salinity issues be they on site or offsite.

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