Australian Government
National Water Commission

Externality pricing in the Australian water sector

Frontier Economics

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Waterlines

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Waterlines

This paper is part of a series of works commissioned by the National Water Commission on key water issues. This work has been undertaken by Frontier Economics on behalf of the National Water Commission.

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Foreword

The National Water Commission is pleased to release *Externality pricing in the Australian water sector*. This report is part of a suite of work undertaken by the Commission to support its keystone project, Urban water in Australia: future directions[1].

The Commission's report, *Urban water in Australia: future directions*, recommends that governments and regulators should recommit to using pricing to promote economic efficiency, broaden the coverage of fully-independent economic regulation across all urban water systems, and ensure more flexible economic regulation that encourages innovation in price and service offerings and better reflects the value of water.

This Waterlines report contributes to pricing policy development by examining the case for adopting pricing approaches for the efficient management of externalities within the urban water sector. It provides a valuable source of analysis for the parties to the National Water Initiative to deliver on their commitment to implement pricing that includes externalities where found to be feasible (para 73 iii).

This report suggests that in many cases, the necessary preconditions do not exist for effective use of price signals to manage externalities. The report provides a set of recommended actions to assess systematically the potential role of externality pricing. It also highlights the continuing effort required to develop mechanisms for measuring externalities so that they can be incorporated better into policy processes.

We welcome feedback and look forward to working with governments and other stakeholders to further advance water reform in Australia.

Chloe Munro

Chair, National Water Commission

April 2011

[1] This project includes the flagship report *Review of pricing reform in the Australian water sector* and three Waterlines reports: *Efficient water resource pricing in Australia: an assessment of administered scarcity pricing in urban areas, Externality pricing in the Australian water sector* and *Competition in the Australian urban water sector.*

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Abbreviations and acronyms

COAG	Council of Australian Governments
Commission/NWC	National Water Commission
ERA	Economic Regulation Authority
IWM	integrated water management
NWI	National Water Initiative
LRMC	long-run marginal cost
WSUD	water sensitive urban design

Executive summary

Externality pricing has been identified as a potential policy instrument to improve the management of urban water, and its investigation is encouraged in the National Water Initiative (NWI). However progress in implementing externality pricing across Australia has been limited.

Frontier Economics was engaged by the National Water Commission (the Commission) to examine the feasibility of *externality pricing* in the urban water cycle as part of a broader review of water pricing reform. Frontier's approach to the task involved the development of a policy framework to guide consideration of the main issues and high-level application of this framework to externalities at various points in the urban water cycle.

The framework helps to identify and define positive and negative externalities throughout the urban water cycle. In simple terms, externalities exist when the decisions made by particular individuals or firms do not factor in the benefits and costs imposed on other parties, including the environment. From society's perspective, the presence of externalities can lead to people undertaking too much or too little of an activity.

Based on recognised policy principles, the framework shows that the presence of externalities may warrant government intervention to improve welfare outcomes for society by better aligning marginal social costs and benefits. Pricing is one of many options for addressing externalities. In theory, its key advantage is that it can be a more flexible and cost-effective means of meeting overall environmental objectives compared with prescriptive 'one size fits all' regulations.

In all cases, governments should first clearly define the nature and extent of the externality and determine which public body or group has effective management control over, or accountability for, the externality. The responsible party should consider a range of policy options to address it (including pricing and doing nothing), assess the benefits and costs of each policy option, and adopt the approach that generates the greatest net benefit for the community (see COAG, 2007).

In most cases, externalities associated with the urban water cycle are already being managed through non-price means. Jurisdictions have generally adopted an approach based on regulation, planning and property rights[2] (entitlements), with the costs of water planning and management passed on to users in a limited number of cases. We consider whether pricing forms a better alternative than current approaches, and whether improved outcomes might be achieved by augmenting current approaches with externality pricing. In our view, there have been significant improvements in the management of some externalities in urban water during the past decade and this limits the circumstances under which additional externality pricing, or changes to externality pricing, is likely to be worthwhile.

There is a broader debate about whether current arrangements are optimal. In many cases, this is not about the choice of policy instrument (i.e. pricing versus regulation) but the optimal level of intervention (e.g. the right limits on the quality of effluent or the right share of water entitlements assigned to the environment).

Demonstrating that intervention to manage externalities is optimal is extremely difficult due to technical and economic challenges in measuring, attributing and valuing the impact of an activity on third parties and the environment. These difficulties affect all approaches to

[2] The use of the term 'property rights' in this report is in the economic sense, rather than the legal sense of property which economists may refer to as private property.

managing externalities and are particularly evident in relation to efforts to assess the externality benefits of integrated water management (IWM) options. By its very nature, pricing externalities may be particularly prone to contested views on the appropriate level of intervention.

Care is also needed in the selection and application of policy instruments for managing externalities. In particular, it is important that externality pricing not be overlayed on top of an existing regulatory mechanism used to address the same issue. Duplicating policy instruments can lead to efficiency losses.

In this context, changing tack in the management of externalities by adopting externality pricing options needs to be considered carefully, on a case-by-case basis. If the main issues relate to determining the appropriate level of intervention, then technical and economic research and community engagement is required. In most cases, governments should first consider the merits of improving the current instruments, and ensure the full efficient costs of water planning and management are recovered from users.

Externality pricing is likely to be most feasible where:

- there are material externalities in the urban water cycle
- there are significant differences in the costs of addressing the externality across different parties and existing mechanisms are inflexible
- changes in price are likely to change behaviour or encourage innovation
- the activity can be measured and monitored accurately and cost-effectively.

Our analysis shows that in many cases, these conditions do not hold, such as in relation to the management of externalities associated with diffuse sources of stormwater run-off and pollution. In other cases, existing arrangements obviate the need for further externality pricing. For example, where quantity-based property rights exist, attempting to use pricing to manage the impacts of water extraction is likely to be confusing and ineffective. In limited circumstances, externality pricing may augment current approaches, such as in managing wastewater discharges to the environment.

Our analysis also indicates that efforts to achieve an optimal balance between consumptive and non-consumptive use are likely best achieved through improved entitlement specification and market transactions in existing rights. Adding an externality charge to the existing property right after it has been assigned is more akin to a resource rent. The main effect of this, in systems with entitlements in place, would simply be a transfer from urban water users to the government. Efficient and sustainable price signals can be sent to customers by ensuring that the volumetric price signal reflects the full environmental opportunity cost of future system augmentations.

An overarching theme is the difficulty in assessing the true value of any externalities, which is the primary barrier to implementing regulatory and/or pricing mechanisms that ensure the optimal level of externality. Overall, however, current arrangements appear to operate reasonably effectively to mitigate known negative externalities related to the urban water cycle, while information on positive externalities is so sparse that only limited conclusions can be drawn on whether these are adequately encouraged or not.

The framework developed in this report and the high-level applications provides a means of sensibly progressing the debate about externality pricing, but is also relevant to the management of externalities in the urban water cycle more generally.

Often in the urban water sector, accountability and management lies with bodies outside of central government agencies such as water businesses and local government. A key

consideration in the management of externalities is identifying which entity is accountable for a specific aspect of the urban water cycle and whether there is a role for governments in managing a specific problem. Governments may not always be the best party to manage and be directly accountable for externalities. Governments therefore need to consider and determine which entity or organisations are best placed to manage and decide on the tools and instruments needed to effectively manage urban water externalities.

It is recommended that all jurisdictions:

- determine the source and materiality of urban water externalities of concern to the community
- determine which party has management accountability and which is best placed to manage the specific externalities of concern
- assess the effectiveness of the current approach to managing these externalities
- assess the potential to improve the current approach or adopt alternatives, including externality pricing
- clarify the preferred approach to managing urban water externalities – by reporting to the Council of Australian Governments (COAG)
- ensure arrangements are in place for recovering the efficient costs of water planning and management in accordance with the 2010 NWI pricing principles
- clarify the policy objectives and means of funding IWM projects that produce positive externality benefits
- periodically monitor, evaluate and publicly report on the outcomes and effectiveness of current approaches to managing externalities.

Nationally, there is a major need to improve the technical and economic evaluation of urban water externalities to enable policymakers to make informed decisions about their optimal management. This requires efforts to better link urban water activities to measureable and attributable effects and evaluating these effects in economic terms, where possible. In this regard, the Commission may be well placed to collate, synthesise and disseminate the findings of existing projects and research around Australia.

1. Introduction

Frontier Economics was engaged by the National Water Commission (the Commission) to examine the feasibility of externality pricing in the urban water cycle as part of a broader review of water pricing reform (NWC 2011) and in conjunction with a companion report on administered scarcity pricing (Frontier Economics 2011).

1.1 Externality pricing and the National Water Initiative

Under the National Water Initiative (NWI), the intergovernmental agreement signed in 2004 to drive national water reform, Australian governments have agreed to pursue the development of 'a nationally-compatible, market, regulatory and planning based system of managing surface and groundwater resources for rural and urban use that optimises economic, social and environmental outcomes'.

In Paragraph 73 of the NWI, the parties have agreed to:

1. continue to manage environmental externalities through a range of regulatory measures (such as through setting extraction limits in water management plans and by specifying the conditions for the use of water in water use licences)

2. continue to examine the feasibility of using market-based mechanisms such as pricing to account for positive and negative environmental externalities associated with water use

3. implement pricing that includes externalities where found to be feasible

In its 2009 biennial assessment, the Commission found that 'some States have implemented or investigated the use of pricing and market-based instruments to address environmental externalities', but also noted 'all States have further work to do to explore the feasibility of such actions'. The Commission recommended that 'NWI parties renew collective and individual efforts to respond to the NWI clause 73 given that well-designed externality pricing can be a powerful and enduring way of dealing with the environmental impacts of water provision and use' (NWC, 2009, p. 186).

The 2008 COAG urban water reform agenda identified externality pricing as one of a range of priorities for further work.

1.2 Purpose and scope of work

This study aims to support efforts by jurisdictions in relation to their commitments under Paragraph 73 of the NWI by examining the feasibility of externality pricing in the urban water sector.

The Commission's scope of work for the task consists of:

- identifying, defining and categorising externalities associated with urban water use (including wastewater, recycled water, stormwater, groundwater)
- identifying and describing different types of externality pricing, and the benefits that they may produce (including recent examples)

- considering the costs, benefits and implementation arrangements for various affected stakeholders (e.g. water businesses, government, regulators, customers and the community)
- identifying the barriers and constraints to efficient externality pricing
- providing recommendations on the suitability of externality pricing and the conditions under which it may be appropriate.

1.3 Approach

There is a range of potential externalities associated with activities in the urban water cycle. Their materiality and the extent to which they are managed effectively by other policy measures vary significantly. A full evaluation of their magnitude, and the effectiveness of current policy tools, is beyond the scope of this study. As such, a definitive assessment of the feasibility of the myriad associated externality pricing options in all urban water systems is also not possible within the scope of this study.

Instead, this study's chosen approach involved developing a framework for externality pricing (Section 2) that steps through the key issues requiring consideration. This framework could be applied by jurisdictions, urban water businesses or other stakeholders to consider the case for any particular externality pricing option.

Importantly, the framework considers externality pricing within the contemporary and evolving urban water policy context, which has been influenced in recent years by:

- further development of other non-pricing instruments for managing the urban water sector's environmental impacts
- policy and regulatory changes for the recovery of costs associated with water planning and management activities in some jurisdictions
- the emergence of integrated water management (IWM) and concepts for developing more water sensitive or liveable cities.

The framework is then applied to a number of broad types of externality pricing options at particular points in the urban water cycle (Section 3). This illustrates how the framework might be further applied in practice and provides a general guide to the feasibility of these options by identifying key factors influencing the relative merits of externality pricing. Based on this analysis, Frontier has provided general conclusions and recommendations on the feasibility of externality pricing in urban water (Section 4).

2. Framework for considering externality pricing options

2.1 Policy principles for managing externalities

Externalities refer to situations when the production or consumption of goods and services impose costs or benefits on others that are not reflected in the prices charged for these goods and services. An externality may be positive or negative. In simple terms, externalities exist when particular individuals or firms make decisions that do not factor in the benefits and costs imposed on other parties, including the environment. From society's perspective, the presence of externalities can lead to people undertaking too much or too little of an activity. In economic terms, externalities are a type of market failure that can reduce overall social welfare[3].

The presence of externalities may warrant government intervention to improve welfare outcomes for society. However, consistent with good policy and regulatory principles, governments should clearly define the nature and extent of the externality problem, consider a range of policy options to address it, assess the benefits and costs of each policy option, and adopt the option or instrument that generates the greatest net benefit for the community (see COAG, 2007).

The options considered should include the possibility of doing nothing because the costs of intervening may be higher than the benefits. In some cases, individuals will have sufficient private incentive to undertake investments that have wider public benefits without government intervention. For example, well-kept private gardens provide wider amenity benefits to neighbourhood residents but households have sufficient private incentives to invest in and maintain their gardens without government funding.

The costs of policy intervention, including unintended impacts, need to be considered. In many cases, the cost of designing, implementing and ensuring compliance with an intervention might be far greater than the benefits obtained. In such cases, intervention is not justified on economic grounds.

Critically, the policy goal should not be to eliminate externalities altogether, as this is often prohibitively costly. Economic principles suggest aiming for optimal levels of externalities, where the marginal benefits of additional intervention at least equal the marginal costs imposed by the externality.

In many cases, other instruments are already in place to manage externalities. For example, defining and assigning property rights over a resource is one approach to addressing externalities. Similarly, a regulatory obligation that requires a water business to offset its greenhouse gas emissions by purchasing greenhouse credits would mean the water business would incur a financial cost when its emissions increased.

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[3] In this paper, we discuss what are known as technological externalities. Another type of externality is a pecuniary externality. As noted by Holcombe and Sobel (2001), 'pecuniary externalities create third-party effects through changes in relative prices or asset prices. Unlike technological externalities, they do not misallocate resources and are necessary for the market to work efficiently'. For example, when irrigators purchase water entitlements in the water market they may increase the market prices faced by other irrigators. However, this increase in price is necessary to signal the value of water in its highest-value uses.

The Productivity Commission (2006) demonstrates that various policy mechanisms to deal with externalities have advantages and disadvantages and that choosing the most appropriate policy response is often context-specific. In some cases, multiple instruments may be appropriate. Key questions for this study are whether pricing is a better alternative than current approaches, and whether improved outcomes might be achieved by augmenting current approaches with externality pricing.

The remainder of this framework explores these concepts in more detail. In particular, it:

- identifies and describes externalities in the urban water sector
- describes the features of externality pricing as a tool to generate improved outcomes
- examines some of the technical issues associated with managing externalities
- provides a comparison of pricing and other policy instruments.

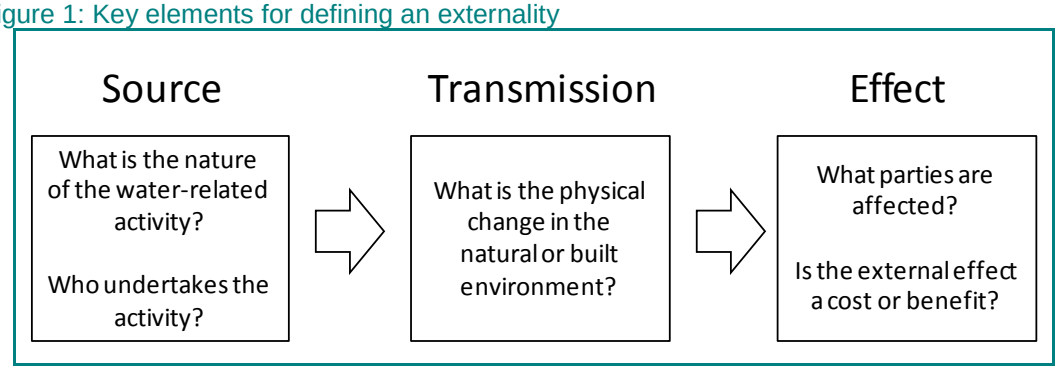
This framework, and its applications examined in Section 3, aim to provide a sense of the different approaches to externality pricing, what might work in different situations, and the pros and cons of different approaches.

2.2 Identifying and defining externalities in urban water

In its detailed consideration of rural water externalities, the Productivity Commission (2006) identified three key features necessary to define a water-related externality (Figure 1). This approach applies equally well to the urban water sector:

- ***Source: the nature of the water-related activity and agent who undertakes the activity***: For example, sources of urban water externalities include the numerous activities of water businesses, customers, individuals and firms at various stages of the urban water cycle, including extraction of water, use of water, transportation and discharge of water and wastewater.
- ***Transmission: the physical change in the natural or built environment that results from the activity.*** These activities result in biophysical changes in the built or natural environment such as changes in waterway flow regimes, groundwater levels, water quality in surface and groundwater systems, infrastructure condition, the terrestrial landscape, and the atmosphere (e.g. greenhouse gas emissions, noise and odour).
- ***Effect: the parties affected and the nature of the external effects (i.e. the costs or benefits).*** The effects are the resultant changes in the economic, social and/or environmental values held by parties such as other water users, water industry employees, and the broader community. The effects might be associated with public health, recreational opportunities along waterways, the value people place on biodiversity and terrestrial and aquatic habitats, enjoyment of urban parks and gardens, and agricultural production. In economic terms, the value of these effects is defined by the 'marginal willingness to pay' of affected parties.

Figure 1: Key elements for defining an externality



Source: Based on Productivity Commission, 2006.

Using this framework, we identify a number of different types of positive and negative externalities related to the urban water cycle (see Table 3 in Appendix A). There are externalities associated with a range of activities including:

- water extraction from rivers and aquifers – e.g. this activity can change the flow regime of the river and its ecosystem health
- water-related infrastructure development and operation – e.g. this activity can create noise and dust that affects local residents
- transmission and distribution of water, wastewater and stormwater – e.g. this activity can involve water pumping which results in greenhouse gas emissions that contribute to climate change
- water use and reuse – e.g. application of water to land may result in runoff that has impacts on neighbouring properties
- water and wastewater treatment – e.g. this activity can involve energy use which results in greenhouse gas emissions
- wastewater disposal – e.g. this activity can result in impacts on the health of the receiving waterway
- other activities affecting water quality and quantity (e.g. land management practices, diffuse sources of urban pollution to waterways via stormwater).

Traditionally, the water sector managed water, wastewater and stormwater separately as a means to mitigate the potential health and environmental impacts of untreated water and effluent. However, the sector is undergoing change as a result of improved treatment technology that allows for the integrated management of water from all sources and the provision of fit-for-purpose water quality. An important motivator for this study is to understand the role externality pricing can play in promoting efficient investment in integrated water management (IWM). In many cases, the broader range of IWM options can contribute to a range of environmental, social and economic values not typically considered by the water sector. These include impacts on urban amenity, greenhouse gas emissions, waterway health, recreational opportunities and public health both positively and negatively (see Centre for Water Sensitive Cities, 2011). In many cases, the full benefits and costs of IWM solutions are not captured by customers or adequately reflected in the decisions made by water businesses.

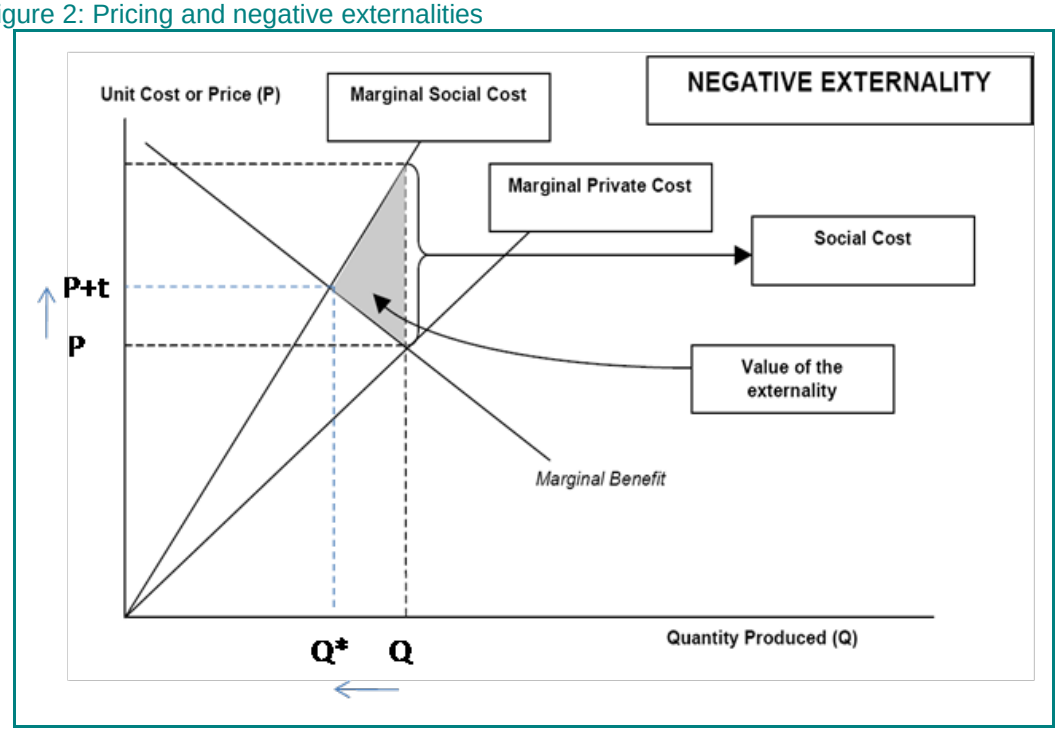
2.3 The in-principle benefits of externality pricing

The current approach to addressing externalities in the urban water sector is predominantly through the use of planning, regulation and direct intervention by governments. For example, wastewater effluent discharges are managed by regulatory instruments including trade waste agreements. Externalities related to altered river flows from water extraction for consumptive use are largely managed by defining property rights in the form of water access entitlements.

There has been increased interest in the potential for using pricing to discourage urban water activities with externality costs and to encourage activities with externality benefits. This may reflect actual or perceived inadequacies associated with current pricing, planning and regulatory approaches.

The core idea of externality pricing is to provide a price signal that aligns the marginal private cost (benefit) of a water-related activity with the marginal social costs (benefits). The figure below illustrates how an externality charge increases efficiency (or overall social welfare). In the example, the marginal social cost of the activity is higher than the marginal private cost due to the negative externality, so too much of the activity is undertaken (Q-Q*). The welfare cost is represented as the shaded area. An example would be a firm using water that discharges wastewater effluent without any means of accounting for the effect of the discharge on the health of the receiving waterway. By imposing an additional charge on wastewater discharge (t), the impactor (i.e. the firm) has an incentive to reduce its discharge to a point (Q*) where overall social benefits are maximised.

Figure 2: Pricing and negative externalities



Source: Institute of Sustainable Futures, 2007

The key advantage of a pricing-based instrument (over regulatory instruments) is that it encourages action in a flexible and lower-cost manner. For example, if an individual or firm can reduce pollution on-site at a cost below the externality price, then there is an incentive for them to do so. If they cannot reduce pollution below the set price (either permanently or temporarily), then they can simply pay the charge.

In some cases, regulation may be effective but overly prescriptive, thus increasing the overall cost of environmental management. For example, the costs of meeting a uniform regulated level of pollution vary from firm to firm. A more flexible price-based signal can be a more cost-effective means of meeting overall environmental objectives compared with prescriptive 'one size fits all' regulations.

In other cases, regulation may be necessary and appropriate. For example, if there are minimum standards that all individuals/firms must attain to protect human health and the environment (e.g. management of highly toxic wastes), then regulation is appropriate. However, there is also the potential for current regulation to target minimum standards, rather than aim for socially optimal levels of externalities.

Overall, externality pricing is a relatively flexible mechanism that could result in more socially optimal outcomes in the urban water sector. However, when considering the role of additional externality pricing, we need to compare current and other potential alternative mechanisms that can achieve the same objectives.

2.4 Technical challenges in managing externalities

Figure 2 highlights the fact that managing externalities in an optimal manner requires the ability to estimate the marginal social cost function and equate this with the marginal benefit. In practice, this is extremely difficult due to measurement, monitoring, attribution and evaluation issues.

Measuring the magnitude of the effect of an externality first requires attributing effects to biophysical changes (i.e. transmission) and linking transmission to the source activity. In practice, there are often a number of technical challenges in linking the source activity to a biophysical change, particularly when a number of contributing factors are involved. For example, water extraction through a pipeline connected to a river (the source activity) will have an impact on the flow regime downstream of the point of extraction (transmission). However other factors such as drought, other points of extraction, and interception activities will also influence the downstream flow regime. The effect of the externality associated with extraction from the pipeline on downstream river health, water quality and recreational opportunities can then become very difficult to differentiate from other factors. Therefore, managing any externality requires a good understanding of the causal pathways from source to effect, including the relative contribution of various factors to measured outcomes.

Similarly, it is often very difficult to measure and value the effects of particular externalities in economic terms. In a submission to a review of national competition arrangements in 2004, industry body the Water Services Association of Australia (WSAA, 2004) noted:

> *The only outstanding issue associated with the previous negotiated NCP reform package for urban water relates to the inclusion of externalities in water pricing. This omission is not due to negligence or unwillingness to act, on the part of the industry but, rather, to the uncertainties surrounding the identification and valuation of the environmental externalities associated with the urban water cycle.*

By their nature, the effects of most externalities are often not valued in monetary terms in a functioning market. However, in economic terms, value relates to what people are willing pay for an outcome, even if they do not actually have to pay or are unable to do so. For example, people do not normally have to pay for the amenity benefits of an urban lake. To assess the impact of an externality, and how this might be valued and therefore priced, a number of non-market economic valuation techniques can be used. Such techniques can indicate the size of any potential problems, although they are subject to uncertainty, and further technical challenges.

Figure 3 presents the range of factors that characterise externalities and which influence the ability of governments to manage them in an optimal manner. For example:

- lack of observability and measurement of water use activities (e.g. metering) can limit the feasibility and scope of certain externality pricing options and cost recovery options (e.g. load-based charging)
- spatial and temporal variability in the effects of externalities (e.g. effects of nitrogen on waterway health) means that the benefit of pricing specific external effects (e.g. from nitrogen loads) will vary on a case-by-case basis
- lack of knowledge and uncertainty about the real value of externalities make it difficult to use such values for pricing or funding purposes.

Figure 3: Characteristics of externalities that influence their management

Characteristic	*Source*	*Transmission*	*Effects*
Observability and measurement	Can the sources be identified? Can the activities of each source be observed? Do activities other than irrigation supply and use result in the environmental change?	Can the environmental changes caused by each source be observed and measured?	Can those who are affected be identified? Can the effects be observed and measured?
Spatial variation	Where are the source(s) located? Are they geographically diffuse? Do many sources contribute to the same effect?	Are the source(s) and effect(s) in a different location? Do the relationships between sources and effects change with location?	Where are the effects located? Are they geographically diffuse? Are many effects attributable to an individual source?
Temporal variation	To what extent do past activities have current (or future) effects? Are activities affected by the natural variability of ecosystems and ecosystem processes?	Are there time lags between source and effect? Are the lags at different temporal scales? Are relationships between sources and effects affected by natural variability?	Can effects be apportioned between past and ongoing activities? Are effects influenced by natural variability?
Knowledge and uncertainty about processes	What is the nature of the relationships between sources and effects — for example, linear, increasing, decreasing, with threshold effects? Are the changes reversible or do they display hysteresis (whereby the nature of the relationship between two variables depends on whether the variables are increasing or decreasing)? Is there uncertainty about the relationship between (observable) activities and changes to environmental conditions? Is there uncertainty about the relation between changes to environmental conditions and effects?		

Source: Dwyer et al. 2006.

Overall, these issues create a major challenge in managing externalities at the socially optimal level. In many cases, it is these challenges that lead to debate about the adequacy of current management approaches.

In relation to externality pricing, these difficulties manifest themselves in the challenge of getting the externality price signal correct, or at least reasonably accurate. If the externality price is too low or too high, socially optimal outcomes will not be achieved. On the one hand, an advantage of externality pricing may be its ability to 'move in the right direction'. Externality prices can also be altered as consumer behaviour in response to initial externality charges is observed. On the other hand, pricing externalities is likely to require a reasonably strong degree of transparency and credibility to be accepted by those affected by the charges, whereas those producing externalities may be more amenable to accepting uniform regulations.

2.5 Comparison of pricing and other instruments

2.5.1 Evolution in other policy instruments used in the urban water sector

Governments currently use a range of instruments to address externalities related to the urban water sector, such as:

- planning and regulation (e.g. discharge licences and recycling targets)
- property rights that internalise externalities by defining ownership (e.g. tradeable quantity-based mechanisms, environmental entitlements)
- education, information provision, moral suasion
- direct action by government (e.g. engineering solutions)
- grants or rebates for direct action.

These instruments can target the person undertaking the activity (source), the affected parties (effect), or the third party able to influence the environmental change (transmission) such as a catchment manager.

In the years leading up to the creation of the NWI (and particularly before the COAG 1994 Water Reform Framework), arrangements for managing urban water externalities were in a relatively early stage of development. For example, there were fewer formal allocations of water to the environment, and the urban water industry was adjusting its management practices to address emerging water quality issues in urban waterways due to urban growth and industrial wastewater.

During the past decade, the management of urban water externalities has improved significantly. For example, many states and territories have developed water planning and property rights approaches (i.e. defining water access entitlements) to balance consumptive and environmental water needs. There has also been a strengthening of environmental regulation, which has led to investments to mitigate the negative effects of water supply, use and disposal (e.g. upgrades of treatment plants).

Currently, there are now arguably fewer urban water externalities that are not addressed in some way by regulations, property rights or other policies.

In many cases, it can also be argued that externalities can be adequately managed by adopting other standard NWI pricing reforms (full cost recovery, tariffs for service provision that reflect the costs of their provision, recovery of the costs of water planning and management, and independent economic regulation) combined with effective regulation and management of externalities through other means (e.g. licensing, water access entitlements).

Through consultation undertaken for this study it is clear that jurisdictions are generally attempting to move towards better pricing and regulation, although progress in some areas is either slow or insufficient (see NWC, 2011). However, there may also be cases where there are gaps or weaknesses in the current approaches (see NWC, 2011). It is important to consider whether externality pricing is an improvement on the existing instruments; and whether those existing instruments would perform better if they were amended, or if externality pricing was applied in addition to them.

2.5.2 Differences between externality pricing and full cost recovery for water planning and management

The NWI and 1994 COAG Water Reform Framework largely conceptualise externality pricing as a component of full cost recovery. This focus on cost recovery is illustrated by the 1998 COAG Pricing Principles, which define externality charges as 'environmental and natural resource management costs attributable to and incurred by the water business'.[4] In this context, the components of full cost recovery include:

- operating, maintenance and administrative costs
- capital costs (provision for the cost of capital consumption and cost of capital)
- costs of managing environmental (negative) externalities through water planning and management activities.

In 2007, however, the NWI Steering Group on Water Charges' *Stocktake of water planning and management charges* made a clear distinction between charges to recover the cost of water planning and management and externality charges. It noted that charging for externalities encompasses activities that seek to internalise the impact (cost or benefit) of the externality to the party causing it (e.g. by imposing a specific charge or tax) rather than simply recovering the costs of managing the impact from relevant parties.

It is important to recognise this difference between cost recovery and externality pricing. However, there is also potential for improved pricing and recovery of efficient costs of water planning and management activities to form an alternative to externality pricing. This is because, in practice, the distinction between charges that internalise externalities and charges that recover costs can become blurred. For example, some water planning and management charges may provide water users with an incentive to undertake less of an activity that results in negative external effects. However, because these charges are typically based on average costs rather than marginal costs, they may provide blunter signals for efficiency than an externality price set at marginal cost.

In principle, current national water reform commitments for full cost recovery and efficient tariffs will be most effective in the management of externalities where the following conditions hold:

- the full costs of compliance with environmental obligations are recovered from impactors based on the need for those costs to be incurred
- environmental regulations are aligned with the community's values (and willingness to pay)
- direct expenditure by government-owned monopoly water businesses is efficient (and subject to independent economic regulation)
- where feasible, tariffs are differentiated to reflect key cost drivers in meeting environmental objectives (e.g. load-based charges for different trade waste pollutants).

Conversely, lack of transparent processes for recovering the cost of water planning and management activities dilute signals to water users about the planning and management costs of their water-using activities and undermine incentives for efficient use of related government resources. In that regard, progress in achieving cost recovery of water planning

[4] To help implement the water reforms, in 1998 the former Agricultural and Resource Management Council of Australia and New Zealand (ARMCANZ) endorsed guidelines for water pricing, including that water businesses should recover, among other costs, the costs of managing externalities (PC 2006).

and management across Australia has generally been slow. In 2009, for example, the Commission found progress in meeting NWI commitments for cost recovery for water planning and management for both surface and groundwater had been very limited (NWC, 2009).

2.5.3 Price versus quantity-based market mechanisms

Other market mechanisms to address externalities include quantity instruments (such as tradable discharge permits or environmental offsets) which restrict certain activities (e.g. nutrient discharges) to an environmentally sustainable level, but allow individuals to bid for available rights to undertake the activity (e.g. discharge rights, water access entitlements). The result of this bidding is a market price that provides signals to water users on the costs of meeting the desired environmental standards.

A comparative disadvantage of a pricing-based approach is that uncertainty may exist in relation to the overall level of pollution that may result, as compared with a market-based mechanism (e.g. a cap and trade system) which sets a quantity limit and allows the market to determine the price (see further discussion below). However, the appropriateness of pricing versus quantity-based tradeable permits will depend on a range of considerations. Table 1 summarises the relevant issues to consider. It is noted that it would be confusing and inappropriate to attempt to manage externalities with a price and quantity mechanism at the same time.

Table 1: Pricing versus quantity instruments for a negative externality

Issue	***Price/taxes***	***Quantity***
Certainty over outcomes	Use when certainty over cost of abatement is more important	Use when certainty over amount of abatement is more important
Costs from overestimating abatement costs	Leads to more than optimal abatement Less costly when: • marginal cost of abatement rises steeply • marginal benefits of abatement diminish slowly.	Leads to less than optimal abatement Less costly when: • marginal cost of abatement rises slowly • marginal benefits of abatement diminish rapidly.
Threshold effects	Lack of certainty over outcomes means significant risks should be managed through other instruments.	Use where there might be environmental thresholds with significant/irreversible damages

Source: Dwyer et al. 2006; Whitten et al. 2007.

2.6 Conclusions

In principle, externality pricing is likely to be most feasible in situations where:

- there are material externalities in the urban water cycle
- there are significant differences in the costs of addressing the externality across different parties and existing management mechanisms are inflexible

- changes in price are likely to change behaviour or encourage innovation
- the activity can be measured and monitored accurately and cost-effectively.

In most cases, policy tools are already in place to manage externalities in the urban water cycle. Pricing could be investigated as a means to either replace or augment existing tools. However, in many cases, using pricing to augment existing approaches may not provide any additional benefits for managing the externality.

It is also important to consider the potential to improve existing tools rather than replacing them with pricing. In particular, there are numerous measurement, monitoring, attribution and valuation challenges associated with the optimal management of externalities using any means of intervention. Therefore, it is important to consider whether management effort needs to be focused on the choice of instrument (e.g. pricing, regulation, property rights) or on efforts to determine the optimal level of externalities.

3 High-level assessment of externality pricing options

3.1 Introduction

This section uses the framework developed in Section 2 to assess the feasibility of potential externality pricing options in the urban water cycle. The general questions used to guide the assessment of externality pricing options for each type of externality are:

- What is the externality and how important is it?
- What is the current approach to managing the externality and is it effective and efficient?
- What are the externality pricing options?
- What are the costs, benefits and implementation issues associated with externality pricing?
- What are the overall conclusions and recommendations on the merits of externality pricing?

Based on our consideration of the relevant literature, and our understanding of externality issues in the urban water sector, Frontier has identified the following five stages of the urban water cycle where the further application of externality pricing is considered:

- water source development and extraction of water from surface and groundwater resources
- the disposal of wastewater to the sewerage system
- point source discharges of wastewater to waterways
- discharges of stormwater to the environment
- integrated water management (IWM) projects.

The first four topics focus on negative externalities in key areas of urban water management, while the final topic addresses the potential for pricing to encourage the production of positive externalities in a cost-effective manner.

As stated in Section 1.3, there many different externalities in each of these areas of the water cycle. It is beyond the scope of this study to cover all of them in detail. As such, the assessment is of a high-level nature, and there is merit in jurisdictions and water businesses undertaking further detailed exploration in some cases.

3.2 Water source development and extraction

Pricing to recognise the impacts of water extraction for potable water use on environmental and other third-party outcomes can occur at a number of levels:

- charging to reflect the environmental impacts of marginal extraction decisions – discussed in this section
- charging to reflect the environmental costs incurred at the time of resource development to provide the water available for use – discussed in this section

- charging to reflect the ongoing costs of managing the water resource for potable water use and environmental use – this is not discussed further (see Section 2.5.2 on water planning and management charges)
- charging to reflect the impacts on other water users of water use/extraction decisions where water users share access to a common pool of water – scarcity pricing is not discussed further in this report, but is considered in detail in Frontier Economics (2011).

3.2.1 What are the externalities and how important are they?

There are negative environmental impacts related to the development of new supply sources and the extraction of water from existing sources (see Appendix A).

Developing and allowing extraction of a water resource generally results in negative impacts on environmental outcomes, as well as benefits to consumptive users. The development of a resource and assigning water rights to extractive users where that water would have otherwise remained available to environmental use is a key decision that has significant environmental consequences.

Some of the negative impacts associated with existing sources do not change with the volume of water currently extracted (i.e. dams constrain fish passage as soon as they are built), while others may vary with the volume of water extracted. Where changes in extraction result in changes in environmental flows they can have significant adverse effects on river or groundwater health (e.g. water quality, habitat) and related ecosystems and their functioning (e.g. biodiversity), which can in turn reduce people's enjoyment of the natural environment (e.g. recreation, environmental values) or the downstream productivity of fisheries and agriculture.

However, an important point discussed in further detail below is that many of these negative impacts of extraction are not incremental *externalities* beyond those already accounted for in the initial decision to set the level of extraction rights and assign these to various parties. Once decisions have been made to allocate NWI-compliant water access entitlements, the impacts of decisions on how much water to extract at any point in time will generally be fully borne by the holder of that entitlement, with no effect on the water available for others (including the environment). For example, if in a particular year an urban water authority uses less water than their entitlement in a regulated water system, it will have more water in storage for use in future years.

Genuine externalities related to water extraction will only occur when rights to access water are not fully specified or independent. Thus, for example, rights to extract water in an unregulated system may be defined in a way that means that any water not taken by a given user becomes available to downstream users (including the environment). This issue is examined in more detail in the discussion below.

3.2.2 What is the current approach to managing the externality and is it effective and efficient?

The property rights approach

In most of Australia, governments have adopted a property-rights based approach (implemented through the NWI water planning and entitlements framework) that seeks to balance consumptive and environmental water needs. By setting extraction limits or rules and assigning entitlements to users, water planners are implicitly seeking to balance the costs and benefits of water extraction to maximise the overall benefits to society from the resource. That is, they implicitly attempt to manage externalities associated with water extraction decisions.

When operationalised, such an approach results in the establishment of operational and extraction rules that define how and when water can be extracted and how releases for the environment and other users are managed.

Exercising a clearly-defined property right once it has been assigned (e.g. an entitlement to extract water assigned to an urban water business) does not result in an incremental externality. If the overall level of extraction embodied in the entitlement is subsequently deemed to be environmentally unsustainable, government may purchase additional water for environmental uses to achieve the desired balance between consumptive and environmental use (and has done so in the rural sector). Water markets provide incentives for all water users (i.e. urban, environmental, rural) to reallocate water over time in response to changing priorities, including environmental needs.

The key debate about the effectiveness of the property rights approach in the water sector is whether decisions about the setting of extraction limits (or the assignment of property rights) actually do maximise benefits from the resource. This relates to issues associated with the environmental benefits and costs of altering environmental water allocations. For the most part, the costs to consumptive users of allocating water to the environment are reasonably well known. For example, the opportunity cost of water in consumptive use is observed in rural water markets. In contrast, there are generally no markets for environmental services supported by environmental flows.

Currently, water planners often use scientific approaches to understand the effects of changes in environmental flows rather than directly valuing environmental benefits. For example, scientists will consider the effect of different flow regimes on the likelihood of maintaining key river health attributes (e.g. flow-related water quality, flow variability) drawing on modelling of ecological responses to changes in hydrology and expert judgment. These risk-based assessments then act as an input to decisions by governments, where the acceptability of environmental risks under different flow regimes is weighed against the costs of meeting those targets.

Specialised techniques are required to value the environmental benefits and costs of altered flow regimes in economic terms. For example, van Bueren and Bennett (2002), Bennett and Morrison (2002) and Loch, Rolfe and Bennett (2002) have applied choice modelling techniques to value river quality improvements (van Bueren & Hatton MacDonald, 2004).

In terms of the effectiveness of the current approach, these empirical issues in valuing the environment are critical. However, they represent challenges to any approach to managing the environment. There have been occasions where environmental water rights have been qualified to secure urban supplies, and where extraction limits have been exceeded in the short term. This may be seen as undermining the property rights assigned to the environment.

Planning and regulation of the development of new sources

As demand approaches the limits of the availability of property rights from surface and groundwater resources, there will be incentives for urban water users/providers/governments to develop new sources. Governments and water businesses face a number of environmental and other obligations when developing new water sources. Designed to mitigate the externalities of new source development, they include:

- environmental planning and works approvals
- undertaking works to mitigate any unacceptable impacts
- broad sustainability objectives that govern business operations (this only applies to some government-owned water businesses)

- other government policies (e.g. decisions to offset the greenhouse gas emissions from desalination).

Existing pricing and charging arrangements

In most cases, urban water businesses have been assigned property rights to extractive use, typically with no explicit charge for the water itself (as opposed to the cost of infrastructure required to treat and supply it to urban customers). Therefore, charges faced by end customers do not usually reflect the opportunity cost or value of the water itself (including its value to alternative uses, such as environmental use) and governments do not typically receive a resource rent (or transfer payment) from this extraction. However, there are some existing and proposed examples in several jurisdictions of variable charges that relate to the cost of extracting water from the environment (see Section 3.2.3 below).

Current urban water charges can, however, provide some signals about the costs of new supply sources, including the externality costs. Where volumetric charges for potable water are set with reference to the long run marginal cost (LRMC) of water supply (i.e. the cost of bringing forward the next supply augmentation), this could provide incentives for customers to reduce their current water use to levels that reflect the external costs of new water sources, if the environmental costs are included in the volumetric price of potable water.

While LRMC pricing is already widely used in Australia, the extent to which current applications reflect the full environmental costs of new source development is unclear. However, LRMC pricing has played a limited role in signalling investment and allocating water to its highest-value uses when water available for urban use has become scarce (i.e. during droughts). The potential for a scarcity price has arisen because there can be a disjoint between water extraction decisions and water use decisions when water authorities hold the extraction rights but households make the water use decisions that determine the volume extracted. In this way, a household does not take into account the fact that its reduced water use will leave more in storage to be available for future periods, because this water is also available to other households. Given the large number of households, this devolves to a collective action problem where all water users react to the tariff charges on their water bill (that often charge close to zero for the water extracted, and include fixed and variable charges for water treatment and delivery). This situation calls for an externality charge of a different type; one that reflects the scarcity value of water for use in future periods, rather than one associated with environmental impacts (see Frontier Economics, 2011).

3.2.3 What are the externality pricing options?

There are two fundamentally different ways to think about pricing of extractions from urban water sources that have been raised in the public debate:

- The first is one that increases the variable charge for water extraction to reflect costs imposed on others by extraction decisions where entitlements are not fully specified or defined and thus extraction decisions by one party have an effect on others (potentially including the environment).
  - For example, once extractive rights have been granted, the way these rights are exercised may also have environmental consequences (either positive or negative) such as by altering the timing of a water release from storage. These environmental implications of using water extractive rights are the true externalities of water extraction. Pricing tools that can make water users take into account these consequences of exercising their extractive rights are therefore externality pricing tools.

- The second relates to charges designed to recoup some or all of the underlying value associated with rights to extract water – which reflect the fact that water is scarce and there are competing demands for it, including by the environment.
  - There is a view that entitlements to extract water have been allocated in the past (e.g. to urban water utilities) without any payment to reflect, for example, the foregone environmental benefits from assigning property rights over a natural resource that would otherwise provide environmental outcomes.

Strictly speaking, when property rights to the resource are already allocated, this latter approach is not an externality price, but a resource rent which recovers additional revenue on behalf of the public for the use of a public resource.

There are some existing and proposed examples of several jurisdictions applying charges that ostensibly relate at least in part to the cost of extracting water from the environment (i.e. from surface water or groundwater). Specific examples include:

- **Water abstraction charges**: The Australian Capital Territory's water abstraction charge (WAC) is designed to meet catchment management, scarcity and environmental costs. The estimate of environmental costs includes 'those that relate to the effect on the environment from the flow of water downstream, including the effect of storing water in dams'.[5]
- **Groundwater abstraction charge:** Western Australia's Economic Regulation Authority (ERA) recently considered including an externality premium in potable water charges to reflect the costs of damage to ecosystems and environmental amenity associated with groundwater abstraction for Perth's water supply. At present there is a groundwater abstraction rule that aims for an average extraction of 120 GL per year. Annual abstractions are increased when dam (surface) storages are low and are reduced when dam storages are high, with a policy target to limit maximum extractions to 145 GL per year.

  Due to recent dry conditions, the Water Corporation advised that allocations below 145 GL per year during the period 2008–12 would significantly increase the risk of a total sprinkler ban. WA's Department of Water further stated it believed that extractions of 120 GL per year average during this period would be difficult to sustain.

  The ERA considered the Department of Water's view (that abstraction of 120 GL per year by the Water Corporation might be appropriate in the longer term but that ongoing environmental consequences would occur in the short term) and indicated that a premium could be added to water usage charges in the short term to reflect the possible environmental externality. The ERA estimated these external costs based on the costs that would have been incurred if abstraction from the Gnangara Mound were reduced to the target level (i.e. the cost of sprinkler bans) (ERA 2009).
- **Tasmanian water resource tax:** In the past, Hobart Water was required to pay a resource tax or royalty on water sold.
- **Water supply tax**: In 1994, the Danish government introduced a water supply tax based on extracted water and passed it onto consumers. The aim of the tax is to 'attach economic value to the use of natural resources and environment in order to minimise over-consumption and the strain on the environment' (Danish Environmental Protection Agency, 1999, p. 65).

Unfortunately, these charges often conflate the distinct issues of externalities and resource rents as described above.

[5] ACT Water Abstraction Charge, http://www.actewagl.com.au/water/networks/wac.aspx

3.2.4 What are the costs, benefits and implementation issues associated with externality pricing?

The impact of a price signal on externalities where property rights are in place

Placing an additional extraction charge on water use to reflect the opportunity cost in environmental use will reduce water use, depending on the size of the charge and the elasticity of demand. However, as discussed above, where fully specified property rights exist, the benefit is likely to accrue to the beneficiaries of those entitlements, rather than to other users or the environment. A critical factor in identifying the impact of pricing the opportunity cost of water extraction therefore relates to the specification of current property rights. It is useful to consider the question 'what would happen if the extractive right to water was not exercised?'

- In the case of clearly defined property rights in a regulated surface water system involving water storage (which typifies urban water systems), one less megalitre of water extraction results in one additional megalitre of water held in storage and available to extract at a later time. The reduced extraction may slightly increase the likelihood of a megalitre of water spilling from the dam and providing water for an unmanaged environmental release. Only where this water extraction in a later period causes different positive or negative environmental impacts (such as altering the flow regime towards or away from natural), does this constitute an externality.
- In the case of a 'use it or lose it' property rights system (such as an unregulated water resource with extraction rights based on levels of passing flows), one less megalitre of water extraction does result in one additional megalitre of water available for downstream users. These users include the environment but could also include other downstream users with extractive rights. In the example of the unregulated water resource, the reduced extraction leads to increased in-stream flows for a section of the waterway, and the length of this section depends on whether there are other downstream users that may extract the additional flows.

These points highlight the complex interactions between a price signal and existing property rights. Externality pricing based on the volume of water abstracted or used will be ineffective in addressing the negative externalities associated with source operations that are invariant to water volumes, such the effects of existing dams on fish passage. This is because there is no link between customers' ongoing water use behaviour and the negative external effect. Governments and water businesses typically use other instruments, such as environmental works, to address these externalities and recover the cost through water planning and management charges.

Where there are additional externality impacts that vary with extractions but are not incorporated into the current property rights regime, there may be value in ensuring that user decisions account for these impacts. For example, a choice to use water may influence flows along a transmission channel or waterway. Changing the timing of extraction decisions may create congestion or other third-party and environmental impacts on the waterway that are not included in the volumetric property right. Externality pricing on these marginal decisions may have a role in these circumstances. However it is difficult to envisage situations where pricing would be preferred over other mechanisms, particularly those that entail more fully specifying property rights (e.g. minimum flow rules, delivery entitlements). Moreover, changes at the margin are likely to be second-order issues of much less importance than setting an optimal overall cap on extractions.

Impacts of a resource rent charge

A charge that seeks to recoup the underlying value associated with rights to extract water (potentially including the foregone environmental benefits of water flows) is a financial transfer from users to the government. As demonstrated above, it will not necessarily change the impact on the environment, depending on the specification of property rights. Where property rights are fully defined, a resource rent tax on a renewable resource such as water would reduce the value of the property right by the value of the tax. An efficiently designed rent for a fully developed renewable resource would not have distorting signals on extraction decisions.

A common problem among existing approaches to setting water abstraction charges is that they lack transparency, and tend to blur resource rent, externality pricing and other motives. For example, the link between abstraction charges and specific environmental outcomes is often unclear (e.g. ACT, Denmark). In Western Australia, the abstraction charge appears to relate to protecting water security as well as the environmental cost of over-abstraction. The apparent aim of the Hobart Water resource rent tax for water, like similar taxes in mining, is to charge for the use of a public resource and return the revenue to taxpayers.

A resource rent would generate additional revenue. The obvious option for dealing with the revenues generated by the tax would be returning them to government.[6] In theory, revenue generated from pricing resource rent could result in additional benefits by allowing government to retire other distorting taxes, or could even be hypothecated for environmental works. However, implementing an externality tax or charge could have legal implications. For example, Dwyer et al. 2006 examined case law on the use of externality pricing and found that any externality price that resembles an excise tax might present governments with legal uncertainties. In September 2010, the ACT Government had its water abstraction charge upheld following a challenge and subsequent appeal by the Queanbeyan Council, which is supplied from ACT catchments.

The comparative benefits of quantity based property rights

Assessing the incremental impacts of an externality price is difficult given that Australia has already taken significant steps towards developing a quantity-based approach to allocating water resources between environmental and consumptive use. There are strong arguments for continuing with the quantity-based property rights approach:

- quantity-based measures using sustainable yield estimates or sustainable diversion limits are better suited to environmental outcomes and their water requirements, as these are not easily valued in economic terms
- a quantity-based measure is not subject to the uncertainty of economic valuation and provides greater assurance that specific measureable limits on extraction are in place (see Section 2.5.3)
- establishing a resource rent would alter the nature of these existing property rights and creates a potential sovereign risk issue.

There are also difficulties in altering extraction charges to reflect changing environmental values in the community. For example, governments would need to define a demand curve for the environment that reflects the opportunity cost of water use in environmental or other non-urban uses under different conditions of resource availability. However, with quantity-based market instruments, governments and others can purchase additional entitlements for

[6] For example, total revenue received in 2007–08 from the ACT water abstraction charge was $29.5 million, of which $29.2 million was collected from ACTEW customers and $250 000 from other licence holders (ACCC, 2009).

environmental use or reduce extraction allowances (although this latter approach also raises sovereign risk issues that need to be managed).

Our analysis suggests there are limited efficiency benefits from augmenting current property rights with a charge aimed at managing existing externalities.

While getting the balance right is obviously a difficult task, in our view, removing current extraction limits and replacing them with a price mechanism is unlikely to be an effective option, as it would introduce significant risks to environmental outcomes, and be politically difficult to implement. Efforts are likely to be better devoted to fully defining existing property rights to address third-party impacts, while enabling transferability between users, and undertaking technical and economic research to determine the optimal balance between consumptive and non-consumptive use so limits can be set at the socially optimal level. This approach is consistent with a key thrust of the NWI.

Pricing to reflect the environmental impacts of new sources

Reducing demand through imposing an externality charge would defer the need for the next-supply augmentation. However, an alternative approach to provide an efficient price signal about the environmental and social impact of new sources would be to incorporate the full environmental, social and financial opportunity costs of future augmentations into the calculation of marginal cost. This could be achieved in a number of ways:

Based on this analysis, Table 2 presents an illustrative example of how negative externalities associated with potable water might be included in a two-part tariff with a variable charge based on LRMC of new source development. The variable charge would capture current and future operating and capital costs (including the cost of addressing externalities) associated with meeting additional water demand. The residual revenue required to cover other costs, such as the cost of managing existing externalities unrelated to the volume supplied, could be recovered through fixed charges.

Table 2: Illustrative urban water tariffs for potable water (based on LRMC)

Fixed access	*Usage*[a]
Cost of managing existing externalities unrelated to volume supplied (e.g. fish ladders)	Future capital and operating costs (including environmental opportunity costs) associated with next-supply option
Existing capital costs	Current variable operating costs (e.g. pumping) and maintenance
Research	
Monitoring and enforcement	

Source: Draws on van Bueren and Hatton MacDonald, 2004.

[a] *There may be scope for variable prices to reflect the opportunity cost of water (see paper on scarcity pricing)*

As discussed in the companion study on scarcity pricing, LRMC pricing has several drawbacks and there is a possibility that the industry may choose to move away from this approach in the future, and to develop more pro-competitive industry models.[7] The role of

[7] Grafton and Ward (2010) note that one of the key problems associated with long-run marginal cost pricing is that in practice there cannot be a unique long-run marginal cost because 'when the supply augmentation occurs is dependent on current, past and future weather events as well as past and

potable water pricing in signalling the environmental costs associated with future source development would need to be reviewed in the context of more fundamental reforms to potable water pricing.

3.2.5 Conclusions on the merits of externality pricing

Overall, it appears there is limited scope for expanding the use of externality pricing for potable water to manage the externalities associated with water resource development and extraction.

- Entitlement regimes are already in place in most urban water systems and have practical benefits in providing greater certainty for ensuring water extractions do not compromise environmental objectives associated with the volume of water available for environmental uses.
- Water abstraction charges are unlikely to be effective in managing the environmental impacts of existing sources where fully specified entitlements are already assigned and establish the sustainable extraction limit.
- Where there are additional externality impacts that vary with extractions but are not included in the current property rights regime, there may be value in ensuring that user decisions account for these impacts. However it is difficult to envisage situations where pricing would be preferred over other mechanisms, particularly those that entail more fully specifying property rights (e.g. minimum flow rules, delivery entitlements).
- Externality pricing for potable water is ineffective in addressing negative externalities that do not relate to the volume of water use, such as the effects of existing dams on fish passage.
- Where concerns about the sustainable extraction limit exist, buyback or reallocation of existing entitlements is likely to be the most effective option.
- For new source development, potable water charges should take account of the full environment opportunity costs to send an efficient signal to water users, which could be achieved through auctioning new entitlements and/or including the full environmental costs in determining marginal cost prices.

3.3 Disposal of wastewater to the sewerage system

3.3.1 What are the externalities?

This assessment examines the externalities caused by water users who discharge effluent to sewerage systems, which is then treated before discharge to receiving environments.

There are externalities related to the negative external effects of residential and commercial/industrial customers disposing wastewater to the sewerage system for subsequent treatment and disposal. Some pollutants may be highly corrosive and damage sewerage or treatment infrastructure. Discharges of non-hazardous pollutants to sewers (e.g. salts, nitrogen, and phosphorus) increase in the cost of treating water for discharge to the environment. In contrast, hazardous pollutants (e.g. metals, corrosive material) can pose

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current volumetric prices'. The authors argue that where regulators suppose there is a deterministic long-run marginal cost, this can lead to sub-optimal investment decisions.

significant health risks to water businesses' workers and increase infrastructure maintenance costs. Some pollutants may only become hazardous to humans at certain levels.

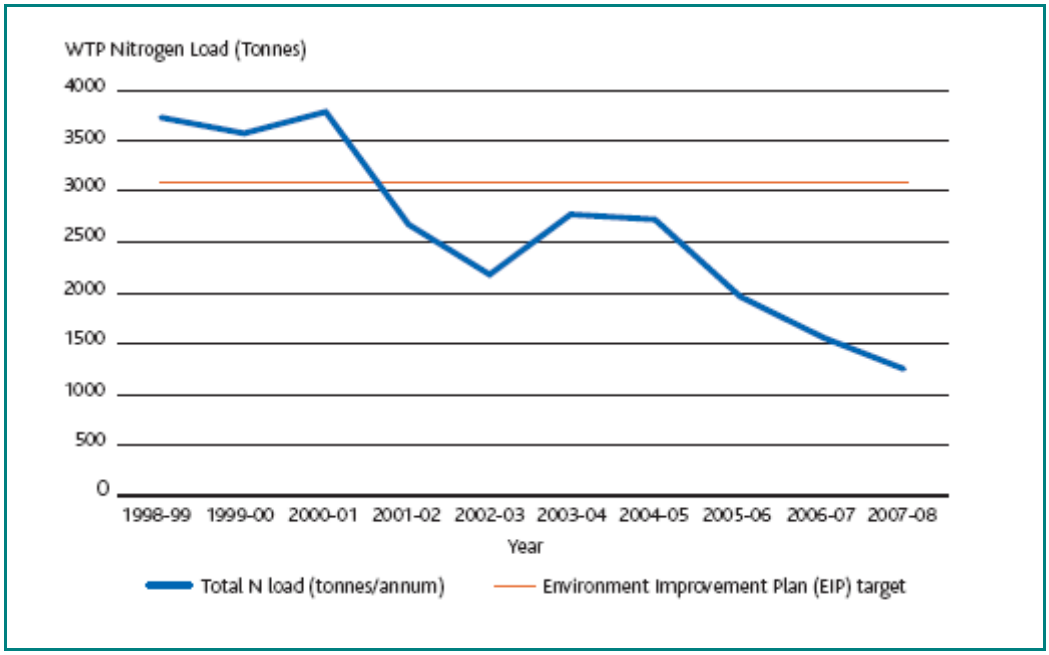
While end-of-system treatment to a particular level occurs before discharge to the environment, public health, amenity and environmental impacts may still arise before this occurs. For example, following heavy rainfall, sewerage systems can overflow or pipes can crack, resulting in pollutants entering the environment (e.g. urban waterways). This can have similar external costs to those described for wastewater and stormwater disposal (see Section 3.4). The potential for externality pricing to apply to treatment plants and other point sources that discharge to receiving waterways is assessed in Section 3.4.

3.3.2 What is the current approach to managing the externality and is it effective and efficient?

Currently, water businesses and water users have obligations that provide an incentive to address negative externalities associated with wastewater discharges. For example, water businesses' treatment plants must meet regulatory standards for safe discharge to the environment. There are also licensing systems in place for various types of users.

During the past few decades, infrastructure works (i.e. mitigation, connecting customers to the sewerage system) to meet regulatory standards have been key tools for managing wastewater discharges. There is evidence that infrastructure investment and regulation has often been highly effective in addressing externalities associated with wastewater pollution. For example, in the past 10 years there have been large reductions in nitrogen loads from the Western Treatment Plant in Melbourne (see Figure 4). This reduction in loads has coincided with stronger regulation of wastewater customers and upgrades of treatment facilities.

Figure 4: Nitrogen loads discharged to Port Phillip Bay from Western Treatment Plant, 1998 to 2008



Source: Melbourne Water and Victoria EPA, 2009

With regard to the effectiveness of regulation in addressing wastewater discharges, Melbourne Water and the Victorian EPA (2009) noted:

> *Most industries now discharge their liquid effluent, referred to as 'trade waste', into the sewerage system for treatment at either Western Treatment Plant (WTP) or*

Eastern Treatment Plant under agreements with Yarra Valley Water, City West Water and South East Water. Some industries need to treat their wastes in order to comply with Trade Waste Acceptance Standards. These arrangements have resulted in a major reduction in the number and significance of industrial discharges into the rivers, creeks and drains that ultimately lead to the bay. Other industries are required by EPA Victoria to treat their effluent to an acceptable standard before it is discharged to a waterway or bay.

A potential shortcoming of existing arrangements for wastewater management, from an efficiency perspective, is an over-reliance on regulation to manage pollutants that do not pose significant risks to public health and safety, infrastructure and the environment. For example, the principles of the waste hierarchy[8], which guide waste management in some states, do not take into account the range of costs and benefits associated with different waste management options (Productivity Commission 2006). That is, the waste hierarchy favours certain waste management activities (e.g. avoidance) over others (e.g. treatment) regardless of relative costs. In contrast, cost-reflective prices for treatment provide an incentive for dischargers to find the least-cost waste management option regardless of what that might be.

Particularly hazardous pollutants that pose significant risks to public health and safety or infrastructure are either prohibited or closely regulated. Other types of external effects, such as those from sewerage overflows following heavy rainfall, are managed through direct management and system operation procedures. For example, Sydney Water can declare substances in sewerage systems or subsystems as critical and restrict their disposal. Most people accept these approaches are appropriate for addressing these issues and the limited role for pricing in managing these problems (other than for recovering management costs or imposing penalties for breaches).

3.3.3 What are the externality pricing options?

As environmental regulations govern the discharge of water from sewerage treatment plants to the environment, a key issue is:

- whether these regulations provide for the socially optimal level of environmental and public health externalities (the alternative of using pricing to manage the discharge of treated effluent and other point sources is examined in Section 3.4) and, if so,
- whether wastewater customers face prices that reflect the marginal cost of treating water to required environmental standards.

For example, it may be that specific pollutants (either loads or concentrations) are the major factor driving treatment costs as opposed to the total volume of wastewater. Other issues include protecting public health and safety and maintaining infrastructure within the sewerage transport and distribution system.

Currently, most residential customers face fixed wastewater charges, or charges based on the volume of water used, due to the costs of metering and monitoring sewerage. Some current approaches for wastewater pricing seek to better reflect the cost of meeting such discharge standards, for example:

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8 The waste hierarchy classifies waste management practices in the following order of desirability: avoidance, reuse, recycling, energy recovery, containment, and disposal.

- **Differentiated wastewater charges:** These are charges based on the content of wastewater (total load, concentration or both). For example, in Melbourne, trade waste tariffs include a variable component to reflect the marginal effects of pollutant discharges on treatment costs (e.g. salt, nitrogen, suspended solids). A similar levy was introduced in The Netherlands in the 1970s based on organic material, nitrogen, cadmium, zinc, lead, nickel and copper (UCD Dublin, 2010).
- **Nodal charging for wastewater treatment system:** Young (2000) proposes setting wastewater charges in proportion to the loads at each node in the sewerage system. The idea behind this is that a group of customers subject to the levy would have a financial incentive to collectively search for ways to reduce treatment costs and the loads of pollutants returned to the environment.

Other potential charging approaches to manage negative externalities associated with wastewater include:

- **Penalties for non-compliance**: Since the early 1980s, a simple fee for non-compliance with pollution standards has been in operation in Korea. The fee applies to 15 water pollutants based on the level of pollution concentration and total load (O'Connor, 1998). The amount of the charge varies with the location of the facility, the duration of excess discharges and the number of previous violations (O'Connor, 1998). In Australia, WSAA (2008) notes some utilities may use premium charges or asset protection charges for non-installation or maintenance of appropriate pre-treatment equipment.
- **Risk-based charges**: these charges reflect the level of risk associated with an activity (e.g. managing high-risk trade waste customers).
- **Indirect approaches (taxing inputs)**: this involves taxing inputs that contribute to water-related externalities (e.g. taxing detergents) (Young, 2000).

The remainder of this section focuses on the potential to develop more cost-reflective trade waste pricing (e.g. for large industrial customers) to provide a signal for customers to undertake optimal investment and discharge. Rather than externality pricing in its strict sense, it examines charges to reflect the cost of meeting particular treatment and discharge standards.

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3.3.4 What are the costs, benefits and implementation issues associated with externality pricing?

The main benefit of improved load-based pricing (and reducing prescriptive regulations for non-hazardous pollutants) is that it allows customers to decide on the least-cost way to manage waste (whether it is avoidance, abatement or treatment), which in turn reduces the overall cost of waste management. By setting a cost-reflective price for treatment, for example, customers with low-cost opportunities to treat waste on-site will have an incentive to do so. In contrast, customers with few on-site abatement opportunities would be able to discharge more waste for treatment downstream.

As described in the companion report reviewing water pricing reforms, City West Water (and the other Melbourne retailers) has introduced more cost-reflective pricing for trade waste.

Load-based pricing has also proven to be effective in reducing in-stream pollution loads in The Netherlands (see Box 1).

Box 1: Wastewater tax in The Netherlands

The Dutch wastewater levy came into effect in 1971 after the Surface Waters Pollution Act was introduced in 1970. The levy was designed to cover the costs of sewerage treatment but differed from traditional charges based on straightforward cost recovery in two respects:

- the levy also applied to direct dischargers (i.e. industries and municipal treatment plants which discharged directly to surface waters)
- the levy was based on specific pollutants discharged (organic material, nitrogen, mercury, cadmium, copper, zinc, lead, nickel, chromium and arsenic) rather than the hydraulic load as is the case with conventional user fees.

Several studies have assessed the effectiveness of the Dutch water pollution levy since its introduction. For example, Bressers (1988) used regression analysis to show a systematic relationship between the increase of the levy rate and the degree to which different industries control pollution. Interviews with 150 enterprises (Schuurman 1988) found that 54 per cent of the enterprises which had reduced pollution pointed to the significance of the levy.

The effect of the levy differed across industries. For example, the levy was cited as the most significant reason for pollution reduction in the food processing industry, while the requirement for permits were more important in the chemicals industry.

By 1996 the net load on surface waters from discharges had been reduced from 45 million inhabitant equivalents (i.e. a standardised measure across individual discharges) in 1970 to 4.6 million inhabitant equivalents. Gross organic discharges from industry were reduced from 28 million inhabitant equivalents in 1970 to 3.3 million.

Past reviews have highlighted the possibility that the incentive effect created by the charges applies only to larger firms whose payment is dependent on direct measurement. They also note that some medium-sized companies may have switched to being charged based on direct measurement because they had made large reductions in emissions and thus direct metering would lead to reduced payments.

The initial fixed cost of continuous measurement of emissions was seen to have discouraged extensive uptake of this option.

Source: UCD 2010

One of the key issues determining the feasibility of load-based pricing for wastewater is the cost of measuring and monitoring wastewater quality. In The Netherlands, for example, the substantial fixed cost of continuous measurement of emissions was a key impediment to extensive uptake of this option.

Currently, Australian water businesses only monitor the quality of discharges from large trade waste customers. The cost of monitoring discharges from normal wastewater customers is generally considered prohibitive, and this is a major barrier to further pricing options.

The contribution of trade waste customers to overall treatment costs will also be relevant to assessing the feasibility of load-based pricing. For example, trade waste makes up a significant proportion of total wastewater collected in places such as Melbourne, Sydney, Adelaide (based on WSAA NPR data, 2010) but accounts for a small proportion of total wastewater collected in the ACT.

Introducing cost-reflective load-based charges may also require transitional arrangements because some customers are likely to have limited scope to respond to price signals. For example, trade waste customers may have already invested in production processes that produce certain pollutants based on the price signal they faced at the time. In the short term,

they may have limited scope to respond to stronger price signals and be subject to significant price increases.

The pricing regime would also need to address potential risks from reducing the direct regulation of discharges. For example, a large increase in discharges from customers in a specific part of the system may create ‘hot spots’ where pollutant concentrations exceed safe levels.

Similarly, it is important to consider how incentives to manage wastewater quality affect wastewater quantity and the operation of sewerage systems and treatment plants.

3.3.5 Conclusions on the merits of externality pricing

Load-based pricing is arguably an application of existing pricing principles based on full cost recovery and sending a cost-reflective volumetric price signal.

Further application of load-based charging for wastewater is most likely to be feasible in areas where trade waste is significant (e.g. Melbourne, Sydney, Adelaide) and effective structures for measuring and monitoring water quality can be put in place. It is therefore not surprising that water businesses in places such as Melbourne and Sydney have already adopted this pricing option in some form.

Given that critical pollutants may change over time and the cost-reflectivity of existing load-based charges could potentially be improved, there may be scope to refine trade waste pricing over time.

Moving to measured volumetric charges for residential wastewater would require massive investment in measurement and monitoring, potentially for very little benefit.

Charges based on wastewater content (as opposed to volume) are less likely to be worthwhile for household wastewater customers or for cities where there are few trade waste customers, due to metering and monitoring costs.

To achieve the full benefits of load-based charging, governments may need to review other (potentially conflicting) policies and regulations for waste management (i.e. the waste hierarchy approach).

3.4 Point source discharges of wastewater to waterways

3.4.1 What are the externalities?

Some externalities arise from direct releases of pollutants to the environment from point sources (e.g. effluents from industrial customers and wastewater treatment plants). Point source discharges can increase concentrations of various nutrients, salts, organic material, chemicals and metals in receiving waterways. These pollutants can build up in the environment, reduce water quality, and damage marine/riverine/riparian habitat and associated biodiversity values.

Often the effects of pollutants will depend on other factors in the environment. For example, the risk of algal blooms depends on the interaction of nitrogen, phosphorus, temperature and other hydrological factors. This means that the cost of discharging pollutants to the environment is often site-specific and hard to quantify ex-ante.

3.4.2 What is the current approach to managing the externality and is it effective and efficient?

Direct regulation is the main instrument used to manage the quality and quantity of effluent discharges from wastewater treatment plants. Similarly, regulation (in the form of licensing) is typically in place to manage the discharge of wastewater from industrial customers, where such discharges are direct to the receiving waterway.

In a few notable cases, such as the Hunter Salinity Trading Scheme and Hawkesbury-Nepean Bubble Licensing Scheme in New South Wales, governments have used market-based instruments to minimise the overall cost of achieving the desired reductions in pollution. The Hunter Salinity Trading Scheme is widely recognised as being successful in achieving salinity targets in a cost-effective manner.[9]

Most wastewater treatment plants are compliant with regulatory standards. However, whether these standards are socially optimal is an important issue that is beyond the scope of this report. In some places, point source pollution remains a problem. For example, in Pine River in South East Queensland total phosphorus levels throughout the estuary are far in excess of the EPA water quality objectives. This is attributed to excess point source loads (McAlister, 2008).

3.4.3 What are the externality pricing options?

Externality pricing for point source discharges of wastewater to waterways could be linked to particular parameters (e.g. loads or concentrations of nitrogen and phosphorus) that have direct impacts on the health of receiving waterways. For example, in addition to covering the cost of sewage treatment, the Dutch wastewater tax also applied to industries and municipal treatment plants that discharged directly to surface water.

As discussed above, load-based pricing for customers releasing wastewater into the sewerage system is also an indirect form of externality pricing for helping to manage point source discharges by reducing the harmful content of the influent to sewage treatment plants.

3.4.4 What are the costs, benefits and implementation issues associated with externality pricing?

In theory, externality pricing levied at the point of discharge to the environment (i.e. industrial users and wastewater treatment plants) could help to control pollutants released to the environment at these point sources. Like load-based charges to wastewater customers, it would have efficiency advantages over prescriptive regulations that set uniform discharge levels across sources (see Section 2.3). Combined with improved monitoring and measurement, pricing could form a tool to encourage behavioural change.

However, additional externality pricing is only likely to be worthwhile where there are significant externality problems associated with wastewater effluent discharge. However, these problems may also be remedied by improving existing regulation and licensing. A challenge in determining the optimal level of externalities is measuring and evaluating them, although several studies have examined the benefits of changes in water quality on recreation and amenity values. For example:

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[9] See for example, NSW DECC <www.environment.nsw.gov.au> and Designer Carrots <www.marketbasedinstruments.gov.au>.

- In NSW, Bennett and Morrison (2001) estimated the value of improving water quality to make it safe for swimming was $87.17 per household and the value per household of improving water quality to make it safe for fishing was $44.05.
- For improvement in water quality in the Bremer River, one study found Australians were willing to pay $21 per year for minimal improvement, $36 per year for moderate improvement and $87 per year for substantial improvement (Robinson, Clouston & Suh, 2002).

There have also been studies on benefits associated with healthy river systems:

- Morrison and Bennett (2004) valued increasing the number of fish species present in the Gwydir and Murrumbidgee and found values of $3.30 to $3.50 per species per household.
- Several studies have valued habitat suitable for protected or threatened water birds, with values ranging from $4.30 to $7.40 per species per household (Morrison & Hatton-McDonald, 2010).

Notably, however, most of these valuation studies have been undertaken for waterways in rural areas, and further research may be required in urban areas to better understand the potential benefits of improved management of wastewater discharges.

As an alternative to pricing, quantity-based instruments along the lines of the Hunter Salinity Trading Scheme may be preferred. As noted in Table 1 above, the appropriateness of pricing versus quantity-based tradeable permits will depend on a range of considerations including the importance of certainty over the quantity of pollution reduction and the potential for environmental thresholds with significant/irreversible damages.

Calibrating an administered externality price to achieve the desired level of pollution abatement from wastewater discharges would be information-intensive, costly to implement (due to the metering and monitoring costs of particular pollutants) and subject to uncertainty. However, some of these metering and monitoring requirements may already be in place to assess compliance with current licence conditions. As previously noted, when there are environmental thresholds over which pollution may cause significant/irreversible damage, pricing may be less appropriate than a quantity-based permit system because pricing provides less certainty on the amount of pollution.

3.4.5 Conclusions on the merits of externality pricing

The appropriateness of pricing for managing wastewater discharges to the environment is context specific. It will be most beneficial where:

- there are significant residual environmental or public health issues associated with current management of these externalities
- the additional costs of monitoring and measurement are low
- the costs of mitigating wastewater discharges vary significantly between different emitters into a system.

Tradeable permits are likely to be more effective than administered pricing in managing direct discharges to the environment from point sources because they provide more certainty about total levels of pollution. Pricing may be more effective in situations where there is significant uncertainty and a general desire to provide a signal to ‘move in the right direction’.

3.5 Diffuse source discharge of stormwater

3.5.1 What are the externalities?

Stormwater runoff in urban areas can have significant effects on flows to urban waterways and affect the local ecology. There are water quality, quantity and timing aspects to consider.

Unlike wastewater, which is typically released to sewers and treated before being released to the environment, polluted stormwater is often discharged directly into the environment from a broad range of diffuse sources (e.g. roads, rooftops, other hard surfaces). In particular, the close link between rainfall and stormwater discharges means the frequency at which large doses of pollutants can enter waterbodies is high relative to discharges from point sources (e.g. see Melbourne Water & EPA Victoria, 2009).

The imperviousness of urban landscapes (i.e. land that is covered by features such as concrete that cannot absorb rainwater) lead to sharper or higher peak flows to waterways. Changes in hydrology (i.e. the flow regime) can be damaging to the aquatic and riparian health of the receiving environment and cause localised flooding. Stormwater discharges can also carry litter and pollutants.

3.5.2 What is the current approach to managing the externality and is it effective and efficient?

A range of approaches is used to manage stormwater externalities including:

- direct intervention (e.g. construction and operation of stormwater infrastructure assets)
- education (e.g. targeting key sources of pollutants where they can be identified)
- mitigation (e.g. street cleaning, infrastructure works such as wetlands for bioretention/flood mitigation, litter traps)
- regulation (e.g. requirements for best-practice stormwater management in new residential areas).

Water customers and landholders are often charged for the costs of managing stormwater infrastructure.

The effectiveness of existing arrangements for managing stormwater pollution is difficult to assess due to the influence of external factors such as rainfall on observed outcomes. During the past decade, for example, drought has substantially reduced flows and reduced contaminant loads to waterways and bays. A return to wetter conditions would see an increase in stormwater loads to waterways and the bays (Melbourne Water & EPA Victoria, 2009). However, as discussed in Section 3.6, concern about the impact of stormwater on urban waterways is a major motivator for IWM.

3.5.3 What are the externality pricing options?

Many activities that are the source of stormwater pollution are diffuse and do not relate to water use, hence direct pricing for stormwater pollution is difficult. For example, pollutants produced by pets and the use of motor vehicles can wash into stormwater drains and waterways. It is simply not possible to identify and measure the contribution of these types of individual activities to stormwater-related externalities. Instruments that target the pollution source directly may be more effective in reducing pollution than water pricing (e.g. regulations governing maintenance of cars, fines for not cleaning up after pets).

Imperviousness taxes provide an alternative to directly metering the causes of negative stormwater externalities. They form a proxy or surrogate approach to measure the impact of particular land uses on stormwater runoff. For example, St Louis recently set charges for stormwater services based on the amount of impervious area on each individual customer's property (Metropolitan St Louis Sewer District, nd).[10] Similar charges apply in other cities throughout the United States and Canada.

Another option is to require water users to offset pollution from new developments. For example, where best-practice stormwater treatment is required in new developments, but is not able to be met on-site, Melbourne Water collects payment in lieu, which is then spent by a Nitrogen Offsets Program to achieve equivalent treatment. The offset program helps to reduce the cost of complying with environmental regulations.

Another option discussed later in Section 3.6 is to fund mitigation projects using pricing mechanisms, where these provide broader public benefits.

3.5.4 What are the costs, benefits and implementation issues associated with externality pricing?

Imperviousness charges have been used in Australia and other countries such as the United States and Canada. However, Young (2000) argues that such surrogate measures typically provide limited incentives for water users to search for innovative solutions. For example, the size of the charge may have to be significant to encourage customers to redevelop their existing properties. Costs of implementing such charges can include undertaking aerial assessments of properties to determine the charges that should apply. Hence, updating charges regularly may not be feasible. Moreover, imperviousness may not be an appropriate measure of stormwater runoff. For example, stormwater runoff from the same roof area would depend on whether a rainwater tank or other diversion devices are in place, and how effectively they are used.

Imperviousness charges are sometimes seen as a more equitable way of sharing stormwater management costs compared with current fixed charges per property, because at least there is some link between the surrogate measure and stormwater discharge. However, some customers may have little scope to alter their existing property layout, and may therefore face significant increases in stormwater charges.[11]

Due to these limitations, mitigation of stormwater pollution may be a more practical approach. One approach to mitigation is to impose an obligation on developers of stormwater infrastructure to meet certain water quality standards. In this context, offsets could help to reduce the cost of meeting regulatory obligations to mitigate stormwater pollution. As noted above, Melbourne Water has run its nitrogen offset program for stormwater projects since 2005 in the Port Phillip and Westernport catchments. Obligations to offset nitrogen are underpinned by the Victorian Planning Provisions that call for local governments to set water sensitive urban design (WSUD) requirements for residential subdivisions, with the costs to be met by developers. The cost of offsets has steadily increased over the life of the program as lower-cost development opportunities for offsets have been exploited.

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[10] The impervious charge provides householders with a tangible cost associated with choices they make regarding landscaping and the building footprint on their house block (although this charge may be insufficient to influence behaviour).

[11] In July 2010, a county judge ruled that the Metropolitan St. Louis Sewer District could no longer collect a fee for stormwater services after ratepayers filed a suit in July 2008 questioning the validity of impervious stormwater user charge.

Most distributional impacts associated with offset programs arise from the policies that mandate best-practice stormwater management rather than the offsets schemes themselves. That is, the regulations impose a cost on developers for a wider community benefit.

3.5.5 Conclusions on the merits of externality pricing

The diffuse nature of stormwater pollution generally makes direct pricing for negative externalities difficult and mitigation is often likely to be a more practical response. Where regulations require specific standards for stormwater development, a pollutant offset scheme could reduce the cost of compliance and is worth considering. Further, there may be a role for funding mitigation projects that provide wider community benefits.

Imperviousness charges would appear to be a costly mechanism to implement given the need for regular monitoring. They would mainly be applicable as an alternative cost recovery mechanism (as opposed to fixed charges per property) and it is unclear whether they would adequately reflect changes made to reduce stormwater impacts (e.g. installing a rainwater tank) or drive significant behavioural change.

3.6 Positive externality benefits of integrated water management

The discussion above highlights many of the difficulties in applying externality pricing to some types of negative urban water externalities, such as diffuse sources of stormwater pollution. Another issue, which proponents of IWM are particularly concerned about, is that existing institutional arrangements for water pricing and investment do not take account of a number of positive externalities associated with such projects and hence under-investment may be the result. This section examines the potential for positive externality pricing to play a role in the urban water sector.

3.6.1 What are the externalities?

Some of the possible externality benefits of IWM projects include:

- waterway health benefits
- amenity benefits from landscape change (e.g. wetlands)
- reduced greenhouse emissions
- reduced localised flooding
- impacts on community wellbeing associated with parks and green spaces
- public health benefits through reduced urban heat island effects (see Centre for Water Sensitive Cities, 2011).

The following discussion explores how IWM can influence the source, transmission and effect of these potential benefits. As discussed in Section 2, the discussion shows the significant challenges in attributing environmental changes to particular interventions (e.g. an IWM project), valuing these benefits, and assessing who the beneficiaries are.

Improved waterway health from reduced stormwater and wastewater effluent to receiving waterways

IWM projects can involve stormwater capture and the creation of urban wetlands that mitigate diffuse source pollution to rivers and the ocean.

In addition, by harvesting wastewater from sewerage systems, recycling can reduce the volume of wastewater arriving at treatment plants and hence the amount of pollutants discharged to the environment from treatment plants. As such, these projects can contribute to the benefits outlined in Section 3.4.

However, it is worth noting that licensed wastewater treatment operators (who must meet discharge standards) would already have a financial incentive to invest in recycled water schemes that reduce wastewater treatment costs. As ERA (2009) has noted:

> *For many wastewater treatment or recycling schemes, the costs associated with environmental impacts can be directly quantified and will often be internalised either as part of the direct cost of a project, or avoidable costs.*
>
> *If the environmental standards that underpin licences are set in a way that is socially optimal, then the costs of meeting those standards will be part of a project's costs, and there will be no other environmental costs to take into account.*
>
> *The costs associated with discharging treated wastewater into the ocean will be internalised through the costs of treatment and wastewater management that are needed in order to produce wastewater of suitable quality for discharge, in accordance with environmental permits.*
>
> *These costs would be avoided in the event of a recycling project, which removed the need to discharge into the ocean, and would therefore be counted as an avoidable cost.*

These avoided costs will be reflected in the operating and capital costs of the wastewater business and can be passed onto wastewater customers through charges.

Amenity benefits from landscape change

It is also often suggested that WSUD produces urban amenity benefits, including the creation of wetlands.

In some cases these benefits would accrue to the broader community, implying that optimal levels may not be provided privately without some form of subsidy.

However, councils and developers have significant financial incentives to invest in WSUD even in the absence of external pricing. Benefits such as landscape amenity may be largely capitalised in the value of the land sold by developers and the increase in property values would increase revenues to councils from rates.

Another potential benefit of WSUD is the avoided costs to developers. For example:

- Lehner et al. (1999) report that eliminating kerbs and gutters at the Prairie Crossing development in Grayslake, Illinois, saved the developer approximately $2.7M (US), with sales being comparable or better than nearby conventional developments.

- Lehner et al. (1999) also report that the Oregon Museum of Science and Industry in Portland redesigned its parking lot and used vegetated swales rather than conventional stormwater management to convey stormwater runoff. This design saved $78 000 (US) in construction costs (Taylor 2005).

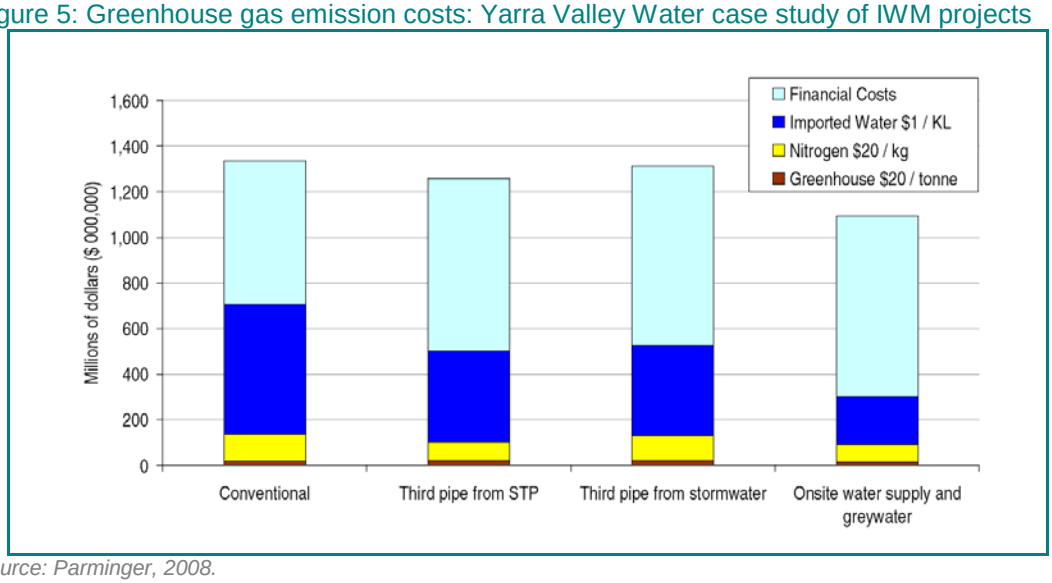
Rather than administered externality pricing for water, it would be more appropriate for project proponents to seek contributions from developers or councils that directly benefit.

Effects on greenhouse gas emissions

Various activities associated with urban water supply, use and disposal can affect greenhouse gas concentrations in the atmosphere. Direct influences on greenhouse gas concentrations include manufacturing concrete for infrastructure construction and incorporating trees, which sequester greenhouse gases, into water infrastructure design. Indirect influences include using energy from fossil fuels to power infrastructure (e.g. treatment processes or pumping to transport water or wastewater).

Some IWM projects, such as local recycling, involve fewer greenhouse gas emissions than traditional sources requiring treatment to potable standard or desalination. Proponents of IWM projects see this as a positive external effect that should be considered in project evaluation. However, the establishment of an economy-wide carbon price or emissions trading scheme in Australia is likely to be the best way of internalising greenhouse gas emissions. Even so, the impact of better accounting for greenhouse gas emissions on the selection of projects is often likely to be small. For example, data from a Yarra Valley Water case study of conventional and IWM projects shows that the greenhouse gas costs account for a fraction of direct financial costs (see Figure 5).

Figure 5: Greenhouse gas emission costs: Yarra Valley Water case study of IWM projects



Source: Parminger, 2008.

Effects of water infrastructure on flood mitigation

The construction of some IWM projects can reduce the incidence of localised flooding (e.g. through the construction of wetlands). This can have external benefits to local residents by reducing the risk of property damage. For example, Taylor (2005) reports that a contingent valuation study conducted in the New England region of the United States estimated the value that wetlands provided in minimising flooding, protecting water supply and improving water quality to be $77.15/acre/year (in 1993 US dollars). However, flood mitigation benefits

will depend on the nature of the current flood pattern and its impacts, and the extent to which the new water project changes the flood regime and damages incurred.

Effects of water use on green spaces and community wellbeing

Green spaces provide various community benefits such as recreation and visual amenity. In recent years, considerable effort has gone into identifying and, in some cases, valuing the various benefits of green spaces. Some studies identify many and varied benefits, such as health benefits from exercise and cultural and psychological benefits (e.g. see Byrne & Sipe, 2010).

Alternative sources such as recycled water and stormwater can provide a substitute for potable water to maintain green spaces such as public parks and gardens, particularly during dry periods when the use of potable water for outdoor watering is heavily proscribed. It has been argued that these benefits are positive externalities of IWM, and are not currently considered in the selection of urban water projects.

However, these arguments overlook the fact that the value of the benefits associated with green spaces is independent of the type of water used to maintain them. That is, people would derive the same benefit from playing in a green park whether it was watered with potable water, stormwater, or recycled water. Consequently, the main factor distinguishing different water sources, in terms of supporting green spaces, is their supply security and cost. The contribution to the security of an efficient portfolio of urban water sources is a core requirement for urban water service providers which should be internalised in investment decision making, regardless of the option selected.

Effects of water projects on human health and wellbeing through reduced urban heat island effects

In recent years some policymakers and academics have raised concerns about the adverse effects of a phenomenon known as the urban heat island effect. Heat islands form as cities replace natural land cover with pavements, buildings and other infrastructure, which contribute to higher urban temperatures. The potential negative effects of this environmental change include increased energy consumption (e.g. air conditioners), greenhouse gases, and compromised human health and comfort (US EPA, 2003). The US EPA has noted the urban heat island effect is particularly important from a human health perspective (i.e. mortality and morbidity), as high urban temperatures place urban inhabitants under heat stress, particularly during heat wave events. In Melbourne, a recent study found that, when minimum overnight temperatures exceeded 24 degrees, there was a 19 to 21 per cent increase in mortality for over-65-year-olds (Nicholls et al. 2008).

According to the US EPA, the sources of heat islands include:

- the construction of tall buildings and narrow streets, which can heat air trapped between them and reduce air flow
- operation of vehicles, factories and air conditioners, which may add warmth to their surroundings
- displacing trees and vegetation, which minimises the natural cooling effects of shading and evaporation of water from soil and leaves (evapotranspiration).

The Centre for Water Sensitive Cities (2011) and others have stated that IWM projects may mitigate the adverse impacts of the heat island effect. For example, IWM projects that

incorporate natural features such as wetlands are claimed to reduce this effect compared with conventional urban designs.

In our view, however, the source, transmission and effects of urban heat island externalities generally have a very tenuous connection to water use and investment. This significantly diminishes the likelihood that water externality pricing will be an effective tool for meeting related policy objectives (e.g. reduced mortalities during heat waves).

For example, water use and investment decisions would appear to have little to do with the first two sources of the heat island effect cited by the US EPA. The construction of tall buildings very close to each other is primarily an urban planning issue. Similarly, people's decisions to operate cars or machinery are more likely to be affected by energy-related policies.

While some IWM projects may lessen the displacement of trees and vegetation, their materiality on external costs such as mortality and morbidity during heat waves has not been established as far as we are aware. For example, the reduced risk of mortality among high-risk groups (e.g. elderly people living in the inner city) achieved by including wetlands in greenfield developments on the city's outskirts would seem negligible. It seems highly likely that more targeted and cost-effective tools for addressing this policy objective are available.

Despite these reservations, there is currently insufficient evidence to draw any definitive conclusions about the effects of IWM projects on urban heat island effects.

3.6.2 What is the current approach to managing the externality and is it effective and efficient?

Governments have encouraged IWM solutions with broader environmental and other public benefits in a variety of ways, including through grants and rebates, recycling targets, and other obligations. In addition, some urban water businesses have attempted to make decisions that fully reflect the economic, social and environmental costs and benefits (see NWC, 2011).

Currently, where implemented, IWM projects are generally funded by urban water customers and governments. There has been increased interest in the potential for encouraging activities with wider public benefits in the urban water sector. For example:

- The Australian Government's Green Precincts Fund is providing funding of $15 million over four years to support project initiatives that encourage water and energy savings measures at the community level. One of its program objectives is to deliver direct environmental benefits at project sites through water and energy efficiency measures.[12]
- The national Cities as Water Supply Catchments program aims to develop more efficient and effective approaches to urban water demand management and supply, and planning, including WSUD.[13]
- In 2009, the Australian Government provided $86 million to 13 organisations to undertake innovative stormwater capture projects to help secure water supplies for Australian cities.
- In 2010, the Australian Government announced $8.85 million funding for the Lower Hunter recycled water initiative in NSW.[14]

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[12] Green Precincts Fund <http://www.environment.gov.au/water/policy-programs/green-precincts/index.html>.

[13] National Cities as Water Supply Catchments program <http://www.nwc.gov.au/www/html/2713-cities-as-water-supply-catchments.asp?intSiteID=1>.

In addition, several state governments have already imposed policies aimed at internalising greenhouse gas emission costs in relation to urban water sources. For example, they have required the energy for new desalination plants to be offset with renewable power sources. In some cases, government-owned water businesses have elected to offset greenhouse emissions independently. However, this has been questioned by some. For example, the Chairperson of the Victorian Water Regulator, Dr Ron Ben-David (2010) noted:

> *During the last price review, quite a number of water authorities put forward proposals to reduce their emissions. To a small extent this involved changes to 'production' processes, but more typically this involved purchasing carbon offsets. In other words, and for completely noble reasons, these water authorities wanted to pay someone else to plant trees or collect methane from waste as a means for acquitting their own greenhouse gas emissions. This quest for carbon absolution ran into millions of dollars and we were being asked to approve higher prices in order to cover these costs in full.*
>
> *There was no business case made for the purchase of offsets. There was no robust testing of customers' willingness to pay for these offsets. There was no clear government requirement for the water authorities to offset their emissions.*

As noted in research undertaken by the National Urban Water Governance Program in Brisbane, there are a number of possible barriers to the uptake of WSUD other than financial considerations. These include concerns about public health, regulation and approval processes, and management arrangements and responsibilities. Recommended actions from this research include an independent scientific review to clarify the public health risks associated with WSUD and the delivery of dedicated capacity-building initiatives as part of large, local WSUD demonstration projects (Taylor, 2007).

The main concerns about the effectiveness of the current approach to funding IWM projects to secure external benefits are that:

- the benefits are often uncertain
- public funding may not be proportional to public benefits due to inadequate assessment of the full costs and benefits
- funding contributions may be best sought directly from the beneficiaries (e.g. developers).

3.6.3 What are the externality pricing options?

Pricing could provide incentives for activities with positive external effects (such as pollution abatement from stormwater capture or visual amenity benefits from WSUD). The idea is to decrease the financial cost of undertaking the activity (either through a price discount or subsidy) to encourage more of the activity (and thereby more external benefits). Rather than subsidies for projects, pricing could be used to provide incentives for measureable beneficial outcomes. Such an approach may be more effective than project-based grants, and may encourage innovation from a broader range of participants. Other pricing options include:

- **Co-funding investment:** this involves directly valuing positive externalities associated with projects (e.g. visual amenity benefits, greenhouse benefits) and providing co-funding for projects based on estimated public benefits.

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[14] DSEWPC <http://www.environment.gov.au/water/policy-programs/urban-water-desalination/stormwater-reuse/index.html>.

- **Tendering for specific environmental outcomes**: this involves governments tendering for specific environmental outcomes that lead to broader public benefits. For example, the government could pay $X per tonne of pollution abatement from stormwater capture. In the rural sector, governments have run tenders for farmers to undertake works that support environmental services including improvements in water quality (e.g. Bush tender, Ecotender).
- **Altering variable recycled water charges:** One of the positive externalities associated with recycled water is the avoided environmental costs from reduced wastewater discharges to the environment. Proposed options for pricing this positive externality include water charge discounts for variable charges. For example, participants in the ERA's inquiry into recycled water pricing in Western Australia suggested decreasing variable charges for recycled water by a set amount commensurate with associated environmental benefits, such as reduced outfalls from treatment plants (ERA, 2009).

3.6.4 What are the costs, benefits and implementation issues associated with externality pricing?

As noted in the preceding discussion, it is highly likely that other policy instruments will be more appropriate than water pricing in promoting the optimal provision of some positive external benefits. For example, town planning and energy policies are more likely to have a discernable effect on heat island effects than governments intervening in water pricing. Moreover, some these benefits do not appear to be linked to particular water sourcing options.

Notwithstanding these issues, there may be cases where water-related activities result in genuine public benefits (e.g. stormwater pollution abatement) that warrant government intervention (e.g. through funding) to achieve the optimal outcome for society. Even where the net benefits of government intervention to promote projects with external benefits are uncertain, transparent pricing and market mechanisms can at least help achieve these objectives in a more cost-effective manner.

Given government commitments to IWM, a key issue is how to get the most out of government funding directed at such projects and ensure legitimate external benefits are appropriately recognised in project evaluation.

The first step is to clarify the environmental objectives being sought. For example, if the government has already committed funding to reduce nitrogen loads discharged to a waterway, the main issue is achieving this reduction in a cost-effective manner. Pricing would enable the proponents of IWM projects to compete for government funds with a range of other mitigation projects based on dollars per tonne of abatement. Similarly, developers of stormwater projects that mitigate specific pollutants could potentially enter into offset arrangements with other developers that cannot meet regulatory requirements on-site. The benefits of these projects would be to reduce the total cost of achieving environmental objectives.

In some cases, governments may want to know the value of external benefits in dollar terms because there are multiple benefits that need to be assessed on a comparable basis (e.g. recreation benefits, pollution abatement etc.). This process can be much more complex and information-intensive. While some external costs (e.g. those associated with greenhouse gas emissions) have been quantified, other benefits are site-specific and often difficult to value (e.g. impacts on rivers, amenity benefits from landscape change).

Despite these challenges, the reality is that several governments are already funding IWM projects and funding decisions have been made based on limited information. Efforts to

improve the rigour, accuracy and consistency of approaches to valuing non-market benefits would promote value for money for taxpayer funds and efficient investments in IWM projects.

More recently, several papers and guidelines have been published on how to incorporate external benefits into project evaluation. For example, Melbourne Water (2007) has prepared guidelines for undertaking triple-bottom-line assessments including approaches to addressing external benefits and costs. As discussed elsewhere in this study, the literature is accruing on how to attach values to particular external costs and benefits. The Environmental Valuation Reference Inventory is a searchable storehouse of empirical studies on the economic value of environmental benefits and human health effects.[15]

A key challenge for efficient IWM investment is developing ways to effectively transfer knowledge from academic and technical studies to the government agencies responsible for funding projects and, in particular, making assessments more practical and cost-effective. Rather than providing high-level guidance that government agencies then need to interpret within the limited time and resources available, there is a case for going to the next level of detail and providing them with an accessible decision-making tool and practical examples that embody best-practice assessment processes.

A key factor influencing the cost-effectiveness of undertaking these assessments is the site-specific nature of urban water externalities. As noted by Young (1996), for example, water values tend to be quite site-specific and each case confronts its own unique issues, and typically requires its own original evaluation. One way to address this issue may be to develop an assessment tool for undertaking cost-benefit analysis and non-market valuation, which states could adapt to their specific circumstances. For example, in the late 1990s and early 2000s, the Victorian Government developed standardised rapid appraisal methods for assessing the costs and benefits of interventions in incidences of flooding, water quality concerns such as blue-green algal blooms, and river health management. These methods were then applied across the state to interventions in each catchment management authority region (Read Sturgess & Associates, 2000). Such rapid appraisal methods are means of standardising assessments to make analysis quicker and more accurate and consistent. Developments in standardising cost-benefit analyses include defining ‘unit values’ (i.e. for benefit transfer), specifying data requirements and developing standardised calculation templates.

While the immediate appeal of this approach is the significant cost and time saving for the government, a major additional benefit is that it increases the comparability of results across assessments. This aids priority setting and enables better decision-making about optimal allocation of funds across regions. Rapid assessment tools and methods can evolve over time, building on previous assessments. Smith (1992) has recommended the establishment of a database of valuation studies to facilitate future benefit transfer and meta-analysis. A similar approach could be applied for assessment of IWM and other water projects.

We note the national Cities as Water Supply Catchments program is attempting to develop robust decision tools to effectively evaluate the full economic costs and benefits of new technologies.

3.6.5 Conclusions on the merits of externality pricing

Despite the challenges in valuing positive externalities, governments are already funding IWM projects and funding decisions have been made based on limited information. Hence, efforts

[15] The EVRI database can be referenced at https://www.evri.ca/Global/Splash.aspx. Last accessed 25 August 2010.

to improve the rigour, accuracy and consistency of approaches to valuing non-market benefits would promote value for money for taxpayer funds and efficient investments in IWM projects.

Externality pricing signals for particular attributes may be one approach to encourage the uptake of efficient IWM projects, once there is greater clarity on the value of these benefits. It may be seen as a way of removing an impediment to the adoption of alternative water sources such as recycled water and WSUD, including by the private sector. It may also be considered as an alternative to direct government funding of particular projects and/or regulatory approaches (e.g. recycling targets). A pricing instrument would provide a means of providing greater transparency around the value of specific positive externalities.

However, arguably, such transparency could and should be provided under current funding approaches. In addition, there will often be significant private incentives to consider 'external benefits' associated with IWM projects in investment decisions, such as the local amenity benefits of urban lakes which would be captured mainly by residents and incorporated in land values. Care is therefore required to ensure that government funding (via pricing or subsidies) does not crowd out funding from the direct beneficiaries, who are better placed to value many localised benefits. IWM project proponents should seek to obtain funding contributions directly from the beneficiaries (e.g. land developers) where the benefits accrue to a localised and clearly defined set of beneficiaries.

4 Conclusions and recommendations

4.1 Conclusions

This report helps to identify and define positive and negative externalities throughout the urban water cycle. Based on recognised policy principles, the framework developed in Section 2 illustrates that the presence of externalities may warrant government intervention to improve welfare outcomes for society by better aligning marginal social costs and benefits. Pricing is one of many options for addressing externalities. In theory, its key advantage is that it can be a more flexible and cost-effective means of meeting overall environmental objectives compared with prescriptive 'one size fits all' regulations. However, in all cases, governments should clearly define the nature and extent of the externality problem, consider a range of policy options to address it (including pricing and doing nothing), assess the benefits and costs of each policy option, and adopt the option or instrument that generates the greatest net benefit for the community (see COAG, 2007).

In most cases, externalities associated with the urban water cycle are already being managed through non-price means. Jurisdictions have generally adopted an approach based on regulation, planning and property rights (entitlements), with the costs of water planning and management passed on to users in a limited number of cases. In our view, there have been improvements in the management of some externalities in urban water during the past decade and this limits the circumstances under which additional externality pricing is likely to be worthwhile.

There is a broader debate about whether current arrangements are optimal. In many cases, this is not about the choice of policy instrument (i.e. pricing versus regulation) but rather debate about the optimal level of intervention (e.g. the right limits on the quality of effluent or the right share of water entitlements assigned to the environment). Demonstrating that intervention to manage externalities is optimal is extremely difficult due to technical and economic challenges in measuring, attributing and valuing the impact of an activity on third parties and the environment. These difficulties affect all approaches to managing externalities and are particularly evident in relation to efforts to assess the externality benefits of integrated water management (IWM) options. By its very nature, pricing externalities may be particularly prone to contested views on the appropriate level of intervention.

Care is also needed in the selection and application of policy instruments for managing externalities. In particular, it is important that externality pricing not be overlayed on top of an existing regulatory mechanism used to address the same issue. Duplicating policy instruments can lead to efficiency losses.

In this context, changing tack in the management of externalities by adopting externality pricing options needs to be considered carefully, on a case-by-case basis. If the main issues relate to determining the appropriate level of intervention, then technical and economic research and community engagement is required. In most cases, governments should first consider the merits of improving the current instruments, and ensuring that the full efficient costs of water planning and management are recovered from users.

Externality pricing is likely to be most feasible where:

- there are material externalities in the urban water cycle
- there are significant differences in the costs of addressing the externality across different parties and existing mechanisms are inflexible
- changes in price are likely to change behaviour or encourage innovation

- the activity can be measured and monitored accurately and cost-effectively.

Our applications in Section 3 show that, in many cases, these conditions do not hold, such as in relation to the management of externalities associated with diffuse sources of stormwater runoff and pollution. In other cases, existing arrangements obviate the need for further externality pricing. For example, where quantity-based property rights measures exist, attempting to use pricing to manage the impacts of water extraction is likely to be confusing and ineffective. In limited circumstances, externality-pricing may augment current approaches, such as in managing wastewater discharges to the environment.

An overarching theme is the difficulty in assessing the true value of any externalities, which is the primary barrier to implementing regulatory and/or pricing mechanisms that ensure the optimal level of externality. Overall, however, current arrangements appear to operate effectively to mitigate known negative externalities related to the urban water cycle, while information on positive externalities is so sparse that limited conclusions can be drawn on whether these are adequately encouraged or not.

Often in the urban water sector, accountability and management lies with bodies outside of central government agencies such as water businesses and local government. A key consideration in the management of externalities is identifying which entity is accountable for a specific aspect of the urban water cycle and whether there is a role for governments in managing a specific problem. Governments may not always be the best party to manage and be directly accountable for externalities. Governments therefore need to consider and determine which entity or organisations are best placed to manage and decide on the tools and instruments needed to effectively manage urban water externalities.

The framework developed in this report and the high-level applications provide a means of sensibly progressing the debate about externality pricing, and the management of externalities in the urban water cycle more generally.

4.2 Recommendations

It is recommended that all jurisdictions:

- determine the source and materiality of urban water externalities of concern to the community
- determine which party has management accountability and which is best placed to manage the specific externalities of concern
- assess the effectiveness of the current approach to managing these externalities
- assess the potential to improve the current approach or adopt alternatives including externality pricing
- clarify the preferred approach to managing urban water externalities – by reporting to COAG
- ensure arrangements are in place for recovering the efficient costs of water planning and management in accordance with the 2010 NWI pricing principles
- clarify the policy objectives and means of funding IWM projects that produce positive externality benefits
- periodically monitor, evaluate and publicly report on the outcomes and effectiveness of current approaches to managing externalities.

Nationally, there is a major need to improve the technical and economic evaluation of urban water externalities to enable policymakers to make decisions about their optimal management. This requires efforts to better link urban water activities to measureable and attributable effects and evaluating these effects in economic terms, where possible. In this regard, the Commission may be well placed to collate, synthesise and disseminate the findings of existing projects and research around Australia.

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Appendix A - Examples of urban water externalities

This table identifies some types of urban water cycle externalities according to the source, transmission and effect.

Table 3: Urban water-related externalities

Source	*Transmission*	*Effects*
a) What is the activity? **b) Who undertakes the activity?**	**What changes to environmental condition can occur?**	**Who can be affected? Are the effects costs or benefits?**
Infrastructure/source development a) Creation of new water supply infrastructure (e.g. dams, desalination, pipes, stormwater) or wastewater infrastructure. b) Government water businesses (or other suppliers) or property developers.	**Dams** Hydrology – creation of water bodies reduces flow downstream. Habitat – water bodies reduce submerged habitat downstream. Ecology – obstruct fish passage. **Desalination/recycling** Habitat – construction may have impacts on coastal areas. **Interconnector pipes** Habitat – creation of easements affects the landscape. **Water sensitive urban design** Hydrology – changes to urban landscape (e.g. wetlands to capture stormwater) can reduce discharges to rivers and ocean and reduce local flooding. Habitat – urban design affects urban landscape appearance. **General** GHG emissions from construction/materials. Creation of local microclimates from water bodies (dams, wetlands). Temporary disturbances of environment during construction.	**Dams** Locals -– reduced flooding (+); impacts on amenity (+/-). Recreation – improved local recreational opportunities (+); reduced fishing or bathing opportunities downstream (-). Public – Existence and option values of biodiversity/habitat (-). **Desalination/recycling/pipes** Locals/tourists – amenity of landscape (-). **Water sensitive urban design** Locals/tourists – improved visual amenity from landscape design (+), reduced flooding (+). Downstream residents/tourists – fewer algal blooms (+). **General** Global – increase in GHG emissions linked to climate change and associated effects (-) Locals – health/amenity effects from changes in ambient temperature (+/-). Nuisance for locals and tourists from construction activities (-).
Infrastructure/source operation a) Activities relating to operating the source (harvesting, operating desalination). b) Water business/supplier.	**Dams/surface or groundwater extraction** Hydrology – dam operation/water extraction can affect river volumes, flow heights and flow variability. Groundwater extraction can affect watertable heights. Ecology/habitat – divergence from natural flow regime affects biodiversity/habitat.	**Dams/surface or groundwater extraction** Locals/tourists – reduced amenity values of waterways (-). Public – existence values of biodiversity/habitat (-). **Desalination** Global – increase in GHG emissions linked to climate

Source	*Transmission*	*Effects*
	Desalination GHG emissions from energy use. Potential increase in noise from plant operation. Discharge of brine/chemicals may affect marine environment. **Reuse/recycling** Odour and supply leaks from reuse systems.	change and associated effects (-) Locals/tourists – nuisance from noise and odour (-); reduce recreation such as fishing (-) Public – effects on existence values for marine environment (-) **Reuse/recycling** Public – health risks associated with exposure to pollutants (-).
Water transport and distribution a) Water is transported from the source to the customer via the bulk network and/or local distribution system **b)** Water business/supplier	Hydrology – Outfalls/leakage/ spillages of potable, recycled water.	Locals – damage to property from flooding (-), health risks (-).
Water use/ reuse a) Use of different water sources (potable, recycled and stormwater). b) Residents/industrial customers.	Water quality – contamination of land or crops from water reuse.	Locals – health risks from contaminated water (-). Irrigators – lost production due to water contamination (-).
Wastewater disposal a) Disposal of wastewater to sewers, rivers. b) Water businesses (water treatment plant)/water users/industry.	Water quality – transport of nutrients, salts or chemicals to waterways; increased concentration of harmful substances in sewerage system. Ecology – changes in water quality leading to algal blooms. Habitat – damage to seagrasses.	Water business – damage to infrastructure (corrosion), health risks to workers from exposure to harmful substances (-). Downstream users – health risk (e.g. drinking water quality)(-) Irrigators – lost production due to water contamination (-). Public – existence values of biodiversity/habitat (-)
Other sources a) Activities not directly related to the supply, use or disposal of urban water but that affects water quality (e.g. land management practices, diffuse sources of urban pollution to waterways via stormwater). b) Urban developers, irrigators, plantations, dryland agriculture, motor vehicles, people installing galvanised roofing, pets.	Changes in water/stormwater quality and volume. Damage to river banks/flooding from peak stormwater flows. Increased concentration of potentially harmful substances in sewerage system/waterways.	Locals/workers – health risks (-). Recreation – impacts on waterway health (-). Public – existence values of biodiversity/habitat downstream (+/-). Locals – damage to property from flooding (-).

Source: Based on Dwyer et al. 2006; Young, M 2000; van Bueren, M & Hatton MacDonald, D 2004.