Australian Water Recycling
Centre of Excellence

Economic viability of recycled water schemes— Technical Report 3

Environmental and social values associated with non-potable recycled water

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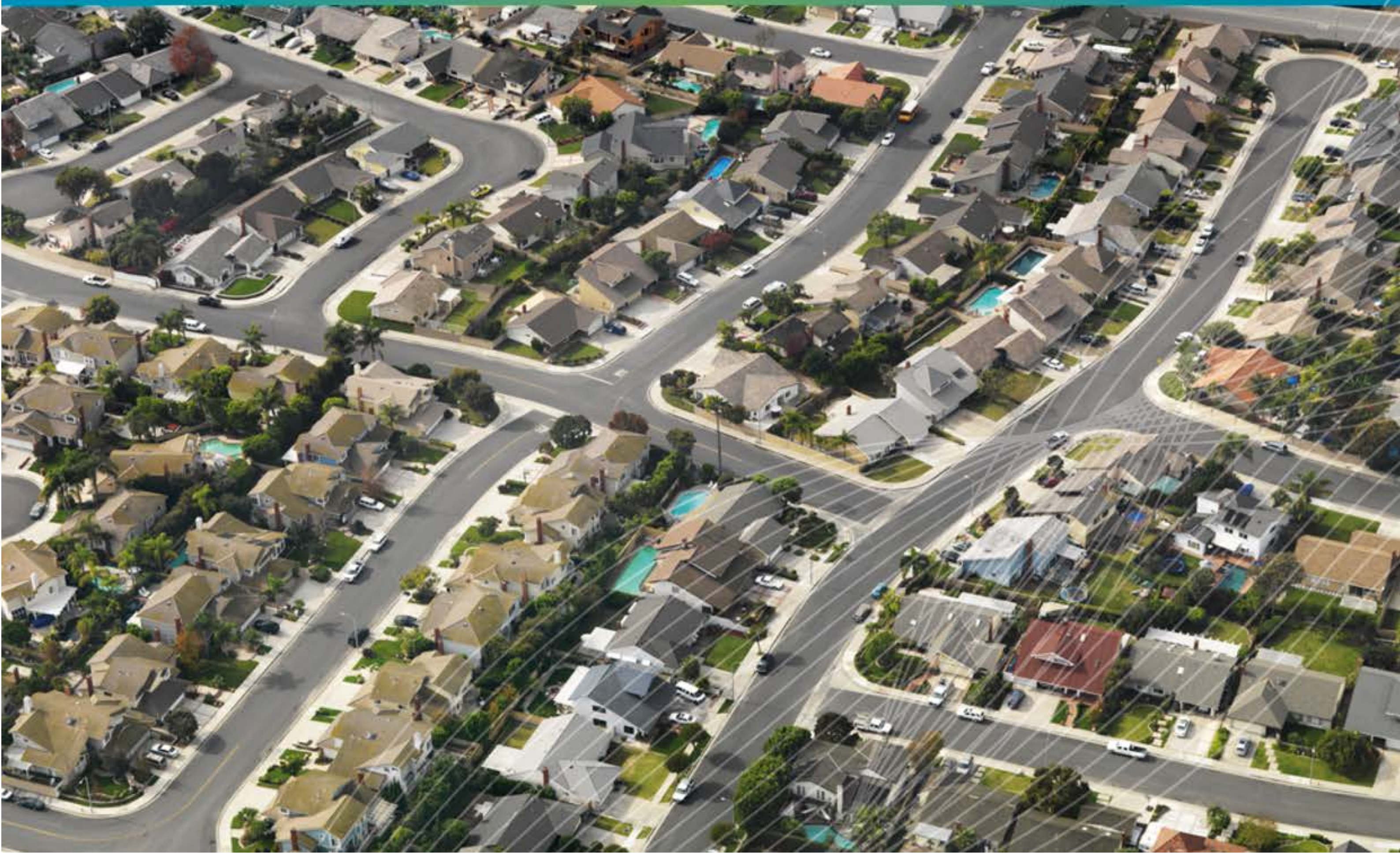

Environmental and social values associated with non-potable recycled water

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About the Australian Water Recycling Centre of Excellence

The mission of the Australian Water Recycling Centre of Excellence is to enhance management and use of water recycling through industry partnerships, build capacity and capability within the recycled water industry, and promote water recycling as a socially, environmentally and economically sustainable option for future water security.

The Australian Government has provided $20 million to the Centre through its National Urban Water and Desalination Plan to support applied research and development projects which meet water recycling challenges for Australia's irrigation, urban development, food processing, heavy industry and water utility sectors. This funding has levered an additional $40 million investment from more than 80 private and public organisations, in Australia and overseas.

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1. Introduction

One major inconsistency in the development of business cases and other feasibility assessments of recycled water projects relates to the incorporation of environmental and social benefits and costs into the assessment framework. Many non-potable recycled water projects have not proven financially viable compared to alternative water supply options, and thus their relative environmental and social costs and benefits become central to assessing their economic value.

Environmental benefits and costs of interest commonly include greenhouse gas emissions (specifically carbon dioxide), the environmental impact of reduced ocean outfalls, odour buffers and land clearing requirements. Some of these are universal (CO2), and some are case specific (environmental impacts of ocean outfall).

Social benefits and costs include the ability to avoid water restrictions, public health and local climate benefits of public open space irrigation, and other quantified expressions of community preferences.

This module will summarise and reference work on the relative biophysical and social impacts of recycled water systems compared with alternatives, but will not add to this body of work. An economic framework will then be outlined for the estimation of environmental and social values that may be achieved by water recycling.

Examples of studies that have estimated environmental and social values will be provided, along with a discussion of the challenges facing their direct estimation or the transfer of estimated values to other contexts. Implications for future use of these values within business cases will also be discussed.

1.1 Structure of this document

The structure of this document reflects the process undertaken in the module:

- Section 2 summarises the biophysical and social impacts of recycled water supply compared with alternatives, drawing on existing research;
- Section 3 defines an economic framework for environmental and social valuation relevant to non-potable recycled water projects;
- Section 4 explores the estimation of environmental and social values of recycled water in practice, focussing on Australian examples; and
- Section 5 provides recommendations for the incorporation of these values into businesses cases and feasibility assessments.

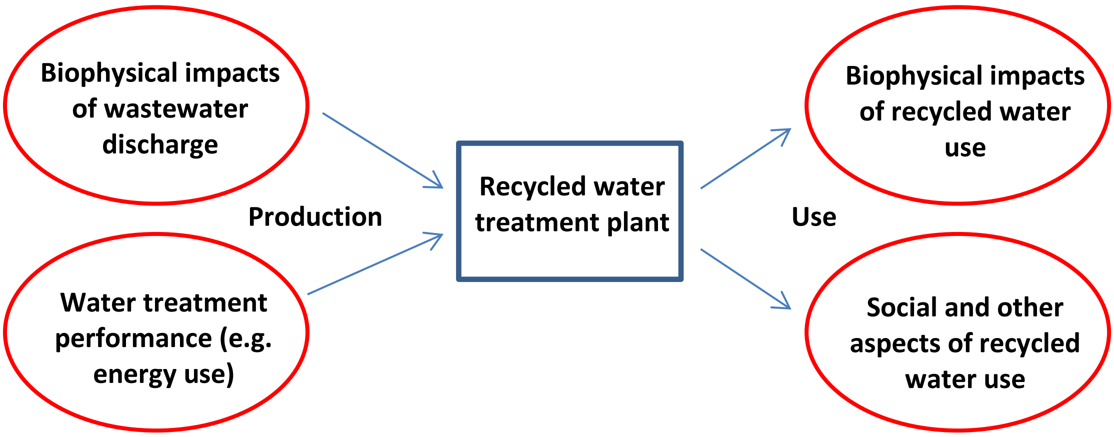
2. Scope of wastewater recycling impact

One aspect of recycled water that makes business case preparation challenging is that impacts occur at many different points of the water cycle. For example:

- as a water source, treatment of wastewater involves energy use that may be higher than surface water, but lower than desalinated water;
- use of recycled water prevents an equivalent volume of wastewater discharge to receiving water, which can affect environmental health and recreational use;
- application of recycled water can have both positive and negative impacts on its receiving environment; and
- a range of other impacts can be associated with recycled water in certain settings, such as its certainty of supply during drought and its sanctioned use during times of water restrictions.

An understanding of the environmental and social values associated with recycled water is predicated upon a sound understanding of the environmental and social impacts of recycled water. These impacts are presented in Figure 1.

Figure 1: Impacts associated with recycled water production and use



Source: MJA analysis.

We discuss these impacts below, and their economic valuation in Section 3.

While not the focus of this report or the broader study, an understanding of the biophysical relationships between recycled water and the environment allows us to understand the environmental attributes that recycled water may possess, as well as some social attributes.[1] This informs us of the changed outcomes that a recycled water project may produce, and allows us to estimate values for those changed outcomes.

Before summarising the key biophysical relationships, it is critical to be aware that while this summary outlines general observed relationships, the relative importance of these relationships will differ by wastewater treatment plant, location of discharge point, and the specific circumstances of each recycled water project.

[1] An example of a biophysical impact that produces a social value is the potential for public open space irrigation to produce a 'micro-climate' impact in the local area, reducing peak temperatures during summer.

For example, while it is generally true that wastewater discharge releases pollutants to receiving waters, the significance of this fact will differ by treatment level and location, and may change over time. The environmental and human health impacts of primary treatment and deep ocean outfall in Sydney in 2012 are measurably lower than shoreline discharge from Bondi in the 1980s. These differ again from highly treated wastewater discharge into Melbourne's Port Phillip Bay.

In short, the below summarises the general relationships, however for any subsequent economic valuation the specifics of each circumstance must be well understood.

Biophysical impact of wastewater discharge - environmental health of receiving waters

Wastewater recycling reduces the volume of wastewater discharged by other means.

Wastewater is typically treated to various standards before being discharged to either inland waterways or ocean outfall. Both of these involve the delivery of various pollutants that can be harmful to receiving waters, the extent of that environmental harm being subject to the level of treatment provided (and thus the volumes of pollutants discharged) and the environment of the discharge point.

Pollutants including high nutrient levels, nitrogen and phosphorus can adversely affect ecosystem function and flora and fauna health of receiving waters, inhibiting the health of indigenous species and facilitating the growth of non-indigenous species (for example, introduced weeds).

> *The high nutrient levels in wastewater can be associated with toxic algal blooms. In addition to the high concentrations of nitrogen and phosphorus in wastewater, negative impacts of other chemicals on aquatic biota have been identified over a range of ecosystems. These impacts include: pathological tissue changes; estrogenicity and other endocrine disruptions; altered dynamics of populations exposed to sewage; shifts in production and body-size spectra of communities; reduction in seagrass with knock-on effects on food webs; and changes to assemblage composition and structure (Schlacher et al. 2005, p.570). In addition, toxic metals found in wastewater discharges have also been found to cause biological contamination. Indications of physiological stress in animals contaminated with trace toxicants have also been observed (Luoma and Cloern 1982, p.137).*[2]

To the extent that wastewater recycling reduces pollutant load discharged to inland and coastal waterways, it reduces the biophysical impacts of wastewater discharge. A number of tools (discussed in the next chapter) can estimate the economic benefit of this reduction, by exploring the value a community places on the environmental improvement that recycling a volume of wastewater achieves. However, this is critically dependent upon an appropriate understanding of that environmental improvement.

Conventional wastewater discharge is a closely monitored and highly regulated action. Environmental and health regulators achieve their obligations by enforcing a range of actions on wastewater service providers:

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[2] Daniels, P., Porter, M., Bodsworth, P. and Coleman, S. (2011). A Compendium of Externality Effects and their Monetary Values for Water Servicing Options: A Study Based on the South East Queensland Context. Water Externalities Report 1. Urban Water Security Research Alliance Technical Report No. 42.

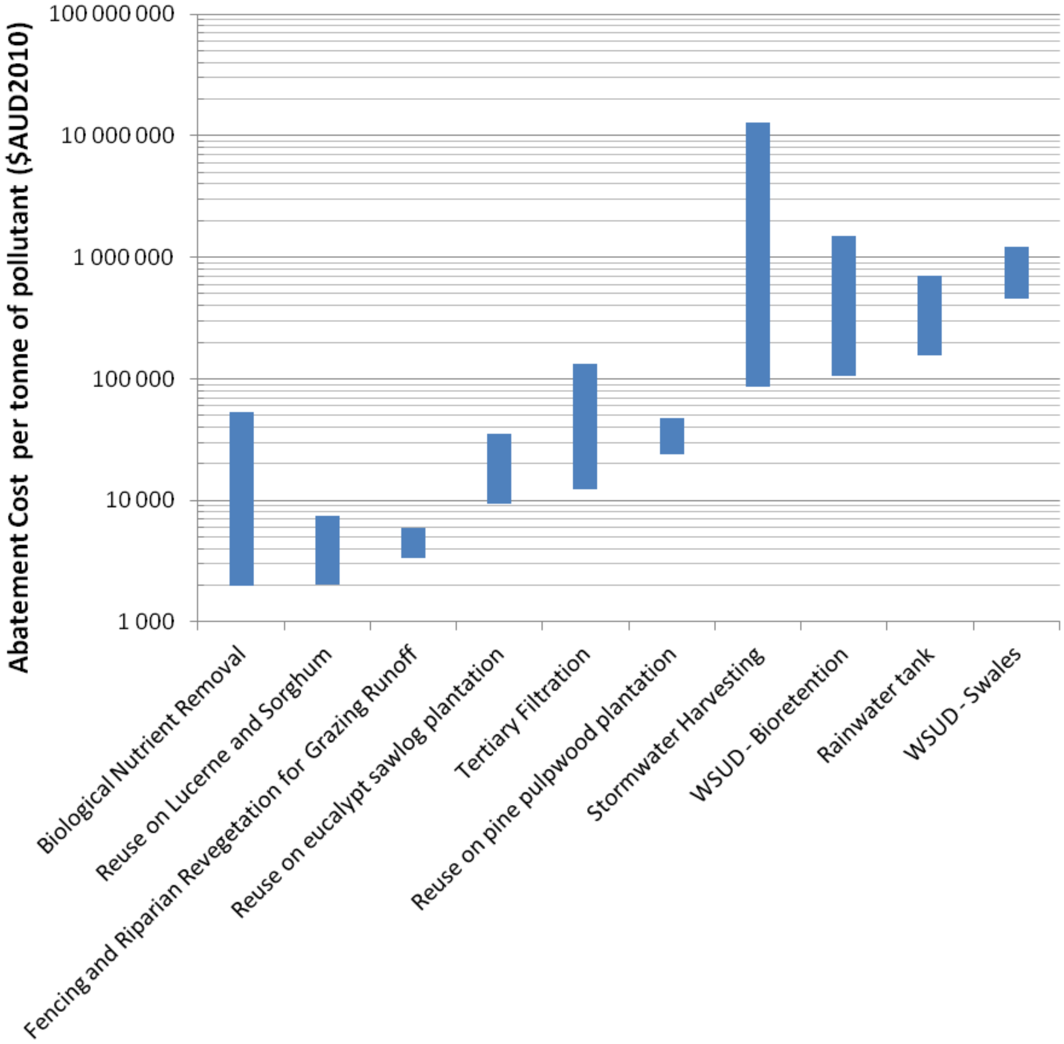
- moving discharge points away from sensitive areas: for example, moving ocean discharge from sensitive shoreline areas to deep ocean outfall where strong currents disperse pollutants at lower environmental and social cost;
- requiring higher levels of treatment for discharge affecting sensitive ecosystems: most inland waterway discharge and coastal discharges to sensitive bays and gulfs require relatively high levels of treatment to remove key pollutants, to reduce receiving water impacts; and
- monitoring of environmental and human health indicators: most wastewater discharge points are monitored for key indicators of environmental and human health, with breaches subject to fines or further management improvements.

It is also worth noting that wastewater discharge is not the sole cause of waterway pollution nor the sole cause of waterway health decline. It is clearly a contributor to waterway stress, along with a range of other pressures such as stormwater runoff from paved surfaces, pollutants from agricultural activities, and reduced flow caused by water harvesting for productive use.

This is an important point because subsequent valuation of the environmental improvement associated with recycled water (and therefore wastewater removed from waterways) is dependent upon an accurate understanding of the relationship between wastewater and waterway health. People may value improvements to waterway health very highly, but incorrect attribution of the waterway health improvement associated with recycled water would produce distortionary results.

Further, improving waterway health may be achievable at much lower cost by targeting sources other than wastewater treatment plants. Figure 2 shows estimates of the relative cost of removing equivalent volumes of nitrogen from South East Queensland waterways. The bars for each method of removal reflect the range of costs for that method, and the different bars reflect the very different costs for achieving the same outcome.

Figure 2: Cost of nitrogen abatement from difference sources, SEQ



Source: Hall, M.R. (2012). The Cost of Pollution: Supporting Cost Effective Options Evaluation and Pollution Reduction. Urban Water Security Research Alliance Technical Report No. 61.

Box 1: Using costs of achieving biophysical changes in economic analysis

It is important to note that the costs of achieving reductions in pollutant loads (such as those presented in Figure 2) are not in themselves estimates of environmental benefits. The environmental benefit of the reduction in pollutant load is the value of the environmental improvement achieved. As such, costs of mitigation are only appropriate for use in a cost/benefit framework when mitigation is required due to a political decision or statutory requirement - for example, because the environmental benefits would outweigh the costs of mitigation or because mitigation was a legal requirement.

Wastewater treatment and by-products

Wastewater treatment for both recycled water use and discharge produces greenhouse gases (methane and CO2) and uses energy within the treatment process. Energy intensity is typically higher than conventional surface water treatment, but lower than desalination.[3] Greenhouse gas production also allows the possibility for use as an energy source, and a revenue source if renewable energy credits are obtained.

Wastewater treatment produces stabilised organic solids as a by-product, which can be deposited to landfill or reused as a fertiliser. Biosolid reuse is typically subject to formal jurisdictional guidelines, and landfill sites are managed by jurisdictional environmental regulators, to protect human and environmental health. The major risk associated with biosolids is infection from microorganisms due to human contact (National Resource Management Ministerial Council 2004). Importantly, both wastewater treatment for recycling and discharge can produce biosolids.

Recycled water use - positive environmental impacts of wastewater?

In some specific circumstances, wastewater discharges may provide a supporting role to the health of receiving waters, especially inland waterways.

As noted above, most wastewater discharge to inland waterways is relatively highly treated, reducing pollutant loads released into receiving waters. It is possible that under very specific circumstances, the wastewater discharge may contribute to certain aspects of ecosystem function by supporting minimum flows. For example, a highly stressed waterway during a drought period or where significant natural flows have been extracted for irrigation, may benefit from the flow rate augmented by wastewater discharge. It may be that the area immediately downstream from the discharge point suffers a negative impact from discharge, but areas further downstream benefit after the pollutant load has been dispersed.

MJA is aware of very limited work exploring this potential outcome, but is aware of anecdotal evidence of wastewater service providers being requested by environmental regulators not to remove wastewater discharge volumes from inland waterways for reasons of environmental health. This points to the use of treated wastewater for environmental purposes.

[3] Dimitriadis, S. (2005). Issues encountered in advancing Australia's water recycling schemes. (Research Brief, No. 2). Department of Parliamentary Services, Commonwealth of Australia. 2005 06.

When comparing against desalination processes, however, it is worth noting that most desalination plants in Australia retain contracts for carbon offsetting of the energy used in the desalination process.

Box 2: Wastewater discharge to waterways as recycled water?

Western Water (Victoria) proposed environmental flows
Western Water is exploring the potential to have treated wastewater that is discharged to waterways be formally recognised by the Environment Protection Authority (EPA) as recycled water supporting environmental flows.
Undertaken through a pilot in partnership with the EPA and the water industry, Western Water is seeking to assist the development of an environmental offsets framework that will allow treated wastewater discharge to be included in an overall improvement to waterway health at a catchment scale.
Thus, the recycled water could be used to either substitute for environmental flows from upstream bulk water storage or provide an additional environmental flows allocation from the treatment plant.
The pilot will be based on biophysical analysis of the impact of recycled water on receiving waterways, and the economic viability of the project compared to alternative recycled water uses.

Sydney Water - St Mary's WWTP
In some cases, wastewater that is treated to a very high level and used to support environmental flows is already being recognised as recycled water. St Mary's WWTP in Western Sydney treats 18GL/a of wastewater using ultrafiltration and reverse osmosis to mimic the environmental flow regime of the now managed waterway. This supports the environmental health of the waterway, aiming to replace an equivalent volume of dam water which can then be freed up for potable use.

Recycled water use - biophysical impacts of recycled water application

There are a number of biophysical impacts associated with the application of recycled water for different uses.

Agricultural use can be beneficial as the high nitrogen and phosphorus content can substitute for expensive fertilisers, producing cost savings to users. However, higher concentrations of nitrite, ammonia and organic nitrogen can affect soil quality over time.[4] Chemicals potentially contained in wastewater can pose a risk to agricultural stock, including nutrient and sodium concentrations, heavy metals, human pathogens and pharmaceuticals.[5] Salinity levels can affect less tolerant crops and contribute to saline groundwater.

Recycled water irrigation of any kind (such as agricultural, public open space, golf courses and residential) can not only affect soil quality over time, but also increase nutrient loads to nearby waterways and groundwater due to run-off and infiltration. Usage needs to be managed to minimise these risks.[6] A number of uses also retain the risk of human infection through physical contact and inhalation, which must also be managed.

Recycled water use - social and other impacts

In addition to the predominantly biophysical aspects of recycled water production and use described above, there are aspects of recycled water use that produce social and other impacts that are important elements in the subsequent assessment of economic values.

[4] TOZE S (2004) Reuse of effluent water – benefits and risks, new directions for a diverse planet. Proc. 4th International Crop Science Congress, 26 September 2004, Brisbane, Australia.

[5] Dimitriadis, 2005.

[6] Residential recycled water use is often monitored by volumetric use by household. Those with regular high use are visited and supplied with information by the recycled water provider to ensure usage does not produce environmental decline.

For example, recycled water supply is climate independent and as a supply source is frequently viewed as high reliability water and a legitimate exception to water restrictions. This affects both private users (such as horticultural and residential users) as well as the general community if used on public open space (POS). The irrigation of POS during periods of restrictions can positively impact on physical and mental health, and potentially reduce peak temperatures due to micro-climate effects.

3. Environmental and social values within an economic framework

Section 2 outlined the types of biophysical and other changes that are associated with recycled water treatment and use, noting that the scale and scope of impacts will be case specific.

Rigorously estimating the economic value associated with these impacts can be undertaken using a number of economic tools, building upon a rigorous assessment of the marginal changes that recycled water treatment and use produces, compared with the situation without recycled water use.

A full economic assessment of the benefits and costs to society (not just those using or supplying the water) will incorporate all benefits and costs of a project, including environmental and social values which may be significant.

Understanding which values are legitimate to include in an economic business case or assessment becomes of critical importance, as does the correct application of the appropriate tool.

This section outlines a rigorous and defendable economic framework for the evaluation of environmental and social costs and benefits, outlining the economic theory and appropriate tools for measurement. We discuss the following concepts:

1. Total Economic Value (TEV).
2. Valuation theory applicable to social and environmental values to measure full economic value

Before we explore these concepts, it is worth reinforcing that economics typically adopts an anthropocentric view of the environment. That is, the value of an environmental improvement is estimated at the value perceived by people. There is no additional value beyond the value assigned by the community. This is not to say that humans must experience the improvement themselves. Humans may (and indeed often do) value environmental improvements that they themselves will not experience, because they conceive a benefit to other people or they believe there is an intrinsic value in the change.

The implication of this is that we estimate the value of an environmental change (as we do any other good) based upon society's Willingness To Pay (WTP) for a change.[7] WTP is a well-established concept for understanding the monetary value of a particular change and assessing whether society would be willing to pay for that change if it were undertaken on their behalf.

The key difference between environmental (and some social) values compared with normal consumer goods is that markets[8] for these goods often do not readily exist, making WTP more complicated to establish. Instead, WTP must be estimated using other means.

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7 Or in some cases, willingness to be compensated for a change.

8 Failure to incorporate the environmental costs of water supply, treatment and wastewater disposal, into the price paid for those services, can be seen as a 'market failure'. In this way, the environmental costs to broader society of wastewater discharge to waterways is not included in the price paid for water and wastewater services. Because the cost is incurred outside of the water transaction, this type of market failure is called an 'externality'.

At times this can be inferred by society's actions and expenditures. Other times it must be explored through asking a representative sample of people to state a preference for an environmental change with an associated cost. Appropriate assessment methods to estimate these values are discussed below.

3.1 Valuation framework – Total Economic Value (TEV)

The most common framework for understanding the full economic value of goods such as water is the Total Economic Value (TEV) framework. The TEV framework identifies not only the value of consumptive water use, but also non-consumptive values that may be environmental or social in nature.

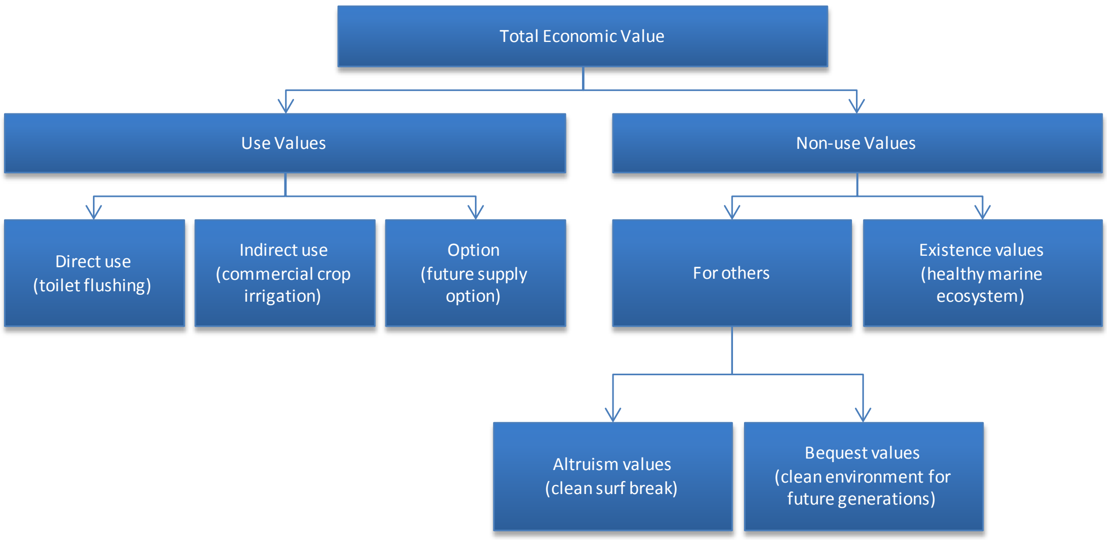
The TEV framework considers a larger sphere of impacts than just consumptive use. The TEV framework has been widely adopted by environmental economists over the past three decades, however there is no one standard categorisation nor standard terminology.[9]

Lancaster's[10] consumer theory argues that that a good possesses a bundle of attributes that combine to form the value the consumer places on that good. A TEV framework teases out these different attributes and their values. Value may be placed on a good such as water through the use of that water for productive ends (such as irrigation of crops), but also for non-use values such as the environmental impacts of water production, regardless of whether the user is directly impacted by these environmental impacts.

The TEV framework is useful for ensuring that all components of value are given recognition in empirical analyses and that 'double counting' of values does not occur when multiple valuation methods are employed.[11]

A diagram showing the components of TEV is shown in Figure 3.

Figure 3: Total economic value framework



9 See for example Turner et al 2003, Inter-Departmental Committee on Environmental Economic Valuation 2003, Robinson 2001 and Rolfe 2007.

10 Lancaster, K.G. 1966. "A New Approach to Consumer Theory." Journal of Political Economy, 74, 132-157.

11 National Research Council Committee on Assessing and Valuing the Services of Aquatic and Related Terrestrial Ecosystems, 2004.

Use values measure the value arising from the actual, planned or possible use of the good in question. Use values can be direct, indirect, or option values. Direct use values measure the willingness to pay for the good as a final consumption good. For example, recycled water use for toilet flushing is a final consumption good, and the willingness to pay for this use is a direct use value. Direct use is the value typically measured in financial analyses.

Indirect use value measures the value that a good has as an intermediate input in some production process whose end good is of value. For example, use of water in the agricultural production process represents an indirect use where the final good produced is the agricultural output. For recycled water that is available but not currently utilised, the water may also provide an option value as it provides an option to use the resource in the future. For example, Melbourne's Eastern Treatment Plant treats up to 100GL/yr of wastewater to 'Class A' standard, most of which goes to ocean outfall. This provides an 'option value' for future use.

Non-use value refers to the willingness to pay to maintain some good in existence even when the individual does not use the resource or plan to use the resource at some time in the future. Non-use values are generally separated into existence, altruism and bequest values. Existence values refers to the WTP to keep a good in existence in the context where the individual expressing the value has no actual or planned use of the resource for herself, or for anyone else. Motivations for having an existence value may include being concerned for the good itself in its own right, or a stewardship motivation. Altruism and bequest values stem from the preference of the individual for others to enjoy and benefit from the resource, even if the individual professing the value does not use the resource themselves. In the case of altruism values, the preference is for others in the current generation to enjoy the resource, whereas a bequest value reflects the preference for future generations to be able to enjoy / benefit from the resource.

In the context of recycled water, non-use values often (but not always) relate to the production of the water, rather than its use. For example, environmental values impacted by discharge of wastewater to the environment benefit from recycled water because discharge is intercepted in the production of recycled water. Similarly, greenhouse gas emissions occur in the production of water, rather than its use.

Some non-use values also relate to the specific use of the water. For example, public open space irrigation with recycled water that avoids water restrictions provides use values to those who actively use the park, and non-use values to those in the broader community who may not benefit themselves from its use, but are willing to pay so that others may benefit from the irrigation.

3.2 Externalities

An externality occurs when a person is affected by a transaction (in this case, the purchase of a unit of water), but is not involved in that transaction. For example, the purchase of wastewater disposal results in an impact on the receiving water environment at ocean outfall and those who use that environment for recreational purposes. A surfer near an ocean outfall discharge point may not have purchased the wastewater services, but may bear some of the cost related to its discharge. This cost is external to those included in the transaction, and does not feature in the price paid.

In contrast, users of recycled water produce no net ocean outfall impacts associated with each unit of recycled water they purchase. As such, this environmental externality does not apply to those services.

Where the external impacts are included in the transaction price (for example through an appropriately determined pollution tax) or are avoided through mitigation measures, then these impacts are said to be "internalised" and do not need to be accounted for independently.

The TEV framework seeks to include all values – both internal and external. The challenge becomes appropriately estimating the value of the externalities.

3.3 Measurement approaches

Appropriately incorporating environmental and social values into a business case requires a strong understanding of the biophysical or other change caused by water recycling and use, and appropriate estimation of the economic value produced by that change using rigorous tools. As discussed, the economic value is revealed by revealing a willingness to pay for the change.

There are a range of tools available to measuring that willingness to pay.

Valuation methods are typically either based on the observed market behaviour of individuals, or through responses to survey questions that reveal the stated preferences of individuals. The former approach is generally termed the revealed preference approach and the latter the stated preference approach to valuation.

The Best Practice Regulation Handbook (Department of Finance and Administration of the Commonwealth of Australia, 2007) of the Office of Best Practice Regulation clearly states a preference for the estimation of economic values using the revealed preference approach. The OBPR notes that valuation estimates based on the observation of individual behaviour in real markets tend to be more credible than those from survey questionnaires. Moreover, observing purchasing decisions directly reveals preferences, whereas surveys elicit unavoidably hypothetical statements about preferences.

While revealed preference approaches are in general preferable to stated preference approaches, in some cases it is impossible to value goods and services using revealed preference approaches. In particular, the non-use value of goods and services cannot be estimated using the revealed preference method. [12]

A summary of the key relevant economic valuation techniques is provided Below. While a more detailed exploration of a full range of revealed and stated preference tools can be found elsewhere, we have included only the key tools applicable for estimating recycled water values.[13]

3.3.1 Revealed preference techniques

Revealed preference tools draw from actual behaviour and expenditure to infer values. They are often used to elicit direct and indirect use values.

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12 For example, the value people place on the preservation of an endangered species cannot be revealed based on actual behaviour.

13 For a full list, please see http://www.finance.gov.au/obpr/docs/handbook.pdf

Hedonic pricing method

A good possesses a bundle of attributes that combine to form its value. As such, the value of a house can be seen to be the combined value of its features, both tangible and intangible. In addition to the number of bedrooms and bathrooms, property prices are affected by sustainability features and infrastructure such as access to recycled water.

The hedonic pricing method isolates the impact of specific variables on property prices, and can determine the effect of recycled water infrastructure on property prices. We undertake a hedonic pricing study as part of our broader project (see Module 2). The method is robust but very data intensive (and thus expensive if purchasing property sales data), also requiring advanced technical skills to undertake.

Replacement cost method

The avoided cost method of valuation assumes the value of an ecosystem service is equal to the cost of replacing that service (or level of service) should it be lost. While technically, cost is not a reflection of value (because one might value the service differently to the cost of replacement), it is sometimes used when willingness to pay is unable to be assessed.

It is possible to use avoided cost in exploring the 'urban heat island' impact of irrigating public open space with recycled water. This could estimate the impact on peak temperatures of the area surrounding an irrigated park, to explore the cooling costs avoided by the reduction in peak temperatures. The key element in this type of analysis is a firm basis in the biophysical changes that recycled water use will produce.

Defensive expenditure method

This method measures the amount people spend to mitigate an unmarketed 'bad', such as residential water restrictions. For example, to avoid water restrictions, people may pre-emptively spend more on alternative water supply options or drought resistant plantings. This expenditure provides evidence of how individuals value a reduction in the negative outcome. If the defensive expenditures eliminate the negative outcome, their total value provides an estimate of the costs of the unwanted effect.

3.3.2 Stated preference techniques

Values for changes produced by recycled water production and use may be held by people not directly using them, or actively benefitting from them. Members of a community may hold a willingness to pay for the existence, bequest and altruism (non-use) values that recycled water production may provide. They may also support recreational use values that healthy receiving waters provide, despite having no intention to ever benefit personally from those values.

Determining the nature and extent of non-use values is more difficult and potentially imprecise than use values, because unlike measurement of use values, there is no market data that can be used to assist estimation. Instead, community WTP for these values must be estimated using hypothetical scenarios with different payment options in which survey respondents are asked to state their preferences.

Critically for this project, application of stated preference tools is a methodologically robust and defendable way of eliciting community preferences (willingness to pay) for recycled water, compared to alternatives. Application of this type of tool can capture and quantify a community's preference for the nature and proportion of recycled water used within that community, as distinct from value gained by the actual user of the water. This is an important input into a business case.

However, it must be acknowledged that these 'stated preference' tools are often considered less robust than revealed-preference approaches available for use values, and can be subject to a range of biases and errors. Their application is becoming more prevalent, but their use is not without criticism.

The two primary stated preference tools are choice modelling and contingent valuation.

Choice modelling

Choice modelling is a survey based valuation method that presents respondents with varying attributes that are accompanied with different prices. In the context of recycled water, the benefits of increased use of recycled water can include substitution of water supplies from a perceived inferior alternative (such as desalination), an improvement to receiving water health, and a value associated with the specific type of use (such as public open space irrigation).

Respondents are asked to choose the option they prefer, which reveals their willingness to pay for varying levels of each attribute. By repeating this process a number of times (each respondent makes numerous choices) and surveying a large number of people, the average community willingness to pay for changes in attributes can be established.

This is a highly technical method that is heavily dependent upon a sound understanding of the marginal changes that recycled water production and use can result in. Conveying this information to respondents in ways they can understand is also a challenge. As such, it can be expensive, require high level expertise to implement, and can produce results that are sometimes contested. It is also subject to a number of biases that often bring results into question. Nevertheless, it can provide useful insights into community values for recycled water not elicited in other studies.

Contingent valuation

Contingent valuation is a survey approach in which respondents are presented with the status quo and an alternative scenario representing a specific change associated with recycled water. Respondents are asked whether they would be willing to pay a sum of money to achieve the outcome, from which community willingness to pay is developed.

Unlike choice modelling, different attributes of ecosystem function are not varied to elicit different willingness to pay levels for different marginal changes. As such, contingent valuation lacks some of the complexity of choice modelling. However, it is recognised that choice modelling places a significant cognitive burden upon respondents by asking them to comprehend and quantify their preferences for various attributes that they would not usually place dollar values upon.[14] As such, contingent valuation can offer a more simplistic and realistic choice to respondents.

One established shortcoming of contingent valuation is the potential for respondents to 'anchor' preferences on the first value presented to them. Another is the potential for 'yea-saying' –

[14] Hanley, N., S. Maurato and R.E. Wright. 2001. "Choice Modelling Approaches: A Superior Alternative for Environmental Valuation?" In Journal of Economic Surveys, Vol 15, No 15.

stating a willingness to pay for an outcome for the purposes of the survey that they would not in reality be prepared to pay.

These problems can to some extent be mitigated with careful survey design.

3.3.3 Benefit Transfer

Implementation of the above tools is technically demanding, time consuming and expensive. Stated preference tools require careful preparation and implementation, and produce results that are questioned by some (but are increasingly incorporated into the economic regulation of water).

For small recycled water projects with limited budgets, implementation of a nonmarket valuation study may be beyond their scope. In such cases, the 'benefit transfer' method has some appeal.

The benefit transfer method can be used to obtain economic values for goods and services by drawing on available valuation information from studies already completed in another location. For example, values associated with recreational fishing in Western Australia may be estimated by applying measures of recreational fishing values from a study conducted in another state of Australia.

Thus, the basic goal of benefit transfer is to estimate benefits for one context by adapting an estimate of benefits from some other context.

However, adapting estimates from one context to another requires technical skills as well as an understanding of the key drivers of values, and how they differ between sites.

Table 1: Methods of benefit transfer

Transfer method	Description	Example
Single point value transfer	A single value is transferred without adjustment from source study to target site	A property premium value for residential recycled water of $5,000/property is transferred from site A to site B
Marginal point value transfer	A single value that allows for site differences is transferred	A property premium value is transferred and adjusted for property numbers and average property prices
Benefit function transfer	A valuation function is transferred, allowing adjustment for variety of site differences	A valuation function with several attributes is transferred from site A to site B (e.g. property size, distance to public open space)
Meta value analysis	Results of several studies are combined to generate a pooled model	Results from studies X, Y and Z are pooled to estimate a value for Site B

Source: Adapted from Rolfe, John. 2006. "A Simple Guide to Choice Modelling and Benefit Transfer" in Rolfe, J and J. Bennett. 2006. Choice Modelling and the Transfer of Environmental Values. Edward Elgar Publishing.

The general approach to benefit transfer involves the following steps:

1. Assess target situation
2. Identify source studies available and select benefit transfer type
3. Assess site differences
4. Assess population differences
5. Assess scale of change in both cases

6. Assess framing issues (scope, scale, instrument)
7. Assess statistical modelling issues
8. Perform benefit transfer.[15]

[15] Rolfe, J., 2006.

4. Environmental and social value estimation in practice

Section 2 outlined the biophysical and social changes that recycled water can produce. Section 3 then outlined appropriate estimation methods for establishing economic values for these changes.

This section explores the practical experience of environmental and social valuation related to recycled water in Australia. The purpose is to demonstrate the range of valuation estimates that have been undertaken in Australia of direct relevance to recycled water economic evaluations, to inform of their use in future assessments.

The key environmental and social values relevant to recycled water include:

- Greenhouse gas emissions in the production and delivery of water including recycled water. The treatment and delivery of recycled water is typically more greenhouse gas intensive than some water supply options (such as dams) and less than others (such as desalination). With the commencement of the Carbon Price Mechanism in Australia, this environmental cost is arguably internalised.
- Ecosystem function of receiving waters for wastewater discharge and recycled water use. Discharge of treated wastewater to ocean outfall or inland waterways can affect the ecosystem function of receiving waters. Importantly, this impact may be negative or positive, depending upon water quality and the level of ecosystem health of the receiving waters.[16]
- Amenity impacts on recreational users affected by wastewater discharge and specific types of recycled water use. Discharges of treated wastewater to ocean outfall and inland waterways can negatively impact on recreational users of surrounding areas (recreational fishing, surfing, boating). Conversely, users of public open space irrigated with recycled water benefit from this irrigation.
- There may also be positive social externalities associated with recycled water use. For example, some studies argue that a ‘micro-climate’ effect of public open space irrigation may exist, which reduces maximum temperatures in the surrounding local area due to evapotranspiration. This reduction in peak temperatures reduces cooling costs to surrounding residents, or the discomfort for those without air conditioners.

Our literature review and consultation has identified very few published willingness to pay studies (such as choice modelling, contingent valuation or hedonic pricing) specifically relating to recycled water.

However, MJA is aware of several WTP studies prepared by water businesses to explore community preferences including recycled water, that were reviewed by economic regulators but not included in a pricing review to justify an investment. Nevertheless, it is expected that economic regulators will be considering WTP as justification for project investments

[16] An area yet to receive adequate scientific attention is the potential for treated wastewater flows to support ecosystem function of stressed inland waterways in need of support to base flows. This contrasts with the conventional wisdom that discharge to waterways of treated wastewater has inherently negative environmental impacts. To this end, wastewater treated to an appropriate level, and discharged in such a way as to support ecosystem function, could more adequately be described as ‘recycled water’.

increasingly in future, as Government targets for recycled water reduce in influence and methodologies become more accepted.

There are a number of WTP studies that have been used in the development of policy settings by Government agencies, often combined with cost-effectiveness assessment of pollution abatement options. These rarely relate specifically to recycled water, focussing more on technologies within treatment plants to reduce pollutant discharge. However, recycled water projects could conceivably produce similar pollutant reductions through reuse.

It is MJA's experience that business cases for recycled water projects rarely involve valuation studies specifically designed to rigorously estimate the nonmarket values associated with the project.

4.1 Environmental impact on receiving waters

Economic assessments of environmental values exist across a range of contexts in Australia, exploring the willingness to pay of different community members for changes in environmental outcomes (such as improvements to wetlands, river health, coastal amenity).

Environmental impact of wastewater discharge on receiving waters is the focus of several Australian studies, reflecting increasing awareness of waterway health decline in major centres around Australia, and the regulatory focus on point source polluters.[17]

While these studies have broad relevance to recycled water (in that wastewater discharges to waterways can impact upon the health of receiving waters), very few economic valuation studies of this nature explore changes directly associated with recycled water. This is a critical distinction – the value a community places on environmental improvement is not the same as a value for recycled water unless water recycling and use produces the same environmental improvement.

4.1.1 Abatement cost – cost effectiveness

Much recent work in this area focuses on the relative abatement costs of achieving reductions in pollutant loads to receiving waters, in major centres experiencing declining waterway health (Adelaide,[18] South East Queensland,[19] Melbourne[20]).

Least cost abatement is appropriate for use in an economic analysis when:

- the economic benefit of the environmental improvement achieved by abatement has been determined through appropriate analysis, and the least cost method of achieving the outcome is being explored;

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17 Point source polluters produce pollution from a single geographical source (such as a wastewater treatment plant). As such, the outcomes of regulatory attention (changes in pollutant load) is simpler to measure than with 'diffuse source' polluters such as the agricultural sector or urban areas producing stormwater runoff.

18 www.epa.sa.gov.au/xstd_files/Water/Report/pw_rights.pdf

19 eprints.usq.edu.au/4023/1/Alam_Rolfe_Donaghy_Publ_version.pdf

20 Melbourne Water is responsible for regional drainage, flood plain and waterway management and values nitrogen removal from Port Phillip Bay at $2,225/kg TN on average. www.melbournewater.com.au/content/library/planning_and_building/information_for_developers/Principles_for_Provision_of_Waterway_and_Drainage_Services_for_Urban_Growth.pdf

- a political decision has been made to achieve the outcome, and cost-effectiveness becomes the appropriate tool for assessment; or
- a regulatory decision has been made to achieve the outcome, and cost-effectiveness becomes the appropriate tool for assessment.

Notably, while the work referenced above explores the cost of abatement from wastewater treatment plants, it does not specifically explore the relative costs of achieving pollution abatement from recycled water (cost per unit of pollution abated by removing wastewater for recycled water use).

Further work would be required to adapt relative abatement costs to adjust for recycled water costs. They are also relatively site specific – adapting this work to a different geographical context would be highly problematic, as most if not all costs may require adjustment.

4.1.2 Economic valuation

Studies have been undertaken exploring community values for improved waterway health, or to avoid further decline.

Recent work in SEQ explored community preferences to avoid declining waterway health, and to improve waterway health from the current condition. A report from 2010 estimated community willingness to pay to avoid specific waterway health decline in SEQ at $290 per household per year. [21]

A further study found the following willingness to pay for different values among Brisbane residents found the following annual values per household for a one per cent improvement in:

- % in public parks and gardens that are green: $1.20
- % creeks and rivers that are healthy: $1.16
- water restrictions (from 1/50 years to 1/100 years): $2.84
- % of Moreton Bay that is healthy: $1.14.[22]

Some of these are best described as social values (irrigation of public open spaces and changed water restrictions), but lend themselves well to analysis of recycled water use. However, transferring the benefits to fit a feasible recycled water project remains a significant challenge.

Other related studies include:

- one of the few Australian studies that explored option value (in addition to existence and bequest values) found that Brisbane households were willing to pay $22.80/year to preserve 15% of water resources in the Fitzroy Basin to retain the option of using them in future;[23] and

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[21] MJA, 2010. Managing What Matters. SEQ Catchments. Accessed at: www.seqcatchments.com.au/managing-what-matters.html

[22] BCC & MJA, 2011. Case study: Integrated resource planning for urban water – Cabbage Tree Creek. Accessed at: www.nwc.gov.au/__data/assets/pdf_file/0019/10387/41_Cabbage_Tree_Case_Study.pdf

[23] Rolfe J and Windle J 2005, 'Valuing options for reserve water in the Fitzroy Basin', Australian Journal of Agriculture and Resource Economics, 49:91–114.

- a hedonic pricing study found that water quality has a significant impact on property values along the Chesapeake Bay, Maryland (USA).[24] This study found that an increase of 100 fecal coliform counts per hundred millilitres of water reduced property prices by 1.5%. The authors conclude that setting a county-wide standard of 200 counts per hundred millilitres would have benefits, measured in terms of increased property values, of up to US$12.1 million.

Again, the values described above relate to important environmental values associated with recycled water. However, the scenarios developed do not specifically relate to the use of recycled water.

4.2 Greenhouse gases

As noted in Section 2, water recycling is generally less energy intensive than desalination. As such, the relative greenhouse gas intensity of recycled water compared to desalination is sometimes considered an externality that should be separately accounted for in a business case.

However, as energy producers are subject to the Carbon Pricing Mechanism from 1 July 2012, relative energy intensity of different options will be internalised into the total costs of any project using energy from the National Energy Grid.

Effectively, carbon performance will henceforth be internalised within energy costs.

4.3 Other community preference valuations

Community preference valuation studies bring together environmental and social values within a 'willingness to pay' analysis. That is, using choice modelling or contingent valuation, they seek to quantify community preferences for outcomes that combine these environmental and social values.

One of the very few published studies estimating community values for recycled water relative to alternative sources was a Choice Modelling study undertaken in 1999 in the ACT.[25] This study found the willingness to pay for the provision of recycled water for outdoor use was $47 per household per year (relative to demand management and extra costs of $50 per household per year). Interestingly, willingness to pay for expanding from outdoor use to the provision of recycled water for all in-house uses was negative $55 per household per year, reflecting community preference to avoid drinking recycled water.

The same study found that moving from a brown landscape, to only 'some brown' was valued at $18 per household per year. This could be interpreted as a community value for public open space irrigation.

Improving environmental flows in some rivers (compared to none) was valued at $42 per household per year. Expanding this improvement to all rivers was valued at a further $22 per household per year. While not explicitly linking recycled water to achieving this environmental

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[24] Leggett, C., Bocksael, N., 2000, Evidence of the effects of water quality on residential land prices, Journal of Environmental Economics & Management, 39, pp. 121-144.

[25] Blamey, R., J. Gordon, and R. Chapman, 1999. 'Choice Modelling: Assessing the environmental values of water supply options', The Australian Journal of Agricultural and Resource Economics, 43:3, pp 337-357.

outcome, it is logical to envisage a scenario in which highly treated wastewater could be used to this end (as it is currently in Sydney).

4.4 Social valuation studies

environmental benefits. This is partly because it is sometimes very difficult to establish the marginal social impact of recycled water, and attribute a dollar value to it.

Social valuation studies include:

- estimates of public health benefits accruing from the irrigative use of recycled water on public open space (POS);
- estimates of the microclimate benefits of POS irrigation on cooling costs for surrounding areas; and
- estimates of the social costs of water restrictions to affected communities.

We discuss these in turn.

4.4.1 Health benefits of irrigated public open space

The links between physical activity and public health are becoming better understood and documented. A 2008 study reported that the costs of physical inactivity to the Australian economy totalled $13.8 billion annually, including over 16,000 premature deaths per year.[26]

A 2000 study ranked physical inactivity as the second biggest risk factor for overall disease burden in Australia, after tobacco (see Figure 4).

Physical activity can improve human health in two broad ways: physical and psychological health. Physical activity is beneficial in both preventative and therapeutic forms for cardiovascular disease, musculo-skeletal diseases, stroke and cancer,[27] and diabetes.[28] Although more difficult to measure, studies have also shown a link between mental health and physical activity, especially relating to depression which is estimated to affect about 10% of the Australian adult population in any given year.[29]

Australian survey data suggests that the proportion of the population undertaking the suggested 30 minutes of moderate physical activity per day reduced from 62% in 1997 to 57% in 2000.[30] ABS data from 2007-08 suggests around 60% of Australian adults do not undertake the suggested amount of exercise.[31]

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26 Medibank Private (2008) The Cost of Physical Inactivity: www.medibank.com.au/Client/Documents/Pdfs/The_Cost_Of_Physical_Inactivity_08.pdf

27 CJC Consulting. 2005. Economic Benefits of Accessible Green Spaces for Physical and Mental Health: Scoping Study. October 2005. Accessed online from: www.forestry.gov.uk/pdf/FChealth10-2final.pdf/$FILE/FChealth10-2final.pdf

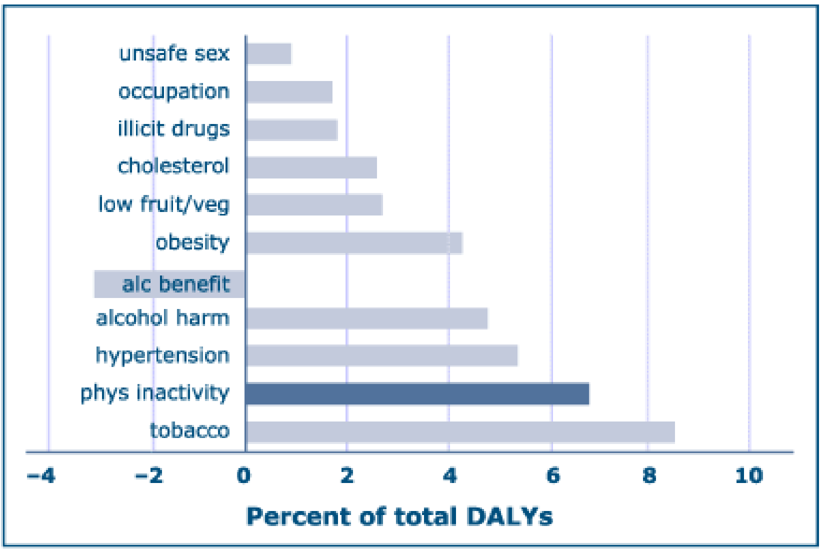
28 Bauman A, B. Bellew, P. Vita, W. Brown, N. Owen. 2002. Getting Australia active: towards better practice for the promotion of physical activity. National Public Health Partnership. Melbourne, Australia, March, 2002.

29 Murray, B. and Fortinberry, A. 2005. Depression Facts and Stats. Accessed online from: www.upliftprogram.com/depression_stats.html

30 Bauman et al, 2000.

31 www.abs.gov.au/ausstats/abs@.nsf/mediareleasesbyReleaseDate/E4A26CF152A501FCCA257905007AA615?OpenDocument

Figure 4: Proportional disease risk in Australia



Source: Bauman et al, 2000.[32]

The links between public open spaces and mental health are becoming better understood, but are nonetheless more difficult to establish clear data for. However, some facts are clear. Natural environments assist recovery from mental fatigue;[33] people prefer natural environments over urban ones, regardless of nationality or culture;[34] people are more positive in attitude and have higher life satisfaction when close to nature;[35] future health problems are likely to be dominated by stress-related illnesses, mental health problems, and cardiovascular disease;[36] exposure to natural environments such as POS assist recovery from all of these health conditions.[37]

Public open space is a major resource for physical activity, through organised sport, walking, running and cycling. In Australia, POS is the third most popular venue for physical activity, after streets and home. [38]

In addition to travel distance, qualitative factors were important to frequency of POS use, such as accessibility (absence of major roads), aesthetic features (trees, lakes, birdlife), maintenance,

32 A 'DALY' or 'Disability Adjusted Life Year' is defined by the World Health Organisation as the sum of the years of life lost due to premature mortality in the population and the years lost due to disability for incident cases of the health condition.

33 Kaplan, S. 1995. The Restorative Benefits of Nature: Toward an Integrative Framework. Journal of Environmental Psychology, 15, 169-182.

34 Herzog TR, Herbert EJ, Kaplan R and Crooks CL. 2000. Cultural and Developmental Comparisons of Landscape Perceptions and Preferences. Environment and Behavior, 32 (3), 323-337.

35 Kuo, FE. 2001. Coping With Poverty: Impacts of Environment and Attention in the Inner City. Environment & Behavior, 33, 5-34.

36 Commonwealth Department of Health and Aged Care & Australian Institute of Health and Welfare. 1999, National Health Priority Areas Report: Mental Health 1998 – A Report Focusing on Depression. Canberra.

37 Parsons, R. 1991. The Potential Influences of Environmental Perception on Human Health. Journal of Environmental Psychology, 11, 1-23.

38 Giles-Corti, B and Donovan, RJ. 2003. "Relative Influences of Individual, Social Environmental, and Physical Environmental Correlates of Walking", in the American Journal of Public Health, September 2003, Vol 93, No.9.

size, and infrastructure. A European study found that residents in high 'greenery' environments were 3.3 times more likely to undertake frequent physical exercise as those in the lowest greenery category.[39]

The marginal health value of recycled water irrigation

Attributing a quantified health value to public open space is a significant challenge. Geographical comparison of areas linking their physical activity rates to public open space provision is frustrated by qualitative differences between parks such as design differences, infrastructure and facilities provided, and even climatic differences (rainfall differs in East and West Melbourne, for example).

Also, correlation is not causation. There may be socio-economic or demographic differences between suburbs that account for differences in public open space use. Areas with better quality parks may also attract residents with stronger demand for those services.

The marginal value of irrigation is to improve the aesthetic appearance and functionality of public open space. Irrigation of sports fields, for example, improves the experience of active users and potentially reduces injuries. This also improves the reliability of sporting events – the surface is more likely to be usable regardless of weather conditions.

The marginal value of irrigating public open space with recycled water is that it can be used regardless of water restrictions, which typically occur during periods of drought. This could be very valuable during a ten year drought as recently experienced in much of Australia, but less so during a period of more normal rainfall when water restrictions are relaxed. During periods of higher rainfall, all public open spaces are green and outside of drought, water restrictions may not be material.

Many urban water utilities plan for water restrictions to occur no more than a certain frequency, such as once every twenty five years. In this context, the public health value of irrigation is the improved health outcomes achieved by avoiding restrictions for one year in twenty five. The actual impact on overall activity rates of having green public open space for an extra year in twenty five is open to question.

Higher values may be estimated if recycled water infrastructure was to be provided to an asset that would otherwise have no access to mains water.

It is also argued that irrigation can leverage other investments that further increase physical activity. While conceivable, those investments would need to be assessed on their own merits.

Box 3 illustrates the estimation of health benefits from POS irrigation, based on one recent quantification estimate.

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39 Ellaway A, Macintyre S, and Bonnefoy X. 2005. Graffiti, Greenery and Obesity in Adults: Secondary Analysis of European Cross Sectional Survey. Viewed online at http://bmj.bmjjournals.com/cgi/content/full/331/7517/611

Box 3: Scenario estimation of health impacts

An illustrative example of the health impacts of irrigation of public open space can be made using the following data, as referenced in an unpublished report prepared for the Victorian Department of Health. In addition to the uncertainties in the data, this example assumes that no additional maintenance would be required and therefore is likely to overstate the results.

Data provided in the study indicates that the cost per physically inactive person is $782 per person per year[40] and that the difference in physical activity rates between average and those with lowest access to attractive public open space is 1.8 per cent.[41] We also assume for this example that the impact of water restrictions is once every 25 years.

Based on these statistics, irrigating a park with recycled water could increase physical exercise levels by 1.8 per cent for the population accessing that park, valued at $782 per person. This prevention occurs every year if the park has no option of irrigation from mains water, or once every 25 years under restrictions if it has access to mains water.

Therefore, the health value of irrigation would be represented by 1.8% x catchment population x $782 pa x (1 / 25):

- for a catchment population of 1,000 people, this is an annual value of $14,000 without access to potable mains, and $563 with potable mains access; and
- for a catchment population of 10,000 people, this is an annual value of $141,000 without access to potable mains, and $5,630 with potable mains access.

While only illustrative, this quantification scenario contains a number of assumptions that are open to challenge. Firstly, the assumed allocation of national physical inactivity costs to that proportion of the Australian population who does not walk enough to justify good health may be unsupportable. Not only may many Australians undertake sufficient exercise by means other than walking, but the costs of physical inactivity may take an entirely different pattern than an average per capita.

Further, while irrigation can be expected to improve the attractiveness of a park, it is not clear that a lack of irrigation would inherently reduce a park's attractiveness from average to lowest during drought. Lastly, the critical link of irrigation to measurable increase in physical exercise is essentially unproven.

While the example is useful to illustrative the process required to determine the health value, the specific data used in the study is unlikely to be considered robust enough to form a core component of a business case.

4.4.2 Reducing Urban Heat Island (UHI)

The UHI effect occurs when urbanised areas experience higher temperatures than surrounding rural areas. UHI is caused by the increase in heat-retaining impervious surfaces that is associated with urbanisation. Human actions in urbanised areas (car use, heating, air-conditioning) also produce heat that is associated with the UHI effect.[42]

Green public open space is considered one way to reduce the UHI effect, and it may be considered that both increasing the area of green public open space, and increasing the irrigated area thereof, may assist. For example, one study found that increasing the area of public open space by ten percent of total land area could achieve reductions in air temperatures by 4 degrees

40 Population data from ABS. 17 per cent of Australian population undertakes sufficient walking to meet recommended levels for good health, with costs of physical inactivity shared among the remaining 83 per cent (Giles-Corti B,Donovan RJ. 2003. Relative Influence Of Individual, Social Environmental, And Physical Environmental Correlates Of Walking. Am J Public Health 2003; 93(9): 1583–1589).

41 Giles Corti et al, 2003. Assumes that during drought the attractiveness of an un-irrigated park reduces from average attractiveness to the lowest quartile of attractiveness.

42 Victorian Department of Health, 2010. Unpublished

Celsius.[43] Reducing extreme temperatures can reduce the financial costs of cooling buildings and the health impacts associated with extreme temperatures.

One of the key challenges in quantifying values for a change of this kind is that studies have typically explored the impact of green POS, not specifically the value of irrigation.

It is theoretically possible to estimate the avoided cooling costs that POS irrigation might produce, using the avoided cost method. This would require detailed data on the relationship between POS irrigation and surrounding peak temperatures.

However, MJA's review of literature in this space has not revealed any study which has created a defendable estimate of the dollar values of these changes.

4.4.3 Avoiding water restrictions

Clearly, water scarcity causing restrictions on outdoor water use imposes costs on households, especially those who enjoy gardening and value green spaces on their properties.

The willingness to pay by communities to avoid water restrictions has been explored within a number of studies, which have shown that communities value access to a relatively unrestricted water supply for indoor and outdoor use (a low level of 'sensible' restrictions, such as time of day, are generally considered acceptable):

- a study conducted in the ACT by Hensher et al (2006) found that water consumers were prepared to pay relatively little to avoid low levels of restriction, but up to $239 per year to avoid longer and/or more severe restrictions (e.g. total sprinkler bans lasting for the whole of summer);
- a choice modelling survey was conducted in the ACT by Gordon et al. (2001) found that residents were willing to pay an average of only $10 per year (in 1997 dollars) to prevent a 10 per cent reduction in water use ($0.52/kL);
- studies conducted in South East Queensland by Allen Consulting Group (2007) using a contingent valuation approach and DBM Consulting (2007) using a choice modelling approach found that consumers were willing to pay an average of $180 and $174 per year respectively to reduce Stage 4 water restrictions from 50% of the time to less than 1% of the time; and
- a study conducted in Perth by Tapsowan et al (2007) using choice experiments found that water users would be willing to pay $130 per year to finance a new source of supply instead of enduring severe water restrictions ($2.80/kL)

As described above, the literature on willingness to pay shows a diverse range of results. This diversity is likely to reflect the differences in specific questions asked in each study, study timing, and different attitudes and circumstances affecting respondents to each study.

Furthermore, these results are only a subset of the overall cost of water restrictions. While some studies also attempted to elicit a willingness to pay from business, the studies did not examine the flow-on impact of water restrictions on industries supported by garden irrigation (such as the turf and garden industry), including lost stock and reduced producer surpluses. Some of the studies also did not specifically address the amenity impact of reduced watering on public parks and gardens.

[43] S.E. Gill, J.F. Handley, A.R. Ennos And S. Pauleit (2007). Adapting Cities For Climate Change: The Role Of The Green Infrastructure. Built Environment Vol 33 NO 1 , P115 - 133.

Although these studies do not explicitly explore the value of achieving the reduction in water restrictions with recycled water, the value of avoiding water restrictions is a use value that could be achieved with a third pipe residential recycled water scheme. However, rather than extending across a community , this value would be retained by only those benefitting from a recycled water scheme, and may be affected by:

- perceived risk of using recycled water around the home, potentially reducing the value; and
- perception of the superior environmental performance of recycled water compared to avoiding water restrictions with other sources.

Benefit transfer with sensitivity to account for the above may be a suitable proposition for adapting these values to recycled water projects.

5. Implications for a practical framework

As shown in Section 0, there are relatively few recent and robust environmental and social valuation estimates that are of direct relevance to recycled water values in the Australian context. This points to the difficulties in developing a precise understanding of the relationship between recycled water and its associated biophysical and social impacts, and then rigorously quantifying the economic values of these.

The most detailed recent work undertaken relates to pollution abatement costs in a number of major centres, however while of relevance to recycled water, water recycling options have not been a specific component of this work. Nevertheless, this work could be adapted to a recycled water context.

Broader economic valuation of environmental and social values is limited to the costs of water restrictions, which could be adapted to recycled water, and one choice modelling study in the ACT from 1999 which specifically asked respondents about their water recycling preferences.[44]

While the health literature clearly points to an association between public health and access to public open space, the links between recycled water irrigation and public health outcomes have not been sufficiently made to allow defendable economic quantification.

Importantly, the dearth of robust work in this space also means that benefit transfer of existing studies to future business cases is difficult. With the possible exception of the 'cost of water restrictions' work (see Section 0), transferring defendable estimates from the studies described herein appears unlikely.

The valuation estimates undertaken in other modules within this study (hedonic pricing and choice modelling) may prove a more dependable source of estimates for benefit transfer, keeping in mind the challenges associated with this method (described in Section 0).

5.1 Suggestions for use of valuation estimates

As noted, robust economic valuation of environmental and social values associated with recycled water is technically demanding, potentially expensive, and must be underpinned by detailed data on the biophysical or other changes associated with a recycled water project.

MJA's review of literature in this space suggests that little rigorous work has been done to quantify environmental and social values of recycled water, and that this gap will not be easily filled (however, work in other modules of this study may be appropriate for benefit transfer).

In this context, we recommend the following in preparing a business case for a specific project:

1. explore the financial benefits and costs of a recycled water project to inform as to the order of magnitude size of environmental and social values required for the project to produce net benefits;
2. if a budget exists for further work, scope the potential for either benefit transfer or primary research into environmental and social values of recycled water; and

[44] MJA notes that a number of unpublished choice modelling studies have been undertaken by water businesses to explore the preferences of their own customers.

3. in the absence of a budget for further work, establish what the ‘threshold’ environmental and social benefits would need to be for the project to produce net benefits, and describe this potential in qualitative terms.

Within a regulatory setting, high levels of rigour can be expected for both primary research and benefit transfer of estimates.