An Introduction to Life Cycle Costing Involving Structural Stormwater Quality Management Measures

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INTRODUCTION

The primary purpose of this paper is to provide a simple data recording sheet to collect life cycle costing information for structural measures that aim to improve stormwater quality, such as gross pollutant traps and constructed wetlands.

The data recording sheet has been prepared to:

- Help stormwater management agencies who manage such assets (e.g. small to medium sized local authorities) to ensure that critical costing-related information is gathered at the start of an asset's life cycle.
- Help funding and research bodies to gather basic life cycle costing information in a consistent manner, and make it simpler for agencies supplying the information.
- Minimise the risk of common mistakes occurring during the collection of costing data which make subsequent life cycle costing difficult.

In addition, the paper provides a brief overview of the Australian Standard for life cycle costing (AS/NZS 4536:1999). This standard provides the theoretical framework for the life cycle costing data recording sheet.

BACKGROUND

The focus on urban stormwater as an important source of water pollution has led to the increased use of infrastructure to improve urban stormwater quality in all Australian states. For example, a recent survey by the Cooperative Research Centre for Catchment Hydrology (Taylor and Wong, 2002) involving 25 stormwater managers from across Australia found that the majority of respondents to the survey reported an increasing trend in use for 10 of 25 structural best management practices (BMPs). The survey also found that none of the 25 BMPs were associated with a widespread decreasing trend in use.

Such infrastructure however comes at a cost. Costs typically include those associated with:

- Site selection processes.
- Grant application costs (i.e. to obtain State or Commonwealth funding for capital works).
- Feasibility studies.

- Conceptual, preliminary and detail designs.
- Project and contract management costs.
- Construction/purchase costs, including *related* costs such as the cost of environmental impact assessment, gaining environmental permits and subsequent environmental management (e.g. erosion and sediment control).[1]
- Routine maintenance costs (including related costs such as disposal of wastes, health and safety training of staff, etc.).
- Renewal and adaptation costs (e.g. unusual costs associated with reconstruction of the asset or adding new features).
- Decommissioning costs.

Developers and stormwater management agencies are now closely examining these costs as they can represent a significant financial investment and long-term financial commitment. Developers particularly want to minimise acquisition costs. Stormwater management agencies want to minimise life cycle costs, and in particular maintenance costs.

In response to the concerns about the cost of this infrastructure, relevant costing data are now being collected by stormwater managers, funding and research agencies. The Cooperative Research Centre for Catchment Hydrology is one of these agencies. Our most recent experience from surveying approximately 60 agencies across all Australian states found that:

- There is little or no consistency in the way that agencies record basic life cycle costing data for structural stormwater quality best management practices.
- Many agencies have recently installed structural measures to improve urban stormwater quality, but have not yet established management systems that clearly record all of the important life cycle costing details. This is particularly the case for small to medium-sized local government authorities.
- It is very difficult to collect some critical life cycle costing details in retrospect, if the data have not been recorded at the start of the asset's life cycle.
- Data that has been recorded often suffers from simple sources of uncertainty which severely compromises its usefulness. Common examples include whether or not GST has been included in the cost estimates (this is particularly relevant to assets that have been 'donated' by the private sector), whether cost estimates include 'on-costs' such as project management/administration, and the dates that expenditure occurred (so that costs can be adjusted for inflation).

The simple data recording sheet presented in this paper aims to help overcome these drawbacks. It could be used by agencies that build and/or maintain these assets as a:

- simple paper-based system for collecting important life cycle costing data;
- framework for an electronic database;
- framework for a simple spreadsheet with expenditure notes; or
- checklist to ensure existing asset/financial management systems record the necessary information.

[1] It is acknowledged that costs associated with environmental impact assessment and gaining environmental permits could be incurred during feasibility studies or design work. However, for the sake of consistency and simplicity, it is recommended that such environmental costs be recorded as part of the cost of "construction".

The work currently being undertaken by the Cooperative Research Centre for Catchment Hydrology involving life cycle costing will produce two outputs:

- In the short-medium term, costing data from around Australia will be analysed to derive relationships between BMP size and cost for a variety of BMP types using 'parametric cost estimating' techniques. These relationships will be used to build a 'life cycle costing module' into the CRC's MUSIC model[2]. This module will allow life cycle costs of BMPs to be estimated during the planning stage of projects, when MUSIC is commonly used as a tool to run scenarios of different stormwater treatment options and configurations.
- Over the next two years, the CRC will also be developing triple-bottom-line assessment methodologies for selecting suitable structural BMPs for a given site. The resulting assessment tools will be developed primarily for use by stormwater management agencies, and will enable financial, social and ecological costs and benefits to be considered in the decision making process. Traditional life cycle costing analysis will be one of the financial inputs to the recommended processes.

SCOPE

This paper addresses life cycle costing as defined in the Australian Standard titled *'AS/NZS 4536:1999 Life Cycle Costing – An Application Guide',* namely "the process of assessing the cost of a product over its life cycle or portion thereof" (p. 6).

The costs being considered in this paper are traditional costs that have a market (e.g. construction expenses) not environmental costs/benefits (e.g. the environmental costs associated with production of the structure's raw materials, or the benefits to ecosystem services due to the structure's role in minimising stormwater pollution).

Other methods can be used to identify and assess the significance of these externalities[3]. Such methods include:

- Life cycle assessment. Such assessment is defined as the "compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle" (AS/NZS ISO 14040:1998, p. 2).
- Cost-benefit analysis that attempts to place an approximate monetary value on environment and social costs/benefits through a variety of valuation methods (see www.ecosystemvaluation.org for a description of these).
- Multi-criteria analysis within a 'triple-bottom-line' assessment framework, where traditional costs, environmental costs/benefits and social costs/benefits are considered.

It is important to realise that traditional life cycle costing as outlined in this paper is only one input to decision making process of siting and design of structural measures to improve urban stormwater quality. Social and environmental inputs should also be considered to gain optimal outcomes for the community. This approach is summarised in Figure 1.

2 'Model for Urban Stormwater Improvement Conceptualisation'. A model developed by the CRC which is widely used across Australia to develop stormwater management plans involving structural BMPs. For more information see: www.catchment.crc.org.au.

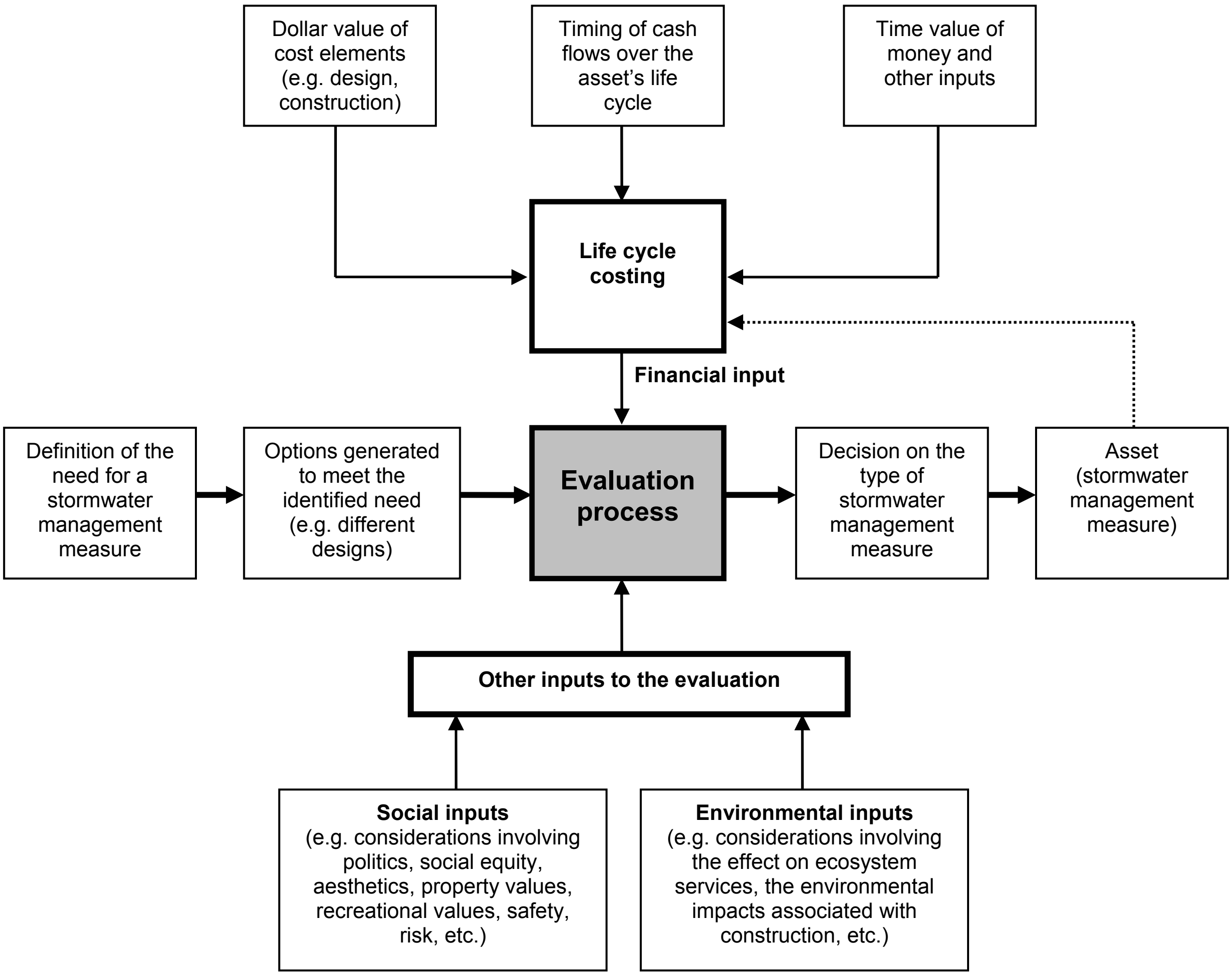
3 An 'externality' can be defined as a cost or benefit that arises from an economic transaction (e.g. the construction of a wetland) and falls on people who don't participate in the transaction (e.g. people living next to the wetland). These costs/benefits may be positive or negative and the assets affected may be tangible (i.e. have markets) or intangible.

AUSTRALIAN STANDARD FOR LIFE CYCLE COSTING

Standards Australia have published a guideline on life cycle costing titled *"AS/NZS 4536:1999 Life Cycle Costing – An Application Guide".* Key elements of this document are summarised here to provide the theoretical framework for the data recording sheet for the collection of critical life cycle costing details.

Life cycle costing is defined in the standard as a "process to determine the sum of all expenses associated with a product or project, including acquisition, installation, operation, maintenance, refurbishment, discarding and disposal costs" (Standards Australia, 1999, p. 4). As described in Figure 1, it often provides one important input into an evaluation process. Such an evaluation process may involve the selection of the best stormwater management measure (or combination of measures) for a particular site.

Figure 1 - Use of Life Cycle Costing In an Evaluation Process Such as the Design of a Stormwater Quality Management Measure



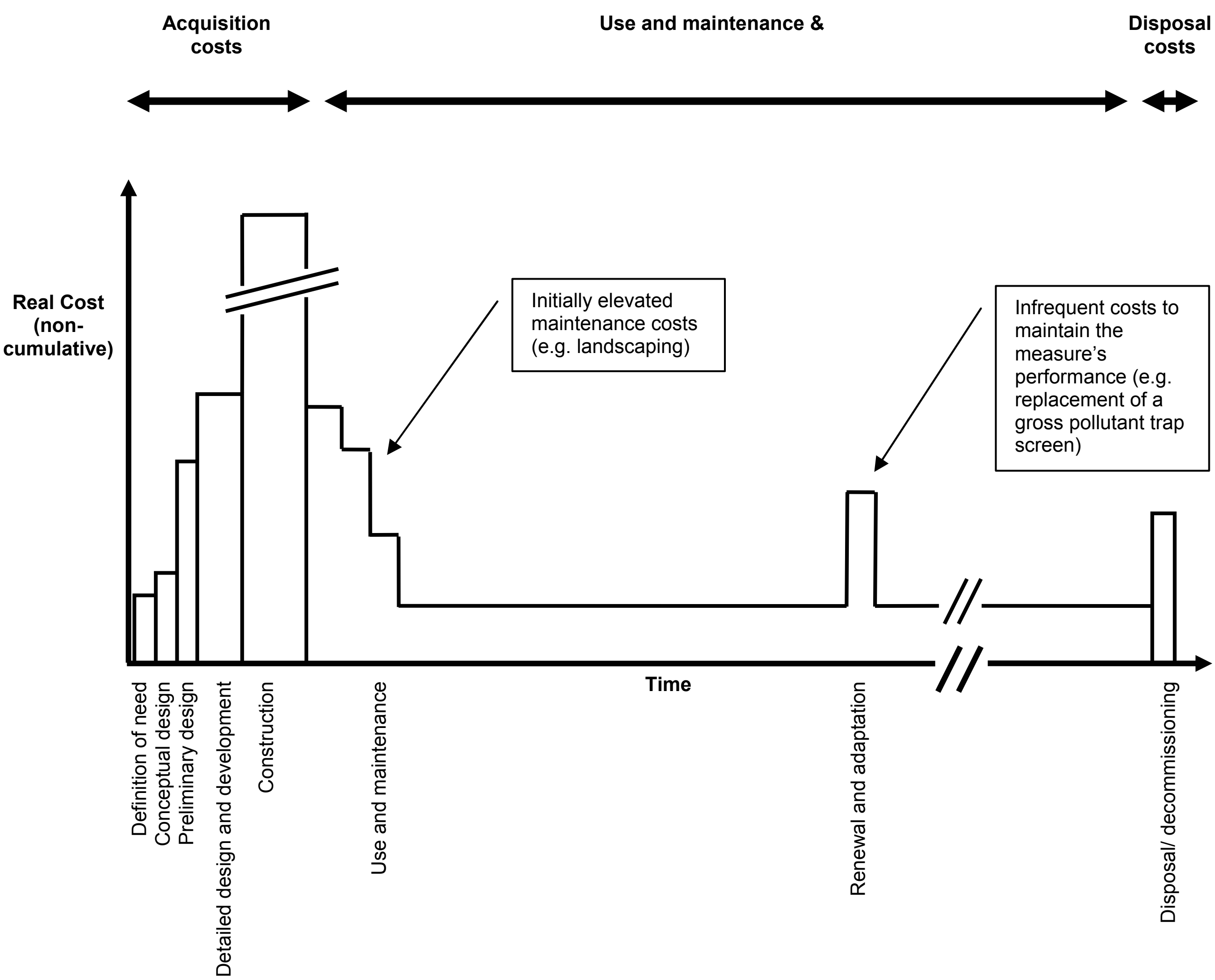
Source: modified from Standards Australia (1999).

AS/NZS 4536:1999 defines several phases in the life cycle of product or asset. These phases represent ‘cost elements’ and are defined as:

1. Acquisition, which should include the following (where relevant):
   - Identification and definition of the need for the stormwater management measure.
   - Conceptual design.
   - Preliminary design.
   - Detailed design and development.
   - Construction (or purchase of a proprietary device).
2. Use and maintenance.
3. Renewal and adaptation.
4. Disposal/decommissioning.

Figure 2 is a conceptual diagram of these phases in the life cycle and cost elements potentially associated with them.

Figure 2 – Phases in the Life Cycle of a Stormwater Quality Management Measure and Potentially Associated Costs



Source: modified from Standards Australia (1999).

The life cycle costing process as set out in the Australian Standard involves six steps which are summarised below. Note however that this "ideal process" is primarily designed for detailed analysis of new products (e.g. electrical appliances), and consequently needs to be simplified for practical application in the stormwater management arena.

1. ***Preparation of a life cycle costing analysis plan.*** This is essentially a project planning step, that outlines the objectives of the analysis, the scope of the analysis, identifies limitations and constraints, identifies the options to be evaluated (if relevant), and estimates the required resources to undertake the analysis.
2. ***Development or selection of a life cycle costing model.*** In its simplest form a life cycle costing model is an accounting structure that breaks down the life cycle costs into cost elements (as shown in Figure 2) and allows for the estimation of costs associated with each of these elements. An example of a simple life cycle costing model is a discounted cash flow spreadsheet that tracks all of the significant costs shown in Figure 2 over time and calculates a life cycle cost. A simplified, hypothetical example is given in Table 1.
3. ***Undertake life cycle costing model analysis.*** This step represents one of the more advanced elements of life cycle cost analysis. Analysis may include identifying cost drivers by examining model inputs and outputs to determine those cost elements that most significantly impact on the overall life cycle cost. Sensitivity analysis may also be undertaken to determine the impact on the results of variations to assumptions and uncertainties (e.g. discount rates). Finally the outputs of the life cycle costing analysis are compared against the initial objectives of the life cycle costing analysis plan.
4. ***Documentation of the life cycle costing analysis***. The Australian Standard for life cycle costing encourages structured documentation of the life cycle costing analysis including a report which contains the following chapters: an executive summary; purpose and scope; life cycle costing model description; life cycle costing model analysis; discussion; and conclusions and recommendations. Again, it is suggested that for application in stormwater management, this step needs to be tempered with considerations of practicality.
5. ***Review of life cycle costing results.*** The Australian Standard for life cycle costing encourages life cycle costing results to be reviewed by an independent analyst to ensure objectivity.
6. ***Update the life cycle costing analysis.*** As knowledge grows on the costs associated with an asset throughout its life cycle, the Australian Standard recommended that the life cycle costing model be updated. This process is represented by the dotted line in Figure 1.

Table 1 – An Example of a Simple Life Cycle Cost Model for a Hypothetical Constructed Wetland

COSTS ($,000) Year (t) =	0	1	2		4	5		7	8		10	11		13	14		16	17	18	19	20	21
Acquisition costs																						
Total costs associated with defining the need for the wetland (e.g. running site selection processes, feasibility studies, grant application costs):	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total conceptual, preliminary and detailed design costs:	40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total construction costs (including project management and/or contract management costs):	0	500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sub-total	55	500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total acquisition costs ("real costs" with a base date of year 0**)**	555	(75.8% of total real costs at year 0)																				
Use and maintenance costs																						
Cost of typical maintenance events, including costs associated with relevant administration, inspections, staff training and waste disposal:	0	0	15	15	5	5	10	5	5	5	5	10	5	5	5	5	10	5	5	5	5	10
Renewal and adaptation costs																						
Cost of unusual restoration events (e.g. additional landscaping, interpretive signage, rebuilding the outlet structure):	0	0	5	0	0	10	0	0	0	0	0	0	0	0	0	0	0	7.5	0	0	0	0
Total maintenance/ renewal costs ("real costs" with a base date of year 0**)**	162.5	(22.2% of total real costs at year 0)																				
Disposal/decommissioning costs																						
Cost of decommissioning the structure at the end of its useful life:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15

Continued …

Table 1 – An Example of a Simple Life Cycle Cost Model for a Hypothetical Constructed Wetland (continued)

COSTS ($,000) Year (t) =	**0**		**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**
Total disposal/ decommissioning costs ("real costs" with a base date of year 0)	15	(2% of total real costs at year 0)																				
Total costs ("real costs" with a base date of year 0)	55	500	20	15	5	15	10	5	5	5	5	10	5	5	5	5	10	12.5	5	5	5	25
Annual inflation rate (using the "new engineering construction" Implicit Price Deflator [ABS, 2003] to estimate the average annual rise in prices over the 1993-2002 period)	2.14%																					
Total costs adjusted for inflation (i.e. "nominal costs")	55	510.7	20.9	16.0	5.4	16.7	11.4	5.8	5.9	6	6.2	12.6	6.4	6.6	6.7	6.9	14	17.9	7.3	7.5	7.6	39
Nominal discount rate (derived from the discount rate used by Brisbane City Council in 2003 for water-related assets)	10%																					
Discounted costs	55	464.3	17.2	12	3.7	10.4	6.4	3.0	2.8	2.6	2.4	4.4	2.1	1.9	1.8	1.6	3.1	3.5	1.3	1.2	1.1	5.3
Net Present Value (at year 0)	552 ($552.036)																					
Life Cycle Cost (LCC) (sum of all discounted costs, or the sum of the NPV and the total costs at year 0)	**607** **($607,036)**	**Equivalent annual payment** ($/yr) = **$30,352** (i.e. LCC/life span)																				

Notes:

- This hypothetical constructed wetland has an unusually short life cycle (20 years) to simplify the example.
- 'Real cost' is defined as the cost expressed in values of the base date (e.g. year 0), including estimated changes in prices due to forecast changes in efficiency and technology, excluding general price inflation or deflation (AS/NZS 4536: 1999). 'Nominal cost' is defined as the expected price that will be paid when the cost is due to be paid, including estimated changes in prices due to the forecast changes in efficiency, inflation/deflation, technology and the like (AS/NZS 4536: 1999).

A SIMPLE DATA RECORDING SHEET FOR COLLECTING LIFE CYCLE COST INFORMATION FOR STRUCTURAL STORMWATER QUALITY MANAGEMENT MEASURES

This data recording sheet provides a framework that breaks down typical cost elements and prompts users to ensure all basic costing data is collected at the start of an asset's life cycle to enable subsequently life cycle cost analysis. It also prompts users to document important additional information that may be needed during subsequent life cycle cost analysis (e.g. whether there were any aspects of the asset's life cycle that contributed to unusually large cost elements).

The sheet has been designed to be consistent with the intent and terminology of the Australian Standard for Life Cycle Costing (*AS/NZS 4536:1999).*

PART A - DESCRIPTION OF THE BEST MANAGEMENT PRACTICE (BMP)

1. Commonly used name for the BMP (e.g. "Hay St. Wetland"): . . . .

2. Type of BMP (tick one box below):

❏ In-ground gross pollutant trap ('circular screen' type)
❏ In-ground gross pollutant trap ('return flow litter basket' type)
❏ In-ground gross pollutant trap ('sediment-oil separator' type)
❏ In-ground gross pollutant trap ('downwardly inclined screen' type)
❏ In-ground gross pollutant trap (other type)
❏ Combined trash rack and sediment trap (open gross pollutant trap)
❏ Litter collection basket
❏ Side entry pit traps for litter
❏ Floating litter trap/boom
❏ Fixed trash rack
❏ Release net (for litter)
❏ Sediment trap or settling basin
❏ Vegetated filter/buffer strip
❏ Vegetated/grassed swale
❏ Porous paving
❏ Bioretention system/infiltration system
❏ Extended detention basin
❏ Constructed wetland (greenfield)*
❏ Constructed wetland (retro-fitted)*
❏ Pond

** This BMP includes a macrophyte zone and upstream sediment basin.*

❏ Other (e.g. combined BMPs): . . . .

(For descriptions of these types of BMPs, refer to 'Urban Stormwater: Best Practice Environmental Management Guidelines' [VSC, 1999]. If you are unsure of the 'type' but it is a proprietary device, just write down the name of the product.)

3. The expected life span of the BMP (in years): . . . .

4. Describe how the 'expected life span' of the BMP was determined (e.g. advice from a product supplier, the design engineer, or the developer 'donating' the asset to Council):

   . . . .
   . . . .
   . . . .
   . . . .

PART B – KEY BMP DESIGN DETAILS

5. Estimate the area of the BMP's catchment (ha).

6. Estimate the percent of the BMP's catchment that is impervious (%).

7. Estimate the BMP's:
   - maximum allowable inflow rate (m^3/sec) for those BMPs without a detention element (e.g. gross pollutant traps); or
   - maximum allowable storage (m^3) for those BMPs with a detention function (e.g. ponds).

8. For vegetated filter/buffer strips, vegetated/grassed swales, porous paving, bioretention systems/infiltration systems, constructed wetlands and ponds, estimate the surface area of the BMP's treatment zone (m^2).

PART C – BMP COST

9. Estimate or track the following costs associated with the BMP:

Cost element[1]	Estimated cost ($)[2] cl									
Financial Year Starting:	**20…**	**20…**	**20…**	**20…**			**20…**	**20…**	**20…**	**20…**
Acquisition costs[3]:										
▪ Total costs associated with defining the need for the BMP (e.g. running site selection processes, feasibility studies, grant application costs):										
▪ Total conceptual, preliminary and detailed design costs:										
▪ Total construction costs (including project management costs, contract management costs, and cost of environmental assessment, permits and management):										
Maintenance costs[3]:										
▪ Costs associated with typical maintenance events (e.g. cleaning out a gross pollutant trap), including costs associated with relevant administration, BMP inspections, staff training and waste disposal:										
Renewal and adaptation costs[4]:										
Disposal/decommissioning costs[5]:										

Notes:

1. These costs should include staff time (incl. on-costs) as well as project, capital and recurrent expenses.
2. Cost estimates should be 'real costs' for the year they were incurred. For example, if the total construction cost was actually $200,000 in the year 2000, then this figure should be used in a column labelled "2000" and not adjusted for inflation/deflation.
3. These cost elements can be broken down further if required. It is recommended that any costs associated with the *purchase of land* be isolated from the life cycle costs associated with the *asset* (i.e. not included in traditional life cycle cost analysis as shown in Table 1). Note that the CRC for Catchment Hydrology is currently developing methodologies to assess the full range of issues that need to be considered when stormwater quality management measures are chosen (e.g. social considerations, ecological considerations, affect on nearby property values, land acquisition costs, opportunity costs, etc.).
4. "Renewal and adaptation costs" are incurred from significant alterations to the BMP (e.g. the addition of safety fencing, interpretive signage, new landscaping features).
5. These costs involve the removal of the BMP at the end of its life-span (e.g. due to redundancy or the need for replacement).

10. Describe how the above costing information was gathered (e.g. estimated or real costs):

. . . .
. . . .
. . . .
. . . .
. . . .
. . . .

11. If relevant, explain any unusual cost elements:
(e.g. unusually large construction costs due to excavation of bedrock or stringent environmental management requirements)

. . . .
. . . .
. . . .
. . . .
. . . .
. . . .

12. Where relevant, explain why the BMP's maintenance costs vary significantly over time (in real terms), and if possible, quantify the nature of these variations:
(For example, a given constructed wetland may require ~$2,000 every year to maintain the landscaping, ~$10,000 every 5 years to clean out the sediment in the inlet zone, and ~$50,000 every 30 years to re-contour and replant the macrophyte zone, where all cost estimates are in 2003 dollars and exclusive of GST)

. . . .
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. . . .

PART D – DOCUMENT CONTROL

13. Name and position of the person entering data into the data recording sheet:

Name: . . . . Position: . . . .

14. Date(s) of data entry: 1) . . . . 2) . . . .
3) . . . . 4) . . . .

Notes:

. . . .
. . . .
. . . .
. . . .
. . . .
. . . .

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