CHALLENGING THE APPROACH TO NON-POTABLE RECYCLED WATER PLANNING

Rachel Watson [1], Simon Fane [1], Kris Kumaran[2], Lydia Aristuti[2]
1. Institute for Sustainable Futures, Sydney, NSW, Australia
2. Sydney Water, Sydney NSW, Australia

KEYWORDS

Recycled water, Reuse, Urban Water Planning, Resilient water systems

ABSTRACT

There is a perception that non-potable recycled water can be an expensive option, particularly for residential developments. This perception is in part due to the way that systems are planned and built to manage reliability of supply and uncertainty in demand. Building on the past 20 years of experience in recycled water investment, this paper firstly reviews the planning assumptions that have a significant impact on recycled water system costs and/or cause ongoing problems with system operation. It then identifies areas where there is the potential for change enabling the creation of a lean recycled scheme.

INTRODUCTION

In an era of rapid population growth, water scarcity and increasing climate variability the need for resilient integrated water solutions is paramount.

Over the past 20-30 years Australia has seen a significant increase in the number of recycled water schemes and the volume of recycled water production. Over this period, non-potable recycled water has evolved from an alternative method of wastewater disposal, to a source of alternative climate independent water in periods of drought to a valuable local water source for integrated water servicing and a water source for facilitating liveable cities (Watson 2017, Radcliffe 2020). Today, deliberate potable reuse has also seen a notable increase in application, being implemented in around 30 locations globally and is being considered in many more (WSAA 2019, Ormerod 2015).

As end uses, treatment types, scales and ownership models evolved, new recycled water schemes were constantly testing the boundaries of regulatory and customer acceptance. Schemes were designed on the best available information. Customer safety and satisfaction and regulatory compliance were key criteria. As customer acceptance of recycled water has grown, industry technical capability has been proven, it is now important to assess if and how schemes can be designed to truly optimise the benefits of integrated infrastructure and minimise overall capital investment.

There is much to be learnt from the existing systems, some of which have been operating for over 20 years. This paper leverages the learnings from past schemes, to better inform the next phase of recycled water investment in the growth areas of Australia's major urban regions. The paper firstly reviews the challenges of planning for competitive recycled water schemes. Using case studies and examples it then identifies how challenging the planning assumptions for recycled water can help to provide lower cost non-potable schemes.

There is concern that the inevitable transition to potable reuse will render non-potable reuse redundant. While potable reuse is a valuable option to consider in integrated water plans, it will not be the preferred solution in every context. In addition, potable reuse is an option that requires significant, sustained investment in collaboration, communication and education across all sectors including the community, stakeholders, regulators, even within utilities themselves. A history of successful non-potable reuse may help to make the transition easier, as was the case in Orange County, California. Finally, potable and non-potable schemes are not mutually exclusive and non-potable schemes can still play a valuable part in providing fit for purpose water in jurisdictions with and without potable reuse. For these reasons, and many others, it is valuable to consider how to optimise non-potable reuse systems.

STUDY METHOD

This was a collaborative project between the planning team in Sydney Water and the Institute for Sustainable Futures. This project used a range of methods to understand the challenges and identify and prioritize opportunities for a revised approach to non-potable recycled water planning. The project used a series of expert interviews with servicing planners within and external to Sydney Water and a diverse range of stakeholders across Sydney Water to identify opportunities for challenging the approach to recycled water planning. It then used case studies, literature and modelling to provide evidence-based alternative approaches to recycled water planning that could optimise recycled water infrastructure, continue to meet customer, operational and regulatory requirements and significantly reduce costs.

One-year post project completion, this paper also reflects on how the outcomes have been incorporated into the planning process.

OUTCOMES

Challenges for efficient recycled water schemes

By examining existing schemes and experience, five key challenges were identified including:

1. Getting the economics and funding models right
2. Coordinated planning and government policy
3. Duplication of infrastructure
4. Demand uncertainty
5. Acceptable risk and public health.

This project focused on challenges 3-5, as they are more directly within the control of recycled water planners. However, the complex and integrated nature of decisions for recycled water means that many of the potential barriers and opportunities are inextricably linked to issues outside the boundaries of control for infrastructure planners.

Opportunities for change and areas for future investigation

Twenty opportunities for change and innovation were identified. The opoprtunities were linked to case studies to help understand where similar initatives had been trialled and the practical implications of change. The greatest potential for high impact shifts, in the near term, were found in activities that reduced costs by down- sizing and/or delayed parts of the recycled water infrastructure (to better match what was needed for service delivery more immediately).

This paper focuses on three of the most immediate and significant opportunities:

- Reducing the duplication of infrastructure by taking a risk-based approach to peak demand servicing
- Reducing duplication of infrastructure, managing demand uncertainty and reducing water quality risks by taking a modular approach to recycled water investment
- Reducing operating costs through innovative operation practices

Taking a risk based approach to peak demand servicing

The issue

Recycled water schemes are perceived as expensive due to the additional infrastructure that is required to provide non-potable reuse often with minimal reductions in the potable water or wastewater requirements. Servicing for peak demand on both the water and the recycled water networks contributes significantly to the additional infrastructure. Infrastructure required to service peak demand contributed to just under 30 per cent of costs on one scheme (Figure 1). It was identified that the planning standards are designed to meet service standards in the worst-case scenario. The worst-case scenario often does not occur in practice.

Both water and recycled water networks are designed to meet peak demands. Currently, it is assumed that a house with both water and recycled water services uses more water overall than a house with just a potable water service. At peak hour the difference is up to 2.4kL/dwelling/day.

The opportunity

The current approach to planning for recycled water sets design parameters to ensure recycled water is supplied to the same pressure and continuity standards as potable water. Most of the recycled water infrastructure is sized in relation to maximum day or maximum hour demand. Maximum day is defined as the highest demand in a 24-hour period experienced in the past 10 years. This means that 20-30 percent of scheme costs are servicing a demand that may occur less than one percent of the time at ultimate design capacity (Figure 2)(Sydney Water 2012).

The planning assumptions and the data that underpins them were developed over a period when recycled water use was evolving and it was uncertain whether and how recycled water would be used, but a lot has changed since then. Research and the ongoing evolution of recycled water has demonstrated:

- Recycled water demand can reduce potable water demand by 35-50 per cent (Stuart 2011)
- Recycled water systems can reduce and attenuate peak demand (Gurung 2014, Willis 2011)
- Potable water efficiency programs have been successful in substantially reducing demand (Willis 2011).
- Recycled water prices have increased significantly and there are high levels of customer acceptance of recycled water, particularly for non-potable uses such as irrigation and toilets (Dolnicar 2010, Hurlimann 2016) so there is an opportunity to change customer messaging to the importance of saving all water
- Demand in new developments evolves slowly and over the time of a development service areas and demand projections can change.
- Regulators are supportive of exploring customer trade-offs between cost and customer service standards (IPART 2012).

By changing peak demand assumptions there is an opportunity to substantially reduce both recycled water infrastructure and infrastructure to supply potable back up and top up. Specifically, using booster pumping or direct pumping instead of elevated reservoirs could save 5 and 30 percent of costs respectively.

Depending on the specific system design and demand profiles, the impact of the change in design may be minimal or may not occur for many years into the future (as the development approaches ultimate demand). If changes to the scale of infrastructure will impact customers' standard of service (continuity and/or pressure) behavioral change (demand management) and incentivizing or requiring customer storage can be considered to mitigate the impacts.

For example, demand management has been used to successfully change behaviour, including reducing peak and average demand in the water and energy sectors. Reducing peak demand via behaviour change will allow the recycled water reticulation infrastructure to be reduced with minimal or no impact to customer service standards. Moving demand from peak periods to off peak periods may also have other operational benefits. Increasing off peak demand may assist with water quality. For example, there are issues with chlorine dosing at Rouse Hill at night because the flow is too low to trigger the flow meter. It may be possible to justify a lower off-peak price based on improving water quality and better use of off-peak energy prices to fill reservoirs.

Reducing peak demand using on-site storage for large customers, particularly those with high peak demands, is another way to minimize the impacts of reducing network infrastructure. For example, large developments in Sydney Olympic Park are required to have onsite storage to balance demand. This provides an added benefit of providing continuity of supply for the customer and allows customers to better manage pressure and flow, reducing meter size requirements.

Alternatively, if impacts are very infrequent and/ or minimal the appropriate service standard could also be re-negotiated.

Not only will these changes reduce costs, it is possible they will have additional benefits in operating costs and water quality. For example, recycled water age due to low flows through initially oversized networks can cause water quality issues in the early years of a large development, requiring additional chlorine dosing or additional flushing of pipes. In the worst case, potable water may need to be supplied until enough of the development is complete to allow the treatment plant to meet a safe operating threshold for water quality.

<u>Reflections 1-year later</u>

Sydney Water is implementing changes to recycled water infrastructure design to reduce costs. Smaller recycled water schemes, for example Colebee and Oran Park/Turner Road, are being designed with direct boosting, instead of elevated recycled water reservoirs. Medium scale schemes, such as Sydney Science Park, are being designed with smart operating systems to manage the peak recycled water demand for irrigation and customer use. This allows the recycled water production capacity and storage to be optimised, with supply being boosted from the treatment plant storage rather than an elevated reservoir. Large-scale recycled water scheme, for example the potential Greater Parramatta and the Olympic Peninsula (GPOP), is being planned with:

- co-location of drinking water and recycled water reservoirs where possible, reducing the infrastructure needs for drinking water top-up. This also reduces the transfer infrastructure needs (smaller pumps and trunk mains)
- potential integration of passive irrigation of street trees, which reduces the infrastructure sizing required for irrigation and generates positive waterway health impacts.

Sydney Water has also started investigating the potential to provide recycled water to customer's rainwater tanks, which will help reduce the capital cost of recycled water network. However, further investigation is still needed to:

- assess any water quality impacts when mixing supplies or storing recycled water
- determine a suitable operating and maintenance model to ensure the reliability of the on-property assets.

Sydney Water has developed customer messaging highlighting the importance of saving all water (potable and recycled). This was primarily driven by the need to save drinking water that is used to top-up recycled water systems during most recent drought, but it also has the potential to create longer-term change in customer recycled water use.

Deferring recycled water infrastructure

<u>The issue</u>

The timing, location and quantum of demand for recycled water is uncertain. Changes in land release sequencing impact the timing and the location of demand. Changes in development density and typology impact the quantum of demand and peaking factors. The typology of demand is often ill defined during the planning phase which makes estimating recycled water demand particularly challenging. For example, the demand of a development with lots of public and private open space will have higher recycled water demands than a development with much less open space. These changes are often caused by factors well outside the water utility's control (Figure 3). In addition, the development frontier is often not linear, or sequenced in a way that makes sense for infrastructure delivery.

The Hoxton Park example (Figure 3) is not an anomaly. A study of eight diverse recycled water schemes from across Australia and discussions with over 80 industry specialists demonstrated that regardless of the end user (residential, industrial, agricultural), significant deviations from forecast demand do happen. Specifically schemes at Aurora (a residential scheme in Victoria), Wide Bay Water (an agricultural scheme in Queensland) and Rosehill (Camellia) (an industrial scheme in Sydney) revealed uncertainties in the size and scale of the scheme. In each case there was both a lower ultimate recycled water demand and a slower rate of demand uptake than expected (ISF 2013).

The opportunity

Opportunities were identified to facilitate modular approaches that reduce upfront investment and allow infrastructure costs to better match actual rather than predicted growth and demand profiles. These approaches can be separated into simple or more progressive modular approaches.

Simple modular approaches

The Melbourne water utilities provide examples of simple modular approaches to recycled water investment. The Aquarevo scheme put in reticulation and will only build and commission a plant when development reaches a capacity that meets operating requirements for treatment and producing recycled water.

South East Water install local infrastructure as developments occur, but only link it up and connect it to their central Eastern Irrigation recycled water scheme when the pockets of development are complete. Over time they have learnt to reduce the number of interconnections between the water and the recycled water system. They now set designated interconnection points for new developments and it is the developer's responsibility to get the infrastructure to the connection point. Yarra Valley Water uses a similar strategy of delaying linking up recycled water infrastructure to recycled water until a certain development threshold is met.

Progressive modular approaches

Studies by ISF (Mukheibir 2013) in Melbourne and Bonacci (2012) in Sydney have demonstrated the significant value in taking a proactive investment path (investing in local recycling when the development opportunity arises) rather than a reactive path (business as usual, take the next tranche of desalination when triggered by demand) at a city scale. By investing in modular approaches, the investments were much more resilient to shocks and trends in demand than a conventional approach. Other unpublished studies in Sydney have shown similar net present values, but modular approaches allowed significant deferral of significant capital in the early stages of the development, which may provide even greater value if demand is significantly delayed.

Reflections 1-year later

Sydney Water is trialling different approaches to the timing of recycled water infrastructure delivery to better align with actual development. For example, the potential large-scale recycled water scheme for GPOP is being planned with:

- deferral of major infrastructure in some areas where development uptake is slow. For example, instead of delivering reservoir and large trunk mains, several precincts can be supplied through booster pumps and smaller reticulation mains.
- staging of treatment capacity to minimise risk of over investment

Sydney Water is also working with suppliers to develop temporary recycled water package plants that can be deployed to provide interim servicing before a permanent recycled water plant is built. These plants can be removed once permanent servicing solution is available and re-located to another area needing temporary servicing.

Processes to improve engagement and collaboration with planning agencies have also been established. These processes aim to confirm and revise growth projections and ensure new developments are able to receive recycled water (either by Sydney Water or external parties).

Minimising treatment costs through innovative operation practices

The issue:

The additional treatment of wastewater to meet recycled water quality standards and the operational challenges managing multiple water supplies, particular the cost of potable top -up, also influences perceptions that non-potable recycled water is expensive.

The opportunity

The project included a broad range of stakeholders from across the organization, allowing innovative solutions to emerge with both capital and operating benefits.

There is potential to use recycled water storages more effectively for both existing and planned recycled water systems. Operating the network and storages differently can reduce (or potentially eliminate) potable top up, for example:

- Currently operating rules commence potable top up if a reservoir drops below a certain pre-set level. Depending on the demand predictions the potable top up may not be required. For existing systems this involves using IICATS and models to optimise control of the system and using weather/demand predictions for pre-filling storages to maximum. A similar approach is currently adopted in the potable network when total fire bans are predicted. For new schemes it involves building in storages with the view to having optimised control with weather/demand related prediction.
- Existing design of recycled water storages require the recycled water to be dumped and reprocessed if there is low demand and chlorine decay. Rather than dumping the already treated recycled water it may be possible to include mixing and chlorine dosing at the storage tank.
- Only treating the recycled water on demand (not the whole wastewater stream)

These changes can reduce operating costs and have the potential to improve process effectiveness and efficiency and reduce energy costs.

Reflections 1-year later

Potential GPOP recycled water reservoirs are being planned with re-chlorination plants to ensure the quality of recycled water in the network meets the specifications.

The importance of providing time and resources to encourage innovation

This project was designed to challenge the current non-potable recycled water planning standards and assumptions. A key finding was that it is not possible or realistic to believe recycled water will be efficient and effective if done in the same way as the past. However, both the situation and the answers are complex. In dealing with complex situations, the people matter at least as much as the structures. Revealing and enriching people's views and ways of thinking helps to diagnose the situation and open up new opportunities.

Innovation and doing something different takes time. Planning timeframes are often very tight, particularly in the current drought context. This limits the time and resources available to test and justify innovative options, creating a risk of reverting to business as usual. This approach demonstrated the value of providing planners with the support, time and collaborative space to enable reflection and to draw learnings from past decisions. It then facilitated the planners in charting the path forwards towards innovative and viable recycled water scheme being adopted in servicing plans.

The process was further enriched by including a wide range of stakeholders from across the organization. This allowed a shared understanding of the breadth and quantum of the issues facing recycled water planning, which created momentum and (energy) for trying alternative approaches. The shared learning process through issues identification from a number of perspectives and case studies allowed collaborative exploration and prioritization of opportunities. As identified above, some of these opportunities had benefits both in capital and operating contexts.

To continue to build on the opportunities that arose from this project and identify and leverage new opportunities, Sydney Water has increased its focus on recycled water as a product. A working group has been set up to assess recycled water from the perspective of service offering, infrastructure planning and commercial models. They are also working with external suppliers more to gain industry insights to designing cost-effective schemes.

CONCLUSION

Optimising recycled water infrastructure to minimise capital and operating costs, while continuing to protect public health and the environment and meeting shifting and expanding customer and community outcomes is complex and challenging. This paper has identified a number of practical opportunities, supported by examples, that would facilitate recycled water investments, through rethinking, innovation and optimisation.

REFERENCES

Beal C and Stewart A (2014) Identifying residential water end uses underpinning peak day and peak hour demand. *Journal of Water Resources Planning and Management 2014 (140)*

Bonacci (2012) Alternative Servicing Strategy for Sydney. prepared for Sydney Water.

Dolnicar, S. and A. I. Schäfer (2009). "Desalinated versus recycled water: Public perceptions and profiles of the accepters." Journal of Environmental Management **90**(2): 888-900

Gato-Trinidad S & Gan K (2014) 'Understanding Peak Demand Factors for Water and Wastewater Supply Systems Design' *Hydrology and Water Resources Symposium 2014.* Barton, ACT: Engineers Australia, 2014: 750-757

Gurung T, Steward R, Beal C & Sharma A (2014) 'Smart meter enabled water end-use demand data: platform for the enhanced infrastructure planning of contemporary urban water supply networks' *Journal of Cleaner Production*

Institute for Sustainable Futures (2013). Demand forecasting: a risky business; Building Industry Capability to Make Recycled Water Investment Decisions, Prepared by the Institute for Sustainable Futures, University of Technology, Sydney for the Australian Water Recycling Centre of Excellence.

IPART (2012) Customer engagement on prices for monopoly services, Research – Discussion Paper, February 2012

Mukheibir, P., T. Boyle and C. Mitchell (2013). "End-use forecasting in the context of building adaptive water services." Water Utility Journal **6**(1): 10.

Ormerod, K. J. (2015). Governing Risk, Reuse, and Reclamation: Water Pollution Control and New Water Resources in the Southwestern United States

Radcliffe J and Page D, (2020) Water reuse and recycling in Australia – history, current situation and future perspectives Water Cycle **1**: 19-40

Stewart, RA 2011. *Verifying potable water savings by end use for contemporary residential water supply schemes*, Waterlines report, National Water Commission, Canberra. https://core.ac.uk/download/pdf/143863388.pdf

Watson R, Mukheibir P, Mitchell C, (2017) Local Recycled Water in Sydney – What's happening and why, OzWater'17, Sydney May 2017

WSAA (2019). All Options on the Table - lessons learnt from the journey of others, https://www.wsaa.asn.au/publication/all-options-table-lessons-journeys-others

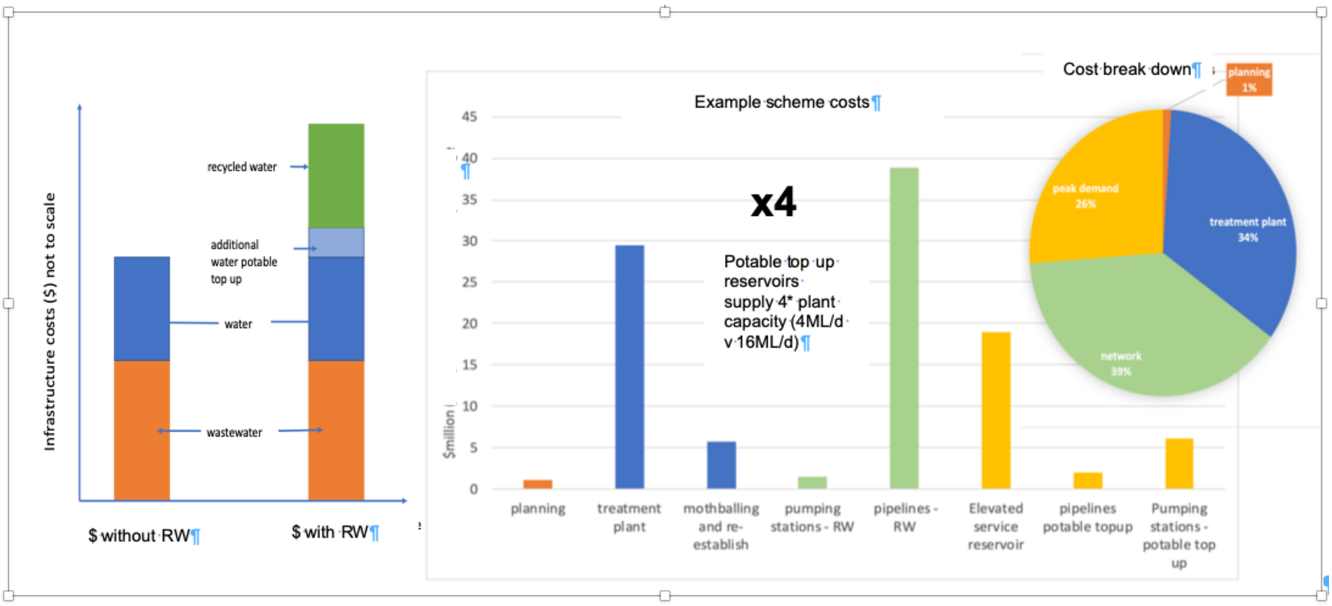


Figure 1: Example of the scale of peak demand servicing costs for a recycled water scheme

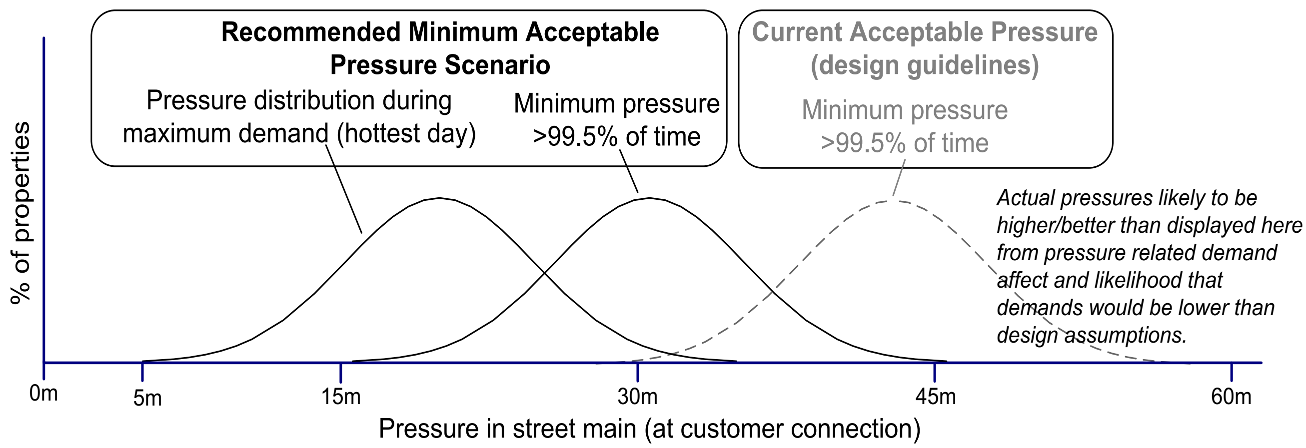


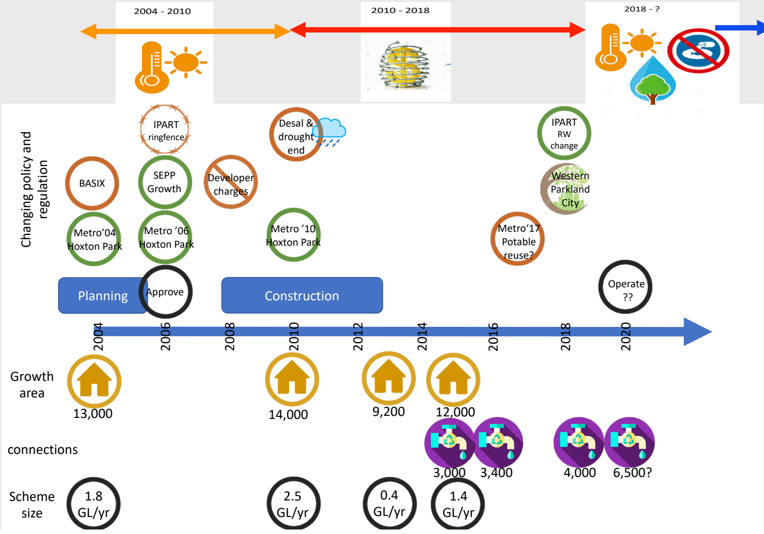
Figure 2: Illustrative examples of pressure profiles for properites at full development

Hoxton Park Case Study (Sydney Water)

Challenge: uncertainty in demand projections

External factors (Government policy and climate) drove changes in service area & customer numbers changing the timing and the size of demand.

Slower than anticipated growth delays demand.



Suburb	2004	2011 Growth Service review	2013 limit area	2015 (DSP)	Now (2019)
Expected date for operation	2009	2013		2019	2020
Edmonson Park	✓	✓	✓	✓ ↑yield	✓
Middleton Grange	✓	×	✓	✓ ↑yield	✓
Ingleburn Gardens	✓	×			✓
Panorama Estate (glenfield rd)	✓	×	✓	✓	✓
Yarranga Industrial	✓	×			✓
Oran Park		part			
Turner Road		part			
Elizabeth Hill			✓		✓
Freemans Reach				✓	✓
Len Waters Industrial Estate					✓
Interim					✓

Figure 3: External factors can strongly influence and change demand quantum and typology