A Business Case for Best Practice Urban Stormwater Management

Version 1.1 – September 2010

Water by Design is a program of the South East Queensland Healthy Waterways Partnership

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Disclaimer

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Water by Design welcomes feedback on this publication, which can be directed to info@waterbydesign.com.au.

Water by Design

Water by Design was established in 2005 and is a program of the South East Queensland Healthy Waterways Partnership. Water by Design builds the capacity of the water and urban development sectors to help successfully implement sustainable urban water management in South East Queensland. Sustainable management of the urban water cycle supports sustainable development, including protection of the natural water cycle.

South East Queensland Healthy Waterways Partnership

The South East Queensland Healthy Waterways Partnership is a collaboration between government, industry, researchers and the community. The Partnership was created in 2001. The partners work together to improve catchment management and waterway health in Moreton Bay and the rivers of South East Queensland between Noosa and the Queensland–New South Wales border. The South East Queensland Healthy Waterways Partnership developed and implemented the *South East Queensland Regional Water Quality Management Strategy* (2001) and its successor, the *South East Queensland Healthy Waterways Strategy 2007–2012* (2008). The Partnership also manages the Ecosystem Health Monitoring Program, which produces an annual report card on the health of the region's waterways, estuaries and bays.

Further information on the SEQ Healthy Waterways Partnership and the Water by Design Program is available from www.healthywaterways.org and www.waterbydesign.com.au.

This document is available for download from www.waterbydesign.com.au.

Executive summary

Many economic, ecological and social values can be seriously affected by a decrease in waterway health. One of the main impacts on waterway health in urban areas is stormwater runoff. Given population and urban development forecasts, a business-as-usual approach to development will accelerate a decline in the health of Queensland's waterways. Managing the negative impacts of urban development, such as increased stormwater flows, and the sediment and nutrient loads associated with these flows, is a priority to ensure the continued health of waterways and their services.

The draft *State Planning Policy for Healthy Waters* (the draft policy) promotes best practice stormwater management for development across Queensland to protect the environmental values of waterways. A key mechanism of the policy is setting design objectives for managing stormwater quality, waterway stability and frequent flows. These design objectives can be achieved by adopting Water Sensitive Urban Design (WSUD). WSUD is an approach to planning and design that aims to ensure urban development is sensitive to natural hydrological and ecological cycles by conserving water supplies, minimising wastewater, and managing stormwater quality and flows. Typical best management practices include erosion and sediment control during construction, rainwater tanks, swales, porous pavements, bioretention systems (raingardens), constructed wetlands, infiltration systems and stormwater harvesting and reuse schemes.

The costs associated with delivering WSUD are often perceived as a barrier to its widespread adoption. **This business case has been prepared to determine if the benefits of applying WSUD practices to achieve best practice stormwater management are *likely* to outweigh the costs for typical development types**.

A simple cost–benefit framework was developed and populated with the likely costs and benefits of using WSUD practices to meet the proposed design objectives for typical low density residential, medium to high density residential, and commercial and industrial developments. The design objectives for erosion and sediment control during the construction phase of urban development were not assessed as part of this business case. Data was gathered through:

- a literature review
- semi-structured interviews with industry stakeholders
- case study assessments of six different development types in Brisbane, Mackay, Townsville and Cairns.

The case study assessments were also used to confirm the practicality of meeting the proposed design objectives using WSUD practices.

Limitations associated with quantifying the benefits meant that it was not possible to conduct a solely quantitative cost–benefit analysis. However, the completed frameworks bring together both quantitative and qualitative values of likely benefits and costs to assist in approximating the net benefit. The benefits include stormwater pollutant load reductions, potentially avoided waterway rectification and maintenance costs, potential property premiums associated with the application of WSUD, and avoided infrastructure costs on flat sites (i.e. <5% grade).

The literature review found that key benefits of best practice urban stormwater management are likely to include:

- reduced pollutants loads discharged to waterways relative to unmitigated urban development, which is estimated to be a potential annual saving of $515 per kilogram of TN removed
- reduced need for rehabilitation and maintenance of downstream waterway environments, which can range from $200–$3,000 per metre of stream per annum
- premiums on land values due to enhanced amenity values and local and regional water quality, which have been estimated to range from 0.25 to 1.0% percent
- educational benefits.

Best practice urban stormwater management will also assist to preserve and enhance waterway-based recreation, current commercial values of waterways such as tourism and commercial fishing, and important non-market values such as the intrinsic value of aquatic ecosystems.

The cost–benefit frameworks, reproduced in the Executive Summary as Tables ES.1 to ES.3, **demonstrate that the benefits of using WSUD practices to achieve best practice urban stormwater management on typical residential, commercial and industrial developments in Queensland are *likely* to exceed the costs.** The potential *quantifiable* benefits alone are likely to outweigh the costs. For example:

- the value of pollution reduction (i.e. total nitrogen only) is estimated to be worth more than the life cycle cost of WSUD assets
- the potential avoided waterway rehabilitation life cycle costs are estimated to be worth around 70% of the life cycle cost of WSUD assets
- the potential property premiums are estimated to be around 90% of the capital cost of WSUD assets.

There are also many important *unquantifiable* benefits of urban stormwater management, such as the contribution towards maintaining the health of aquatic ecosystems and the services they provide.

In addition to presenting the likely net benefit of best practice urban stormwater management, this business case also determined a number of key points:

- When implemented well (such as being considered appropriately at the material change of use or reconfiguration of a lot stage of development), WSUD practices can be accommodated within developments without loss of developable land.
- WSUD has sufficient flexibility to comply with the current town planning provisions of local governments' while meeting the broader requirements of the draft policy.
- Geographic location influences the size of the WSUD treatment systems required and therefore the cost. Where rainfall is higher, treatment systems generally need to be slightly larger to achieve the stormwater quality objective when rainwater tanks are included in the treatment train. For example, the size of a bioretention filter area in an urban renewal development is 1.1% of the total catchment area in Brisbane, but 1.6% is required in Cairns.
- The cost of applying WSUD practices to achieve best practice stormwater management should not significantly impact on the profitability of residential, commercial and industrial developments. For example, the acquisition (capital and design) costs of establishing WSUD to meet the stormwater management design objectives for residential developments are typically less than 1% of the cost of a new dwelling. The capital cost of WSUD is of a similar magnitude to the potential property premium attributable to improved water quality in local waterways.
- For residential developments, WSUD-related costs are likely to be borne by local householders, while benefits are distributed over a wide range of geographic, social and temporal scales. For commercial or industrial developments, the costs may either be borne by the tenants (reflected in marginally higher rents) or the owners (reflected in marginally higher capital or purchase costs).

The business case assessment illustrates that by adopting WSUD practices for best practice stormwater management, the stormwater management design objectives established by the draft *State Planning Policy for Healthy Waters* and its supporting codes and guidelines can be practically achieved for typical urban developments captured by Queensland's Integrated Development Assessment System. In addition to being practical, the assessment suggests that the widespread application of best practice stormwater management using WSUD practices to new development in Queensland *should* produce a net benefit to society.

Table ES.1 WSUD cost–benefit framework: low-density residential developments

SEQ HWP

SEQ HWP

Shaun Leinster

Example bioretention systems in low density residential development

LIKELY COSTS FOR TYPICAL DEVELOPMENTS

Major quantifiable costs (estimated)

1. **Acquisition (capital + design) costs** *(Note: included in life cycle cost):*
   - $1,600–$4,000/lot (average = $2,800/lot)
   - $21,100–$39,750/ha (average = $30,425/ha).
2. **Annual maintenance costs** *(Note: included in life cycle cost):*
   - $20–$40/lot (average = $30/lot)
   - $260–$520/ha (average = $390/ha).
3. **Life cycle costs (acquisition + maintenance + renewal + decommission):**
   - $2,365–$5,410/lot (average = $3,890/lot)
   - $29,675–$71,690/ha (average = $50,680/ha).
4. **Annualised life cycle costs (acquisition + maintenance + renewal + decommission):**
   - $95–$215/lot (average = $155/lot)
   - $1,185–$5,410/ha (average = $3,330/ha).

Minor potential costs:

- Additional development assessment, compliance checking and enforcement costs associated with WSUD assets (relatively minor and reducing over time as WSUD becomes mainstream practice).
- Potential increase in maintenance tasks for residents (for at source or streetscape WSUD).
- Environmental costs associated with sourcing materials for the WSUD measures (e.g. biofiltration media).

LIKELY BENEFITS FOR TYPICAL DEVELOPMENTS

Major quantifiable potential benefits (estimated)

1. **Value of the reduction in TN loads in stormwater:**
   The equivalent wastewater treatment cost to remove annual TN loads:
   - $2,110–$5,150/ha/yr (average = $3,630/ha/yr)
   - 95%–180% of the annualised life cycle cost of the WSUD treatment train (average = 110%).
2. **Potentially avoided costs associated with downstream waterway rehabilitation and maintenance:**
   - $8,000–$60,000/ha (life cycle cost) of development (average = $34,000/ha of development)
   - 25%–85% of the life cycle cost of the WSUD treatment train (average = 67%).
3. **Potential increase in property values (premium):**
   - $11,000–$44,000/ha (average = $27,500/ha)
   - 52%–110% of the acquisition cost of the WSUD treatment train (average = 90%).
4. **Potential development costs that are avoided (applicable only on flat sites, i.e. < 5%):**
   - $36,000/ha
   - 120% of the average acquisition cost of the WSUD treatment train.

Major unquantifiable potential benefits

Contribution to protecting the numerous values associated with healthy downstream waterways:

- ecosystem services (which may include some of the benefits below)
- recreational and commercial fishing
- tourism
- seafood industry
- option, existence and bequest values.

Community amenity at local and regional scale (i.e. connection to water cycle).

The monetary value of many of these unquantified benefits is very high (see Table 4.2), but the relationship between the application of WSUD in a catchment and the maintenance of these values in downstream waterways has not been quantified.

Minor potential benefits

- Increased rate of sales and amenity associated with developments with landscaped WSUD features, such as streetscape bioretention systems (see Lloyd et al., 2002).
- Shading and urban cooling (potentially reducing energy consumption).
- Some direct and indirect aspects of implementing WSUD will result in changes to the configuration of development that could enhance open space.
- Education and research.

Conclusions regarding the relative magnitude of likely costs and benefits:

Considering all the costs and all the potential benefits of applying WSUD to achieve the proposed stormwater management design objectives, it is concluded that the **benefits are *likely* to outweigh the costs for typical low-density residential development in Queensland.**

The estimated acquisition costs of applying WSUD within low-density residential developments equate to an average cost of approximately $2,800 per dwelling. This value is equivalent to 0.7% of a house and land package worth $400,000. This cost will usually be passed onto the homeowner, so it should not significantly impact the profitability of development.

The estimated annual maintenance costs are an average of $30/year. Where councils undertake the maintenance of WSUD assets in public areas, this cost is likely to be passed onto homeowners via rates.

Considering just the quantifiable benefits, on average, the value of TN reduction is worth more than the total life cycle cost of WSUD measures. The potentially avoided waterway rehabilitation costs (expressed as life cycle cost) are worth around 67% of the life cycle cost of WSUD and the potential property premiums are worth around 90% of the acquisition cost of WSUD. Considering the quantifiable benefits in a lumped group, *the potential quantifiable benefits are likely to outweigh the costs.*

Table ES.2 WSUD cost-benefit framework: medium to high-density developments


Alan Hoban


Shaun Leinster


SEQHWP

Example of bioretention systems in medium to high density residential development

LIKELY COSTS FOR TYPICAL DEVELOPMENTS

Major quantifiable costs (estimated)

1. **Acquisition (capital + design costs** *(Note: included in life cycle cost):*
   - $350–$1,200/lot (average = $775/lot)
   - $29,680–$46,180/ha (average = $37,930/ha).
2. **Annual maintenance costs** *(Note: included in life cycle cost):*
   - $3–$40/lot (average = $22/lot)
   - $260–$520/ha (average = $390/ha).
3. **Life cycle costs (acquisition + maintenance + renewal + decommission):**
   - $345–$1,670/lot (average = $1,110/lot)
   - $40,135–$71,720/ha (average = $55,930/ha).
4. **Annualised life cycle costs (acquisition + maintenance + renewal + decommission):**
   - $15–$65/lot (average = $45/lot)
   - $1,615–$2,870/ha (average = $2,240/ha).

Minor potential costs:

- Additional development assessment, compliance checking and enforcement costs associated with WSUD assets (relatively minor and reducing over time as WSUD becomes mainstream practice).
- Potential increase in maintenance tasks for residents (for at source or streetscape WSUD).
- Environmental costs associated with sourcing materials for the WSUD measures (e.g. biofiltration media).

LIKELY BENEFITS FOR TYPICAL DEVELOPMENTS

Major quantifiable potential benefits (estimated)

1. **Value of the reduction in TN loads in stormwater:**
   The equivalent wastewater treatment cost to remove annual TN loads:
   - $2,470–$5,930/ha/yr (average = $4,200/ha/yr)
   - 150%–205% of the annualised life cycle cost of the WSUD treatment train (average = 185%).
2. **Potentially avoided costs associated with downstream waterway rehabilitation and maintenance:**
   - $8,000–$60,000/ha (life cycle cost) of development (average = $34,000/ha of development *(value estimated using a low-density residential development case study)*
   - 20%–85% of the life cycle cost of the WSUD treatment train (average = 60%).
3. **Potential increased property values (premium):**
   Medium density:
   - $35,000–$70,000/ha (average = $52,500/ha)
   - 120%–150% of the acquisition cost of the WSUD treatment train (average = 135%).

   High density:
   - $175,000–$350,000/ha (average = $262,500/ha)
   - 480%–700% of the acquisition cost of the WSUD treatment train (average = 520%).
4. **Potential development costs that are avoided (applicable only on flat sites, i.e. <5%):**
   - $36,000/ha
   - 95% of the average capital cost of the WSUD treatment train.

Major unquantifiable potential benefits

Contribution to protecting the numerous values associated with healthy downstream waterways:

- ecosystem services
- recreational and commercial fishing
- tourism
- seafood industry
- option, existence and bequest values.

The monetary value of many of these unquantified benefits is very high (see Table 4.2), but the relationship between the application of WSUD in a catchment and the maintenance of these values in downstream waterways has not been quantified.

Minor potential benefits

- Increased rate of sales and amenity associated with developments with landscaped WSUD features, such as streetscape bioretention systems (see Lloyd et al., 2002).
- Shading and urban cooling (potentially reducing energy consumption).
- Some direct and indirect aspects of implementing WSUD will result in changes to the configuration of development that could enhance open space.
- Education and research.

Conclusions regarding the relative magnitude of likely costs and benefits:

Considering all the costs and all the potential benefits of applying WSUD to achieve the proposed stormwater management design objectives, it is concluded that the **benefits are *likely* to outweigh the costs for typical medium to high-density residential development in Queensland.**

The estimated acquisition costs of applying WSUD within medium- to high-density residential developments equate to an average cost of approximately $775 per dwelling. This value is equivalent to 0.2% of a unit or townhouse worth $350,000. This cost will usually be passed onto the homeowner, so it should not significantly impact the profitability of development.

The estimated annual maintenance costs are an average of $22/year. Where councils undertake the maintenance of WSUD assets in public areas, this cost is likely to be passed onto homeowners via rates.

Considering just the quantifiable benefits, on average, the value of TN reduction is worth more than the total life cycle cost of WSUD measures. The potentially avoided waterway rehabilitation costs (expressed as life cycle cot) are worth around 67% of the life cycle cost of WSUD and the potential property premiums are worth around 90% of the acquisition cost of WSUD. Considering the quantifiable benefits in a lumped group, *the potential quantifiable benefits are likely to outweigh the costs.*

Table ES.3 WSUD cost-benefit framework: commercial and industrial developments


SEQ HWP

Robin Allison


SEQHWP

Example bioretention systems in commercial and industrial developments

LIKELY COSTS FOR TYPICAL DEVELOPMENTS

Major quantifiable costs (estimated)

1. **Acquisition (capital + design) costs** *(Note: included in life cycle cost)*:
   - $42,900–$54,750/ha (average = $48,825/ha).
2. **Annual maintenance costs:** *(Note: included in life cycle cost)*:
   - $390–$490/ha (average = $440/ha).
3. **Life cycle costs (acquisition + maintenance + renewal + decommission):**
   - $58,270–$73,485/ha (average = $65,880/ha).
4. **Annualised life cycle Costs (acquisition + maintenance + renewal + decommission):**
   - $2,330–$2,940/ha (average = $2,635).

Minor potential costs:

- Additional development assessment, compliance checking and enforcement costs associated with WSUD assets (relatively minor and reducing over time as WSUD becomes mainstream practice).
- Environmental costs associated with sourcing materials for the WSUD measures (e.g. biofiltration media).

LIKELY BENEFITS FOR TYPICAL DEVELOPMENTS

Major quantifiable potential benefits (estimated)

1. **Value of the reduction in TN loads in stormwater:**
   The equivalent wastewater treatment cost to remove annual TN loads
   - $4,430–$11,280/ha/yr (average = $7,860/ha/per)
   - 190%–380% of the annualised life cycle cost of the WSUD treatment train (average = 300%).
2. **Potentially avoided costs associated with downstream waterway rehabilitation and maintenance:**
   - $8,000–$60,000/ha (life cycle cost) of development (average = $34,000) (Value obtained for low-density residential development)
   - 15%–80% of the life cycle cost of the WSUD treatment train (average = 52%).
3. **Potential increase in property values (premium):**
   This value has not been quantified for commercial and industrial developments for these case studies.
4. **Potential development costs that are avoided (applicable only on flat sites, i.e. <5%):**
   - $36,000/ha
   - 75% of the capital cost (average) of the WSUD treatment train.

Major unquantifiable potential benefits

Contribution to protecting the numerous values associated with healthy downstream waterways:

- ecosystem services
- recreational and commercial fishing
- tourism
- seafood industry
- option, existence and bequest values.

The monetary value of many of these quantified benefits is very high (see Table 4.2), but the relationship between the application of WSUD in a catchment and the maintenance of these values in downstream waterways has not been quantified.

Minor potential benefits

- Shading and urban cooling (potentially reducing energy consumption).
- Enhanced streetscape amenity may deliver premium on rents received by landlords, as a result of potential increased patronage for retail and service businesses.

Conclusions regarding the relative magnitude of likely costs and benefits:

Considering all the costs and all the potential benefits of applying WSUD to achieve the proposed stormwater management design objectives, it is concluded that the **benefits are *likely* to outweigh the costs for typical commercial and industrial development in Queensland.**

The estimated acquisition costs of applying WSUD within commercial and industrial developments equate to an average cost of approximately $48,825 per hectare. Construction costs for commercial and industrial developments can range from about $10–$40 million per hectare. The cost of WSUD is therefore about 0.1%–0.5% of construction costs.

Considering just the quantifiable benefits, on average, the value of TN reduction is worth more than the total life cycle cost of WSUD measures. The potentially avoided waterway rehabilitation costs (expressed as life cycle cost) are worth around 67% of the life cycle cost of WSUD and the potential property premiums are worth around 90% of the acquisition cost of WSUD. Considering the quantifiable benefits in a lumped group, the *potential quantifiable benefits are likely to outweigh the costs.*

CONTENTS

1 Introduction

The draft *State Planning Policy for Healthy Waters* (the draft policy) promotes best practice stormwater management for urban development across Queensland to protect the environmental values of waterways. A key mechanism by which it does this is setting design objectives for managing stormwater quality, waterway stability and frequent flows. The design objectives can be achieved through adopting Water Sensitive Urban Design (WSUD) practices. However, the costs associated with delivering WSUD are often perceived as a barrier to its widespread adoption (Colmar Brunton, 2005).

A business case was undertaken to identify if the benefits of WSUD to achieve best practice stormwater management are likely to outweigh the costs. Specifically, the business case looked at the likely costs and benefits of using WSUD practices to meet the proposed design objectives in the draft policy for typical, low-density residential, medium- to high-density residential, and commercial and industrial developments. The design objectives for erosion and sediment control during the construction phase of urban development were not assessed as part of this business case. In addition, not all development types were addressed. For example, the business case does not cover some small developments such as 1 into 2, nor does it cover rural-residential developments.

This report provides the outcome of the business case, specifically:

- contextual information, including the need for urban stormwater management, an explanation of WSUD and a brief overview of the draft policy (Section 2)
- an explanation of the assessment method (Section 3)
- an overview of the cost and benefits (Section 4)
- key findings from the assessment, including populated cost–benefit frameworks that show the social, environmental, and financial costs and benefits for typical residential, commercial and industrial developments (Section 5)
- a summary and conclusion (Section 6).

Detailed case study information is available in a separate report titled *A Business Case for Best Practice Urban Stormwater Management: Case Study Report* (Water by Design, 2010) *(referred to as Case Study Report)*.

2 Context

2.1 Urban development and protecting waterway health

There is a direct link between urban development and waterway health. Urban development changes the natural hydrological cycle. The impervious areas of developments, such as roads, roofs, driveways and footpaths, prevent water from infiltrating and evapotranspiring. Stormwater is conveyed more frequently and in greater volumes than occurs naturally via a system of pits and pipes to receiving waterways. This causes waterway erosion and significant disturbance of in-stream ecology. If untreated, stormwater carries large volumes of pollutants such as nutrients, sediment and litter that can seriously impact the health of aquatic ecosystems. This is known as urban diffuse pollution.

Many waterways in urban areas in South East Queensland are not meeting waterway health objectives (SEQHWP, 2009) and freshwater coastal streams with the poorest water quality in South East Queensland are located downstream from areas of urban development (SEQHWP, 2005). This situation is expected to worsen given population growth, which is driving urban development.

Figure 2.1 illustrates that stormwater runoff from urban diffuse sources will represent the largest percentage growth in pollutant loads in South East Queensland waterways over the coming years, considering future population growth and urban growth estimates.

Queensland's waterways, however, have significant economic, ecological and cultural importance. For example, in South East Queensland:

- commercial fisheries and aquaculture are worth about $45 million per annum for the total value of the catch (Marsden Jacob Associates, 2006)
- recreational fishing expenditure is worth about $195 million per annum (Henry & Lyle, 2003)
- property values in the region are indirectly underpinned by the quality of the aquatic environment and the amenity they provide to the population. (Marsden Jacob Associates, 2006).

Similar values are common across other coastal catchments in Queensland, with values higher closer to the Great Barrier Reef (Marsden Jacob Associates, 2009c). It is therefore of great importance that urban stormwater runoff is effectively managed in Queensland to maintain or enhance the health of aquatic ecosystems, and protect the many economic, ecological and cultural values of waterways.

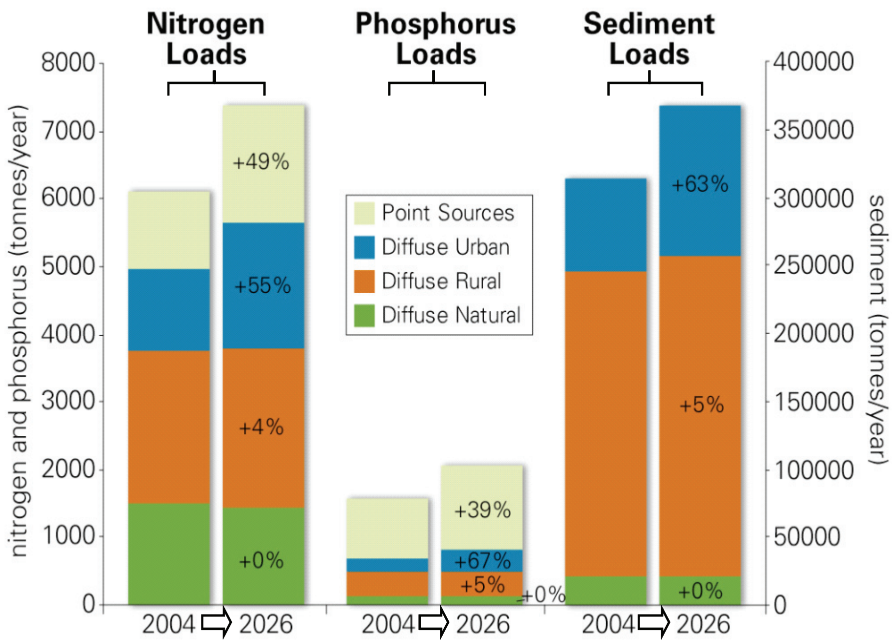

Figure 2.1 Changes in the annual load of pollutants entering South East Queensland waterways if no additional measures are undertaken (Source: *South East Queensland Healthy Waterways Strategy 2007–2012*).

2.2 WSUD and stormwater management

WSUD is an approach to planning and design that addresses the impacts of urban development on the hydrological cycle and aquatic ecosystem health. It aims to:

- minimise the impact on existing natural features and ecological processes (e.g. through the reduction of pollutants entering waterways)
- minimise impact on the natural hydrologic behaviour of catchments
- protect the quality of surface and ground waters
- minimise the demand on the reticulated water supply system
- incorporate the collection, treatment or reuse of runoff, including roofwater and other stormwater
- reduce run-off volumes and peak flows from urban development
- re-use treated effluent and minimise wastewater generation
- increase social amenity in urban areas through multi-purpose greenspace, landscaping and integrating water into the landscape to enhance social and ecological values
- add value while minimising development costs (e.g. drainage infrastructure costs)
- harmonise water cycle practices across and within the institutions responsible for waterway health, flood management, pollution prevention, and the protection of social amenity (National Water Commission, 2009).

One key aspect of WSUD is stormwater management. In the context of stormwater management, the primary aim of WSUD is to treat stormwater to remove pollutants and manage stormwater hydrology to protect downstream aquatic ecosystems. WSUD practices to achieve these aims include rainwater tanks, swales, porous pavements, bioretention systems (raingardens), constructed wetlands, infiltration systems and stormwater harvesting and reuse schemes. Refer to the *Case Study Report* (Water by Design, 2010) for further information on the WSUD systems used in this business case and Section 5.4 for photos of examples. The *Concept Design Guidelines for Water Sensitive Urban Design* (Water by Design, 2009) contains additional information on WSUD systems and best practice approaches.

In the context of protecting Queensland's waterways within and downstream of urban centres, implementing WSUD within new developments is considered to be essential. WSUD is therefore a key element of the draft *State Planning Policy for Healthy Waters 2009*.

2.3 Draft *State Planning Policy for Healthy Waters*

Voluntary implementation of best practice urban stormwater management to protect waterway environmental values is unlikely without government intervention. This is because the development market fails to adequately incorporate broader social and environmental values and developers often have insufficient private incentives to enhance stormwater management.

In recognition of the need for greater government intervention to protect waterway health from urban stormwater impacts, the draft *State Planning Policy for Healthy Waters 2009* has been developed. The aim of the policy is to achieve the requirements of the *Environmental Protection (Water) Policy 2009* through appropriate land use planning, assessment of development, and infrastructure provision. This includes ensuring urban development manages stormwater to protect environmental values.

The draft policy, and the corresponding draft *Development Assessment Code* (Annex 1 of the draft policy) for urban stormwater management, references the draft *Best Practice Environmental Management Guidelines — Urban Stormwater* (DERM, 2009). These guidelines define design objectives for best practice urban stormwater management, which are summarised in Table 2.1.

The objectives are consistent with those contained in the *South East Queensland Regional Plan 2009–2031: Implementation Guideline No. 7: Water Sensitive Urban Design*, which requires implementation of WSUD practices for urban stormwater management in South East Queensland. The objectives apply to new developments in Queensland greater than six lots or developments greater than 2500 m^2.

Table 2.1 Stormwater management design objectives for Queensland as proposed by the draft *State Planning Policy for Healthy Waters 2009* and the *South East Queensland Regional Plan 2009–2031: Implementation Guideline No. 7*.

POLICY OBJECTIVE	INTENT	PERFORMANCE TARGETS
Stormwater quality	To protect receiving water quality by limiting the quantity of discharged stormwater pollutants. Applicable to all urban developments, excluding developments that are less than 25% impervious and that comply with the frequent flow objective.	Treat in accordance with best practice for each climatic region. Minimum required reductions in total pollutant loads, compared to untreated stormwater runoff from developments, are defined for: Total Suspended Solids (TSS), Total Phosphorus (TP), Total Nitrogen (TN) and gross pollutants. The minimum reduction varies between regions in Queensland (refer to Table 3, Case Study Report (Water by Design, 2010)).
Waterway stability	To prevent exacerbated in-stream erosion downstream of urban areas by controlling the magnitude and duration of sediment-transporting stormwater flows.[1]	Limit the post-development peak one-year Average Recurrence Interval (ARI) event within the receiving waterway to the pre-development peak one-year ARI event discharge.
Frequent flow	To protect in-stream ecosystems from the significant effects of increased runoff frequency by ensuring the frequency of hydraulic disturbance to in-stream ecosystems in developed catchments is similar to pre-development conditions. [2]	Capture and manage the design runoff capture depth (mm/day) from all impervious areas so that the frequency of surface runoff is the same as pre-development conditions: - developments with a total fraction impervious <40%: design runoff capture depth = 10mm/day - developments with a total fraction impervious >40%: design runoff capture depth = 15mm/day. Note: Runoff capture capacity needs to be replenished within 24 hours of the runoff event.

1 The waterway stability objective only applies to developments that drain to un-lined, non-tidal waterways and wetlands or if the local council intends to decommission a lined waterway and re-instate a natural channel.

2 The frequent flow objective only applies in catchments that pass through or drain to unlined non-tidal waterways and wetlands that are not degraded or classified as being of High Environmental Value (HEV), or slightly disturbed streams (as described in *Environmental Planning Policy (Water) 2009)* where the local council intends to rehabilitate.

3 Method

3.1 Overview

As part of constructing the business case, a cost–benefit framework was developed that brings together quantitative and qualitative values of benefits and costs associated with applying WSUD to achieve best practice stormwater management for typical low-density residential, medium- to high-density residential, and commercial and industrial developments. The *purpose* of the frameworks is to allow:

- a broad assessment of whether the benefits are likely to outweigh the costs
- stakeholders to easily evaluate the best available data to draw their own conclusions.

Table 3.1 outlines the simplified cost–benefit framework. The framework considers financial, environmental and social values to determine the outcome of applying WSUD to society as a whole. Costs and benefits are divided into 'major' and 'minor' categories. Major costs and benefits are those that are most relevant to this business case.

The following tasks were undertaken to gather information to populate the frameworks:

- **literature review and interviews** with industry stakeholders to identify a list of all the potential costs and benefits of implementing stormwater management using WSUD practices, and to gain quantitative and qualitative data relating to costs and benefits
- **case study assessment** of six different development types in Brisbane, Mackay, Townsville and Cairns to test the practicality of WSUD practices for meeting the proposed stormwater management design objectives and to identify the associated costs.

The methodology for the literature review, interviews and case study assessments are described in Sections 3.2–3.4.

Within the scope and resources of this project, it was not possible to conduct a solely quantitative 'cost–benefit analysis' due to limitations with quantifying benefits. Valuing environmental and social elements such as ecosystem services can be difficult as they typically do not have a recognisable financial value and few valuation studies are applicable.

Table 3.1 Cost and benefit framework

LIKELY COSTS FOR TYPICAL DEVELOPMENTS	LIKELY BENEFITS FOR TYPICAL DEVELOPMENTS
Major quantifiable costs (estimates)	**Major quantifiable potential benefits (estimates)**
• *Acquisition (capital + design costs)* • *Annual maintenance costs* • *Life cycle costs* • *Annualised life cycle costs*	• *Value of the reduction in TN loads in stormwater* • *Potentially avoided costs associated with downstream waterway rehabilitation and maintenance* • *Potential increase in property values* • *Potential development costs that are avoided (applicable only on flat sites i.e. <5%)*
	Major unquantifiable potential benefits (estimates)
	Example: • *Protection of the numerous values associated with healthy downstream waterways*
Minor potential costs	**Minor potential benefits**
Example: • *Additional development assessment, compliance checking and enforcement costs associated with WSUD assets*	*Example:* • *Increased rate of sales associated with developments with landscaped WSUD features*
Conclusions regarding the relative magnitude of likely costs and benefits:	
Assessment of whether the benefits are likely to outweigh the costs.	

3.2 Literature review

A focused literature review was undertaken to gather the most up-to-date and relevant information available on the potential benefits and costs associated with the application of WSUD for best practice stormwater management. The findings of the literature review are incorporated in Section 4. The review found that a small number of previous studies have tried to estimate the benefits of urban stormwater management and waterway health. There are a number of limitations with the available data:

- many studies relate to a large geographic scale, which makes it difficult to undertake a robust economic assessment of the benefits and costs of WSUD at a development scale
- many of the existing studies consider the benefits in an aggregated form, providing limited insight to the distribution of benefits between areas and to different segments of the community
- some quantifiable benefits are geographic or development specific—it is not always legitimate to transpose benefits to another geographic location or development type.

3.3 Semi-structured interviews

Confidential semi-structured interviews were undertaken with executives in four organisations that are likely to be directly and indirectly impacted by the draft policy. The purpose was to better understand some of the economic and commercial impacts of applying WSUD to achieve best practice stormwater management, including commercial impediments to voluntary uptake.

3.4 Case study assessment

Assessment of six typical developments was undertaken to assess the practicality and cost of applying WSUD practices to achieve the stormwater management design objectives across a range of development types and climatic zones. The key output from this work was a **quantitative understanding of the cost** to achieve the design objectives and **calculation of the mean annual loads** of pollutants removed from stormwater via WSUD practices.

The case study assessment builds on the findings of the *WSUD: Developing Design Objectives for Urban Development in South East Queensland* (SEQHWP, 2006) and *Queensland Best Practice Environmental Management Guidelines — Urban Stormwater Technical Note: Derivation of Design Objectives* (DERM and EDAW, 2009). The results of the assessment are presented in the *Case Study Report* (Water by Design, 2010).

3.4.1 Case study developments

The case study developments represent examples of 'greenfield' and 'infill' development that would be captured by the State's *Integrated Development Assessment System*, the draft *State Planning Policy for Healthy Waters* and the *South East Queensland Regional Plan 2009–2031: Implementation Guideline No. 7*. These case studies are explained in detail in the *Case Study Report* (Water by Design, 2010) and are summarised below:

- Case study 1: Residential greenfield development on a sloping site (gradient of 5% or greater). The case study site covers an area of 76 ha within an overall subdivision of approximately 1,000 ha. There are 951 detached houses, with a typical lot size of between 400–700 m².
- Case study 2: Residential greenfield development on flat topography. The case study site covers an area of 6.4 ha within an overall subdivision of approximately 100 ha. There are 84 detached houses within the site, with typical lot sizes between 400–500 m².
- Case study 3: Residential townhouse development. The case study site comprises 25 two-storey townhouses plus the site has landscaped areas, an internal road network, visitor parking spaces and a loading bay.
- Case study 4: Urban renewal development (high-density development). The case study is a large-scale urban renewal project involving conversion of an industrial area into a high-density residential development. The development includes 7 ha of high-rise residential towers and 5 ha with five-storey residential apartment buildings. There are 25 separate buildings within the site. (Note that the WSUD solution for case study 4 has been developed as two options, A and B. These are further described in Section 2.4.3).
- Case study 5: Commercial development. The case study is a small-scale commercial development comprising a neighbourhood shopping centre with 15–20 ground-level shops on a 0.42 ha site. A central arcade separates two buildings.

- Case study 6: Industrial development. The case study is a medium-scale industrial development comprising a factory and warehouse on a 1 ha site. The single building is surrounded by an internal driveway and car park with approximately 100 car parking spaces.

Each case study is a real development that has either been designed or built somewhere in Queensland, with or without WSUD practices. Choosing case studies based on real developments ensures the developments' characteristics are generally consistent with current town planning scheme provisions and reflect current stakeholder and market expectations in Queensland.

3.4.2 Locations

The case study assessment was undertaken for four climatic regions: Brisbane, Mackay, Townsville and Cairns. The four locations were chosen as they allowed the assessment of WSUD under different climatic conditions. They also represent areas where significant pressure on waterway health is expected as a result of increases in population growth and urban expansion. Brisbane was selected for South East Queensland as it represents the climatic 'mean' of the region.

3.4.3 Scenarios

To determine what *additional* costs, if any, are added to developments as a result of best practice stormwater management using WSUD practices, for each case study a 'WSUD case' scenario (where the stormwater management design objectives are met) was compared to a 'base case' scenario. The base case reflects a development that complies with existing mandatory State Government policy, including:

- The *Queensland Development Code—Mandatory Parts 4.2 and 4.3* (Department of Infrastructure and Planning, 2009) requires the use of an alternative (other than reticulated supply) water source for most new dwellings and buildings. It does not, however, apply to multi-story residential buildings (i.e. case study 4) and compliance in the Townsville region is voluntary. Rainwater tanks are the most commonly applied solution to achieve this requirement.
- The *Queensland Urban Drainage Manual* (Department of Natural Resources and Water, 2007) provides specific guidance on flood management requirements for developments. Most local governments apply this guidance to developments by requiring any potential increase in stormwater flood flows are managed, and this typically comes in the form of flood detention storage.

Therefore, the **base case** scenarios assume:

- conventional stormwater drainage management
- flood management (flood detention storage)
- rainwater tanks sized in accordance with the *Queensland Development Code*[3] (except for case study 4 which the alternative water source requirement does not apply).

For each WSUD case study scenario, additional WSUD practices were required, above and beyond the base case, to meet the stormwater management design objectives defined by the draft *State Planning Policy for Healthy Waters*. Therefore the **WSUD case** scenarios assume:

- all the base case practices
- **bioretention systems** for compliance with the stormwater quality and frequent flow objectives[4]
- **detention storage** for compliance with the waterway stability objective[5].

The WSUD practices were identified for each of the case studies using the approaches outlined in the *Concept Design Guidelines for WSUD* (Water by Design, 2009) and *Deemed to Comply Solutions - Stormwater Quality* (Water by Design, 2009).

For case study 4, where the base case does not include rainwater tanks, two potential WSUD solutions were developed. Case study 4A incorporates rainwater tanks to collect roof runoff and assumes reuse of this water for internal and external purposes with roofwater detention tanks used to provide a portion of the storage volume required for the waterway stability objective. Case study 4B does not include rainwater tanks or roofwater detention tanks. All stormwater treatment is provided in bioretention systems and underground detention tanks are used to provide a portion of the storage volume required for the waterway stability objective.

3 Note that in Townsville, the *Queensland Development Code* for rainwater tanks does not apply. For the purposes of comparison in this business case, the case studies in Townsville have been modelled with rainwater tanks. In general, if rainwater tanks are not included, the bioretention size (filter area) will be in the order of 1.5 % of the catchment area in Townsville. This is approximately 0.1–0.3% larger than the bioretention sizes modelled as part of the case study (depending on development type).

4 Refer to Section 3.2 of the *Case Study Report* (Water by Design, 2010) for a description of how the frequent flow management objective is met.

5 Refer to Sections 2.3.3 and 2.4 of the *Case Study Report* (Water by Design, 2010) for a description of how the waterway stability objective has been applied to the case studies. In summary, the waterway stability objective will not apply in many development situations. Where it does apply, flood storage would be likely to be required and the waterway stability detention storage will be integrated into the flood storage at minimal or negligible cost.

The performance of each scenario was calculated using desktop and modelling analysis. Refer to Section 3 of the *Case Study Report* (Water by Design, 2010) for a detailed description of methodology.

3.4.4 Costings

The cost information (unit rates) used for this assessment is based on a review of recent reference material, advice from suppliers (e.g. rainwater tank suppliers), actual costs incurred in recent projects and on data from related research projects.

In relation to costs:

- For the base cases, only the cost of the rainwater tanks was calculated. Calculation of full development costs (e.g. cost of earthworks, pipes, etc.) was beyond the scope of the project. Please refer to *Stormwater Infrastructure Options to Achieve Multiple Water Cycle Outcomes* (Bligh Tanner and DesignFlow, 2009) for detailed costings of stormwater infrastructure for the greenfield case studies.
- For the WSUD cases, all costs of the WSUD practices were calculated and presented to identify the **additional** costs associated with achieving the stormwater management design objectives (i.e. costs in addition to those of the base cases).
- Where possible, the costs address only the marginal cost relative to the base case scenario. For example, the bioretention systems in each of the case studies typically occupy areas that would otherwise be landscaped as turf or garden beds. Therefore, the net cost of bioretention systems calculated for the business case is the cost of the bioretention system less the cost of typical landscaping. Refer to Section 4 of the *Case Study Report* (Water by Design, 2010) for a more detailed explanation of the costing methods and assumptions.

4 Costs and benefits overview

There are many benefits and costs associated with best practice urban stormwater management. This section tables the key costs and benefits of using WSUD practices to meet the proposed design objectives that were identified in the literature review, stakeholder interviews and case studies. This information forms the basis of the populated cost–benefit frameworks.

Local costs and benefits have been given the highest priority where available, otherwise national or international estimates have been cited. All values are in 2009 Australian dollars unless otherwise noted.

4.1 Costs

Meeting the stormwater management objectives using WSUD requires acquisition, operational and renewal costs that accrue to developers, councils and the general public. In addition to the easily identifiable financial (direct) costs, implementing WSUD involves an opportunity (indirect) cost as some practices may exclude the use of land for an alternative purpose such as buildings, landscaping or open space. The incremental (additional) costs associated with the proposed policy change are of most relevance to this report.

Some research has been undertaken in relation to these costs, particularly in greenfield residential areas (e.g. Taylor & Fletcher, 2006), and for structural stormwater quality best management practices. Typical WSUD practices and their associated costs include: capital, design, site acquisition, and approval and regulatory costs (Taylor, 2005b). Ongoing operation and maintenance costs are also required. There are also other costs, such as environmental costs associated with obtaining raw materials, as well as construction and maintenance activities.

Table 4.1 lists the identified potential costs associated with the application of WSUD practices to new development in Queensland to meet the stormwater management design objectives. Direct financial costs for the case studies are provided in the *Case Study Report* (Water by Design, 2010).

Assumptions and limitations :

- Cost estimates for WSUD measures assume typical development conditions (e.g. no acid sulfate soils etc.).
- Acquisition costs (including design and construction costs) are based on experience on real projects in Queensland and from stakeholder consultation on projects in SEQ from the years 2006 to 2009.
- Maintenance costs have been defined through a combination of literature review, local cost information for Queensland and unit rates assessment.
- Given the limited information about renewal and decommissioning costs for WSUD infrastructure, these costs were estimated as a fraction of the acquisition costs (Refer to the *Case Study Report* (Water by Design, 2010) for details).

Table 4.1 Typical WSUD-related cost elements to achieve the stormwater management design objectives

ITEM	DESCRIPTION OF COST ELEMENTS	DISTRIBUTION	POTENTIALLY RELEVANT VALUES	DATA SOURCE
Direct financial				
Total life cycle *	The sum of an asset's costs over its life span with future costs discounted to a base date. Includes acquisition, annual maintenance, operational, renewal and decommissioning costs.	Developers, local government and households	Refer to the *Case Study Report* (Water by Design, 2010) for component costs and life cycle costs associated with each of the case studies. A summary is contained in Section 5.2.	Case study assessment
Acquisition *	Capital costs of construction and establishment of the WSUD measures. Costs of design and assessment of WSUD measures. Site acquisition costs, where relevant.	Developers and households	As above. The case studies illustrate that, when designed properly, WSUD practices can be readily incorporated into land set aside for landscape or flood management. Therefore, no land acquisition has been assumed in the case study results.	Real projects in Queensland and case study assessment
Annual maintenance *	Maintenance during the first two years (elevated cost) and ongoing maintenance (e.g. weeding, replanting, sediment removal, etc.).	Developers (initially), local government or private ownership	As above.	Literature review and case study assessment
Operation	Costs associated with running a WSUD measure (e.g. rainwater tank pumps).	Local government and households	-	Not relevant to the six case studies, but potentially relevant to other WSUD designs
Renewal	Resetting or rebuilding the infrastructure once the design life is reached (e.g. replacing media in the bioretention system and replanting it).	Local government and households	As above.	Case study assessment
Decommission	In some circumstances, WSUD measures will be decommissioned.	Local government and households	As above.	Case study assessment
Indirect financial				
Reduction in area for other uses	Foregone opportunity to use land for other purposes (e.g. active public open space).	Developers and ultimately households	Highlighted as a potential cost during interviews, but dependent on development design constraints. When designed properly WSUD practices can be readily incorporated into land set aside for landscape or flood management. If located in land set aside for landscape, some active landscape uses may be reduced.	Stakeholder interviews
Environmental costs	Associated with obtaining raw materials, construction and maintenance.	The community	Entirely dependent on the nature of the environmental resource and whether it is disturbed or used.	Not quantified during the case study assessment

Table 4.1 (contd)

ITEM	DESCRIPTION OF COST ELEMENTS	DISTRIBUTION	POTENTIALLY RELEVANT VALUES	DATA SOURCE
Indirect financial (contd)				
Training and education costs	Capacity building within government and the development industry to assist the delivery of WSUD.	State and local government, developers and ultimately households	Highlighted during interviews, but acknowledged that these costs will ultimately be passed onto households.	Stakeholder interviews
'Hidden costs' of development	Environmental monitoring, delays in gaining development approval, environmental permits, insurance etc.	Developers	Raised as a potential risk during interviews, but estimates of costs are not available. Given that the new design objectives are applicable statewide, these costs should decrease over time.	Stakeholder interviews
Exposure to risk	An organisation's exposure to financial risk, if WSUD assets fail.	Local governments and the development industry	Data unavailable.	Not quantified during the case study assessment
Non-market				
Maintenance burden for residents	Maintenance burden for residents and landowners where WSUD assets are held in private ownership.	Community	Data unavailable.	Not quantified during the case study assessment
Nuisance flooding	Inconvenience associated with nuisance flooding (e.g. temporary ponding of water in residential areas).	Community	Values are likely to be negligible. Such costs can be avoided or minimised through good design.	Not quantified during the case study assessment
Community health and safety	Impact on the health and wellbeing of nearby residents who may be affected by potential nuisances such as mosquitoes.	Community	Such costs can be avoided or minimised through good design. Some studies indicate enhanced natural amenity can lead to increased community health and wellbeing. Evaluation of health-related costs and benefits associated with stormwater management projects is best done on a *qualitative* basis due to the difficultly of placing a monetary value on pain or discomfort.	Holder (2003). Not quantified during the case study assessment

Note:

* Major cost elements that should dominate the assessment of the likely net benefit of applying WSUD to new developments in Queensland.

4.2 Benefits

Best practice urban stormwater management via WSUD potentially provides a range of benefits. The majority of benefits are non-market benefits and estimations of their economic worth are limited. Quantifiable benefits include the value of annual reduction in pollutant loads discharged to waterways.

Most benefits occur over a long temporal scale albeit with some immediate benefits, like the improved amenity of a development. Many of the benefits are returned to the wider community or region, rather than to householders or developers. For example, the application of WSUD practices to stormwater management problems within urban areas can benefit the health of local or regional waterways. Improvement of waterway health in turn provides benefits to the waterway-related industries and recreational users of waterways.

Table 4.2 lists the potential benefits associated with the application of WSUD practices to meet the proposed stormwater management objectives for developments in Queensland.

Assumptions and limitations:

- WSUD will only contribute partially to some of these benefits e.g. fishing, tourism.
- Some of the benefits (e.g. avoided development costs and premium on land values) will vary depending on site conditions and location.
- Quantifying a property premium value due to improvement in regional water quality is not straightforward. The health of regional waterways, however, is an important aspect of property in Queensland and the value of land and property in Queensland is underpinned by the recreational and amenity values provided by its waterways and open space. Note that for the purposes of this assessment a conservative property premium value has been attributed to WSUD.
- Although Councils have the obligation to preserve the environmental values of waterways (under the *Environmental Protection Act 1994*) it is acknowledged that local governments will not always complete waterway rectification in scenarios where WSUD is not adopted and waterways are degraded.

4.3 Distribution of costs and benefits

Costs associated with WSUD can often be indirectly borne by households, particularly via land costs and local government rates or body corporate fees. The distribution of these costs between households will be influenced by commercial decisions of developers and by planning decisions and rate determinations of local governments. In some instances, such as commercial and industrial developments, the costs of WSUD can be borne by tenants or owners. The majority of the benefits will then accrue to a wide section of current and future community members via a mix of lower costs, an enhanced environment, and benefits such as improved recreational opportunities, and stronger tourism industries.

Table 4.2 Typical benefits of WSUD practices to achieve the stormwater management objectives

ITEM	DESCRIPTION OF POTENTIAL BENEFIT	DISTRIBUTION	VALUE ESTIMATES POTENTIALLY RELEVANT TO THE APPLICATION OF WSUD (BOTH DIRECTLY AND INDIRECTLY)	DATA SOURCE (WHERE AVAILABLE)
Indirect financial				
Avoided waterway rehabilitation costs*	Implementing WSUD practices will enhance waterway stability by reducing the volume and velocity of runoff during rainfall events. This will reduce in-stream erosion, the disturbance of in-stream ecosystems and the risks to ecosystem function within waterways (Walsh et al., 2004). There is, therefore, the potential to avoid stream rehabilitation costs if WSUD is applied to developments.	Local governments, community	Capital cost rates range from \$200–\$800/m for a number of Gold Coast City Council projects to \$2,500–\$3,000/m for Brisbane City Council projects. Rates vary depending on the extent and scope of works. Maintenance cost rates are approximately \$25/m of stream per year.	DesignFlow estimates, Brisbane City Council, Australian Wetlands Pty Ltd.
Premium on land values (linked to a range of social values)*	Some WSUD practices (e.g. constructed wetlands) that are included in, or are additional to, a development's green space may create a market premium for adjacent land.	Developers and households	The premium on land close to urban green space (e.g. in Ipswich) is around 10% for properties within 500 m of open space. Premium on land adjacent to water, in particular open water, can be as high as 100%.	Marsden Jacobs Associates (2007a)
		Developers and households	Research in Western Australia indicates property values increase by 7% when located adjacent to natural wetlands that are preserved, or newly created stormwater treatment wetlands.	Tapsuwan et al. (2007)
	Marketability of sustainable developments.	Developers and households	Positive perceptions of WSUD were noted by market research, which showed over 85% of homebuyers drawn from Melbourne's growth corridors support the introduction of bio-filtration systems, wetlands and water reuse schemes into their neighbourhoods.	Lloyd (2002)
	Protection of water quality in receiving waters improves land prices.	Households	A review of six studies that attempted to measure the effect of water quality on the value of nearby properties in Washington found the premium associated with improvements in water quality typically ranges from 1%–20%.	Washington Department of Ecology (2003)
		Households	There was a drop in property values for water frontage lots around Lake Boga (Victoria) after major algal blooms in the summers of 1993–94 and 1994–95. Property valuations in late 1995 indicated on average, lakeside properties were worth 20%–25% less than before the blooms.	Read Sturgess and Associates (2001)
Avoided development costs on flat sites	Infrastructure costs such as conventional pits, pipes and earthworks can be reduced through alternative stormwater conveyance and management approaches.	Developers	The avoided capital cost on flat sites is estimated to be at least \$36,000 per hectare on flat sites.	DesignFlow estimates
Estuarine and marine ecosystem management costs avoided	Potential to reduce management costs associated with changes in Moreton Bay, the Great Barrier Reef and other similar ecosystems.	State and federal government, local governments, community	Some evidence is available, but it is insufficient to develop quantitative estimates.	

Table 4.2 (contd)

ITEM	DESCRIPTION OF POTENTIAL BENEFIT	DISTRIBUTION	VALUE ESTIMATES POTENTIALLY RELEVANT TO THE APPLICATION OF WSUD (BOTH DIRECTLY AND INDIRECTLY)	DATA SOURCE (WHERE AVAILABLE)
Indirect financial (contd)				
Tourism reliant on waterway health	The tourism sector, particularly in the Great Barrier Reef, is reliant on the quality of experience, which is partially reliant on waterway health.	Tourism and associated industries	The economic contribution to the national economy of the recreational dive and snorkelling industry in the Great Barrier Reef catchment is between $690 million and $1.09 billion per annum.	Marsden Jacobs Associates (2009b)
			The value of the freshwater recreational fishing industry in South East Queensland is estimated to be approximately $3 million per annum ($2002).	Taylor (2002)
			The estimated direct expenditure by local residents on recreational fishing in the Maroochy River is $19 million per annum.	CSIRO (2008)
			The estimated annual expenditure of South East Queensland resident anglers is $193 per angler ($2001).	Marsden Jacobs Associates (2006)
Seafood industry reliant on waterway health	Commercial fishing is partially reliant on waterway health.	Industry	The value of commercial fishing in the Moreton region is estimated at $33 million per annum ($1998).	Taylor (2002)
Non-market				
Waterway health*	Non-market values associated with improvement of waterway health.	Community	Queensland — 1% change in the proportion of waterways in good health is worth $6.35 per household per annum ($2009).	Windle and Rolfe (2006)
			South East Queensland — 1% improvement or preservation worth $3.74 per household per annum ($2009).	Windle and Rolfe (2006)
			Mackay — 1% improvement or preservation worth $8.56 per household per annum ($2009).	Windle and Rolfe (2006)
			The value of the Maroochy River to the local council through direct investment (funded by an environmental levy) in the 'Improving our waterways program' was $1.4 million in 2006/07.	CSIRO (2008)
			The global average value of estuaries has been estimated at $22,832/ha/year, seagrass as $19,004 /ha/year, and wetlands as $14,785 /ha/year (in US$1994).	Constanza et al. (1994)
			Blackwell estimated the value of lakes and rivers in Australia to be $1,528,078 ($2005) per km^2.	Blackwell (2005)
Reduced pollutant loads*	Lower loads of pollutants discharged to downstream waterways and ultimately receiving ecosystems.	Utilities and ultimately households.	Levelised annual treatment costs to remove nutrients from wastewater in urban areas range from $180,000–$850,000 per tonne of TN removed and from $80,000–$600,000 per tonne of TP removed (national estimates).	BDA Group (2006)
Wetlands	Non-market values of wetlands in South East Queensland.	Community	One-off value of wetland protection estimated at $11–$19 per household.	Clouston (2002)

Table 4.2 (contd)

ITEM	DESCRIPTION OF POTENTIAL BENEFIT	DISTRIBUTION	VALUE ESTIMATES POTENTIALLY RELEVANT TO THE APPLICATION OF WSUD (BOTH DIRECTLY AND INDIRECTLY)	DATA SOURCE (WHERE AVAILABLE)
Non-market (contd)				
Urban cooling	Shading and cooling offered by vegetated WSUD treatment systems.	Community	Where urban cooling does occur, benefits of avoided energy consumption for air conditioners and reduced CO_2 emissions could be significant, albeit unquantified.	Cleugh et al. (2005)
			Shading offered by trees in car parks in the United States of America resulted in a local air temperature reduction of 1–2 degrees Celsius.	McPherson et al. (2002)
Area's general livability and amenity	WSUD potentially enhances amenity (e.g. wetlands and the marginal benefit of well-designed, vegetated bioretention systems (compared to lawn or turf)).	Community	A survey of 300 property owners and prospective buyers from four greenfield development areas in Melbourne found that 85%–90% of respondents supported the integration of grassed and landscaped bio-filtration systems into local streetscapes to manage stormwater.	Lloyd (2002)
Recreation	WSUD has the potential to enhance open space.	Community	Previous analysis of the economic benefits of outdoor recreation in South East Queensland found that a 1% enhancement in outdoor recreation opportunities is worth around $12 per household per annum, while the same increase in recreational fishing opportunities is worth around $2 per household per annum.	Marsden Jacob Associates (2008)
Education	Provision of a research or educational asset.	Community	Data is unavailable.	
Ecological 'existence' values	The impact on the ecological health of affected local or regional ecosystems ('existence' values).	Community	It is estimated that residents of the (former) Maroochy Shire were willing to pay up to $2 million per annum for non-use values associated with Moreton Bay and its environs.	Taylor (2005b)
Ecological 'option' values	The impact of the value of having healthy aquatic and riparian ecosystems for potential use in the future (i.e. 'option' values).	Community	A New Zealand study found that the 'option price' (i.e. the sum of use, preservation and option values) is $17.05 (NZ$2004), expressed as a mean willingness to pay per household per year for users and non-users of the River.	Taylor (2005b)
Ecological 'bequest' values	The impact of the value of providing healthy aquatic and riparian ecosystems for future generations (i.e. 'bequest' values).	Community	The Rakaia River study by Kerr et al. (2004) found the present value of preservation values of the river to be approximately $19 million (NZ$2004).	Taylor (2005b)

Note:

* Major benefits that should dominate the assessment of the likely net benefit of applying WSUD to new developments in Queensland.

5 Key findings

This section outlines the key findings from the assessment, including:

- Section 5.1 — general observations from the technical assessments of the case studies
- Section 5.2 — a summary of the costs associated with WSUD
- Section 5.3 — quantification of some of the benefits
- Section 5.4 — cost–benefit frameworks (including qualitative benefits) to compare key costs and benefits for the case studies.

5.1 Technical findings and practicality of applying WSUD

From the case studies, the following general observations can be made:

- **WSUD and urban design:** In each of the case studies, the stormwater management design objectives can be achieved without any material change to the urban design or loss of developable land. This is a significant finding as the interviews identified the potential loss of saleable land as a common concern for developers. Bioretention basins were integrated into landscaped areas and simple adjustments made to the stormwater drainage layout to support WSUD. It is important to note, however, that the earlier WSUD practices are incorporated in urban design, the better and more cost effective the outcome will be. Currently, in many development situations, WSUD is not being considered early in the design process, as many stakeholders are still learning about how to apply WSUD. This is resulting in poor design, the loss of developable land and, ultimately, the cost of WSUD is higher than necessary.
- **Treatment size:** The size of bioretention systems required to meet the stormwater management design objectives vary from 0.8%–1.6% of the development footprint. This represents the actual flat surface area of the bioretention systems with additional areas required for batters[6].
- **Climatic region and rainwater tanks:** Geographic location influences rainfall patterns, which in turn affect the size of the required treatment systems. If rainwater tanks are not adopted to meet the requirements of the *Queensland Development Code*, the stormwater treatment size (i.e. bioretention system) generally needs to increase to meet the stormwater quality objectives. The lower the rainfall, the larger the increase that is needed. Using case study 4 as an example, where tanks are not part of the development, the filter area (i.e. flat area) of the bioretention stays the same in Cairns, increases in Townsville by 0.1%, and increases in Brisbane by 0.5%. The reason for these geographic differences is that the rainwater tanks are treating (reusing) a relatively larger portion of annual runoff volume from the site in the lower rainfall areas like Brisbane. In Cairns, the proportion of rainfall that is reused from tanks is much smaller compared to total annual runoff from the site.
- **Practicality:** The stormwater management design objectives can be practically achieved through implementing WSUD practices.

5.2 Costs

The direct financial costs are the most readily identifiable costs associated with WSUD practices. The acquisition costs and the annual maintenance costs of achieving the stormwater management design objectives are presented in Table 5.1 (see *Case Study Report* (Water by Design, 2010) for detail). The total life cycle costs are presented in Table 5.2. These costs have been calculated on a dollar per lot and dollar per hectare basis.

A life cycle cost period of 25 years has been used for this assessment as this is the typical period used for public cost–benefit analysis. Impacts after 25 years rarely have a material impact on benefits or costs due to the discounting used. A real discount rate of 5.5% has been used, which is supported by Queensland Treasury who usually suggests a real discount rate of between 5% and 6% (Queensland Treasury and DIP, 2008).

6 Based on the case studies, the total area of the bioretention (including batters) is 1.7 to 3.0 times larger than the filter area (based on a batter slope of 1:3 to 1:4). The actual figure is dependent on the bioretention design and topography, development constraints etc.

The tabulated costs in Table 5.1 represent the incremental cost of going from the base cases to the WSUD cases (i.e. the additional cost to achieve the stormwater management design objectives using WSUD practices). To provide context, the cost of complying with the stormwater management design objectives is less than complying with the current *Queensland Development Code*:

- Case studies 1 and 2 — the base case acquisition cost of rainwater tanks is $3,000/dwelling with an annual maintenance cost of $90/dwelling. This is compared to the incremental acquisition cost of the WSUD case of $1,700–$2,500 per dwelling with an incremental annual maintenance cost of $20–40/dwelling.
- Case study 3 — the base case acquisition cost of rainwater tanks is $2,500/dwelling with an annual maintenance cost of $90/dwelling. This is compared to the incremental acquisition cost of the WSUD case of $800–$1,200 per dwelling with an incremental annual maintenance cost of $10/dwelling.

Key points regarding **acquisition costs** are:

- Implementing the stormwater management components of WSUD is typically less than 1% of the total cost of establishing a new dwelling.
- The acquisition costs of implementing WSUD elements range from approximately $400 per dwelling for units in large complexes to around $4,000 for more complex WSUD elements for detached houses in case study 2 in Cairns.
- As housing density increases, the acquisition cost decreases. In a detached dwelling development, acquisition costs of the WSUD solution are approximately $1,600–$4,000 per household. In a townhouse development, this reduces to $800–$1,200 per dwelling, and for units it reduces to about $400 per dwelling. The same can be said for total life cycle costs. In a detached dwelling development, total life cycle costs of the WSUD solution are approximately $4,000–$5,000 per household. In a townhouse development this reduces to $1,000–$1,500 per dwelling, and for units it reduces to about $500 per dwelling.

In summary, the acquisition costs of establishing WSUD to meet the stormwater management objectives are likely to be less than 1% of the cost of a new dwelling.

Key points regarding **ongoing costs** are:

- Ongoing operating and maintenance costs per annum for WSUD elements to meet the stormwater management objectives range from less than $5 a year per dwelling for units to around $50 a year per dwelling for detached houses in areas such as Cairns.
- The ongoing costs of maintaining WSUD assets in public areas will initially be met by local governments and may be partially offset by reductions in other council costs such as waterway rehabilitation. Local government would likely recover the increase in costs through rates revenues as it would be inefficient to establish more sophisticated administrative ways to recover the costs (e.g. charging a specific levy in areas where WSUD has been established). The impost on council budgets is likely to be negligible. For example, the annual growth in WSUD management costs in Brisbane would require an increase in total revenue of approximately 0.005%.
- For residential rental properties, owners will likely pass on costs in full via rents. For commercial or industrial developments, sharing of costs between owners and lessees would be determined by prevailing market circumstances (e.g. vacancy rates, ability of tenants to pass on costs to their customers, or conditions of existing lease agreements).
- The ongoing costs for WSUD assets on private land may be covered by a body corporate, for example, and will again eventually be passed onto households.

In summary, the ongoing operation and maintenance costs of WSUD assets to meet the stormwater management objectives for typical residential developments are likely to be met by local governments or body corporates and are likely to be less than $40 per annum per new dwelling. For Councils, maintenance costs are likely to be distributed across the local government area and an overall increase in rates revenue would be in the order of 0.005% (in Brisbane). These costs may, at least partially, be offset through reduced costs of waterway rehabilitation.

Table 5.1 Case study acquisition and maintenance costs (A$2009): Incremental cost of going from the base cases to the WSUD cases (i.e. the likely *additional* cost of achieving the stormwater management design objectives)

		BRISBANE		MACKAY		TOWNSVILLE		CAIRNS	
	Case study description	**Acquisition costs $/lot***	**Annual maintenance $/lot***	**Acquisition costs $/lot***	**Annual maintenance $/lot***	**Acquisition costs $/lot***	**Annual maintenance $/lot***	**Acquisition costs $/lot***	**Annual maintenance $/lot***
1	Residential greenfield (large scale) on sloping topography	1,690	20	2,535	30	2,745	35	3,165	40
2	Residential greenfield on flat topography	2,490	25	3,235	30	3,235	30	3,985	40
3	Residential townhouse development	790	10	970	10	1,055	10	1,230	10
4A	Urban renewal development	255	5	300	5	345	5	370	5
4B	Urban renewal development (no rainwater tanks)[7]	370	5	345	5	370	5	370	5
5	Commercial development**	10,730	95	9,200	80	11,500	100	11,500	100
6	Industrial development**	46,200	455	42,900	425	49,500	490	49,500	490
		$/ha * **		**$/ha*** **		**$/ha*** **		**$/ha*** **	
1	Residential greenfield (large scale) on sloping topography	21,200	260	31,800	390	34,450	425	39,750	490
2	Residential greenfield on flat topography	33,000	325	42,890	420	42,890	420	52,780	520
3	Residential townhouse development	29,680	290	36,320	360	39,590	390	46,180	455
4A	Urban renewal development	36,300	360	42,900	425	49,500	490	52,800	520
4B	Urban renewal development (no rainwater tanks)	52,800	520	49,500	490	52,800	520	52,800	520
5	Commercial development	51,100	455	43,800	390	54,750	490	54,750	490
6	Industrial development	46,200	455	42,900	425	49,500	490	49,500	490

Note:

* Lot refers to household or dwelling.
** Per lot estimates for industrial and commercial cases are dependent on lot numbers and sizes, which vary considerably.
*** Ha refers to the whole development area.

7 The alternative water use requirements of the *Queensland Development Code* do not currently apply to high-density residential. Therefore, two WSUD solutions were trialled, with and without rainwater tanks.

Table 5.2 Case study life cycle costs (A$2009): Incremental cost of going from the base cases to the WSUD cases (i.e. the likely *additional* cost of achieving the new stormwater management design objectives)

		BRISBANE			MACKAY			TOWNSVILLE			CAIRNS		
	Case study description	**$/lot***	**$/ha**	**Annualised cost $/ha/yr**	**$/lot***	**$/ha**	**Annualised cost $/ha/yr**	**$/lot***	**$/ha**	**Annualised cost $/ha/yr**	**$/lot***	**$/ha**	**Annualised cost $/ha/yr**
1	Residential greenfield (large scale) on sloping topography	2,365	29,675	*1,185*	3,545	44,510	*1,780*	3,840	48,220	*1,930*	4,430	55,635	*2,230*
2	Residential greenfield on flat topography	3,385	44,825	*1,795*	4,395	58,260	*2,330*	4,395	58,260	*2,330*	5,410	71,690	*2,870*
3	Residential townhouse development	1,075	40,315	*1,615*	1315	49,335	*1,975*	1,435	53,775	*2,150*	1,670	62,730	*2,510*
4A	Urban renewal development	345	49,305	*1,970*	410	58,270	*2,330*	470	67,235	*2,690*	500	71,720	*2,870*
4B	Urban renewal development (no rainwater tanks)	500	71,720	*2,870*	470	67,235	*2,690*	500	71,720	*2,890*	500	71,720	*2,870*
5	Commercial development**	14,405	68,585	*2,745*	12,345	58,785	*2,350*	15,430	73,485	*2,940*	15,430	73,485	*2,940*
6	Industrial development**	62,755	62,755	*2,510*	58,270	58,270	*2,330*	67,235	67,235	*2,690*	67,235	67,235	*2,690*

Note:

* Lot refers to household or dwelling.

** Per lot estimates for industrial and commercial cases are dependent on lot numbers and sizes, which vary considerably.

The annualised cost = the life cycle cost divided by the lifespan of the costing analysis (i.e. 25 years).

5.3 Benefits

As outlined in Section 4, the benefits of applying WSUD to achieve best practice stormwater management are likely to have a significant value. There are many benefits and the benefits are associated with important financial, environmental and social values. However, most are difficult to quantify due to their non-market form and the limited valuation studies that are applicable and available. In addition, the relationships between the application of WSUD and valued benefits (e.g. the annual value of a local recreational fishing industry) are rarely quantifiable. The following sections provide quantitative *estimates* of a few of the benefits that are likely to accrue from the application of WSUD to new developments in Queensland to meet the proposed stormwater management design objectives.

5.3.1 Pollutant loads

One of the key outcomes sought by the draft policy is a reduction in urban stormwater pollutant loads (relative to untreated urban stormwater) to protect the environmental values of waterways. Table 5.3 summarises the pollutant load reductions from implementing WSUD practices to achieve the stormwater management design objectives on the case study sites. This is based on results presented in the *Case Study Report* (Water by Design, 2010).

Reduced pollutant loads from urban stormwater runoff *could* be a substitute for other treatments designed to meet water quality objectives, for example augmenting a wastewater treatment plant to reduce phosphorous or nitrogen loads, typically under some form of water quality offset arrangements. Previous analysis has determined these point-source treatment costs can be significant, with levelled annual costs ranging from \$180–\$850 per kg of TN removed and from \$80–\$600 per kg of TP removed per annum (BDA Group, 2006 and Gaylard, 2005).

In Victoria, Melbourne Water manages a *Stormwater Quality Offsets Program*. Stormwater offsets are a financial contribution from developers to Melbourne Water for regional water quality works undertaken elsewhere within the catchment to offset pollution loads not treated within the development. Treatment within the development is generally required as per Clause 56.07 of the Victorian Planning Provisions.

Variations in offset contributions take into account local elements that contribute to nitrogen generation and the cost of offsite nitrogen treatment. Offsite treatment was calculated at \$800/kg of total nitrogen (TN) for the 2005/06 to 2006/07 period (Melbourne Water, 2006). This value compares with the point source annualised cost presented above.

These values have been used, in combination with the annualised life cycle cost of WSUD presented in Table 5.2, to assess a potential dollar benefit associated with reducing nitrogen in stormwater using WSUD. For each case study, the annual reduction in pollutant loads of TN as a result of the WSUD element has been calculated.

The TN loads removed were then converted into a *conservative* dollar value using an estimated treatment cost from the literature. This annual benefit value has then been compared to an annualised life cycle cost for the WSUD treatments used in the case studies. The value of removing the TP, based on avoided wastewater treatment plant costs, is close to \$0. This is because the incremental cost of removing the TP once the TN is removed is very low.

As indicated in Table 5.3, the potential benefits of just the TN pollutant load reduction provided by the WSUD measures are *likely* to outweigh the life cycle costs of these measures.

Assumptions and limitations:

- The calculation of the annual reduction in pollutant loads of TN as a result of the WSUD element for each case study did not include the pollutant loads removed in the base case scenario — that is loads associated with rainwater reuse.
- A levelised annual treatment cost of \$515 per kilogram of TN removed was adopted. This is the average of the \$180–\$850 range presented in the literature and significantly less than the figure currently used by Melbourne Water for their Stormwater Quality Offset Scheme (i.e. \$800). The costs were originally calculated to provide estimates for efficient pricing of wastewater services. While it is recognised that there are inherent limitations with adopting the estimates for the calculation of stormwater pollution load reductions, these are the best estimate available.

Table 5.3 Stormwater pollutant load reductions (TN only): associated costs and potential benefits

CASE STUDY DESCRIPTION		TN REMOVED (KG/HA/YR)	POTENTIAL ANNUAL TN REMOVAL TREATMENT COSTS ($/KG/YEAR)	ANNUALISED LIFE CYCLE COST OF WSUD[8,9] ($/HA/YR)
Brisbane				
1	Residential greenfield (large scale) sloping topography	4.1	2,110	*1,190*
2	Residential greenfield on flat topography	4.9	2,520	*1,790*
3	Residential townhouse development	4.8	2,470	*1,610*
4A	Urban renewal development	5.9	3,040	*1,970*
4B	Urban renewal development (no rainwater tanks)	8.2	4,220	*2,870*
5	Commercial development	13.3	6,850	*2,740*
6	Industrial development	8.9	4,580	*2,510*
Mackay				
1	Residential greenfield (large scale) sloping topography	5.8	2,990	*1,780*
2	Residential greenfield on flat topography	6.6	3,400	*2,330*
3	Residential townhouse development	6.1	3,140	*1,970*
4A	Urban renewal development	7.5	3,860	*2,330*
4B	Urban renewal development (no rainwater tanks)	9.5	4,890	*2,690*
5	Commercial development	14.5	7,470	*2,350*
6	Industrial development	9.9	5,100	*2,330*
Townsville				
1	Residential greenfield (large scale) sloping topography	5	2,580	*1,930*
2	Residential greenfield on flat topography	5.4	2,780	*2,330*
3	Residential townhouse development	5.3	2,730	*2,150*
4A	Urban renewal development	7.6	3,910	*2,770*
4B	Urban renewal development (no rainwater tanks)	7.9	4,070	*2,870*
5	Commercial development	12.8	6,590	*2,940*
6	Industrial development	8.6	4,430	*2,690*
Cairns				
1	Residential greenfield (large scale) sloping topography	9	4,640	*2,230*
2	Residential greenfield on flat topography	10	5,150	*2,870*
3	Residential townhouse development	9.5	4,890	*2,510*
4A	Urban renewal development	11.5	5,920	*2,870*
4B	Urban renewal development (no rainwater tanks)	13.3	6,850	*2,870*
5	Commercial development	21.9	11,280	*2,940*
6	Industrial development	14.5	7,470	*2,670*

8 The incremental costs of WSUD compared to the base case.
9 The life cycle of the WSUD elements has been modelled over 25 years.

5.3.2 Avoided cost of waterway rectification and maintenance

The use of WSUD practices for best practice urban stormwater management results in reduced loads of pollutants discharged to downstream waterways, less disturbance of aquatic ecosystem and limited erosion of downstream waterways. This is relative to a 'business as usual' approach (i.e. base case), where experience indicates that without adopting WSUD practices local governments need to undertake maintenance of downstream waterways and, in many cases, periodically rehabilitate the waterway. There are many examples in Queensland where significant local government effort and funding has been required to rectify and maintain waterways and water bodies as a result of poor catchment management in urbanised areas. For example, the construction costs were estimated to be $640,000 in 2004 to rehabilitate a 260m stretch of an Oxley Creek tributary that had significantly scoured. This is a cost that would be avoided, or partially avoided, if WSUD is adopted to achieve the stormwater management design objectives.

This avoided cost has been estimated for the purpose of the business case by defining typical waterway rehabilitation and maintenance requirements that would be incurred if WSUD practices are not adopted. Specifically, the cost estimates were developed using a number of assumptions:

- Representative unit rates per linear metre of stream for major rehabilitation works and annual maintenance works were used. Capital cost rates range from $200–$800/m for a number of Gold Coast City Council projects to $2,500–$3,000/m for Brisbane City Council projects. Costs vary depending on the extent of work undertaken. Maintenance cost rates are approximately $25/m of stream per year.
- The unit rates per linear metre of stream were converted to unit rates per square metre of development, using Case Study 1. A range of $25–$200/m was used as a potential range, which represents the smallest capital cost rate from the stakeholder interviews and average maintenance costs. The waterway in Case Study 1 stream length of 1,000 m for the 75.75 ha development area.

Table 5.4 summarises the avoided costs compared to the WSUD life cycle costs for Case Study 1, which contains a waterway and is an example of a typical greenfield development.

Using Case Study 1 as an example, the value of this potential benefit is still significant, despite the life cycle costs of the WSUD treatment being higher than costs of the waterway rehabilitation works.

Assumptions and limitations:

- The erosion potential of an urban waterway is subject to a number of factors including both stormwater management and the geomorphological characteristics of the waterway. Some waterways are prone to erosion more easily than others. While erosion is a likely outcome in many urban waterways with unmanaged stormwater inflows, it is not always an outcome.
- Local governments will not always complete waterway rectification when WSUD is not adopted, so the avoided financial costs are likely to be at the lower end of the estimated range.

Table 5.4 Potential avoided cost of waterway rectification and maintenance

CASE STUDY DESCRIPTION		ESTIMATED LIFE CYCLE COST OF WATERWAY REHABILITATION WORKS ($/HA OF DEVELOPMENT)	WSUD LIFE CYCLE COST ($/HA)			
			Brisbane	Mackay	Townsville	Cairns
1	Residential greenfield (sloping)	8,000–60,000 (average = 34,000)	29,680	44,510	48,220	55,640

5.3.3 Property values

WSUD can add value to property prices in two key ways:

1. WSUD practices (e.g. bioretention systems, wetlands):
   a. improve amenity within the development (e.g. via vegetated WSUD measures)
   b. provide a 'sustainable development' marketing angle
   c. can add passive recreation value to the development (additional landscape, increased ecology etc.).
2. Water quality and stream health in receiving waterways is maintained or enhanced in:
   a. local streams and creeks (freshwater)
   b. regional waterways (estuarine and marine).

The following data was obtained from the literature on house price premiums potentially associated with WSUD:

- The semi-structured interviews identified the value associated with the recreational and amenity value of waterways in Queensland is typically worth 2–5% of the total value of property. This represents an average value across Queensland. The closer to waterways the higher the property value (or premium) and the further away from waterways the lower the property value.
- Research undertaken by CSIRO (2008) found that the Maroochy River underpins property value in the region to the value of $951 million. This represents 8–10% of the total value of property within the region of the river.
- Research in Western Australia (Tapsuwan et al., 2007) indicates property values increase by 7% when they are located adjacent to preserved natural wetlands or newly created stormwater treatment wetlands (i.e. a type of WSUD measure).
- A study in Washington (US) found the premium associated with improvements in water quality on nearby properties typically ranges from 1%–20%.

A potential value of 1% for property premiums associated with WSUD represents the lowest end of the range of reported values in literature (and is less than the 2 – 5% range obtained from local developers during the interviews). It is not straightforward to take this number and adopt it for the case study assessment, so a more conservative estimate has been adopted to estimate likely property premiums associated with WSUD. It is also recognised that the value for a detached dwelling is likely to be higher than for a unit or a townhouse. For the purpose of the case study assessment, the following conservative property premium values have been adopted:

- 0.25%–1.0% for detached dwelling developments (Case Studies 1 and 2)
- 0.25%– 0.5% for the townhouse and unit developments (Case Studies 3 and 4).

These values take into account the impact on amenity in the development due to the WSUD practices as well as local and regional water quality.

Table 5.5 summarises the estimated property premiums potentially associated with WSUD for Case Studies 1, 2, 3 and 4a.

It is not clear how WSUD affects property premiums on commercial and industrial sites and therefore this benefit has not been calculated for Case Study 5 and 6.

The results in Table 5.5 indicate that the premium on property values that is likely to be associated with WSUD will either outweigh the acquisition (capital) cost of implementing WSUD within residential developments, or return the majority of the acquisition cost.

Table 5.5 Property premiums potentially associated with WSUD

CASE STUDY		POTENTIAL PROPERTY PREMIUMS ASSOCIATED WITH WSUD ($/HA)	ESTIMATED ACQUISITION COSTS OF WSUD MEASURES ($/HA)			
			Brisbane	Mackay	Townsville	Cairns
1	Residential greenfield (sloping)[10]	11,000–44,000	21,200	31,800	34,450	39,750
2	Residential greenfield on flat topography [11]	11,000–44,000	33,000	42,890	42,890	52,780
3	Residential townhouse development [12]	35,000–70,000	29,680	36,320	39,590	46,180
4a	Urban renewal development [13]	175,000– 350,000	36,300	42,900	49,500	52,800

10 Using an average house price of $400,000 and 11 dwellings per hectare.

11 Using an average house price of $400,000 and 11 dwellings per hectare.

12 Using an average townhouse price of $350,000 and 40 dwellings per hectare.

13 Using an average unit price of $350,000 and 200 dwellings per hectare.

5.3.4 Avoided development costs

In many situations, the application of WSUD practices to an urban development can reduce or avoid the cost associated with other elements of the development. At a local scale, infrastructure costs such as conventional pits, pipes and earthworks can be substantially reduced through alternative stormwater conveyance and management approaches. At a regional scale, the adoption of WSUD provides an alternative source of water close to the demand at-source, reducing the need for increased trunk and regional infrastructure. Given rainwater tanks form part of the base case, the focus of the benefits assessment is at the local scale — the case study scale.

Boubli and Kassim (2003) undertook a study of two typical urban developments in Sydney and illustrated that WSUD could be applied to these sites without increasing the overall development costs. This is supported by practical experience at development projects across Queensland where significant cost savings have resulted due to the incorporation of WSUD and its influence on engineering and urban design (i.e. Bellvista at Caloundra, North Shore at Townsville). In particular, the adoption of conventional urban design and 'pit and pipe drainage' on flat sites can result in significant development costs as a result of the large diameter pipes and earthworks required to drain these sites.

WSUD adopts an at-surface approach to conveying and treating stormwater on flat sites, which reduces or avoids this cost. Refer to the *Concept Design Guidelines for Water Sensitive Urban Design* (Water by Design, 2009) for further details.

Table 5.6 illustrates the costs in drainage and earthworks that are potentially avoided through adopting WSUD practices for Case Studies 2, 4 and 6, which are flat sites. The costs are based on the following assumptions:

- Conventional urban design makes very little allowance for draining stormwater on flat sites — it does not support surface drainage. The capital cost of conventional pit and pipe drainage (base case) is $55,000 per hectare (Bligh Tanner and DesignFlow, 2009). When the site is designed to allow surface drainage on pavements within 'kerb and channel' or swales, the extent of 'pit and pipe drainage' is estimated to reduce by at least 20% (i.e. $11,000 per hectare). Additionally, some of the pit and pipe costs form part of the WSUD case costs—the overflow pit within the bioretention basin is incorporated into the unit cost of the basin.
- Filling is typically required to drain flat sites via conventional pit and pipe systems to the receiving waterway or drainage system. This is due to large pipe diameters. The capital cost of earthworks required to raise the development to allow for drainage is approximately $10 per m^3. This would be higher if imported fill is used. For the case studies, it was assumed that the whole site would require a minimum of 0.25 m of additional fill for the base cases.

Considering the above assumptions, the avoided capital cost on flat sites is likely to be in the order of **$36,000 per hectare**, or $34,123 in terms of a life cycle cost.

Although the life cycle costs of the WSUD case are likely to be higher than the avoided development costs, the value of this type of potential benefit is significant.

The avoided cost estimates are conservative. The actual avoided cost will vary considerably depending on site conditions and experience in developments such as Bellvista and North Shore show that the avoided costs are considerably higher than the WSUD costs.

Table 5.6 Potential avoided development costs associated with the application of WSUD on flat sites

CASE STUDY DESCRIPTION		AVOIDED CAPITAL COST ($/HA)	AVOIDED ANNUALISED LIFE CYCLE COST ($/HA)	ACQUISITION COSTS OF WSUD ($/HA)	ANNUALISED LIFE CYCLE COST OF WSUD[14,15] ($/HA/YR)
2	Residential greenfield on flat topography	36,000	1,365	33,000–52,800	*1,800–2,900*
4A	Urban renewal development	36,000	1,365	36,300–52,800	*2,000–2,800*
4B	Urban renewal development (no rainwater tanks)	36,000	1,365	52,800	*2,900–2,900*
6	Industrial development	36,000	1,365	42,900–49,500	*2,300–2,700*

14 Range provided for all geographic locations (climatic zones) considered during the assessment.
15 The life cycle of the WSUD elements has been modelled over 25 years.

5.4 Cost–benefit frameworks

Populated assessment frameworks are provided in Tables 5.7, 5.8 and 5.9. The framework has been applied as follows:

- Table 5.7 — low-density residential (case studies 1 and 2)
- Table 5.8 — medium to high-density residential (case studies 3 and 4)
- Table 5.9 — commercial and industrial (case studies 5 and 6).

The *purpose* of these frameworks is to bring together likely costs and benefits associated with the application of WSUD to new developments in Queensland to achieve best practice stormwater management, so that:

- a broad assessment can be made regarding whether the benefits are likely to outweigh the costs
- stakeholders can easily evaluate the best available data, for their own conclusions.

Table 5.7 WSUD cost-benefit framework: low-density residential developments


SEQ HWP


SEQ HWP


Shaun Leinster

Example bioretention systems in low density residential development

LIKELY COSTS FOR TYPICAL DEVELOPMENTS

Major quantifiable costs (estimated)

1. **Acquisition (capital + design) costs**
   (Note: included in life cycle cost):
   - $1,600–$4,000/lot (average = $2,800/lot)
   - $21,100–$39,750/ha (average = $30,425/ha).
2. **Annual maintenance costs**
   (Note: included in life cycle cost):
   - $20–$40/lot (average = $30/lot)
   - $260–$520/ha (average = $390/ha).
3. **Life cycle costs (acquisition + maintenance + renewal + decommission):**
   - $2,365–$5,410/lot (average = $3,890/lot)
   - $29,675–$71,690/ha (average = $50,680/ha).
4. **Annualised life cycle costs (acquisition + maintenance + renewal + decommission):**
   - $95–$215/lot (average = $155/lot)
   - $1,185–$5,410/ha (average = $3,330/ha).

LIKELY BENEFITS FOR TYPICAL DEVELOPMENTS

Major quantifiable potential benefits (estimated)

1. **Value of the reduction in TN loads in stormwater:**
   The equivalent wastewater treatment cost to remove annual TN loads:
   - $2,110–$5,150/ha/yr (average = $3,630/ha/yr)
   - 95%–180% of the annualised life cycle cost of the WSUD treatment train (average = 110%).
2. **Potentially avoided costs associated with downstream waterway rehabilitation and maintenance:**
   - $8,000–$60,000/ha (life cycle cost) of development (average = $34,000/ha of development)
   - 25%–85% of the life cycle cost of the WSUD treatment train (average = 67%).
3. **Potential increase in property values (premium):**
   - $11,000–$44,000/ha (average = $27,500/ha)
   - 52%–110% of the acquisition cost of the WSUD treatment train (average = 90%).
4. **Potential development costs that are avoided (applicable only on flat sites, i.e. < 5%):**
   - $36,000/ha
   - 120% of the average acquisition cost of the WSUD treatment train.

Major unquantifiable potential benefits

Contribution to protecting the numerous values associated with healthy downstream waterways:

- ecosystem services (which may include some of the benefits below)
- recreational and commercial fishing
- tourism
- seafood industry
- option, existence and bequest values.

Community amenity at local and regional scale (i.e. connection to water cycle).

The monetary value of many of these unquantified benefits is very high (see Table 4.2), but the relationship between the application of WSUD in a catchment and the maintenance of these values in downstream waterways has not been quantified.

Minor potential costs:

- Additional development assessment, compliance checking and enforcement costs associated with WSUD assets (relatively minor and reducing over time as WSUD becomes mainstream practice).
- Potential increase in maintenance tasks for residents (for at source or streetscape WSUD).
- Environmental costs associated with sourcing materials for the WSUD measures (e.g. biofiltration media).

Minor potential benefits

- Increased rate of sales and amenity associated with developments with landscaped WSUD features, such as streetscape bioretention systems (see Lloyd et al., 2002).
- Shading and urban cooling (potentially reducing energy consumption).
- Some direct and indirect aspects of implementing WSUD will result in changes to the configuration of development that could enhance open space.
- Education and research.

Conclusions regarding the relative magnitude of likely costs and benefits:

Considering all the costs and all the potential benefits of applying WSUD to achieve the proposed stormwater management design objectives, it is concluded that the **benefits are *likely* to outweigh the costs for typical low-density residential development in Queensland.**

The estimated acquisition costs of applying WSUD within low-density residential developments equate to an average cost of approximately $2,800 per dwelling. This value is equivalent to 0.7% of a house and land package worth $400,000. This cost will usually be passed onto the homeowner, so it should not significantly impact the profitability of development.

The estimated annual maintenance costs are an average of $30/year. Where councils undertake the maintenance of WSUD assets in public areas, this cost is likely to be passed onto homeowners via rates.

Considering just the quantifiable benefits, on average, the value of TN reduction is worth more than the total life cycle cost of WSUD measures. The potentially avoided waterway rehabilitation costs (expressed as life cycle cost) are worth around 67% of the life cycle cost of WSUD and the potential property premiums are worth around 90% of the acquisition cost of WSUD. Considering the quantifiable benefits in a lumped group, *the potential quantifiable benefits are likely to outweigh the costs.*

Table 5.8 WSUD cost-benefit framework: medium to high-density developments

Alan Hoban

Shaun Leinster

SEQHWP

Example of bioretention systems in medium to high density residential development

LIKELY COSTS FOR TYPICAL DEVELOPMENTS

Major quantifiable costs (estimated)

1. **Acquisition (capital + design) costs**
   (Note: included in life cycle cost):
   - $350–$1,200/lot (average = $775/lot)
   - $29,680–$46,180/ha (average = $37,930/ha).
2. **Annual maintenance costs**
   (Note: included in life cycle cost):
   - $3–$40/lot (average = $22/lot)
   - $260–$520/ha (average = $390/ha).
3. **Life cycle costs (acquisition + maintenance + renewal + decommission):**
   - $345–$1,670/lot (average = $1,110/lot)
   - $40,135–$71,720/ha (average = $55,930/ha).
4. **Annualised life cycle costs (acquisition + maintenance + renewal + decommission):**
   - $15–$65/lot (average = $45/lot)
   - $1,615–$2,870/ha (average = $2,240/ha).

LIKELY BENEFITS FOR TYPICAL DEVELOPMENTS

Major quantifiable potential benefits (estimated)

1. **Value of the reduction in TN loads in stormwater:**
   The equivalent wastewater treatment cost to remove annual TN loads:
   - $2,470–$5,930/ha/yr (average = $4,200/ha/yr)
   - 150%–205% of the annualised life cycle cost of the WSUD treatment train (average = 185%).
2. **Potentially avoided costs associated with downstream waterway rehabilitation and maintenance:**
   - $8,000–$60,000/ha (life cycle cost) of development (average = $34,000/ha of development) (value estimated using a low-density residential development case study)
   - 20%–85% of the life cycle cost of the WSUD treatment train (average = 60%).
3. **Potential increased property values (premium):**
   Medium density:
   - $35,000–$70,000/ha (average = $52,500/ha)
   - 120%–150% of the acquisition cost of the WSUD treatment train (average = 135%).

   High density:
   - $175,000–$350,000/ha (average = $262,500/ha)
   - 480%–700% of the acquisition cost of the WSUD treatment train (average = 520%).
4. **Potential development costs that are avoided (applicable only on flat sites, i.e. <5%):**
   - $36,000/ha
   - 95% of the average capital cost of the WSUD treatment train.

Major unquantifiable potential benefits

Contribution to protecting the numerous values associated with healthy downstream waterways:

- ecosystem services
- recreational and commercial fishing
- tourism
- seafood industry
- option, existence and bequest values.

The monetary value of many of these unquantified benefits is very high (see Table 4.2), but the relationship between the application of WSUD in a catchment and the maintenance of these values in downstream waterways has not been quantified.

Minor potential costs:

- Additional development assessment, compliance checking and enforcement costs associated with WSUD assets (relatively minor and reducing over time as WSUD becomes mainstream practice).
- Potential increase in maintenance tasks for residents (for at source or streetscape WSUD)
- Environmental costs associated with sourcing materials for the WSUD measures (e.g. biofiltration media).

Minor potential benefits

- Increased rate of sales and amenity associated with developments with landscaped WSUD features, such as streetscape bioretention systems (see Lloyd et al., 2002).
- Shading and urban cooling (potentially reducing energy consumption).
- Some direct and indirect aspects of implementing WSUD will result in changes to the configuration of development that could enhance open space.
- Education and research.

Conclusions regarding the relative magnitude of likely costs and benefits:

Considering all the costs and all the potential benefits of applying WSUD to achieve the proposed stormwater management design objectives, it is concluded that the **benefits are *likely* to outweigh the costs for typical medium to high-density residential development in Queensland**.

The estimated acquisition costs of applying WSUD within medium- to high-density residential developments equate to an average cost of approximately $775 per dwelling. This value is equivalent to 0.2% of a unit or townhouse worth $350,000. This cost will usually be passed onto the homeowner, so it should not significantly impact the profitability of development.

The estimated annual maintenance costs are an average of $22/year. Where councils undertake the maintenance of WSUD assets in public areas, this cost is likely to be passed onto homeowners via rates.

Considering just the quantifiable benefits, on average, the value of TN reduction is worth more than the total life cycle cost of WSUD measures. The potentially avoided waterway rehabilitation costs (expressed as life cycle cot) are worth around 67% of the life cycle cost of WSUD and the potential property premiums are worth around 90% of the acquisition cost of WSUD. Considering the quantifiable benefits in a lumped group, *the potential quantifiable benefits are likely to outweigh the costs.*

Table 5.9 WSUD cost-benefit framework: commercial and industrial developments


SEQ HWP


Robin Allison


SEQHWP

Example bioretention systems in commercial and industrial developments

LIKELY COSTS FOR TYPICAL DEVELOPMENTS

Major quantifiable costs (estimated)

1. **Acquisition (capital + design) costs**
   (Note: included in life cycle cost):
   - $42,900–$54,750/ha (average = $48,825/ha).
2. **Annual maintenance costs:**
   (Note: included in life cycle cost):
   - $390–$490/ha (average = $440/ha).
3. **Life cycle costs (acquisition + maintenance + renewal + decommission):**
   - $58,270–$73,485/ha (average = $65,880/ha).
4. **Annualised life cycle Costs (acquisition + maintenance + renewal + decommission):**
   - $2,330–$2,940/ha (average = $2,635).

LIKELY BENEFITS FOR TYPICAL DEVELOPMENTS

Major quantifiable potential benefits (estimated)

1. **Value of the reduction in TN loads in stormwater:**
   The equivalent wastewater treatment cost to remove annual TN loads
   - $4430–$11,280/ha/yr (average = $7,860/ha/per)
   - 190%–380% of the annualised life cycle cost of the WSUD treatment train (average = 300%).
2. **Potentially avoided costs associated with downstream waterway rehabilitation and maintenance:**
   - $8,000–$60,000/ha (life cycle cost) of development (average = $34,000) (Value obtained for low-density residential development)
   - 15%–80% of the life cycle cost of the WSUD treatment train (average = 52%).
3. **Potential increase in property values (premium):**
   This value has not been quantified for commercial and industrial developments for these case studies.
4. **Potential development costs that are avoided (applicable only on flat sites, i.e. <5%):**
   - $36,000/ha
   - 75% of the capital cost (average) of the WSUD treatment train.

Major unquantifiable potential benefits

Contribution to protecting the numerous values associated with healthy downstream waterways:

- ecosystem services
- recreational and commercial fishing
- tourism
- seafood industry
- option, existence and bequest values.

The monetary value of many of these quantified benefits is very high (see Table 4.2), but the relationship between the application of WSUD in a catchment and the maintenance of these values in downstream waterways has not been quantified.

Minor costs:

- Additional development assessment, compliance checking and enforcement costs associated with WSUD assets (relatively minor and reducing over time as WSUD becomes mainstream practice).
- Environmental costs associated with sourcing materials for the WSUD measures (e.g. biofiltration media).

Minor benefits

- Shading and urban cooling (potentially reducing energy consumption)
- Enhanced streetscape amenity may deliver premium on rents received by landlords, as a result of potential increased patronage for retail and service businesses

Conclusions regarding the relative magnitude of likely costs and benefits:

Considering all the costs and all the potential benefits of applying WSUD to achieve the proposed stormwater management design objectives, it is concluded that the **benefits are *likely* to outweigh the costs for typical commercial and industrial development in Queensland.**

The estimated acquisition costs of applying WSUD within commercial and industrial developments equate to an average cost of approximately $48,825 per hectare. Construction costs for commercial and industrial developments can range from about $10–$40 million per hectare. The cost of WSUD is therefore about 0.1%–0.5% of construction costs.

Considering just the quantifiable benefits, on average, the value of TN reduction is worth more than the total life cycle cost of WSUD measures. The potentially avoided waterway rehabilitation costs (expressed as life cycle cost) are worth around 67% of the life cycle cost of WSUD and the potential property premiums are worth around 90% of the acquisition cost of WSUD. Considering the quantifiable benefits in a lumped group, the *potential quantifiable benefits are likely to outweigh the costs.*

6 Summary and conclusions

This business case investigated whether the benefits of applying WSUD practices to achieve best practice stormwater management are *likely* to outweigh the costs for typical urban development in Queensland.

There are many benefits and costs associated with using WSUD practices. Some are quantifiable financial values, while other values are not readily represented in financial terms, such as the value associated with protecting downstream aquatic ecosystem services. While costs are relatively easy to estimate, many benefits are difficult to quantify with confidence.

The cost–benefit frameworks (Table 5.7, Table 5.8 and Table 5.9) brought together both quantitative and qualitative data relating to *likely* benefits and costs of using WSUD practices to achieve the stormwater management design objectives for residential, commercial and industrial developments. The literature review, semi-structured interviews with industry stakeholders and case study assessments of six different development types in Brisbane, Mackay, Townsville and Cairns provided data on the costs and benefits of meeting the proposed stormwater management objectives to populate the frameworks

The cost–benefit frameworks demonstrate that, when considered as a whole, the potential benefits of WSUD practices to achieve best practice stormwater management on typical developments in Queensland are likely to exceed the estimated costs. It is, however, acknowledged that these benefits and costs are affected by geographic location, are incurred by different stakeholders, at different times, and at different scales.

In addition to presenting the likely net benefit of WSUD, this business case also found the following:

- When implemented well (e.g. early in the design process), WSUD practices can be accommodated within developments without loss of developable land.
- WSUD has sufficient flexibility to comply with the current town planning provisions of local governments while meeting the broader intent of the draft policy.
- Geographic location influences the size of the treatment systems required and therefore the cost. Where rainfall is higher, treatment systems generally need to be slightly larger to achieve the stormwater quality objective when rainwater tanks are included in the treatment train. For example, a bioretention size (filter area) will need to increase from 1.1% in Brisbane to 1.6% (expressed as a portion of catchment area) in Cairns (based on an urban renewal development type)
- The cost of applying WSUD should not significantly impact on the profitability of typical residential, commercial and industrial development. For example, in residential developments the acquisition costs of WSUD practices to meet the stormwater management design objectives is typically less than 1% of the cost of a new dwelling. This acquisition cost is similar in magnitude to expected property premiums associated with WSUD (see Tables 5.7 and 5.8).
- WSUD-related costs are likely to be borne by householders, tenants or owners, while benefits are distributed over a wide range of geographic, social and temporal scales.

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