The critical role of impact distribution for local recycled water systems

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Small-scale or local recycled water systems are increasingly being installed in urban centers in Australia, and throughout the world. These (often private) systems are in building basements, parks, on industrial sites and within small communities that are already serviced by existing public centralized water and wastewater networks. A consistent and fair assessment of the value of such local recycling systems, particularly in relation to centralized extension, augmentation and replacement, has proved to be problematic. This paper reveals why. It suggests that the traditional characterization of impacts into social, environmental, economic and at times technical groupings misses a key aspect in understanding the relative costs, benefits and risks of these systems: their distribution across the wide range of stakeholder groups. This paper proposes that accounting for the distribution of impacts is critical for assessments that include options of different scales and different levels of responsibility as there is a significant difference in the impact distribution between conventional urban water services and small-scale, local recycled water systems. This will help practitioners better understand the consequences of varying the impact distribution, particularly when moving from substantially public responsibility and ownership of assets to a mix of public and private responsibility and ownership.

Keywords: **Urban water planning, Decentralized infrastructure, Sustainability assessments**

1. Introduction: What are local recycled water systems and why would they be considered as an option in the urban context?

Until recently decentralized water and wastewater systems have generally been reserved for locations that were remote, difficult and/or too costly to service. However, the water industry is entering a period of challenge and change. Continuing to maintain and expand the capacity of existing centralized systems to manage and respond to ageing infrastructure and demand growth, while managing shifting expectations in terms of sustainability, livability, resilience and security, is proving both expensive and technically challenging (Marlow et al. 2013). The combination of these drivers plus technological change has led practitioners in the water industry to consider alternatives to the large, separated, centralized water and wastewater service delivery paradigm (Etnier et al. 2007a, Ferguson et al. 2013, Marlow et al. 2013, Mitchell et al. 2010, Mitchell et al. 2008, Nelson 2008, Pahl-Wostl 2002, Pinkham et al. 2004, Willets et al. 2007).

One option gaining popularity is the use of small recycled water systems (called local systems in this paper) within the urban system (Etnier et al. 2007a, Mitchell et al. 2010, Mitchell et al. 2008, Nelson 2008, Pinkham et al. 2004, Willets et al. 2007). These (often private) systems are being installed in building basements, parks, on industrial sites and within small communities, in addition the existing public centralized water and wastewater networks. When located within the urban water system, local systems can be extremely diverse; in their source, treatment methods, discharge locations, end uses and management models (Gikas and Tchobanoglous 2009, Watson 2011, Water Services Association of Australia 2010). Sources can include industrial water, sewer mining, blackwater, greywater and stormwater and the systems can discharge to the environment or back to the sewer. These local systems create variations in geographical scale of service compared to the existing centralised water and wastewater services. In addition, due to potential differences in ownership and management models local recycled water systems can also shift the conventional allocations of risk and responsibility associated with larger scale water infrastructure solutions.

A consistent and fair assessment of the value of local recycled water solutions, particularly in relation to centralized extension, augmentation and replacement, has proven to be problematic. It is challenging to consider and compare options that vary in scale, service outcomes and where the responsibility lies for planning and operation (Mitchell et al. 2007). Decisions in the water industry are generally complex and require decision makers to consider a wide range of perspectives and alternatives. Adding small systems into the mix of more traditional urban options increases both the diversity of options to be considered and the complexity of trade-offs (Ferguson et al. 2013).

This paper firstly reviews how impacts (benefits and disbenefits) are commonly used in the water industry to compare options and make decisions. While there are many studies (and tools) on the economics of potable and non-potable reuse (Khan 2013; Marsden Jacob Associates 2013; Raucher et al. 2006); very few take into consideration the distribution of costs and benefits across the range of stakeholders, such as developers, small system owners, customers, the broader community and the utility. Using the Australian regulatory and institutional context as an example, this paper identifies why the use of traditional sustainability assessments is limited, particularly for private investment in local systems – because they generally cannot or do not consider the significant changes in the distribution of impacts created by local recycled water systems. That is: the number of groups impacted, the way positive and negative impacts and risk are distributed between groups, and the timing of the impacts and the scale of the impacts are different for local recycled water compared to traditional urban centralized water and wastewater services.

This paper proposes that clearly identifying the distribution of the impacts, who is impacted, how and when will help explain why the assessment and implementation of these local systems has been problematic to date. Further, articulating the significance and scale of impact distribution helps identify why these systems are so different to conventional urban water services. It is important to make transparent both the assessment of impacts for the whole of society and the allocation of costs, benefits and risks across all of the affected stakeholders. This will allow for perverse outcomes for some stakeholders to be revealed, which will be informative for decision makers, particularly when considering whether to assist the industry in its initial stages or to make regulatory changes to more fairly distribute impacts in the longer term.

2. Reviewing urban water planning and delivery frameworks – examining sustainable decision making frameworks in the context of changing roles of scale and responsibility

2.1. The public sector is traditionally responsible for planning and managing urban water services

Delivering urban water and wastewater services is widely recognised as a government responsibility. Decisions in the water industry are complex, considering when and where to invest and to what standard. In Australia, at least, the decisions have become highly politicized from time to time (Productivity Commission 2011, Water Services Association of Australia 2013) and decision makers must consider a wide range of perspectives and alternatives. In the context of already complex decisions, the range of viable options and the complexity of trade-offs have continued to increase as principles of sustainability, integrated water management, water-sensitive urban design and liveable cities have emerged and evolved (Ferguson et al., 2013).

To help manage these complexities and trade-offs and include principles of sustainability, a number of decision-making frameworks and tools have been developed and adopted. There are different methods used in the urban water industry to compare the sustainability impacts of different urban water options (Fane et al. 2010). Federal and state governments in Australia generally prefer infrastructure decisions to include cost-benefit analysis (see, for example COAG (Council of Australian Governments) 2007, Commonwealth of Australia 2006, Office of Financial Management 2007, Resources and Industry Division - Queensland Treasury 2000). Cost-benefit analysis can include environmental and social impacts, but they need to be monetized using standard economic techniques, contingent valuation, or willingness to pay studies (Commonwealth of Australia 2006).

Commonly, strictly economic evaluations largely exclude sustainability and social considerations as these can be problematic to value. A range of alternative and complementary qualitative analysis tools, designed to include a wide range of (non-monetary) considerations have been developed and used within the urban water industry. These tools include multi-criteria analysis (Fane et al. 2010, Hajkowicz and Higgins 2008, Lundie et al. 2004), triple bottom line assessment (Taylor and Fletcher 2005), SWARD (Ashley et al. 2003) and scenario planning (Deng et al. 2013, Sitzenfrei et al. 2013). These tools allow for a multi-perspective analysis that helps to compare unquantified considerations and recognize the trade-offs required to balance multiple objectives and multiple viewpoints.

There are a number of critiques on the use of sustainability assessments in infrastructure decision making. Sustainability assessments can be limited as they contain multiple dimensions and require value judgments (Lai et al. 2008, Marlow et al. 2013). There is also an argument that suggests sustainability assessments can be improved through the collection and calculation of more comprehensive and representative data or the development of more robust models that allow multiple scenarios to be examined (Fagan et al. 2010, Makropoulos et al. 2008, Sitzenfrei et al. 2013). An alternative view is that sustainability assessment improvements are too focused on better data and better models, instead of investigating the trade-offs and interactions between the environment, society and the economy (Pahl-Wostl 2002). In the context of better understanding the trade-offs and interactions between the environment, society and the economy, this article suggests that considering impact distribution is particularly critical when comparing large centralized options with many smaller decentralized options.

In situations where the planning, delivery, risk and cost recovery all remain with the same party or the general community, these broader sustainability assessment processes can be useful aids to help incorporate wider social concerns and environmental values into the decision making process (Ashley et al. 2003, Hajkowicz 2007, Wang et al. 2009). However, local recycled water systems can substantially shift the roles and responsibilities of the different stakeholder groups (Pahl-Wostl 2002). So, when the responsibility for planning is separate from delivery and operation, and there is not adequate consideration of the impacts of that change in where responsibility lies, these whole of society assessment processes can neglect important outcomes. For example, in China, the best whole of society economic solution was identified as new developments incorporating a distributed recycled water system in their basement to minimise the impact on the constrained centralised system (Liang & van Dijk 2010). Although these systems are installed – their total benefit is minimised through poor operation (Liang & van Dijk 2010).

2.2 The dominance of public sector responsibility for delivering all urban water services is changing.

A close nexus between decisions, investment, responsibility and cost recovery has historically held for urban water and wastewater infrastructure. Government-owned water authorities, the predominant suppliers of urban water and wastewater services, have been operating as regulated monopoly businesses. The majority of decision making and investment in urban centers has been publicly driven and backed. Postage stamp pricing (where everyone in a given area pays the same price, regardless of local costs) is common (Productivity Commission 2011).

The water industry has entered a period of challenge and change (Howe and Mitchell 2011). Technological change, government incentives and new markets are providing an opportunity to fundamentally shift the current water service and delivery paradigm. The green market[1], prolonged

[1] Where a price premium is gained for premises with a higher perceived environmental standard compared to similar premises. This market is growing rapidly and has primarily been realised through the commercial

water restrictions and a suite of regulatory changes have facilitated direct private investment in water infrastructure. Direct private investment in small-scale water infrastructure is historically common practice in rural areas but usually at the household scale (e.g., rainwater tanks and simple on-site wastewater treatment systems). This type of investment is on the rise in urban areas (e.g., mandated rain tanks in new development areas in many states). However, the current scale and location of private investment in local infrastructure beyond the household scale in urban areas with existing centralized services is unprecedented in Australia.

The drivers to invest, and therefore the way decisions are made by public water utilities and private investors, can be quite different (Institute for Sustainable Futures 2013, Watson et al. 2013). In the historical urban water context public investment has been for broader social and environmental benefits. Private investment has generally been instigated in more discretionary circumstances and is more likely to be financially based.

The historical paradigm of urban water service provision (including governance, planning, investment, operation and maintenance) is changing in the face of some key challenges and opportunities. Figure 1 demonstrates the changing space of water infrastructure investment. As can be seen in the top half of the figure, historically, public utilities have been the principal investors, focused only on basic service provision (e.g., near term investment in response to drought; medium term investment in response to capacity constraints from population growth or to replace ageing infrastructure). Decisions based on sustainability assessments align well with the broader social and environmental outcomes that traditional public centralized urban water services have sought to provide. The more traditional large infrastructure options have remained a public responsibility and funded in the usual manner through the postage stamp price. Historically private sector investment was aimed at meeting broader service outcomes (e.g., to meet the green market requirements; to service outlying areas beyond public utility service coverage), as can also be seen in the top half of Figure 1. Discretionary private sector services such as in-building and precinct recycled water for green building credits are delivered based on willingness to pay and market forces.

With the range of services and the role of both the public and private sector evolving, as demonstrated in the lower half of Figure 1, the lines between public service provision and private discretionary services is blurring. Increasingly, public utilities are adding ‘livability’ to their mission statements, and investing in broader service options, and private providers are providing basic infrastructure, e.g., desalination. Recently though, there are examples both internationally and locally that have used sustainability assessments to demonstrate the potential of local systems to provide a benefit to society overall and private benefits (Chen and Wang 2009, Ferguson et al. 2013, Lazarova et al. 2001, Liang and van Dijk 2010, Lundie et al. 2004, Marsden Jacobs and Brisbane City Council 2011, Mukheibir et al. 2013, Schwecke et al. 2007, Sharma et al. 2009, Yamagata et al. 2003). Including both small and large scale options into the assessment process has often been associated with changes in funding, risk and responsibility. With the introduction of more local options into the wider urban water planning process, the mix of private and public responsibilities for the delivery of the options continues to evolve. See for example the mix of source, scale and ownership models assessed for Kalkallo, Melbourne Australia (Sharma et al. 2009), or Melbourne’s Northern Growth Corridor (Yarra Valley Water, Melbourne Water & Office of Living Victoria 2013). Local and site based options have had a wider mix of responsibility mechanisms, including private responsibility for delivery, operation and funding, even though they help to provide broader service outcomes.

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sector via ‘green building’ ratings tools, such as the Green Building Council of Australia’s Green Star rating or The US Green Building Council’s Leadership in Energy and Environmental Design (LEED). In Australia there is some evidence of a residential green market, with some pockets of development leveraging the marketing potential of providing sustainable, resilient and integrated water services – see for example Central Park and Pitt Town. Or similarly see the Dockside Green development in Victoria, British Columbia.

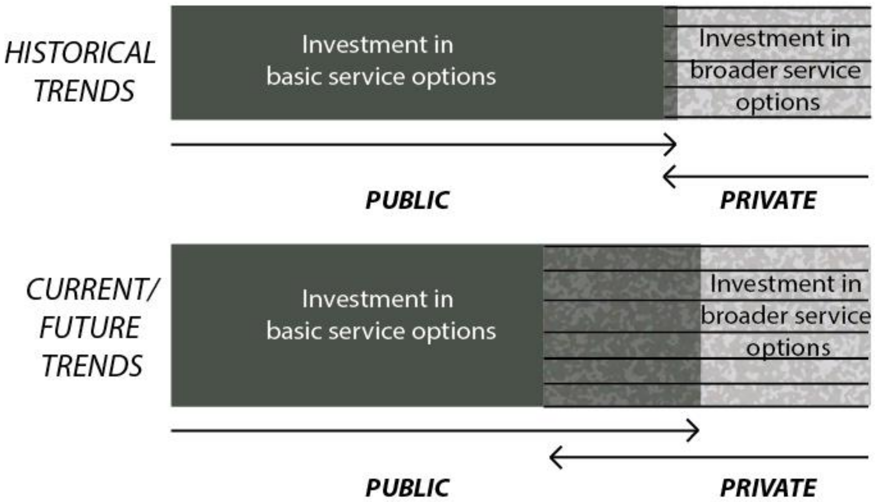

Figure 1: The changing space of water infrastructure investment. Historically, public investments focused on basic services and private sector investments targeted more discretionary outcomes, but that distinction is blurring.

3. Variations of scale and changing responsibilities between public centralized options and private local options make the consideration of distribution critical

3.1. The groups impacted by public centralized systems differ from private local systems

The introduction of local recycled water systems into an urban water system introduces new, and changes existing, roles and responsibilities for decision making, ongoing management and funding of water and wastewater infrastructure. For example, where recycled water systems are installed in building basements for green building credits, or on a golf course for secure irrigation the ownership, funding and management of that system is private, as opposed to the public utility ownership and management of the water and wastewater. Alternatively a new development such as Bingara Gorge, Sydney has a private supplier responsible for wastewater and recycled water management and planning and the public utility plans and manages water supply. As can be seen, a major difference between centralized systems and local recycled water systems is that local systems have higher potential to be privately owned. For a centralized system there are four key impact groups: the environment; the regulators; the community and the utility (illustrated in the left of figure 2). The whole community generally uses the service and the utility is usually the owner, the operator and the developer, although they may contract out some of these responsibilities. Current pricing, institutional and regulatory frameworks have been established in the urban water industry based on monopoly service provision, where the community as a whole pays equitably for a system that generally they all receive similar benefits and services. However, for a private local system there are seven or eight key impact groups: the environment, the regulator, the utility, the wider community serviced by the utility, the user of the local recycled water system, the owner (and/or operator) of the local recycled water system, and the developer of the local recycled water system (illustrated in the right of figure 2). The distribution of impacts becomes important because as the next section will show, the distribution, particularly of costs and risks, shifts to groups that are fundamental in ensuring the ongoing viability of the system, while the benefits are still spread over a much broader group.

The complexity of impacts and interrelations is increased with the introduction of a private system within a larger publically-owned system, as can be seen in Figure 2. Even for the environmental and regulatory categories where the types of impacts are similar, the management of the impacts, and therefore the risk profile and magnitude of potential cost, becomes more complex. For example, the regulators change from managing one (or a few) large uniform entities to many small and diverse entities. It is likely that the increase in entities increases costs for the regulator, for example in NSW it is estimated it costs more to regulate a small number of private providers under the WIC Act, that the four major public water utilities (Independent Pricing and Regulatory Tribunal 2013). In contrast, Pinkham et al. (2004) found no evidence to support claims of higher regulatory burden for smaller schemes. Therefore increased regulatory costs are likely to be highly dependent on the requirements of specific regulatory regimes.

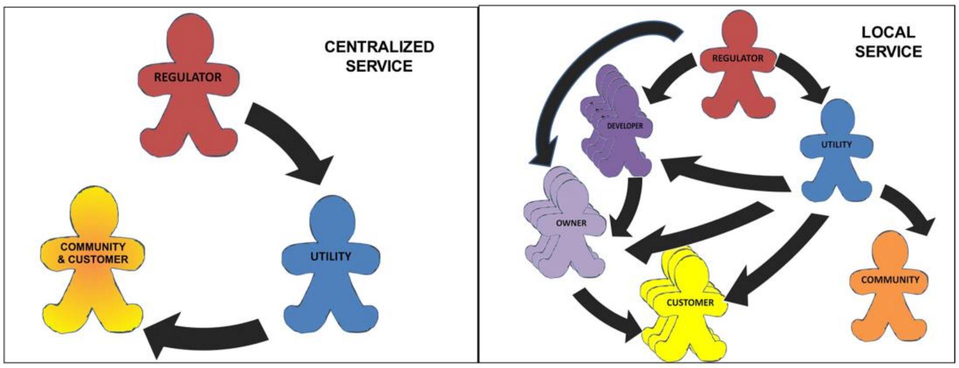

Figure 2: Mapping roles and interactions for conventional centralized and emerging local approaches. Local approaches have more stakeholders and more complex arrangements.

Traditional sustainability assessments are limited in that they generally fail to examine and account for firstly, distribution and the role distribution plays in the viability of the preferred options, and secondly, for risk, albeit to a lesser extent. This is not to say distribution and risk are not considered, they often are, but in a separate process (for example a risk assessment, resilience assessment or a sensitivity analysis) (Institute for Sustainable Futures 2011). Where the local recycled water systems (or other local solutions) are developed and owned by someone other than the centralized water utility the distribution of impacts (who is impacted, when and how and to what extent) changes significantly when compared to a centralized water service scenario, as the remainder of this paper will show.

3.2. The distribution of positive and negative impacts and risks are different for centralized systems and local systems

Not only is distribution important because there are more groups to consider, but the groups are now affected in different ways. The impact balance – the positive impacts versus the negative impacts in the context of risk will dictate how valuable local recycled water is to any one particular group.

Table 1 presents a summary of the types of impacts of local recycled water. Although some impacts listed in Table 1 may seem to have minimal significance from a whole of society perspective they are potentially very significant from the perspective of the person impacted. This is particularly important if the impact becomes the main or only impact a group experiences, or if the change represents a major shift from the centralized scenario.

Table 1: Impacts of local recycled water systems

	Benefits	Costs	Risks
Economic	Flexibility (size, timing, location, technology, source); scalability [Ut][D][C][Com] Centralised resilience; reliability; maximise centralised asset life; water security [Ut][Com] Avoided costs in centralised system; private funding leverage [Ut][Com] Increased property values [D][O][Com][U]; planning concessions [D]; premium rent/ price for prestige 'green buildings' [O]; productivity benefits of green buildings [U], branding [D][O][U] Reduced fertiliser costs [U]; reduced injury/ field rehabilitation costs [Com] Business resilience due to "non-restricted" outdoor water use	Capital and operating costs; loss of treatment/ management economies of scale [O][U] New regulatory regimes; increased regulatory burden [R] Loss of centralised revenue and payments [Ut]; subsidies for new markets and meeting political targets [Com]	Degradation of centralised & other RW using infrastructure; stranded assets [Ut] $ associated with time delays; extra planning scrutiny & approval effort & regulatory & institutional barriers & complexity [D] Vulnerable to misuse/ shock loads; poor performance due to skills shortage; poor capex/opex tradeoff decisions [O][U] Duplication; inefficient treatment; redundant capacity [O][U][Com] Emergency failure provisions/ Provider of last resort [Ut][Com]
Environmental	Reduced discharges and extractions from environment nutrient recovery; water quality improvement; groundwater recharge; organic chemical breakdown [Com] Reduced heat islands, reduced soil erosion & air quality benefits from green open space; [Com] Treatment targeted for source and end use; incorporation of WSUD; potential for stormwater integration [Com]	Energy consumption; reduced water return to the environment [Com]	Reduced crop yields [U], reduced soil health [U][Com], water quality reductions from salinity, nutrients and other concentrated pollutants; [Com] Poor allocation of resources due to duplication [Com]
Social	Customer choice; new or different services; different levels of service available [U] heath & social benefits from green open space; contribution to liveable cities [Com] public & industry education; private sector opportunities; equity with impacts being closer to users [Com]	Aesthetic impacts [Com]	Human health; poor public perception [U] Costs & Consequences of failure can have greater impact on small group [U][O];

Key: [C] – customers of local recycled water system; [U] – user of local recycled water system; [Ut] – centralized urban utility; [D] – developer of local recycled water system; [O] – owner of local recycled water system; [Com] – wider community

In Sydney, the economic regulator (IPART) developed and now must manage an entirely new regulatory regime to accommodate private entry into the water market. While this once off cost and effort may be minor in the long term, and be outweighed by the overall benefits of effective competition, it is a substantial burden for the regulator in the short to medium term. As an example, in NSW the Water Industry Competition Act 2006 has already undergone two lengthy reviews, the mandate (particularly who is covered by the Act) has changed twice, and a workable retailer and supplier of last resort regime has only just been established.

Public health regulators go from managing one large, generally public utility, to managing many small, possibly unknown and unproven entities. The public health regulator gets limited benefit from the reduced risk of a major failure or contamination event, but they get greatly increased risk from multiple smaller providers. The change in risk profile for health regulators is a major concern, particularly when coupled with the past historical failures of small systems and the proven health benefits of centralized systems (see for example the discussion in (NSW Government 2012) on the increased challenges in protecting public health with increased use of small scale, integrated privately provided solutions). Even if public health risk has a minor influence in the overall sustainability assessment it is very important for the health regulator and has a major influence on their perception of the value and sustainability of local recycled water systems, especially those separated by lesser known entities.

From a public utility's perspective, private local recycled water systems may result in extra responsibilities. For example, calculating avoided costs, managing system interfaces, being nominated as retailer or supplier of last resort and potentially dealing with customers who are confused as to who their service provider is for recycled water. The utility may also lose revenue, and there may be pressure to develop a different price structure for systems that have reduced demand, even if there is no change to the utility's costs. As an example, in Sydney an independent review of pricing has been conducted following concerns of revenue loss by the public utility, with a perception private utilities may focus on projects in low cost areas, leaving a smaller customer base to cross-subsidize [2] the more expensive parts of the system (Independent Pricing and Regulatory Tribunal 2015a, 2015b; Sydney Water 2015). The utility does potentially receive benefits in terms of reliability, resilience and avoided costs, but these benefits are currently poorly understood, and there is not a consistent and agreed way to calculate their value (Watson, Mitchell & Fane 2013).

In some circumstances there may be a 'green' market for a recycled water system or as part of a greater green building package (Chanan and Ghetti 2006, Green Building Council of Australia 2010, Hurlimann and McKay 2007). However, the difficulties and costs associated with managing and maintaining a recycled water system may still result in the systems being poorly managed or switched off. There is a particular risk of a capital/ operating cost imbalance if there is a weak link between construction responsibility and operating responsibility. This risk was identified by Pinkham et al. (2004) in their assessment of decentralized wastewater risks. Anecdotal evidence from the green building industry in Australia also suggests this is a risk, particularly where focus is on design and construction not the long term performance.

The balance between positive and negative impacts for any group involved in decision making is critical to the viability of the scheme. Any group involved in the decision making at a planning or operational stage is likely to make decisions to minimise their negative impacts and risks and maximize their positive impacts. For example, a sustainability assessment from a whole of society perspective may suggest that local recycled water is a sustainable solution for a particular development (as was the case in Liang and van Dijk (2010). However, the more tangible and direct costs and the risk and responsibility burden may shift from a broad and general distribution for centralised systems (the whole of society) to a much smaller group. This may be seen as a fair and equitable means of shifting the cost burden of growth and development to the beneficiaries (the developers or the owners) (Pinkham et al. 2004). However, if this results in systems being mandatory and there is no mechanism for transferring the value of the less tangible and less direct benefits that accrue to society, the systems may struggle to be financially feasible/ viable, causing them to be poorly operated or switched off (Chen and Wang 2009, Liang and van Dijk 2010).

[2] See discussion on arbitrage and 'cherry picking' in these submissions

These examples demonstrate that the decision makers perception of the balance of costs, benefits and risks are a critical factor in whether the system will be installed and/or efficiently and effectively operated. However, it is not just the control over the decision in relation to costs and benefits, but also when a particular group has the opportunity to understand the costs and benefits and when they are able to make decisions. These individual decision points are separate and distinct from the assessment of the sustainability of the system from a whole of society perspective.

As Pinkham identified, part of the perception will be based on whether the risks are controllable (whether the particular group has the opportunity to manage the risk/s) or uncontrollable (the group has no ability to manage the risk) (Pinkham et al. 2004) . For example, private local recycled water systems can provide resilience and reliability benefits to the centralized system (Institute for Sustainable Futures 2011). However, depending on the regulatory and planning framework, utilities may see this as a high risk way of obtaining reliability and resilience benefits. The utility may have no or limited influence over the ongoing decisions regarding operation, capacity and management of the small systems. From a utility's perspective, they may be able to obtain many of the benefits private local recycled water systems provide (resilience, reliability, and avoided costs) through their own planning processes and be able to reliably recover the additional costs through postage stamp prices.

The shifting of the burden of risk can also affect the decision to proceed. If a developer is installing traditional infrastructure the risk of delays during the planning approval phase minimal. However, non-traditional infrastructure such as local recycled water systems can have a very long and complex approval period that may result in delays, which is a significant direct upfront cost to the developer (NSW Government 2013). The difference in risk profile is critical to the developer's decision whether to install a local recycled water system. Although the delays may be minor in the life of the infrastructure as a whole, they are significant to the developer's timeframe.

3.3. The timing of positive impacts in relation to negative impacts will influence decisions

Who receives the costs and benefits, and when and how that value is recognized is an important factor in determining the overall success of a scheme. The timing of the costs, particularly when the costs are realized in relation to the benefits will also influence the decision to invest in local recycled water. In NSW, there is a requirement for new housing to meet BASIX requirements. BASIX requires a home to be 40% more energy and water efficient than an average home (NSW Government No Date). If recycled water is used to meet these requirements in a new development, the developer may be required to pay developer charges to the supplier upfront before the lots are sold. If a rainwater tank and efficient appliances are used to meet the requirements the cost is covered by the property purchaser when building the home. In contrast, in the middle of a drought when a golf course is rapidly losing members, investing in a recycled water system immediately provides water that improves course conditions critical to ongoing business viability (WERF 2006).

Most of the major economic costs and risks, such as the capital, the regulatory burden, and the planning risk, for distributed recycled water systems occur before opportunities to collect revenue. Some of the economic and social benefits, such as planning concessions, capital savings and increased service choice will also occur pre- or just post-operation. However many of the economic benefits cannot occur until the scheme is operating. Furthermore, some economic benefits are entirely contingent on other external and regulatory factors and their realization is unpredictable. For example, centralized resilience and reliability and the benefits of delayed centralized infrastructure augmentation are both difficult to measure and the benefits are only realized at some point in the future, depending on other factors such as environmental stresses on existing supplies and overall demand growth. In addition many social and environmental benefits can only occur in the future, and are difficult to measure and directly attribute to the local recycled water system. These benefits include public and industry education, water quality improvements, heat island reductions, values associated with healthy green space and improved playing field conditions.

3.4. Global averages used for centralized planning have very little meaning at a small local scale limiting benefit transfer

In many planning and assessment processes for water and wastewater services multiple small local options are amalgamated to allow them to be compared to a single large centralized option. The amalgamation process can lose many of the key localized benefits or make them difficult to identify using averages. For example, flexibility is a key benefit of decentralized systems (Pinkham et al., 2004). Flexibility is not just about 'just in time' investment but also technology choices and treatment levels better matching discharge, end use or waste contamination level. Using small systems allows the best technology and option to be used at each location at different points in time. This can allow the inclusion of integrated solutions, recycled water of different standards, and different sources where appropriate. However, using a generic option to describe, cost and score a non-uniform and adaptable option often results in flexibility benefits being lost (Watson et al. 2012). For example, in the City of Sydney strategic servicing strategy, developed by Sydney Water and government stakeholders, the 'decentralized' options were not specific about whether they included stormwater reuse, rainwater tanks, sewer mining or only in-building blackwater. Each of these kinds of options has different benefits and limitations, and these differ further according to the context (scale and timing) of each option.

Although it is recognized that local recycled water systems can help existing centralized systems manage the impacts of growth, and reduce public expenditure on centralized augmentations recognizing this benefit is not a simple process. How benefit transfer is managed depends on the actual benefit and the perception of why the scheme is being installed and who should contribute, as demonstrated in the following three very different examples. In some areas where the centralized system is severely constrained installing local recycled water systems for new development is mandatory, and receives no public funding. For example in Beijing, China where the the building developers and building owners fund the full costs as a reflection of them benefiting from the development going ahead (Liang and van Dijk 2010). In New York State, USA where installing distributed recycled water systems is voluntary, an ongoing 25% discount is given off water and wastewater bills as a reflection of avoided costs to the centralized network, both in operating and future capital expenditure (Etnier et al. 2007b, Zavoda 2005). In Sydney, Australia, where the installation of local recycled water systems is also voluntary, two different approaches have been used. When Sydney was subject to a severe drought and to improve supply reliability the government wanted to encourage recycling and private investment, one off grants were provided (for example through the NSW Governments Water and Energy Savings Fund). However, once large capital investments were made to secure water supply for Sydney in the medium term and the drought broke, the government subsidies and grants ceased. Funding for small systems in Sydney is now calculated on the avoided costs they can provide for the centralized system (if any) less the customers willingness to pay (Independent Pricing and Regulatory Tribunal 2011).

The scale difference between local systems and large centralized infrastructure can become significant when calculating the potential costs local systems avoid in the centralised network. It is difficult to calculate the value of avoided costs for small increments of demand in relation to infrastructure with very large capacity. This is particularly true for water, since once a lumpy investment has been made, it is usually viewed as a 'sunk' or unavoidable cost in the context of cost-benefit analysis (Commonwealth of Australia 2006). This means once a decision to augment infrastructure is made there is little opportunity over the short to medium term for decentralized investments to 'avoid' costs. Also networks can account for up to 80 percent of total system capital costs and wastewater capital costs are often based on factors that are unlikely to be reduced with individual local schemes (Water Services Association of Australia 2007). For example Malabar sewage treatment plant treats about 500ML/d (average dry weather flow), the Sydney desalination plant at Kurnell can produce 250ML/d. In comparison a local recycled water plant are usually much smaller, for example Pennant Hills Golf Course 0.6ML/d, Pitt Town and Discovery Point 0.3ML/d. The very large flows in the large centralized systems make it difficult for any one particular local recycled water scheme to create enough of a difference to qualify for avoided costs. However, as has been shown in projects such as City of Sydney Master Plan (Healey et al. 2012) or in Melbourne (Mukheibir & Mitchell 2014), the cumulative impact of many distinct local recycled water projects can have a significant impact on future centralized infrastructure planning. In Melbourne, a policy approach to invest in small scale recycled water infrastructure as opportunities became available had potential savings in the order of billions of dollars over a 50 year time horizon in comparison to an approach that focused only on extending supply through increasing desalination (Mukheibir, Boyle & Mitchell 2013).

4. Conclusion

This paper makes three clear and distinct contributions to knowledge in this sector. Firstly, it demonstrates that the distribution, timing and certainty of impacts for local recycled water schemes can vary significantly from that of the more traditional centralized water and wastewater infrastructure options. Secondly, it demonstrates that these variations will have a major impact on whether a decision is made to invest in local recycled water systems and the way those investments are made (particularly who funds the investment and the capital and operating trade-offs). Thirdly, it proposes an extension to the conventional categories for sustainability assessment to address this gap: including the recipients of the impacts and the timing.

The implication of these findings is significant. While traditional sustainability assessment can make the general case for these systems, further analysis is needed. The further analysis needs to explicitly recognize the effect the redistribution of impacts to a range of parties.

While the traditional characterization of social, environmental, economic and (at times) technical impacts is systematic, intuitive and fits well within established frameworks it is limited, particularly for the assessment of small private systems in relation to large public ones. The clear articulation and consideration of the distribution of local recycled water impacts is critical to a fair and robust comparison in relation to expansion or augmentation of an existing centralized system. Clearly identifying the differences in the distribution of impacts of centralized systems and local systems can also help to explain different perceptions within the community around the significance of particular impacts and associated risks.

The categories of developer, owner, user, utility, regulator, environment and wider community, directly reflect the way impacts are distributed. By examining the range, magnitude and timing of impacts via their distribution a better understanding of the importance of distribution of impacts on the decision to use and invest in this type of infrastructure can be gained.

The issue impact timing, particularly costs in relation to benefits, is also key for some parties. The timing and relative certainty of the costs in relation to benefits can directly influence the decisions to invest in local recycled water. Because of the much larger number of parties involved at different stages of the decision making process for local recycled water, compared to centralized systems, the decision making time horizon for many parties is often quite different to the ‘whole of society’ long term view.

The point of considering the timing of impacts and their relative distribution is to help to identify whether there are currently costs or benefits which are being unfairly apportioned, and whether there is a case for developing mechanisms to redistribute the impacts. Identifying the significance, scale and timing of impact distribution between options is an important precursor to investigation how or when transfer payment mechanisms may be appropriate, either to assist the industry in the initial stages or to more fairly distribute impacts in the longer term. The significance and influence of the changes in impact distribution between centralized and local systems should also be considered when making decisions about regulatory frameworks and changes to other government policy positions.

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