Water Constraints driving advanced WSUD in Regents Park, Sydney

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Abstract

Developers Mirvac are currently constructing a residential community known as Ashgrove in Regents Park in western Sydney. This development differs to most because private open space is limited and a body corporate manages both substantial communal open space and the integrated water cycle management system that shapes it.

Pre-development flows from the site resulted in unacceptable flood damage caused by capacity limitations downstream. In addition there was a need to comply with BASIX, conserve water and protect the Duck River from any additional poor quality runoff. In these circumstances, it was clear that a traditional development in this location would add additional water constraints. The only way to develop this land profitably while simultaneously reducing water constraints was to develop an integrated approach to managing water on the site.

Faced with this dilemma, Mirvac had the impetus and courage to request an advanced and integrated WSUD solution. An integrated solution was one which would need to:

- address water quality management and protect Duck River
- respond and relate to the existing industrial and residential development both up and downstream
- reduce the flood risk to an acceptable level
- conserve water in line with BASIX
- respond to the very limited private open space on this development
- ensure that if water cycle infrastructure was to be placed in the public open spaces that it would not sterilise the space
- above all, be a solution capable of being managed by the community who would ultimately own the system.

An integrated approach was developed by the planning team which successfully addressed each of these objectives. The system comprised:

- A treatment train was developed to manage water quality.
- This integrated with the flood risk objective by also functioning as a detention system.
- Through the use of detention basins, the water quality management devices could be reduced in size.
- Stormwater was harvested from the local and upstream catchment to compensate for a portion of the site that could not be easily harvested and which was allowed to run off untreated.
- Because stormwater (and not roofwater) was harvested and it needed to be reused for toilet flushing and irrigation it needed to be fit for its intended use and this integrated with the water quality objectives of the project.

The water cycle infrastructure is located wholly within the public open space. Importantly this space was still able to be landscaped to meet the needs of a community who had very little private space within their house lots. Sustaining this manicured landscape in a dry and altered climate relies on a regular supply of clean water for irrigation.

This integrated solution was developed only after the costs and social acceptability of both a communal and a private approach was measured and compared.

This development demonstrates that there are sound ecological, economic and social reasons to put in place communal or cluster scale water cycle management systems. For many years it has been suggested that stormwater harvesting posed unacceptable levels of risk. Ironically it has taken a change in the social structure of our developments to address the public health risks associated with hitherto Australia's most untapped resource.

Introduction

Mirvac, one of Australia's more prominent developers, purchased the Old RAAF Stores Depot (Figure 1) following the site's use as an Olympic Non-Competition venue in 2000. The site is located on the fringes of the Duck River floodplain, about 400m east of the river.

The planning team of Economists, Architects, Town Planners, Project Managers and Engineers developed a design and layout that can be described as "new urbanism". It represents a response to contemporary lifestyles and issues.

Figure 1: The Regents Park, Ashgrove Estate site, adjacent to the Duck River which is a tributary of Parramatta River and Sydney Harbour. Image courtesy of Google Earth.

The adoption of a new urbanist approach at Regents Park demonstrates how urban development can successfully manage many contemporary social and environmental issues, including the hydrological impacts of climate change. From a water cycle management perspective, new urbanism can be characterised as a response which:

- Seeks to create a sense of community and belonging by limiting private space and maximising instead public open space. This creates fantastic opportunities for Water Sensitive Urban Design (WSUD) because stormwater treatment trains which are a hallmark of WSUD require space. More importantly, it dictates the kind of treatment train that can be put in place. It limits the use of rainwater tanks and OSD on private space and conversely promotes the adoption of communal scale harvesting of stormwater and detention.

- Creates open communities where passive surveillance is a major feature. This facilitates the implementation of WSUD because streets now look onto and surround parks. The parks can contain all of the water cycle infrastructure necessary to manage the water constraints present. This contrasts markedly with traditional developments which have a "combined detention basin and water quality pond" located on one lot at the bottom of the development most often out of sight and rarely maintained for that reason. At the Ashgrove Estate, however, the parkland and all the water cycle infrastructure contained within it is woven seamlessly into the fabric of the development.
- Empowers a community – through a body corporate - to own and maintain the public infrastructure that serves the whole estate's community. Under such an approach, communities can begin to turn stormwater runoff - which would otherwise be a waste stream that would pollute Duck River - into a valuable resource.

Design Objectives

Auburn Council placed a limit on the maximum discharge of stormwater from the site. This was an unusual approach because there is more than 30 Ha of both residential and industrial land upstream of the site which discharged through the site. To its credit, Council had a good knowledge of the flows and flood regime in this part of its LGA and understood what needed to be achieved. The discharge limit was based on the capacity of the downstream stormwater infrastructure.

Council also required stormwater quality targets to be met. These included reductions of key pollutants leaving the site in accordance with the EPA Council Handbook (Total Suspended Solids 80%, Total Nitrogen and Total Phosphorus 45%). While Council stipulated compliance with the EPA Council Handbook water quality targets, they did not want to have the risk of open water bodies or bear the cost of maintaining any wetlands or ponds. The central landscaped area within the development also had to remain free from flooding in a 1 year storm event and to drain rapidly following a storm event. This requirement was considered to be critical as there was such limited private space on the development.

Council also prohibited the use of flush kerbs adjacent to all parkland and demanded that kerb and gutter be used. Argument against flush kerb was based on Council's perception that litter would get washed into the parkland.

There was an overall objective for the public open space areas to become aesthetically pleasing landscaped spaces. This project was highly unusual because it was the water cycle constraints that initially shaped the public open spaces. The actual formation was designed by an engineer and the landscape architect responded to the given landform. This normally occurs in reverse.

Finally, Mirvac was required to meet the BASIX provisions in NSW requiring each property to reduce water demand by 40%. At the time of developing solutions, BASIX was in its infancy as a planning instrument and only the detached dwellings (of which there were 115 proposed) needed to comply with BASIX.

These requirements posed a serious design challenge. The allocation of 2.55 hectares of the 12 hectare estate for public open space, however, enabled a sophisticated and integrated approach to be developed by STORM.

Design responses

Any combination of traditional engineering responses would not be able to adequately satisfy the development objectives for this site. Significant detention volume would be required to achieve flood attenuation and water quality objectives. Such an approach would require a large land take that would effectively sterilise this land.

It was clear that the only way to make the project feasible was to develop an integrated solution. This meant that a multi-objective drainage system was required that integrated each of the following:

- the recreational amenity
- a detention system for peak flows
- a potable water source substitution and delivery system
- a water quality management system
- the site's stormwater system with the stormwater system feeding into it from outside of the estate. This meant that there was an increased risk that a spillage outside of the estate would be unknown and the harvested stormwater polluted. Industrial areas were excluded from the harvesting catchment and retained within the existing trunk drainage system.

- The land use and available space provided by a new urbanist approach to the development.

In response, STORM proposed a stormwater detention, treatment and harvesting system that was fully integrated with landscaped open space. This is shown in Plate 1 below.

Plate 1: Bioretention Basin A.

Basin A (Plate 1) is at the head of the communal system. Here water draining from this estate and an existing 5 Ha residential estate are first treated by a CDS to remove gross pollutants and coarse sediment. The water is then filtered through a river gravel media prior to conveyance into one of the two bioretention basins on the site. The river gravel basin's inherent porosity also functioned to keep 1 year return period flows below ground so that the landscaped area above is kept "playable" 99% of the time.

The heavy and dispersible clays on this site necessitated the use of a liner on the water quality treatment devices to ensure that dispersible material did not migrate into the system. This was a critical design constraint because dispersible clays forms colloids which reduce the transmissivity of the water to such an extent that disinfection by UV is not possible (as UV is not able to penetrate into the water column).

After detention in Basin A, the water is conveyed to Basin B and C.

The configuration of the whole system is shown in Figure 2.

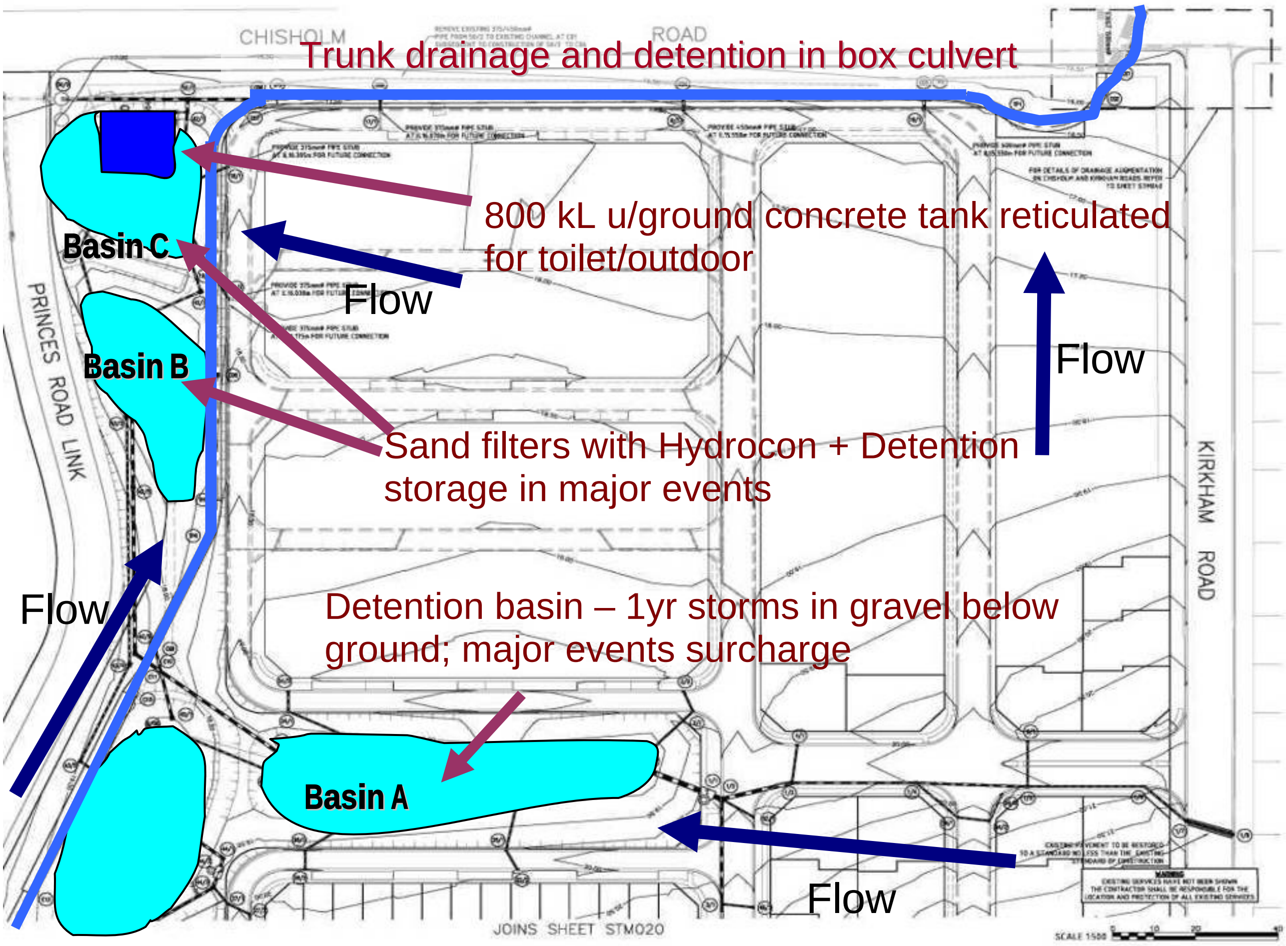

Figure 2 Ashgrove Estate – Water cycle general arrangement.

The introduction of up to 1 year storm events (up to 1 m^3/s of water) into Basin A - below ground without any water reporting to the surface - was achieved by using specially modified permeable pipes. Additional holes needed to be drilled into the standard HydroCon pipe to achieve an exfiltration rate of 10 L/s/metre of pipe. The additional holes needed to be located in regions of reduced physical stress on the pipe to maintain the pipe strength.

At the downstream end of Basin A, permeable pipe was again used to collect the water without the water reporting to the surface. Only in large storm events would the pipes surcharge and begin to use the surface storage capacity of this basin.

Piped outflow from Basin A was directed to Basin B (Plate 2) for water quality filtration.

This basin is almost imperceptible except when water ponds within it. It has HydroCon pipes which are used to deliver the flow into the filter media (again below ground) with surface storage above the bed of the basin. After water has seeped vertically down through the basin it is collected by a subsoil manifold and from here conveyed into the 800 kL storage tank.

Basin C (Plate 3) serves much the same purpose as Basin B but drains a different catchment. Its purpose is to detain peak flows, to filter the stormwater to meet Council's water quality objectives and to ensure the water has a turbidity of less than 2 NTU so that UV disinfection can occur prior to reuse. If the harvested stormwater is to be used for toilet flushing, it must have less than 10 faecal coliforms per 100 ml, requiring disinfection. Filter the water in the bioretention basins ensures it is clear enough to achieve 100% disinfection.

It is noted that some industry practitioners only screen stormwater using a GPT prior to storage and reuse. However, the risks of using the water for spray irrigation on an uncontrolled site were considered to be too great to rely on a GPT alone for treatment.

After storage in an 800 kL concrete tank located under Basin C, the stormwater is pumped to the disinfection unit. It is then supplied directly to houses for flushing toilets, private space irrigation or for car washing, or is conveyed to the public open space irrigation system.

Buoyancy of a buried concrete structure within the detention basin posed further design constraints. Hydrostatic pressure relief valves were installed within the tank to take account of the risk of floatation of an empty tank under conditions such as a rapid filling of the groundwater resulting from a short duration storm event. In such a case the tank may not fill for some time following the event as the stormwater slowly percolates through the system.

A water balance on this site revealed over 10 million litres of water per year would be saved by this system.

The UV system provided an interesting design challenge because hydraulic losses through the units can be so high. A system with low losses and self cleansing capability was chosen over a lower cost system with high hydraulic losses requiring manual brush screening. The higher cost UV system actually resulted in lower life cycle costs, compared to a lower cost system requiring a larger pump and more maintenance.

Plate 2 Bioretention Basin B

Plate 3 – Basin C with 800 kL stormwater storage beneath

Another issue which arose with the design of the disinfection system was that of temperature control. Because stormwater is not always in demand and therefore not always pumped around the estate, it was possible for water to remain stagnant inside the UV unit for prolonged periods. During this time the water would be heated by the lamps until it eventually boiled with the potential to damage the system. A solution was developed which measured the temperature of water inside the UV unit and recirculated the water if the temperature rose above 45 degrees Celsius.

The UV disinfection unit is shown below in Figure 3.

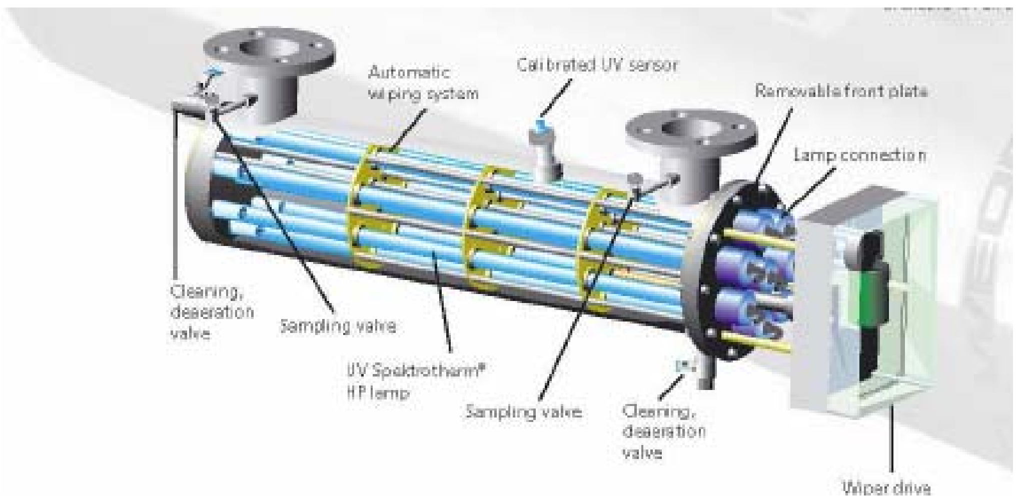

Figure 3 Self cleansing UV disinfection unit used at Ashgrove Estate.

The pump station relies on the use of constant pressure pumps. These pumps have been developed for the building industry to boost pressure in high rise buildings. Limiting the number of starts to prolong pump life is achieved by maintaining a constant pressure in the delivery line through a pressure vessel.

It was necessary to construct an automated bypass system that would permit the toilets to be flushed from mains water. This had been done many times before at a household scale using products such as Rainbank. Applicable components had to be found to achieve the same outcome at a much larger scale.

The pump station, valve and UV disinfection configuration is shown below in Figure 4. It is important to note that disinfection takes place on demand, i.e. water is disinfected immediately prior to use as there is no residual left in the system.

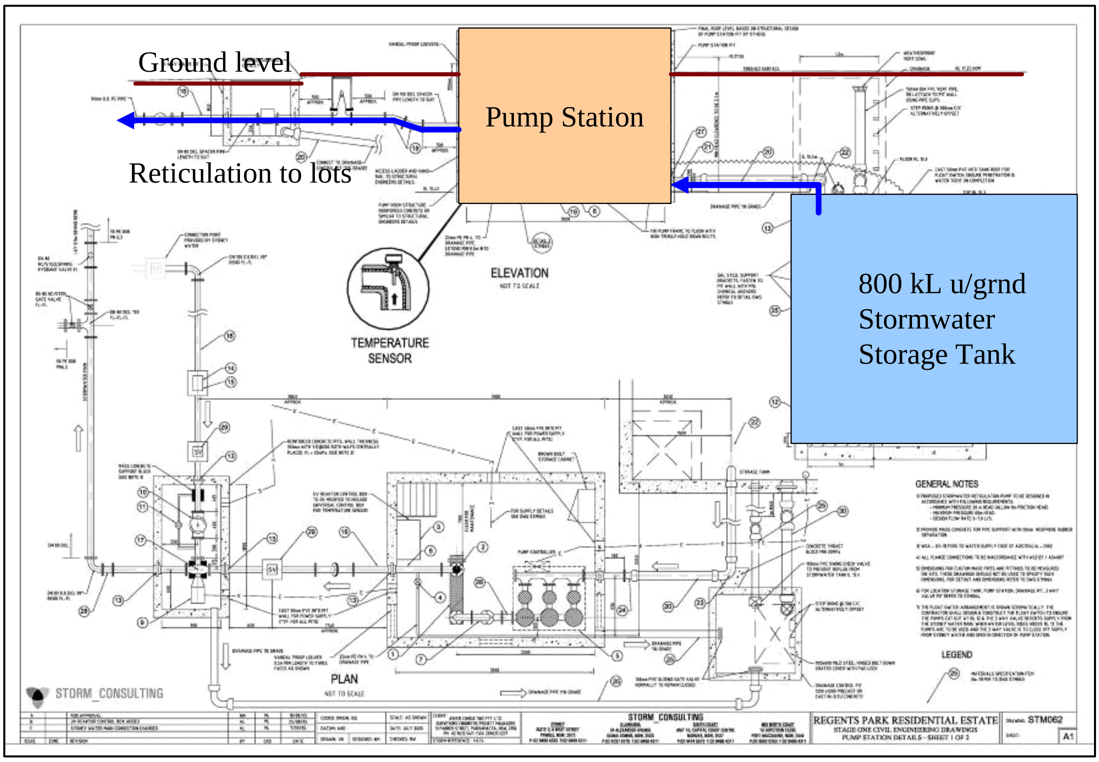

Figure 4 Pump station, UV disinfection and automated valve box

Life Cycle Costs

Mirvac undertook a detailed analysis of the costs of constructing a communal scale stormwater system such as this (supplying 115 houses with toilet flushing water, plus enough water to irrigate 2.55 hectares of open space), versus the use of rainwater tanks on each lot.

It is worth noting that rainwater tanks on each lot would not enable the public open space to be irrigated and so irrigation of the open space would then be limited to what could be bought from the potable system – i.e. very limited water.

Table 1 Approximate Costs per dwelling of a Communal harvesting scheme versus rainwater tanks on each lot.

COSTS PER DWELLING	Capital Cost	Ongoing Maintenance	Usage Charges [(1)]
Stormwater Harvesting Scheme Construction (based on actual construction costs)	$6,200	$260 PA	
Typical Household Rainwater Tank [(1)] based on actual construction costs from other developments	$5,500	$300 PA	
Household Use (Saving) [(1)]			$79 PA
Landscape Irrigation (Saving) [(2)]			$58 PA
Stormwater Harvesting Savings	($700)	$40 PA	$137 PA
Break Even	Approx. 4yrs		

Notes:

(1) Based on a typical new dwelling with above ground 3,100L tank excluding internal plumbing costs using 172 L/day harvested of 425 L/day total @ $1.264/kL.

(2) Irrigation volumes have been applied at 77.28 kL per week at $1.634/kL.

Table 1 shows that while the capital costs of constructing a communal system such as the one constructed at Ashgrove is marginally more expensive (a cost differential of $700 per dwelling), lower operating costs and avoided water bills soon come into to play to deliver a system with a much lower life cycle cost.

To Mirvac equally there is value in selling a “serviced” development, i.e. the ultimate homeowner will not have the direct responsibility for maintaining his or her own rainwater tank and pump. The communal approach also enables maintenance to be carefully programmed and undertaken with minimum effort.

Harvesting of stormwater is not something that could be readily undertaken by an individual homeowner. However harvesting of stormwater provides a significant benefit to harvesting of roofwater alone. Roads and paving can make up 30% of the surfaces in a dense urban environment. This just about doubles the effective catchment area that can be harvested with a consequent increase in water yields.

Harvesting of roofwater is certainly less risky than harvesting of stormwater, however, using the technology and methods developed by STORM, it was considered possible to filter water to such an extent that it would be fit for its non-potable end use.

Conclusion

A life cycle analysis which compares harvesting of stormwater for toilet flushing and outdoor non-potable end uses has been shown to be cheaper than harvesting of roofwater on new developments. Harvesting of stormwater at a communal scale for indoor non potable reuse has been made possible through the establishment of a community titled estate coupled with advanced and integrated WSUD solutions. Community title enables delivery of services to the community that would not otherwise be possible.

The integrated solution developed by STORM was a response to considerable water constraints which presented significant obstacles to development. The solution needed to carefully manage the constraints and risks of such an approach to water management. This project proves conclusively that development in Australia does not need to be constrained by water constraints now or in the future – integrated WSUD solutions are capable of overcoming almost any constraint. It also proves that mainstream Australian development can be sustainable and highly innovative.