Stormwater Management Manual for Western Australia

5 Stormwater Management Plans

Department of Water
Government of Western Australia

SWAN RIVER TRUST

Cover photograph: Catchment management planning workshop. (Source: Department of Water.)

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Consultation and guidance from the Stormwater Working Team

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SWAN RIVER TRUST

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Preface

A growing public awareness of environmental issues in recent times has elevated water issues to the forefront of public debate in Australia.

Stormwater is water flowing over ground surfaces and in natural streams and drains as a direct result of rainfall over a catchment (ARMCANZ and ANZECC, 2000).

Stormwater consists of rainfall runoff and any material (soluble or insoluble) mobilised in its path of flow. Stormwater management examines how these pollutants can best be managed from source to the receiving water bodies using the range of management practices available.

In Western Australia, where there is a superficial aquifer, drainage channels can commonly include both stormwater from surface runoff and groundwater that has been deliberately intercepted by drains installed to manage seasonal peak groundwater levels. Stormwater management is unique in Western Australia as both stormwater and groundwater may need to be managed concurrently.

Rainwater has the potential to recharge the superficial aquifer, either prior to runoff commencing or throughout the runoff's journey in the catchment. Urban stormwater on the Swan Coastal Plain is an important source of recharge to shallow groundwater, which supports consumptive use and groundwater dependent ecosystems.

With urban, commercial or industrial development, the area of impervious surfaces within a catchment can increase dramatically. Densely developed inner urban areas are almost completely impervious, which means less infiltration, the potential for more local runoff and a greater risk of pollution. Loss of vegetation also reduces the amount of rainfall leaving the system through the evapo-transpiration process. Traditional drainage systems have been designed to minimise local flooding by providing quick conveyance for runoff to waterways or basins. However, this almost invariably has negative environmental effects.

This manual presents a new comprehensive approach to management of stormwater in WA, based on the principle that stormwater is a RESOURCE – with social, environmental and economic opportunities. The community's current environmental awareness and recent water restrictions are influencing a change from stormwater being seen as a waste product with a cost, to a resource with a value. Stormwater Management aims to build on the traditional objective of local flood protection by having multiple outcomes, including improved water quality management, protecting ecosystems and providing livable and attractive communities.

This manual provides coordinated guidance to developers, environmental consultants, environmental/community groups, Industry, Local Government, water resource suppliers and State Government departments and agencies on current best management principles for stormwater management.

Production of this manual is part of the Western Australian Government's response to the *State Water Strategy* (2003).

It is intended that the manual will undergo continuous development and review. As part of this process, any feedback on the series is welcomed and may be directed to the Drainage and Waterways Branch of the Department of Water.

Western Australian Stormwater Management Objectives

Water Quality
To maintain or improve the surface and groundwater quality within the development areas relative to pre development conditions.

Water Quantity
To maintain the total water cycle balance within development areas relative to the pre development conditions.

Water Conservation
To maximise the reuse of stormwater.

Ecosystem Health
To retain natural drainage systems and protect ecosystem health .

Economic Viability
To implement stormwater management systems that are economically viable in the long term.

Public Health
To minimise the public risk, including risk of injury or loss of life, to the community.

Protection of Property
To protect the built environment from flooding and waterlogging.

Social Values
To ensure that social, aesthetic and cultural values are recognised and maintained when managing stormwater.

Development
To ensure the delivery of best practice stormwater management through planning and development of high quality developed areas in accordance with sustainability and precautionary principles.

Western Australian Stormwater Management Principles

- Incorporate water resource issues as early as possible in the land use planning process.
- Address water resource issues at the catchment and sub-catchment level.
- Ensure stormwater management is part of total water cycle and natural resource management.
- Define stormwater quality management objectives in relation to the sustainability of the receiving environment.
- Determine stormwater management objectives through adequate and appropriate community consultation and involvement.
- Ensure stormwater management planning is precautionary, recognises inter-generational equity, conservation of biodiversity and ecological integrity.
- Recognise stormwater as a valuable resource and ensure its protection, conservation and reuse.
- Recognise the need for site specific solutions and implement appropriate non-structural and structural solutions.

Contents

Summary

The aim of this chapter is to provide a process for the preparation, implementation and review of stormwater management plans. Stormwater management plans address how urban stormwater quantity and quality should be managed to protect ecological, social/cultural and economic values. A stormwater management plan is used to assist decision making to ensure that remedial measures (structural and non-structural) in existing developed areas are undertaken in a cost-effective, integrated and coordinated manner, and decisions in relation to new development (including redevelopment) are made with the implications for stormwater impacts taken into account.

There are many reasons for preparing a stormwater management plan, including to:

- improve budget coordination and stormwater related spending;
- reduce road and building flooding risks;
- reduce public health/safety and environmental impact risks from stormwater infrastructure;
- reduce water quality issues (e.g. algal blooms and fish deaths) in receiving water bodies;
- reduce impacts from water quantity issues (e.g. declining local groundwater levels, erosion of water bodies, or altered water regimes in receiving water bodies);
- improve coordination within and between agencies and groups; and
- establish processes and contingencies to address emergency/pollution issues and to adopt a proactive stormwater management approach.

A stormwater management plan is a document that addresses urban stormwater from a management perspective, rather than a development perspective, to ensure that the economic, ecological and social/cultural values of the area are protected and enhanced and that management issues are addressed in a coordinated manner. This chapter does not provide information for the preparation of plans that fulfil the planning requirements of new urban developments.

This chapter describes a process for preparing plans that address how to implement best practice urban stormwater management within a given area. A stormwater management plan can be prepared by local governments, catchment groups and regional natural resource management groups/councils for a local government area, a catchment area, or a sub-catchment (this is particularly relevant when local government areas or catchment areas are large and/or have many issues to address).

The process for preparing a stormwater management plan is outlined in Figure 1, and described in detail on pages 4-37. An example layout and content of a stormwater management plan is provided in Table 7 on pages 33-34, and a summary checklist of the process is on pages 34-35.

1 Introduction

1.1 Aim of the stormwater management plans chapter

The aim of this chapter is to provide a process for the preparation, implementation and review of stormwater management plans. A stormwater management plan is a document that addresses urban stormwater from a management perspective, rather than a development perspective, to ensure that the economic, ecological and social/cultural values of the area are protected and enhanced and that management issues are addressed in a coordinated manner.

This chapter outlines:

- What are stormwater management plans? (Section 2)
- Why prepare a stormwater management plan? (Section 3)
- Who prepares stormwater management plans? (Section 4)
- How do you prepare stormwater management plans? (Section 5)

1.2 Scope of the chapter

This chapter provides guidance for local government, regional council groups and catchment groups on preparing stormwater management plans that address how to implement best practice urban stormwater management within a given area. A stormwater management plan can be prepared for a local government area, a catchment area, or a sub-catchment (this is particularly relevant when local government areas or catchment areas are large and/or have many issues to address). The process described in this chapter is particularly applicable to proactively managing stormwater in areas that contain significant areas of traditionally drained urban land uses, or priority catchments[1]. The plans can include actions that provide mechanisms to ensure best practice stormwater management is included in future urban developments. See Section 2 for more information on the recommended scope of stormwater management plans.

The chapter does not provide information for the preparation of plans that fulfil the planning requirements of new urban developments; this is addressed in the land and water planning process. The *Draft State Water Plan – Water Planning Framework* (Government of Western Australia 2006) describes the hierarchy of water plans and interaction with the land use planning system at appropriate stages. The Department for Planning and Infrastructure and the Department of Water are preparing documents that will describe in more detail the integrated land and water planning framework and provide checklists to ensure that all information necessary to meet the planning requirements are met.

This chapter builds on the methodology, text and learnings from Western Australian and Australian guidelines and management plans, including: the Victorian Stormwater Committee (CSIRO 2000) *Urban Stormwater: Best Practice Environmental Management Guidelines* and the subsequent work by the Victorian EPA and Melbourne Water in refining the stormwater management planning process; the NSW Environmental Protection Authority's 1997 *Draft Managing Urban Stormwater: Council Handbook* (EPA NSW 1997); the *City of South Perth Integrated Catchment Management Plan* (JDA Consultant Hydrologists & Ecoscape 2004); the *Western Suburbs Regional Organisation of Councils – Regional Strategy for Management of Stormwater Quality* (JDA Consultant Hydrologists 2002); the *Stormwater Management Plan, Town of Victoria Park, Volume 2* (URS 2005); and the Eastern Metropolitan Regional Council's (WA) adaptation of the Victorian process (EMRC 2002), which was tested on the *Draft Canning Plain Catchment Management Plan* (Parsons Brinckerhoff, Acacia Springs Environmental & Ecological Engineering 2003). Text has also

[1] Priority catchments are catchments or sub-catchments that are experiencing water quality or quantity problems resulting in part from inadequate stormwater management (e.g. catchments or sub-catchments of the Swan-Canning, Peel-Harvey and Vasse-Wonnerup estuaries).

been adapted from the *National Water Quality Management Strategy: Australian Guidelines for Urban Stormwater Management* (ARMCANZ & ANZECC 2000).

This chapter is the first version of a Western Australian guideline for preparation of stormwater management plans. Once the process has been piloted, the content of the chapter can be revised and examples and case studies can be developed and included in the document. It is envisaged that this chapter and the process described will evolve as local experience develops in the preparation of these plans.

1.3 Terminology and key definitions

Average recurrence interval (ARI): The average, or expected, value of the periods between exceedances of a given rainfall total accumulated over a given duration.

Drainage water: Consists of stormwater runoff and/or shallow groundwater that have been intercepted by drains.

Receiving environment: Areas that receive stormwater runoff, including: wetlands, waterways, coastal waters/dunes, groundwater and bushland areas.

Stormwater: Stormwater is water flowing over ground surfaces and in natural streams and drains, as a direct result of rainfall over a catchment. Stormwater consists of rainfall runoff and any material (soluble or insoluble) mobilised in its path of flow.

Threat: A threat is considered to be an activity or land use with potential to damage the local or receiving environment social/cultural, ecological or economic values, via impacts to stormwater quantity or quality.

Urban: Land used for residential, rural-residential, commercial or industrial development (includes regional townsites).

Values: Values may include economic values (e.g. water use, aquaculture, stormwater reuse), ecological values (e.g. aquatic fauna and flora, urban bushland) and social/cultural values (e.g. historical, public health and safety, recreational, visual amenity, spiritual).

Water bodies: Waterways, wetlands, coastal marine areas and shallow groundwater aquifers.

1.4 The target audiences

This chapter has been written for agencies and groups that prepare stormwater management plans – that is, local governments, catchment groups and regional natural resource management groups/councils. However, it is mostly aimed at local governments to help them prepare a plan to improve stormwater management in their area.

2 What are stormwater management plans?

Stormwater management plans address how urban stormwater quantity and quality should be managed to protect ecological, social/cultural and economic values. A stormwater management plan is used to aid with decision making to ensure that (a) remedial measures (structural and non-structural) in existing developed areas are undertaken in a cost-effective, integrated and coordinated manner and (b) decisions in relation to new development (including redevelopment) are made with the implications for stormwater impacts taken into account. The plans are similar to local government operational plans (such as Remnant Vegetation Management Plans).

In some catchments, a stormwater management plan will also address the management of groundwater drainage, since stormwater and groundwater drainage discharge are often managed with the same systems.

A stormwater management plan can be prepared for a local government area, a catchment area, or a high priority sub-catchment (this is particularly relevant when local government areas or catchments are large and have many issues to address). Where a municipal boundary divides a catchment and the stormwater from one local government area discharges into another, any plans prepared for the area should propose strategies to work with neighbouring local governments to address cross-catchment stormwater management issues. If a stormwater management plan covers a catchment area and more than one local government, this will require collaboration between relevant local government authorities and possibly the local natural resource management catchment council/group.

A stormwater management plan should recommend actions based on cost, effectiveness in protecting or restoring the ecological, social/cultural and economic values of the catchment and receiving environments, opportunities for implementation, and capability of the stormwater manager to implement. The plans should also define mechanisms and arrangements for the implementation of these actions, including management, funding, performance review, monitoring, reporting and future revision of the plan (ARMCANZ & ANZECC 2000).

The process described in this chapter can also be used to develop plans that address broader catchment issues or broader water cycle issues (i.e. water supply, wastewater, water for the environment, drainage), such as an integrated catchment management plan or a total water cycle management plan.

3 Why prepare a stormwater management plan?

There are many reasons for preparing a stormwater management plan, including to:

- improve budget coordination and stormwater related spending;
- reduce road and building flooding risks;
- reduce public health/safety and environmental impact risks from stormwater infrastructure;
- reduce water quality issues (e.g. algal blooms and fish deaths) in receiving water bodies;
- reduce impacts from water quantity issues (e.g. declining local groundwater levels, erosion of water bodies, or altered water regimes in receiving water bodies);
- improve coordination within and between agencies and groups;
- establish processes and contingencies to address emergency/pollution issues and to adopt a proactive stormwater management approach.

Stormwater management plans provide objectives for how stormwater should be managed in an area and a process to manage stormwater in a considered and coordinated manner that targets priority issues. Ensuring that priority issues are managed with the most appropriate measures improves the way that budgets are assigned and spent. Having an agreed plan also provides a clear pathway for preparation of future budgets and projects.

Stormwater management plans can provide a process to apply a consistent, holistic best practice stormwater management approach for developed and developing areas. Plans are particularly useful for improving stormwater management in established urban areas, where the land use planning process for individual redevelopment sites is often at an insufficient scale for stormwater management improvement. Plans also provide opportunities for improving stormwater management practices in established urban areas that are not undergoing redevelopment activities.

Stormwater management plans also provide a mechanism for recognising the impacts of stormwater on

the receiving environment. Environmental management issues should be grouped under topics or assets and management actions developed to address them. The stormwater management plan and other plans such as remnant vegetation management plans, floodplain management plans, wetland management plans and waste management plans will provide improved environmental management in a catchment or local government area.

An important outcome is that plans establish a basis for ongoing commitment, cooperation and coordination between stakeholders.

4 Who prepares stormwater management plans?

A stormwater management plan can be prepared by local government, catchment groups or regional natural resource management groups/councils, or by a multiple partner group. The primary author is usually determined by the scope of the plan (see Section 2) or the main trigger (see Section 3) behind the identification of the need for a plan.

5 How do you prepare a stormwater management plan?

A stormwater management plan should include a review of:

1. Stormwater frameworks and issues within national, State and regional contexts.
2. Reports prepared for the study area.
3. Catchment values to be protected, stormwater threats and recommended management options.
4. Management options.

The *Decision Process for Stormwater Management in WA* (Department of Environment & Swan River Trust 2005) should be referred to when preparing stormwater management plans. It provides a decision framework that should be applied when planning and designing stormwater management systems.

It is expected that the plan will be prepared largely using existing or readily available information held by councils, government agencies and natural resource management (NRM)/catchment management groups, in addition to a catchment audit and input from the community. Water quality monitoring data or modelling is not essential, but would be very useful for identifying threats and developing management options.

Figure 1 shows the process for preparing stormwater management plans.

Simpler plans could be prepared by local governments that do not have extensive urban areas (e.g. some regional towns), or could be used as preliminary plans before preparation of more extensive plans. These simpler plans can be prepared either by selecting suitable steps from Figure 1, or by not doing each step as comprehensively as the process discussed in this chapter.

Step 1 Preliminary activities

Identify relevant stakeholders
Gain stakeholder commitment
Establish project framework and scope
Define study sub-catchments
Define information requirements

Step 2 Identify current status – catchment characteristics, condition and practices

Identify catchment characteristics and condition
Identify land use activities
Document and review current stormwater management systems, practices and processes

Step 3 Identify values of receiving environments

Identify and assess values of receiving environment

Step 4 Identify stormwater threats

Identify and assess activities or land uses with potential to damage the local or receiving environment social/cultural, ecological or economic values, via impacts to stormwater quantity or quality

Step 5 Identify management objectives

Identify the vision and short-term and long-term objectives
Identify outcomes for performance monitoring and evaluation

Step 6 Establish and implement a prioritisation process

Identify priority management issues

Step 7 Prepare a priority issues paper

Step 8 Consider management options and strategies

Identify management options

Step 9 Develop management actions

Step 10 Prepare an implementation plan

Identify estimated costs and funding options
Identify responsibilities and timelines
Identify partnership arrangements to be established with stakeholders

Step 11 Prepare stormwater management plan

Prepare draft stormwater management plan
Stakeholder review of plan
Finalise stormwater management plan
Approval of stormwater management plan

Step 12 Implementation

Implement recommended actions of the plan

Step 13 Ongoing performance monitoring and review

Figure 1. A process for developing a stormwater management plan.

5.1 Identify and engage stakeholders

The early stage of a stormwater management planning project requires the identification and involvement of all relevant internal and external stakeholders. As discussed in ARMCANZ and ANZECC (2000), keys to achieving more effective action include:

- generating commitment to a best practice approach;
- establishing agreed priorities and management strategies or actions; and
- establishing a basis for ongoing cooperation with and coordination between stakeholders.

The early identification of stakeholders and the development of a consultation plan will result in a management plan that is more likely to have identified relevant issues and be supported and implemented. For example, Indigenous heritage sites and values should be identified at the beginning of the planning process. Contact the Indigenous Support Unit at Department of Water to receive contact details for local Indigenous stakeholders.

Local government is generally responsible for the majority of stormwater management systems within a catchment; however, this will vary depending on the catchment. The Water Corporation has responsibility for the majority of the arterial (main) drainage systems in the Perth metropolitan area, while Main Roads Western Australia is responsible for stormwater systems on freeways and State roads under its control. State agencies such as Department of Water, Department of Environment and Conservation, Department of Health, Swan River Trust, Department for Planning and Infrastructure and Western Australian Planning Commission also have an important role in policy, planning and regulation. Many stakeholders, such as industry, businesses, residents and the community, influence the quality and quantity of stormwater. Other stakeholders, such as catchment / community groups, local Indigenous groups and regional natural resource management groups often have significant local catchment management knowledge and should be engaged. A discussion of stakeholder roles and responsibilities is provided in Chapter 2.

Stakeholders should be consulted to determine current practices in the catchment; its environmental condition, values and threats; and their vision or objectives for the catchment/stormwater management and suggested solutions.

Stakeholders should be provided with options for the level of participation and involvement in preparation of the plan. When a stormwater management plan is prepared by multiple partners (e.g. local government, NRM groups and Department of Water), up-front commitment (including funding/in-kind contributions and the timeline for preparation) will be required to ensure development and completion of the plan. This commitment could be obtained by preparation of a partnership agreement or suitable partnering arrangements signed by relevant parties.

It is good practice to identify long-term management responsibilities at the early stages of the planning process. Where the local government is the main driver/author of the plan, it should be decided early if the plan will be recommending actions that are the responsibility of numerous stakeholders. This will depend on the capacity and expectations of other stakeholders and will require effective engagement and ownership of the plan by the relevant stakeholders. Preparation and signing of partnership agreements/partnering arrangements could also increase key stakeholders' commitment to implementation of the plan.

The level of consultation of the general community will depend on the local issues (e.g. is the local community active in environmental management, or are there contentious issues), the consultation processes of the local government and the recommendations of the Project Steering Committee (see Section 5.2 for discussion of project teams). However, public consultation could include: (1) identification of values and priority issues, (2) identification of possible management actions and (3) review of the draft stormwater management plan. Refer to the *Community Involvement Framework* (Department of Environment 2003a) for more information about how to undertake community consultation.

Further information on consulting with stakeholders can be found at the Urbanwater.info website, particularly at <http://www.urbanwater.info/catchment/audit/3-Stakeholders.cfm>. Guidance on facilitating groups of stakeholders can be found in the *Facilitation Toolkit: A Practical Guide for Working more Effectively with People and Groups* (Keating 2003). Also see the references listed in Section 7.

5.2 Establish project teams

It is suggested that a group be formed within local government that consists of representatives (including senior officers) from across functional areas in local government (such as planning, engineering, environment, asset management, environmental health and parks and gardens) to oversee development of the plan. To increase the likelihood of Council support of the plan, it is recommended that the internal group includes at least one Councillor as a member. For example, the City of Stirling has formed a cross-functional group for the development of their Integrated Water Cycle Management Strategy.

For most stormwater management plans (particularly plans for local government areas and catchment areas), it is strongly recommended to have a Project Manager, Project Steering Committee and Project Working Group. For small-scale plans (e.g. a plan prepared for an existing industrial area), a Project Steering Committee and Project Working Group may not be necessary. The Project Manager, Project Steering Committee and Project Working Group would each play a critical role in ensuring that all relevant issues are identified and an appropriate level of commitment and involvement is secured throughout the study.

Their suggested roles and responsibilities are briefly discussed below; they are based on the local government being the main lead for the project. Alternatively, the main leader could be a catchment group or a regional natural resource management group.

Project Manager:

The Project Manager is responsible for the overall coordination of the project, including liaison between the author (e.g. a consultant might be employed to write the plan) and local government staff involved in the project. The Project Manager will usually be a senior local government officer. The Project Manager (with help, if required, from project officers from Department of Water, the main drainage service provider and the regional NRM group) is responsible for ensuring that there is adequate representation, commitment and involvement from all relevant areas of local government and other agencies. The Project Manager is responsible for liaising with senior managers across functional areas within local government to ensure general satisfaction with outcomes of the planning process at key stages of the project. Where sign-off is required, it is the role of the Project Manager to consult with individual managers. The Project Manager is also responsible for leading the review process within the Project Steering Committee (incorporating comments from all stakeholders) and providing a concise set of feedback comments to the author.

Project Steering Committee:

The Project Steering Committee is responsible for overseeing the project and will assist the author by providing guidance and feedback on development of the plan. The Project Steering Committee will generally consist of a group of preferably no more than ten people, with senior representatives of local government, Department of Water, Department of Environment and Conservation, the arterial (main) drainage service provider (e.g. Water Corporation), the regional NRM group (or NRM sub-regional groups, where appropriate), Department for Planning and Infrastructure, Department of Health (or the local government Environmental Health Officer) and at least one representative from local community groups/ residents associations. Project Steering Committee meetings should be convened at critical milestones (e.g. to obtain endorsement of draft and final plans) and on an 'as needs basis' (e.g. to obtain the group's input on a specific issue) during the development of the stormwater management plan. The Project Steering

Committee's role at these key stages is to ensure satisfactory completion of milestones and quality of output. The Project Steering Committee should assist with the final prioritisation of management actions.

Project Working Group:

The Project Working Group could include members of the Project Steering Committee, as well as other stakeholder representatives from local government, relevant State government agencies, regional NRM groups and community groups/residents associations/special interest groups. Its role would be to:

- identify and assess issues;
- facilitate communication with and input from representative stakeholder groups;
- review documentation; and
- provide comment and advice to the Project Steering Committee.

Workshops could provide the Project Working Group an opportunity for increasing the awareness and understanding of issues and opportunities related to management of urban stormwater. Project Working Group workshops should help encourage ongoing cooperation and coordination within local government and between local government and other stakeholders.

Sub-teams can also be established to research or discuss issues in more detail and make recommendations to the Project Working Group and the Project Steering Committee.

5.3 Establish project framework

It is important that the project objectives, processes and timeframe are clearly defined, understood and accepted by all parties at the commencement of the project. Key dates for all meetings and workshops should be determined at this stage to maximise stakeholder involvement. It is the Project Manager's responsibility to ensure that participants have a clear understanding of the stormwater management planning process and the importance of their commitment and involvement in development of the plan.

The first task should be establishment of the overall framework for the plan and the preparation process, in consultation with stakeholders. The areas for discussion could include:

- roles and responsibilities of project partners;
- budget for preparation of the plan;
- establishing a timeline and key milestones for preparation of the stormwater management plan;
- the aim of the plan (see Section 5.3.1);
- the scope of the plan (see Section 5.3.2);
- the boundaries and sub-catchments for the plan (see Sections 5.3.3 and 5.3.4);
- public and other stakeholder consultation processes (see Section 5.1);
- scoping of information requirements, such as catchment condition, values and threats (see Sections 5.4, 5.5 and 5.6); and
- identifying an implementation and performance review program (see Sections 5.12 and 5.14).

5.3.1 Identify the aim of the stormwater management plan

The aim of the plan should be determined at the beginning stage and it should be clearly stated in the plan documentation. An example aim would be: to improve the health and amenity of the catchment through improved stormwater management practices. Other examples are: to reduce the occurrence of algal blooms in X water body through improved stormwater management practices; or to identify opportunities to maximise the sustainable use of stormwater as a water source.

5.3.2 Identify the scope of the stormwater management plan

A stormwater management plan must clearly state its scope. For example, will it be addressing management of stormwater (i.e. rainfall runoff), or will it also be including modification of groundwater levels for urban development (as stormwater and groundwater drainage discharge are often managed via the same systems)?

5.3.3 Identify the stormwater management plan boundary

The stormwater management plan boundary must be identified. Will it be a local government, catchment, or sub-catchment (particularly relevant when local government areas or catchments are large and have many issues to address)? If a plan is prepared for a local government area that crosses more than one catchment, the plan should propose how the cross-catchment stormwater issues will be addressed. For example, neighbouring councils could form an operational partnership on how to manage cross-boundary stormwater issues. If a significant amount of stormwater discharges into a neighbouring council area, it is advisable that a joint management plan be developed. If the plan boundary is to be a catchment boundary, then the stormwater management plan will need to be a joint project between relevant local governments (if the catchment consists of more than one local government). For an example of a joint project, see the Western Suburbs Regional Organisation of Councils' *Regional Strategy for Management of Stormwater Quality* (JDA Consultant Hydrologists 2002).

5.3.4 Identify sub-catchments

The study area could be divided into a series of sub-catchments to form the basis for identifying values and threats and formulating and prioritising management actions. Sub-catchments should be delineated based on hydrological/hydrogeological boundaries, along with consideration of land use patterns and receiving environment types. Information sources include existing stormwater/drainage system detail, field inspection and topographic data. The type of receiving environment of the regional drainage network of each sub-catchment should be identified (e.g. a river, wetland, ocean, basin, park, reserve, or diffuse infiltration area). Figures showing the sub-catchments would then be prepared. These maps will help during preparation of the plan and they should be included in the draft and final stormwater management plans. Figure 2 shows an example of a sub-catchment map.

Checklist – *Project framework*

☑ Aim and scope of the plan have been established.

☑ Stakeholders' roles and responsibilities are understood.

☑ Stakeholders are committed to involvement in preparation of the plan (including provision of requested data, where relevant) and to implementation of the plan (where applicable).

☑ Stakeholders understand the nature of stormwater impacts and management.

☑ Key project objectives are clearly defined and understood.

☑ Study area boundary and sub-catchments have been determined.

☑ Available information and data has been requested.

☑ The timetable for the study has been established by relevant stakeholders (e.g. the Project Steering Committee and the Project Working Group).

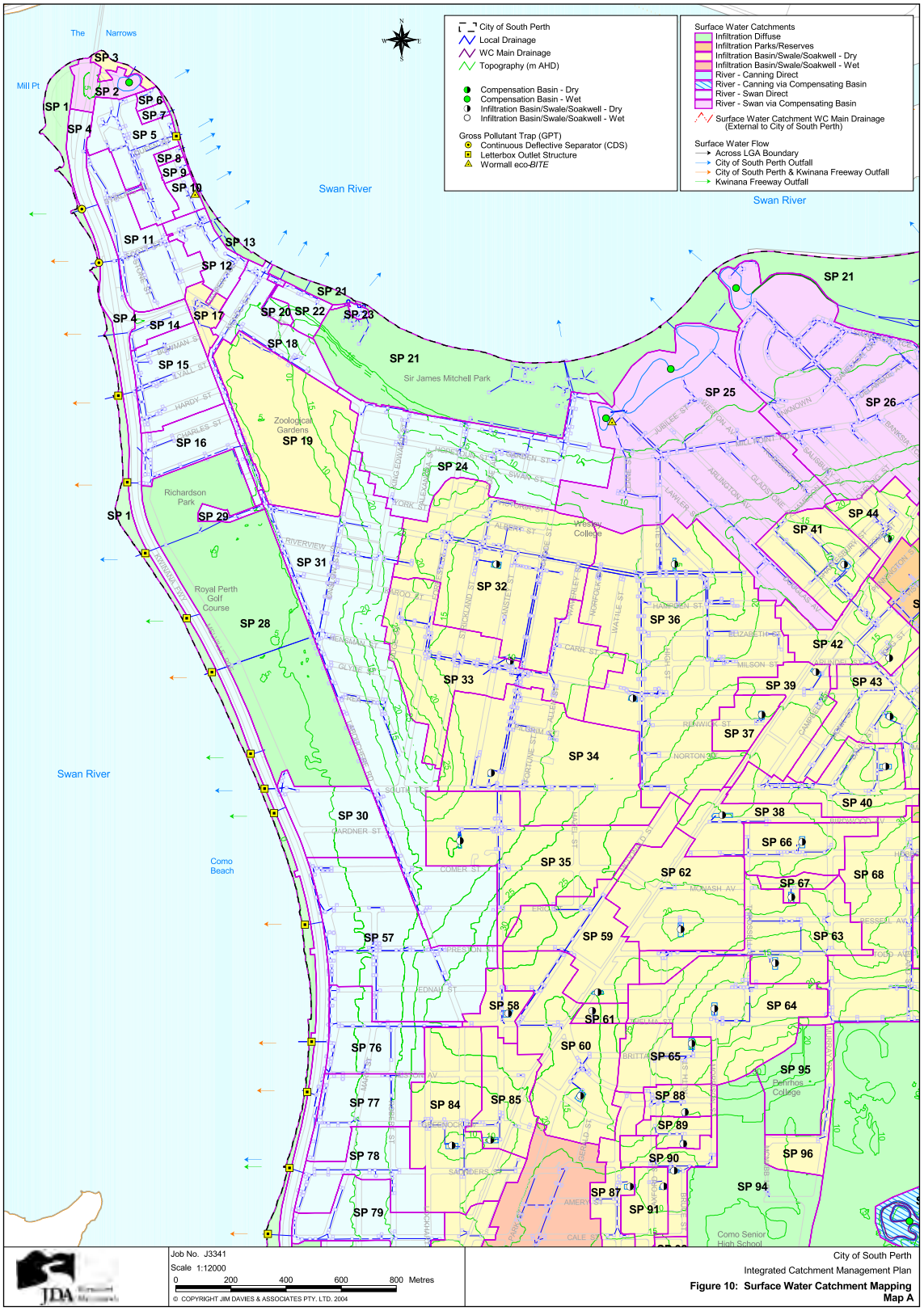


Figure 2. Example of sub-catchment mapping, City of South Perth. (Source: JDA Consultant Hydrologists & Ecoscape 2004.)

5.4 Identify current status—condition, characteristics and practices

It is important to gain an understanding of the extent that existing activities and land uses might impact stormwater quantity and quality and receiving environments, and how existing processes within local

government, State agencies and community groups manage stormwater issues.

The stormwater management plan should consider the findings or recommendations of existing plans and reports that may affect stormwater management in the subject area. These documents will also include relevant information regarding the catchment condition, practices, values and threats. The following may be relevant:

- Regional and local natural resource management strategies
- Local, district or regional urban water management strategies and plans
- Drinking Water Source Protection Assessments and / or Plans
- Water allocation plans
- Catchment management plans
- Local government environment management plans (e.g. remnant vegetation management plans and waste management plans)
- State and Local Planning Schemes
- State and Local Planning Policies and Strategies
- State and local government State of the Environment Reports
- Environmental or stormwater management plans of neighbouring local governments, particularly if the catchment covers more than one local government area
- Biodiversity plans and strategies
- Wetland management plans
- Waterway management plans (such as River Action Plans)
- Floodplain management plans
- Water quality status reports
- Coastal area management plans
- Recreation plans / strategies

Where applicable, it is suggested that the information gathered about catchment characteristics and condition (Section 5.4.1), land use activities (Section 5.4.2) and stormwater management practices (Section 5.4.3) is produced in map (preferably GIS) format and presented as thematic overlays. This will help identify issues that require prioritised management. For example, by overlaying structural stormwater management measures and natural water bodies, the location of conveyance devices such as pipes and drains that are directly connected to natural water bodies can be identified.

A number of local governments in Western Australia are participating in the ICLEI Water Campaign™ program[2]. There are many links between the Water Campaign™ and the stormwater management planning process. Information collected by a local government through the Water Campaign™ may have direct relevance to the content of a stormwater management plan and vice versa. It is recommended that local governments working on a stormwater management plan and the Water Campaign™ link this work in order to maximise the benefits of both processes[3].

5.4.1 Identify catchment characteristics and condition

A good understanding of the current condition of the study area will provide a baseline from which any improvements or deterioration can be determined once the stormwater management plan is implemented.

[2] The Water Campaign™ is a voluntary, international, freshwater management program that aims to build the capacity of local government to reduce water consumption and improve local water quality. The Water Campaign™ is delivered by ICLEI-Local Governments for Sustainability Australia/New Zealand (ICLEI-A/NZ) in collaboration with local and State governments, water authorities and the Australian Government. The Water Campaign™ is delivered in Western Australia by ICLEI-A/NZ in collaboration with the Department of Water as part of the Western Australian State Water Strategy.

[3] If your council would like advice on how to do this, or would like to learn more about the Water Campaign™, contact the WA Water Campaign™ Manager at ICLEI-A/NZ on (03) 9639 8688. Further information regarding the Water Campaign can also be accessed on the Water Campaign™ website <http://www.iclei.org/anz/water>.

Information about the catchment condition will also help with the identification of issues and the determination of priorities.

Note: Lack of information on the condition of the catchment and the receiving environment for many catchments is acknowledged as a constraint, but it should not prevent the preparation and implementation of a stormwater management plan. Numerous actions can be implemented to improve stormwater management. When data on the catchment is collected, it can be incorporated in an updated plan.

See Table 1 for some environmental condition information that should be gathered. Note: Website addresses are provided in Section 7. The Shared Land Information Platform (SLIP) provides access to the Government's land and geographic spatial information via one website. The SLIP website is being finalised and is due to be launched in mid-2007.

5.4.2 Identify land use activities

Describe the current and proposed land use activities within the catchment. This is critical to understanding the current stormwater threats from certain land use types and likely impacts associated with future changes in land use. Planning scheme zones should be used as a basis for defining current and future land use activities. Aerial photography can be used to help identify current land use activities. A field inspection of the study area should be undertaken to confirm land use activities and determine current threats (see Section 5.6 for a discussion of threats).

In addition to long-term land uses, transient activities (such as building construction) should also be considered. This is particularly important for catchments that support continued urban growth, where considerable portions of land may exist in a developing state over an extended period. Mobile activities (such as mobile mechanics, vehicle washing / detailing and carpet cleaning) should also be considered.

Activities to be documented include those listed in Table 2. Potential sources of information are also provided. Note: Website addresses are provided in Section 7. The Shared Land Information Platform (SLIP) provides access to the Government's land and geographic spatial information via one website. The SLIP website is being finalised and is due to be launched in mid-2007.

5.4.3 Identify existing stormwater management systems, practices and processes

When assessing stormwater management it is important to determine the characteristics of the existing stormwater management system, the maintenance of stormwater management devices, and the construction and maintenance of impervious surfaces (such as roads and carparks) and public assets (such as parks). Additionally, the way that day-to-day planning and management activities are undertaken should be reviewed, as they have a direct impact on stormwater management within the study area. These activities include:

- strategic planning for future development and land use;
- assessment and approval of development proposals;
- construction, management and maintenance of infrastructure;
- regulation, enforcement and education activities;
- internal and external coordination and communication between different levels and departments within local government and relationships with external agencies (i.e. organisational culture).

In undertaking these activities, local government applies certain procedures and policies based on various protocols, documents and planning tools. These provide the foundation for good stormwater management and reduce reliance on reactive management actions in the future.

Table 1. Data sources for catchment characteristics and condition

Data	Source
Topography and soil type. This includes acid sulphate soil risk, slope, permeability, erodibility, dispersivity and nutrient retention ability. This will determine risk to water quality from polluting land uses, risk of soil erosion, and risk of disturbance of acid sulphate soils during land development / land use activities and construction of stormwater management devices. Note: Only general soil type and acid sulphate soil information can be accessed from the recommended sources. Site assessments will need to be conducted to determine actual soil type, slope, permeability, etc.	Soil type from the SLIP website and Department of Agriculture; topography from the Landgate website; acid sulphate soil mapping from the Department of Environment and Conservation website.
Climate (seasonal rainfall, duration of storms, evaporation rates). If possible, include rainfall average recurrence interval / rainfall intensity / peak discharges for the catchment.	Bureau of Meteorology.
Wetlands and their buffers – location, type, management category and condition.	Department of Environment and Conservation website for the wetland mapping dataset and other wetland information (Note: the DEC website does not include data about specific wetland buffers); local government; NRM/Catchment/Friends of Groups.
Waterways and their foreshore areas – location, type and condition.	Department of Water website; NRM/Catchment/ Friends of Groups.
Groundwater levels and hydraulic conductivity of the soil – regional and if possible, the shallow system (and how it is influenced by drains that intercept groundwater). Note: On-site tests will need to be conducted for local groundwater levels and hydraulic conductivity.	Department of Water website.
Surface water hydrology, including floodplains, flooding and baseflow characteristics.	Department of Water.
Surface and groundwater quality (this includes stormwater drains and receiving water bodies).	Department of Water website; local government; NRM/Catchment/Friends of Groups.
Remnant / native vegetation – type, condition and linkages / corridors; rare, priority or threatened species; Threatened Ecological Communities.	Department of Environment and Conservation; BushForever mapping on the Western Australian Planning Commission's website; local government; NRM/Catchment/Friends of Groups; aerial photographs; plant biodiversity database for the Perth Metropolitan Region via WALGA.
Native fauna, including threatened and priority species.	Department of Environment and Conservation; Western Australian Museum's FaunaBase website; NRM/Catchment/Friends of Groups.
Pests - species and distribution.	Local government; Department of Health; NRM/ Catchment/Friends of Groups; Department of Agriculture website; Department of Environment and Conservation's FloraBase website.

Table 2. Land use activities and data sources

Land use activities	Information source
General land use types and zoning (e.g. residential, rural-residential, commercial, light industry and general industry). Should distinguish between old and new industrial areas (due to different practices and associated risks).	Local government; Landgate website; Department for Planning and Infrastructure.
Public open space/parks/other recreational areas/reserves/regional and national parks and reserves. Categorise into passive (e.g. parks) and active (e.g. sports ovals and golf courses) recreation areas. Highlight areas of open space that might be suitable for stormwater management systems and/or storage of flood water during extreme rainfall events, without compromising the primary purpose of the open space area (such as recreation).	Local government; Landgate website; Department of Environment and Conservation (for regional and national parks and reserves).
Public Drinking Water Source Areas – Catchment Areas, Water Reserves and Underground Water Pollution Control Areas supplying public drinking water.	Department of Water.
Major infrastructure services (e.g. roads, public carparks, bridges, major sewerage pipelines, sewerage pumping stations and their overflow route/system).	Local government; Water Corporation; Main Roads Western Australia; Landgate website.
Location of impervious surfaces that have an opportunity to be retrofitted to introduce perviousness.	Local government.
Licensed premises under the *Environmental Protection Act 1986* and **potential point sources of pollution**.	Department of Environment and Conservation for licensed premises; local government.
Illicit discharges to the stormwater system (i.e. illegal or inappropriate waste streams, such as wastewater, entering the stormwater system).	Inspections (e.g. investigating the origin of pipes and drains that discharge into local government, Water Corporation or Main Roads Western Australia sumps and drains).
Areas without reticulated sewerage (i.e. areas with on-site wastewater disposal).	Local government; Water Corporation.
Contaminated sites.	Department of Environment and Conservation; Department of Health.
Demographic characteristics and population projections – to gauge the community's recreational needs and the desired use of water bodies.	Local government; Australian Bureau of Statistics.

The following management practices, activities and programs that contribute to stormwater management within the study area should be identified and documented (see Table 3). Note: Website addresses are provided in Section 7. The Shared Land Information Platform (SLIP) provides access to the Government's land and geographic spatial information via one website. The SLIP website is being finalised and is due to be launched in mid-2007.

Table 3. Systems, practices and processes that contribute to stormwater management

Data	Source
Flow paths for stormwater runoff from minor (> 1 year ARI and < 10 year ARI) to major (> 10 year ARI) rainfall events. Calculations should be based on *Australian Rainfall and Runoff – A Guide to Flood Estimation* (Institution of Engineers Australia 2001).	Local government; Water Corporation.
Define any **regional drainage system** within the study area.	Local government; Water Corporation.
Location, type, size/capacity, condition and ownership of structural stormwater management devices such as drains, pipes, pollutant traps, compensating basins, infiltration areas (e.g. swales, soakwells and basins), side entry pits, 'living streams' and constructed wetlands.	Local government; Water Corporation; Main Roads Western Australia; this information will eventually be on the SLIP website.
Identify stormwater management devices that: – are causing unreasonable flooding (including blocked drains or undersized basins, if known); – have public health and safety issues (e.g. mosquitoes, steep banks); – are directly connected to a receiving environment (e.g. a stormwater pipe or open drain discharging directly into a wetland or waterway); – are causing erosion/scouring; – are subject to high levels of sediment or litter accumulation; – are providing insufficient water quality treatment; – with modification, could provide other uses (e.g. recreation, amenity, water supply, or re-establishing the local water regime); and – are over-designed. This information in particular needs to be surveyed and entered into a database (preferably GIS) to enable efficient asset management.	Local government; Water Corporation; residents associations; NRM/Catchment/ Friends of Groups; field inspection.
Location of **impervious surfaces** that could be retrofitted to introduce perviousness, particularly priority areas such as those located near water bodies.	Local government; aerial photographs; field inspection.
Management of structural stormwater devices (such as inspection/ monitoring programs, frequency and methods of maintenance and who is responsible for maintenance).	Local government; Water Corporation; Main Roads Western Australia.
Road/pavement construction and maintenance practices (e.g. street/ footpath/carpark construction, repairs and sweeping). Include scheduled major upgrading/maintenance works to identify opportunities for introduction of improved stormwater management practices.	Local government; Main Roads Western Australia.
Management of local government premises, such as waste/chemical management at depots and graffiti removal from buildings.	Local government.
Maintenance of parks/ovals/recreation areas (e.g. fertiliser, water and pest management, plant selection, and management of prunings and lawn clippings).	Local government; owners of private recreation areas, such as golf courses and lawn bowls greens.

Data	Source
Waste management strategies, such as recycling programs and litter management.	Local government; Department of Environment and Conservation; Regional Councils.
Education and awareness programs that reduce the impact of activities on stormwater quantity and quality.	Local government; Department of Environment and Conservation; Regional NRM groups; Swan River Trust; Regional Councils; Water Corporation; Department of Water.
Local government stakeholder **consultation** and involvement protocols.	Local government.
Regulation and enforcement efforts. Existing regulation and enforcement initiatives should be reviewed to consider their relevance to stormwater management and to gain insight into local government's and State government's capacity for implementing new initiatives that may be recommended as part of the stormwater management plan.	Local government; Department of Environment and Conservation.
Emergency pollution response procedures.	Fire and Emergency Services Authority of WA (FESA); local government; Department of Environment and Conservation.
Employee training (i.e. the training that employees of local government, Water Corporation, Main Roads Western Australia and local commercial/ industrial businesses receive).	Local government; Water Corporation; Main Roads Western Australia; local commercial/ industrial businesses.
Relevant information from the **land use planning process**, including the Town Planning Scheme, Local Planning Strategies, planning policies and corporate plans, Urban Water Management Strategies and Plans. The local government planning documents present opportunities to address stormwater management. The planning scheme and its supporting documents should be comprehensively reviewed to consider how they incorporate stormwater management. Opportunities for improvement should be identified to form the basis of recommended strategies. The components and functions of the approvals process should also be summarised (e.g. through the use of a flow chart), and opportunities identified to incorporate better stormwater management practices at the planning and approvals stages (e.g. development or updating of local planning policies).	Local government; Department for Planning and Infrastructure.

Checklist – *Current condition, characteristics and practices review*

☑ Field investigations have been undertaken.

☑ Interviews and consultation with relevant local government officers and other stakeholders have been undertaken.

☑ All relevant information and data has been obtained, reviewed and catalogued.

☑ Maps of wetlands, waterways, remnant vegetation, Public Drinking Water Source Areas, the stormwater/drainage system and land uses have been prepared.

☑ Database (preferably GIS) of stormwater device management has been developed, which should include who is responsible for maintenance of the device.

☑ Current practices and processes have been reviewed, including the planning scheme, supporting documentation, the approval process, maintenance practices and the nature of coordination and resourcing.

5.5 Identify economic, ecological and social/cultural values

A key goal of the stormwater management plan is to protect and enhance the values of the local and receiving environments. Values may include economic values (e.g. water use, aquaculture, stormwater reuse), ecological values (e.g. aquatic fauna and flora, urban bushland) and social/cultural values (e.g. historical, public health and safety, recreational, visual amenity, spiritual). These values form the basis of what the community expects in terms of their interaction with, and enjoyment of, the local and receiving environment. Values help determine the importance of an asset and define the objectives for managing stormwater. They also determine factors that will be barriers or motivators to changing stormwater management practices. Economic, ecological and social/cultural values are discussed further below:

Economic values: Economic values include water body uses, stormwater use, economic values of the receiving environment (e.g. fishing and tourism), values of land used for stormwater management and values of land adjacent to stormwater management devices.

Ecological values: Ecological values are defined as particular values or uses of the environment that are important for a healthy ecosystem or for public benefit, welfare, safety or health and which require protection from the effects of pollution, waste discharges and deposits (ANZECC & ARMCANZ 2000) and from the effects of altered water regimes.

The ecological values of downstream environments (i.e. downstream environments that are located outside of the plan boundary) should also be included. This will be particularly important for values of receiving environments that relate to recognised conventions, regional agreements, policy or legislation (e.g. Ramsar wetlands, Conservation category wetlands, Resource Enhancement wetlands, Rare and Threatened Species protected under the WA *Wildlife Conservation Act 1950*, Regional Natural Resource Management Strategies, WA Environmental Protection Policies, and national registers).

Social/cultural values: Social values include public health and safety, recreational uses and visual amenity. Cultural values include historical and spiritual significance, and scientific and educational uses. To identify heritage sites, see the Register of the National Estate, the National Heritage List, sites protected under the *Aboriginal Heritage Act 1972*, sites registered under the *Heritage of Western Australia Act 1990*, and the Register of Heritage Places database.

Values should be categorised into specific value types, as shown in Table 4. Please note: the description in Table 4 provides examples of valuation issues; it does not provide all of the issues that would need to be considered when assessing values.

Existing plans and strategies, such as regional natural resource management strategies, registers and databases, catchment/environmental management plans, remnant vegetation management plans, wetland management plans, river restoration plans and urban water management plans/strategies will provide some values information. The identification of catchment characteristics and condition (Section 5.4.1) and land use activities (Section 5.4.2) will also provide some values information.

Where values have not been previously determined, they will need to be based on qualitative and anecdotal information. It is important that the value assessment focuses on aspects of the local and receiving environment that may be affected by stormwater. The assessment of values should be based on available information collated by the authors, advice provided by the Project Steering Committee, the Project Working Group, other stakeholders (e.g. State government agencies and the local community) and field investigations. Adequate community consultation is particularly important for determining values. This might require a community survey. However, to ensure that the community is not asked the same questions twice, it should be determined if they have previously been consulted to determine catchment values. See Section 5.1 for more information on consulting stakeholders.

The assignment of value ratings should then be based on the judgement of the Project Steering Committee and Project Working Group.

Within each sub-catchment, a description of the characteristics of each value type should be provided. The description should explain the specific nature of the value and its significance in a local and regional context (i.e. compared with similar value types in other sub-catchments within the study area).

Table 4. Value Types

Value Category	Specific Value Types	Description
Economic	Property/ infrastructure	Stormwater system contribution to protection of property/infrastructure from flooding. Property value associated with proximity to water. This may include values associated with visual amenity and access. Property values of land used for stormwater devices.
	Other	Economic benefits associated with receiving water bodies (e.g. fishing and tourism, or water used for public drinking water supply or irrigation). Economic benefits associated with using stormwater as a water source.
Ecological	Water bodies	Rareness or representation of that habitat type; water quality; habitat quality and diversity; extent, quality and rarity of flora and fauna species; extent of exotic species (such as weeds and feral animals); provision of flood conveyance and storage; forming part of an ecological corridor; drought refuge; capacity to improve water quality.
	Terrestrial areas	Extent and quality of natural communities, including quality, diversity and rarity of flora and fauna species; extent of exotic species; forming part of an ecological corridor.
Social/ cultural	Recreational amenity	Public access and utilisation for passive and active recreation; formal linkages; extent of open space; facilities such as car parks and picnic areas; continuity of open space; visual attractiveness.

Value Category	Specific Value Types	Description
Social/ cultural (continued)	Public health	Stormwater system contribution to minimisation of risk to public health and safety from flooding. Minimisation of risk to public health and safety from drowning in stormwater structures. Existence of aquatic foods that are safe for human consumption. Water bodies that are safe for primary (e.g. swimming) and secondary (e.g. boating and fishing) contact recreation due to absence of toxic algal blooms. Level of disease and nuisance vector insects (i.e. mosquitoes and midges). Public drinking water sources that are protected from contamination to ensure safe, good quality drinking water.
	Visual/ landscape amenity	Aesthetic appreciation of the natural and built environment, including consideration of natural and constructed structures, landscapes and places of importance; visual access; relationships to adjacent facilities.
	Indigenous cultural heritage	Places and sites of Indigenous heritage value such as artefact sites, landscape and places of significance (e.g. relating to story telling), ceremonial sites, campsites and trails.
	Non-indigenous cultural heritage	Places and sites of heritage value, including sites of pioneering significance, historical buildings and infrastructure, trails and transport routes.
	Scientific and educational	Components that can be monitored to improve understanding of the natural environment or stormwater devices. Areas that have high educational values.

Using the following scale, the receiving environments should be scored for their economic, social/cultural and ecological values:

1 = None, the attribute does not contribute to the value of the asset
2 = Minor, the attribute contributes to the asset at a local level
3 = Moderate, the attribute contributes to the value of the asset at a local and regional scale
4 = Important, the attribute contributes to the value of the asset at a local, regional and State scale
5 = Significant, the attribute contributes to the value of the asset at a local, regional, State and national level
Unknown = unable to answer

An overall score for value can be obtained by adding the ecological, social/cultural and economic scores. A maximum score of 15 can be obtained. The high, medium and low value score bands are as follows:

High = 10-15
Medium = 5-9
Low = 1-4
Alternatively, the methodology used for the Town of Victoria Park stormwater management plan (URS 2005) was to score the ecological, social/cultural and economic values as high (3), medium (2) or low (1) and add up all of the value scores for each receiving environment, then rank the receiving environments based on the total score.

5.6 Determine threats

This step involves identifying and confirming the nature and source of threats. A threat is considered to be an activity or land use with potential to damage the local or receiving environment's social / cultural, ecological or economic values, via impacts to stormwater quantity or quality.

Stormwater (and groundwater, if applicable to the scope of the plan) threats should be assessed and documented for each study sub-catchment. Table 5 provides a list of generic stormwater threats that could be considered when assessing threats for each sub-catchment.

Data will rarely be available on the impact of land use activities on receiving environments. However, an informed assessment can be based on professional judgement and experience, as well as factors such as local knowledge, field investigations, land use, monitoring data, spills history, complaints, age of infrastructure (ARMCANZ & ANZECC 2000) and advice provided by stakeholders. Discussions should take place with key people in local government, Department of Environment and Conservation, Department of Water, the NRM/catchment management group, the arterial (main) drainage service provider (if within a declared arterial (main) drainage service area) and other groups suggested in Section 5.1. It will be necessary to justify and explain the basis for assigning a rating to a particular threat. Proposed significance ratings should be reviewed and endorsed by the Project Working Group and Project Steering Committee before their final adoption. Assessing the current practices (Sections 5.4.2 and 5.4.3) will provide much information about threats. For example, if there is infrequent or no maintenance of stormwater infrastructure, the threats will be greater (such as increased localised flooding, increased pollutant discharges, or increased mosquito numbers).

A good estimate of water quality risks from various land use activities can be determined from the *Water Quality Protection Note: Land Use Compatibility in Public Drinking Water Source Areas* (Department of Environment 2004a).

A list of major site-specific and transient activities with potential to damage receiving environments should be prepared that identifies:

- the type of threat; and
- a significance rating of the threat.

Within each sub-catchment, each threat type is assigned a significance rating of 1 to 5 (see list below). In arriving at a significance rating, consideration should be given to the magnitude and the frequency of occurrence and if the threat is acute or chronic.

Threats could be scored:

1 = No threats of significance
2 = Minor
3 = Moderate
4 = Severe
5 = Extreme
Unknown

The high, medium and low threat bands are defined as:

High = 4-5
Medium = 3
Low = 1-2

Alternatively, the Town of Victoria Park Stormwater Management Plan (URS 2005) scored threats in a sub-catchment as high (3), medium (2) and low (1). These scores were summed and the sub-catchments ranked.

Table 5. Generic stormwater threats

Threat	Cause	Key Impacts
Residential land use runoff	Atmospheric deposition and build-up from traffic; car washing; fertiliser and pesticide application; animal wastes; poor waste management (domestic litter); lawn clippings and leaf litter; and pool emptying.	Increased flow, sediment, nutrients, litter, oxygen depleting material (e.g. leaves and lawn clippings), hydrocarbons, pathogens, trace metals, pesticides, salinity and surfactants.
Industrial land use runoff	Atmospheric deposition and build-up from traffic; poor waste management; accidental spills; and illegal discharges.	Increased flow, sediment, nutrients, litter, oxygen depleting material, hydrocarbons, pathogens, pesticides, surfactants, heavy metals, trace metals and solvents.
Commercial land use runoff	Atmospheric deposition and build-up from traffic; poor waste management practices; accidental spills; and illegal discharges.	Increased flow, sediment, nutrients, litter, oxygen depleting material, hydrocarbons, pathogens, trace metals and surfactants.
Construction and development sites	Vegetation loss; poor sediment and erosion control; uncontrolled wash-down of equipment; chemical spills; and poor management of waste and materials.	Increased sediment, litter, chemicals and hydrocarbons.
Road and carpark runoff	Atmospheric and vehicular deposition and accumulation; litter; and chemicals from traffic accidents.	Increased flow, sediment, litter, heavy metals, trace metals, hydrocarbons and chemicals.
Surface runoff flow modification	Changes to runoff characteristics due to constructed impervious surfaces and collection and disposal of stormwater.	Altered water regimes in natural water bodies; formation of acid sulphate soils; flooding of buildings, roads and paths.
Groundwater level modification	Modification of the natural groundwater levels to allow for development.	Stress to groundwater dependent ecosystems, such as wetlands; formation of acid sulphate soils.
Open space runoff (e.g. golf courses and sporting grounds)	Fertiliser and pesticide application and litter from public gardens, parks, sporting facilities, golf courses; and discharge of low quality water from ornamental lakes.	Increased nutrients, pesticides, litter and oxygen depleting materials.
Inadequate maintenance of stormwater devices (e.g. drains, sumps, gross pollutant traps and side entry pits)	Accumulation, then release of pollutants out of unmaintained or poorly maintained stormwater devices; blockages of devices from uncleared sediment, litter, etc.; water pooling due to blockages from uncleared litter, sediment, etc.	Increased sediments, heavy metals, trace metals, nutrients, oxygen depleting substances, toxins and hydrocarbons; flooding of buildings, roads and paths; increased mosquito numbers.

Threat	Cause	Key Impacts
Landfill and contaminated sites	Runoff or leaching from landfills and contaminated sites.	Increased oxygen depleting material, pathogens, sediments, nutrients, litter, trace metals, hydrocarbons and toxins.
Septic and sewer leakage	Groundwater infiltration and surface overflow from sewage systems.	Increased oxygen depleting material, pathogens and nutrients.

Checklist – *Values and threats assessment*

☑ Values and threats have been identified, assessed and documented.

☑ Significance ratings of values and threats have been reviewed and endorsed by the Project Working Group and Project Steering Committee.

5.7 Determine management objectives

Stormwater management objectives aim to define the outcomes sought in the management of stormwater to maintain, protect or restore values. The objectives should ideally define outcomes sought, rather than strategies to be employed, in order to facilitate flexibility and encourage innovation in the management of stormwater. Ideally, objectives should be SMART: specific, measurable, achievable, relevant and linked to a timeframe (ARMCANZ & ANZECC 2000).

The stormwater management planning process should define a vision for the catchment, short-term objectives and long-term objectives.

Establishing objectives will help develop desired outcomes for evaluation planning. Monitoring and evaluation plans should be prepared as part of the stormwater management plan development process. See Section 5.14 and Chapter 10 for more information.

Chapter 2 (Sections 4.1, 5.1, 5.2 and 5.3) and the *Decision Process for Stormwater Management in WA* (Department of Environment & Swan River Trust 2005) should provide a basis for stormwater management plan objectives. The applicable NRM Regional Strategy must also be reviewed, as regional management objectives may have been determined. Water quality targets might have been established by the Environmental Protection Authority, Swan River Trust or a catchment management body.

Vision: Describes the vision of the future catchment condition. It could include a statement about the condition of the catchment and/or a receiving water body in the next 20 to 40 years. A vision is something that the various stakeholders and the community can identify with and support and is an important step towards achieving the objectives of the stormwater management plan.

Short-term objectives: These are the objectives set for the resolution of specific issues over a short timeframe (less than 3-5 years). The timeframe must be specified. Example short-term objectives are:

- Identify and prioritise the retrofitting of existing stormwater management devices to meet the guidelines in Chapters 6 and 9 of the Manual.
- Develop partnerships with neighbouring local governments to improve stormwater management.

- Reduce mosquito problems in X sub-catchment through improved stormwater management.
- Improve habitat values of X stormwater structural control from low to medium.
- Increase overland flow towards X water body.
- Replace X drain with overland flow within the buffer/X metres of X water body.
- Reduce the amount of litter in stormwater runoff exiting X (name of major shopping centres / streets and major active recreation areas).
- Improve recreational access to X (name of waterway, wetland, etc.).
- Improve coordination and planning of asset / infrastructure maintenance.

Long-term objectives: The objectives set for the resolution of specific issues over a long timeframe (greater than 3-5 years). The long-term objectives should reflect the WA stormwater objectives and principles provided in the Preface. Example objectives are:

- Protect public and private buildings from flooding and waterlogging in the 100 year ARI event.
- Reduce the amount of impervious surfaces within the study area by X%.
- Reduce the amount of direct stormwater discharge into X receiving water body/bodies.
- Maintain the pre-development hydrologic regime and meet the ecological water requirements of the receiving environment (specific receiving environments can be named here).
- Increase the amount of stormwater reuse systems with the study area by X%.
- Reduce the X (e.g. total phosphorus or total suspended solids) concentration in X water body to X mg / L. Reduce the X (e.g. total phosphorus or total suspended solids) load to X water body by X%.
- Reduce the frequency/severity of algal blooms/fish kills within X water body by X%.
- Ensure stormwater structural controls meet public health and safety standards.
- Identify appropriate local government policies, schemes and process documents for the inclusion of stormwater management objectives and measures.
- Implement stormwater management objectives and measures to identified local government policies, schemes and process documents by 20XX.
- Increase opportunities for multiple uses of stormwater structural controls.

Checklist – *Management objectives*

☑ Define a vision for the catchment and short-term and long-term objectives.

☑ Identify outcomes for performance monitoring and evaluation.

5.8 Define priority management issues

Part of the stormwater management planning process includes defining priority management issues to be addressed by actions in the stormwater management plan. The identification of condition, activities, values, threats and objectives plays an important role in determining the priority management issues.

Prioritisation options include:

- Map overlays and/or GIS of the spatial information gathered in Sections 5.4, 5.5 and 5.6 can be used to highlight some of the obvious areas that require management. In particular, include overlays of wetlands, waterways, Public Drinking Water Source Areas and native vegetation; land use types; stormwater management infrastructure; major roads; contaminated sites; and stormwater systems causing flooding problems. These maps are also good tools for workshops and presentations.
- The *WA Salinity Investment Framework* (Department of Environment 2003b) process used multiple-criteria analysis to prioritise investment. A matrix of three bands of value and three bands of threat was used, which then determined high value, high threat (the top priority for management), low value, low threat (the lowest priority for management), and so on (see Figure 3). The process documented in Sections 5.5 and 5.6 will produce the three bands of values and threats (high, medium and low). This process was adapted further by the South West Catchments Council during development of the *South West Regional Strategy for Natural Resource Management* (South West Catchments Council 2005), by incorporating the condition of the asset. See Figure 4 for an adaptation of this process, which incorporates the value, threat and condition. Projects that overcome the threats to Tier 1 assets are the priority projects, then projects can be determined for Tier 2 assets. Some assets might be impacted by multiple threats and some projects can address more than one threat. The priority should be to invest in assets of high value or with multiple values. The next priority is to invest in assets in best condition. Then invest in assets that are subject to the highest threat. Then the following factors should be considered: level of community interest is high; condition of the asset is deteriorating; high likelihood of success and/or a technically feasible solution; desirable cost-benefit ratio; etc.
- A panel (e.g. a Steering Committee) can be used to quickly prioritise the highest risks and develop suitable management actions. The panel can use various facilitation/prioritisation processes to assist decision-making. See the *Facilitation Toolkit: A Practical Guide for Working more Effectively with People and Groups* (Keating 2003) and the on-line toolbox (<http://www.coastal.crc.org.au/toolbox/>) for how to facilitate groups.
- See Appendix A for an example of an assessment process. This process was adapted from CSIRO (2000); however, it is very complicated and has the most value for catchments that are complex and where obviously high priority risks are already undergoing management.

Assets		Value		
		High	**Medium**	**Low**
Threat	**High (Existing and/or near and substantial <2020)**	**1st Tier**	**2nd Tier**	**3rd Tier**
	Medium (Intermediate time and/or not a great extent 2020-2075)	**2nd Tier**	**2nd Tier**	**3rd Tier**
	Low (Long term >2075 or already impacted significantly)	**3rd Tier**	**3rd Tier**	**3rd Tier**

Figure 3. WA Salinity Investment Framework prioritisation process (Department of Environment 2003b).

Threat/Value		Value		
		High	**Medium**	**Low**
Threat	**High**	**Tier 1**	**Tier 2**	**Tier 3**
		High condition	High condition	High condition
		Medium condition	Medium condition	Medium condition
		Low condition	Low condition	Low condition
	Medium	**Tier 2**	**Tier 2**	**Tier 3**
		High condition	High condition	High condition
		Medium condition	Medium condition	Medium condition
		Low condition	Low condition	Low condition
	Low	**Tier 3**	**Tier 3**	**Tier 3**
		High condition	High condition	High condition
		Medium condition	Medium condition	Medium condition
		Low condition	Low condition	Low condition

Figure 4. Adaptation of the South West Regional Strategy for Natural Resource Management prioritisation process (South West Catchments Council 2005).

For more information on risk assessment, see *Australian/New Zealand Standard Risk Management AS /NZS 4360:1999* (Standards Association of Australia 1999) and *Handbook: Environmental Risk Management – Principles and Process HB 203:2006* (Standards Association of Australia 2006).

Checklist – *Priority management issues*

☑ A prioritisation process has been established.

☑ Priority management issues have been identified.

5.9 Prepare a priority management issues paper

This stage involves development of an issues paper that highlights key management issues by bringing together the outcomes from the identification of current catchment condition, characteristics and practices, and the prioritisation process. The paper provides an opportunity to reflect on the work undertaken to date and to confirm the key outcomes with the internal local government stormwater management group, Project Working Group, Project Steering Committee and other stakeholders. It also offers an opportunity to maximise local government and stakeholder ownership of the outcomes of the plan. For example, it could be sent to the local government Councillors for noting.

The paper should:

- Summarise the outcomes of the prioritisation process.
- Identify gaps between current stormwater management and best practice.
- Identify obvious barriers and constraints to achieving progress towards best practice. Barriers can include technical issues (such as lack of available land), funding and resistance to change practices. Section 2.3 of Chapter 7 and Chapter 8 provide information on education programs that help to overcome barriers.
- Describe the priority management issues, their extent and implications.

It should be written in a direct and concise style, suitable for an audience of senior managers, Councillors and community members not directly involved in the stormwater management planning process.

Checklist – *Priority management issues paper*

☑ A priority management issues paper has been prepared.

☑ A priority management issues paper has been sent to the Project Working Group, Project Steering Committee, senior local government officers and Councillors.

☑ The Project Working Group and Project Steering Committee have reviewed and endorsed the priority management issues. These priority management issues should form the basis for developing management actions.

5.10 Identify management options

Options for addressing the priority management issues should be identified. These should include a range of both structural and non-structural controls and involve retrofitting existing developed areas and existing structural controls. The following questions should be asked when determining the potential options:

- Is it addressing the protection or restoration of a high priority asset or value?
- Can it address multiple threats and protect or provide multiple values (e.g. does it reduce public health/ safety risks or reduce algal bloom outbreaks; or does it provide recreation values, or habitat values, or water conservation or supply opportunities, as well as stormwater management functions)?
- Is it cost-effective (i.e. are there sufficient benefits for the cost)? Costs should include life-cycle planning, construction and maintenance costs.
- Is there adequate capacity for implementation (i.e. are there sufficient resources, expertise and powers)?
- Are there opportunities for implementation (e.g. is it practical, such as sufficient space to install a particular structural control or to allow access for maintenance equipment)?
- What are the maintenance requirements (frequency, cost and methods)?
- Can it be integrated with other stormwater management measures and therefore form part of a treatment train?
- Who will be responsible for implementation?
- Will it be acceptable to the community?
- Does it encourage partnerships between stakeholders?

Detail about management options is provided in other chapters of the Manual, particularly Chapters 6, 7, 8 and 9.

Financial, social and ecological elements must be assessed to determine the most appropriate strategies – this is often termed triple bottom line assessment. See the guidelines produced by the Cooperative Research Centre for Catchment Hydrology (2005) on triple bottom line assessment of urban stormwater management measures.

Expertise will be required to select a set of possible actions that may meet the needs of the study area. People undertaking this role must be broadly familiar with the benefits and constraints of all possible options. As this is a major challenge for one person, a multi-disciplinary team approach is recommended.

Checklist – *Management options*

☑ A range of structural and non-structural control options that would address the priority management issues have been identified.

5.11 Develop management actions

After suitable management options have been identified, a suite of management actions should be selected and documented in the stormwater management plan. Management actions should address existing issues, as well as measures to prevent possible issues from occurring in the future. They might also involve catchment monitoring and review when insufficient information currently exists (such as water quantity and quality monitoring or additional ecological studies).

Regional natural resource management strategies and catchment management plans should be reviewed to ascertain their management strategies, actions and targets and to see how the stormwater management plan fits within that context.

Management actions should be developed in consultation with the internal and external stakeholders that will be responsible for implementation.

The following list includes some management actions that should be included in a stormwater management plan (where applicable).

- **Funding.** Establish a budget and dedicated source of funding to implement the management plan actions. The funding program should be sent to Council for review and endorsement.
- **Undertake water quantity and quality modelling and additional ecological studies**, if required to assist development of future actions.
- **Establish water quality and quantity targets**, if none exist for the study area.
- **Develop and implement a water quality monitoring program,** including a sampling and analysis plan to identify pollution sources, establish baseline water quality data and establish water quality targets.
- **Minimise effective imperviousness**[4] in the study area. Stormwater management plans must determine the location of impervious surfaces and which pipes/drains discharge directly into waterways, wetlands and coastal waters and how the imperviousness and direct connection will be minimised. Minimising effective imperviousness significantly improves the quality of stormwater that discharges to receiving environments and helps re-establish the pre-development hydrologic regime. See Walsh et al. (2004) for more information on how water quantity management improves water quality in receiving waterways. Refer to Chapters 6 and 9 for methods to increase perviousness and minimise direct connection. Reduction of effective imperviousness can be achieved by:

[4] Effective imperviousness is the combined effect of the proportion of constructed impervious surfaces in the catchment, and the connectivity of these impervious surfaces to receiving water bodies.

- the retention of pervious surfaces (e.g. bushland, parkland and street plantings);
- retaining small rainfall events at-source through the installation of infiltration systems (such as pervious paving, swales and soakwells) or using stormwater on-site (e.g. rainwater tanks);
- identifying impervious surfaces that are suitable to be replaced with pervious surfaces and undertaking phased replacement;
- the removal of pipes/drains that discharge directly into waterways, wetlands and coastal waters and the introduction of overland flow across vegetated surfaces.

- **Improve the protection and restoration of wetlands and waterways** (i.e. in accordance with Chapter 2 principles and approaches). In particular, wetland and waterway buffers should be established and maintained and the pre-development hydrologic regime should be re-established, where appropriate. For example, the stormwater management plan could state the values of the wetlands and waterways and the principles and approaches for their management (such as revegetation of wetlands and waterways and their buffers). However, it is preferable for detailed management actions to be documented in wetland and waterway management plans. Refer to *A Guide to Managing and Restoring Wetlands in Western Australia* (Department of Environment and Conservation, in preparation) and the *River Restoration Manual* (Water and Rivers Commission/Department of Environment 1999-2003). If environmental, wetland or waterway management plans have been developed, then actions recommended in the stormwater management plan should be consistent with those plans.
- **Retain native vegetation wherever possible and plant local native plants in Council plantings.** Implementation might require preparation or alteration of Council policy or guidelines regarding remnant vegetation management and Council plantings. It might also involve development of a vegetation management strategy and actions to implement the *Sustainable Landscaping Strategy* (North Metro Catchment Group Inc. 2006).
- **Review stormwater management infrastructure** for quantity management and quality treatment effectiveness. See Chapters 7 and 9 for more information.
  - Develop a program for planned inspection and condition monitoring of infrastructure, including a system for reporting monitored issues, such as localised flooding or mosquito breeding. This will allow for maintenance to occur when the 'need arises', rather than conducting maintenance on a timed basis.
  - Review infrastructure for quantity capacity (this will require modelling) and water quality treatment effectiveness where this detailed information does not exist.
  - Include data about infrastructure that have been identified as requiring retrofitting.
  - Develop a system of data management. For example, develop an asset/infrastructure maintenance database.
- Development and implementation of an **asset/infrastructure management program** that is costed (so that projects can be budgeted) and includes an action timeline. The program should include construction and maintenance of local government roads, carparks, pavements, premises/buildings, vehicles, gardens/reserves and stormwater management infrastructure (e.g. sumps, soakwells, drains, gully pits, etc.). This also includes maintenance activities such as road/pavement sweeping; side entry pit eduction; and fertilisation, plant selection and maintenance in streetscapes and parks (e.g. prepare and implement a parks and reserves management plan). Pollutant hotspots (e.g. side entry pits located at the bottom of hills) should be identified so that they are added to a program for more regular inspection and maintenance. The program should include provision for convenient updating of infrastructure records, preferably an electronic system. A stormwater infrastructure register should be established. New infrastructure would be registered on the database as part of the development approval process. This would help local government monitor what is currently installed and predict future local government maintenance requirements. Asset management programs should also be prepared by other infrastructure providers, such as Main Roads Western Australia and Water Corporation. See Section 2.2 of Chapter 7 for more information.

- **Retrofitting** stormwater infrastructure and catchments to implement treatment trains, to improve stormwater infrastructure performance, to integrate stormwater infrastructure within the urban landscape (e.g. integrated within public open space, rather than installed within fenced-off areas), to reduce public health/safety risks, or to improve stormwater quality treatment. For example: Retrofit X drain to create a vegetated swale within the buffer of X water body. See Chapter 6 for more information about retrofitting.
- Recommend which **local government policies, processes and planning instruments** require amendment. Development Control Plans/Town Planning Schemes/Design Guidelines/Local Planning Strategies and Policies might require amendment (or production) to address stormwater management and to ensure that best practice is implemented in new developments. This might also require internal local government development assessment and approvals processes to be amended to incorporate improved stormwater management. There should be a clear process for integrating stormwater quantity and quality management practices within the local government processes, as they are often managed separately and water quality management often involves less obvious stormwater management issues (such as road/pavement construction and maintenance, and street tree selection and maintenance). This could also include working with other stakeholders (such as other local governments, State government agencies and regional NRM groups) on the preparation of catchment or sub-catchment integrated catchment management plans.
- Investigate opportunities for potential **stormwater reuse** (as a water source) for systems that currently discharge directly to the coast or to estuaries, subject to the receiving water bodies receiving their ecological water requirements.
- **Improve coordination/communication arrangements,** including improving coordination and communication internally between different sections of the local government (e.g. planning, environmental health and engineering sections), and between local government and external stakeholders. Identification of deficiencies will form the basis for the formulation of management strategies to guide local government. For example, Glenorchy City Council (Tasmania) established a Stormwater Management Coordinating Committee where officers from different sections (e.g. planning, environmental health and road and hydraulics engineering) met regularly to coordinate stormwater and waterway management (Derwent Estuary Program 2005). The City of Stirling (WA) has formed a similar group. As discussed in Chapter 7, the section managing the local government's stormwater program should able to draw upon a wide range of skills to implement the program, including skills in town planning, law, civil engineering, community consultation, marketing, environmental management, psychology and statistics. Using the philosophy of 'adaptive environmental management', stormwater managers need to be prepared to engage in responsible risk-taking, leading to improved understanding, program modification and ultimately better outcomes. A culture of responsible risk-taking within the organisation typically requires strong leadership and continual reinforcement.
- **Undertake education/capacity building projects**. A capacity building project should target activities that are a known significant risk to the management of stormwater and receiving water bodies. Many activities cause environmental harm, so the limited resources should be directed at practices that will reduce risk. Industry capacity building programs could be undertaken (e.g. Motor Trade Association of Western Australia's Green Stamp Program <http://www.mtawa.com.au>) – either forming a partnership with an existing program, or working with the relevant agencies, industry associations and NRM/catchment groups to develop a program. Capacity building programs could be used to address risks from mobile activities. Education projects could include activities such as installation of local government demonstration sites (e.g. catchment-friendly gardens). See Chapters 7 and 8 for more information on developing education programs.
- **Regulation and enforcement** applies to enforcement of controls on construction sites, pollution offences, etc. through the use of Unauthorised Discharge Regulations 2004. See Sections 2.4.2 and 2.4.3 of Chapter 7 for more information.

- **Emergency/pollution response**. For example, review local government and Main Roads Western Australia emergency response plans (ensure that waterways, wetlands, open drains/living streams, stormwater detention/retention areas and public drinking water source reservoirs and bores are shown on maps/datasets that should be used during emergency responses).
- **Litter and gross pollutants.** Implement a carpark, road and pavement sweeping program. Install adequate (type and number) litter bins at litter hotspots and have an emptying schedule. Undertake litter cleanup days and litter prevention education. Install litter traps (as a back-up to all of the other actions that must be undertaken) at runoff points from litter hotspots (e.g. within carparks of commercial areas such as shopping centres) and have a maintenance program to ensure they do not become pollution sources. Installing numerous smaller litter traps throughout the catchment (close to the pollution sources) reduces the risks from overflowing and litter biodegradation compared to relying on large litter traps placed at outfalls to receiving water bodies. See Sections 2.2.3 and 2.2.4 of Chapter 7 for information on litter management strategies and Chapter 9 for information on structural (e.g. gross pollutant traps) litter treatment options.
- **Pollution sources.** Include specific actions (i.e. non-structural controls) or structural devices that should be implemented to address specific pollution sources, particularly in priority sub-catchments. For example, conduct further investigation of pollution sources, such as identifying and addressing industrial/commercial sites discharging directly into stormwater drains, sumps and basins. See Chapters 7, 8 and 9 for more information.
- **Document stormwater management requirements for new developments**. These can be included in local government documents such as Development Control Policies.
- **Establish management targets that could include targets for water quality and quantity**.
- **Establish a monitoring and evaluation plan** to assess if the stormwater management plan is being implemented and if the actions are resulting in measurable change. See Section 5.15 and Chapter 10.

Detailed examples of management actions can be found in the following reference:

Derwent Estuary Program 2005, *A Model Stormwater Management Plan for Hobart Regional Councils – a Focus on the New Town Rivulet Catchment*, Derwent Estuary Program, DPIWE, Tasmania. Available from: <http://www.derwentriver.tas.gov.au>.

Checklist – *Management actions*

☑ Management actions that are clearly linked to priority management issues have been identified.

5.12 Prepare an implementation plan

The stormwater management plan should include action cost estimates and how actions will be funded. The plan should provide indicative costing for each action or program (if the actions can be grouped into programs) as this will be useful for planning and budgeting works. These issues can be identified in an implementation plan, which should be included in the stormwater management plan.

The implementation plan should clearly define who is responsible for implementing actions and include an implementation timeline. Table 6 provides an example of the structure of an implementation plan table. Note: An actual implementation plan would contain more specific information.

If a stormwater management plan has actions for other agencies/groups, there should be a formalised agreement or partnership arrangement with the other agencies/groups regarding implementation of the recommendations. This agreement or partnership arrangement should be prepared while the implementation plan is developed.

Table 6. Example structure of an implementation plan table

Threat	Value	Management Action	Estimated cost		Responsibility	Timeline	KPIs
			Capital	Ongoing			
Inadequate maintenance of stormwater devices	Aquatic habitat Property/ infrastructure	Review stormwater infrastructure for quantity management and quality treatment effectiveness.		xxx	Local government, Water Corporation and Main Roads WA.	2007	Stormwater infrastructure review completed.
	Public health and safety	Develop and use electronic infrastructure management program.		xxx	Local government.	2007, then ongoing.	Infrastructure management program developed and implemented.
Surface runoff flow modification	Aquatic habitat Property/ infrastructure	Install infiltration systems (e.g. pervious paving, soakwells and swales).	xxx	xxx	Local government, Main Roads WA, developers and landowners.	2007, then ongoing.	Number of infiltration systems installed.
		Introduce stormwater use systems (e.g. rainwater tanks).	xxx	xxx	Local government and landowners.	2008, then ongoing.	Number of Council stormwater use systems installed.
		Identify impervious surfaces that can be replaced with pervious surfaces.		xxx	Local government.	2008, then ongoing.	Identification and documentation of impervious surfaces suitable for replacement.
		Replace impervious surfaces with pervious surfaces.	xxx	xxx	Local government.	2009, then ongoing.	Number of impervious areas replaced with pervious surfaces.
		Replace direct discharge into water bodies (e.g. via pipes) with overland flow systems on a prioritised basis.	xxx	xxx	Local government, Water Corporation and Main Roads WA.	2008, then ongoing.	Number of direct discharge systems replaced with overland flow systems.
Etc.							

The implementation plan will also need to include a performance monitoring and review program. It is recommended the performance monitoring and review program be developed in the planning phase of the project. For example, Key Performance Indicators (KPIs) or similar measurement tools can be used. See the *Draft Herdsman Lake Integrated Catchment Management Plan* (North Metro Conservation Group Inc. 2007) for example KPIs. See Section 5.15 for more information.

Checklist – *Implementation plan*

☑ Responsibilities for implementation of management actions have been agreed.

☑ An implementation plan has been prepared.

5.13 Produce Stormwater Management Plan documents

It is recommended that the Stormwater Management Plan be produced in two volumes. The first volume should contain a summary of the stormwater management plan, its management actions, the implementation plan and figures. Further details on the process and supporting documentation should be in the second volume.

A draft plan should be prepared for review and comment by stakeholders, including the Project Steering Committee and Project Working Group.

The final plan should be referred to project partners and the local government for review and endorsement, including adoption by Council.

The final plan should be available for public access, on the local government or regional NRM group website and in copies held in the Council library.

Table 7 provides an example layout and contents of a stormwater management plan.

The following plans have been prepared in Western Australia, which can be reviewed as stormwater management plan examples:

- *City of South Perth Integrated Catchment Management Plan* (JDA Consultant Hydrologists & Ecoscape 2004). Available via <http://www.southperth.wa.gov.au> (search for 'catchment management plan').
- *Stormwater Management Plan, Town of Victoria Park* (URS 2005). Available by contacting the Town of Victoria Park 9311 8111 or <admin@vicpark.wa.gov.au>.
- *Western Suburbs Regional Organisation of Councils – Regional Strategy for Management of Stormwater Quality* (JDA Consultant Hydrologists 2002). Available by contacting JDA Consultant Hydrologists on 9388 2436 or WESROC on 9387 0953.

Checklist – *Stormwater management plan*

☑ A draft plan, preferably in two volumes (with extra details and supporting documentation included in volume two), has been prepared.

☑ A draft plan has been submitted to stakeholders for review and comment.

☑ The plan has been finalised and made available for public access.

Table 7. Example layout and contents of a stormwater management plan

Layout	Contents
Title Page	Provide the title, date and authors.
Acknowledgments	Acknowledge individuals, groups and organisations for assistance, support or funding provided for the project.
Contents	Contents page.
Glossary	Include explanations of terminology used in the plan. Lists of abbreviations and acronyms (if used) and their meanings should be included.
List of Tables	
List of Figures	
Management Plan Recommendations	List the management plan recommendations (such as when the plan should be reviewed) and the management actions.
Summary	Provide a summary of the intent and major findings of the plan.
Introduction	Sections likely to be included could be: a background to the study; location of the study area; scope of the plan; objectives of the plan; and key definitions. See Sections 5.3.1 – 5.3.3 for information to include.
Catchment Context	This section places the plan in the context of the catchment and describes the relationship between the catchment and stormwater management. It should include a description of the link between the plan and other strategies, plans and relevant legislation. See Sections 5.3.3, 5.3.4, 5.4 and 5.4.1.
Approach	Explain the plan preparation process. This may include a description of the methods employed for information collection, stakeholder consultation, prioritisation assessment and management strategy determination. See Sections 5.1, 5.2, 5.8, 5.9 and 5.10.
Sub-catchments	Explain how sub-catchments were delineated and provide a figure showing the sub-catchment locations. See Section 5.3.4.
Study Area Characteristics	This should include information on: climate; geology, soils, topography; wetlands; waterways; groundwater; surface drainage (e.g. floodplains); surface water and groundwater quality; remnant vegetation; fauna; and historical and existing land use. See Sections 5.4.1 and 5.4.2.
Existing Stormwater Management Practices and Processes	Review: stormwater management devices; catchment hydrology and flow paths of minor and major rainfall events; planning documents; maintenance practices; capacity building (including staff training and education programs); regulation and enforcement; and emergency/pollution response. See Section 5.4.3.
Ecological, Social/ Cultural and Economic Values	Identify ecological, social/cultural and economic values of the local and receiving environments and how these values were determined. The process for values identification is in Section 5.5.
Threats	Identify threats to the local or receiving environments and how these threats were determined. See Section 5.6 for the process of determining threats.
Management Objectives	Document the vision and short-term and long-term objectives. Section 5.7 describes the establishment of visions and objectives and provides example objectives.
Priority Management Issues	Document the priority management issues. See Section 5.8 for more information.

Layout	Contents
Management Actions	This section should state the proposed management actions to address the priority management issues. The process for determining actions is in Sections 5.8, 5.9 and 5.10. Example management actions are provided in Section 5.11.
Implementation Plan	Include an implementation plan documenting how the stormwater management plan will be implemented. See Section 5.12 for the process for preparing an implementation plan and Section 5.14 for how to implement the stormwater management plan.
Performance Monitoring and Review	Document how the stormwater management plan will be monitored and reviewed. See Section 5.15 for more information.
Conclusions and Recommendations	Include a summary of the catchment characteristics. Conclude with the major issues and opportunities and the recommendations of the plan.
References	
Appendices	Extra details such as questionnaire results, calculation results, etc.

5.13.1 Summary of checklists for preparation of a stormwater management plan

☑ Aim and scope of the plan have been established.

☑ Stakeholders' roles and responsibilities are understood.

☑ Stakeholders are committed to involvement in preparation of the plan (including provision of requested data, where relevant) and to implementation of the plan (where applicable).

☑ Stakeholders understand the nature of stormwater impacts and management.

☑ Key project objectives are clearly defined and understood.

☑ Study area boundary and sub-catchments have been determined.

☑ Available information and data has been requested.

☑ The timetable for the study has been confirmed by relevant stakeholders (e.g. the Project Steering Committee and the Project Working Group).

☑ Field investigations have been undertaken.

☑ Interviews and consultation with relevant local government officers and other stakeholders have been undertaken.

☑ All relevant information and data has been obtained, reviewed and catalogued (preferably in a GIS format).

☑ Maps of wetlands, waterways, Public Drinking Water Source Areas, remnant vegetation, the stormwater/drainage system and land uses have been prepared.

☑ Database (preferably GIS) of stormwater device management has been developed, which should include who is responsible for maintenance of the device.

☑ Current practices and processes have been reviewed, including the planning scheme, supporting documentation, the approval process, maintenance practices and the nature of coordination and resourcing.

☑ Values and threats have been identified, assessed and documented.

☑ Significance ratings of values and threats have been reviewed and endorsed by the Project Working Group and Project Steering Committee.

☑ A vision and short-term and long-term objectives have been defined.

☑ Outcomes for performance monitoring and evaluation have been identified.

☑ A prioritisation process has been established.

☑ Priority management issues have been identified.

☑ A priority management issues paper has been prepared.

☑ A priority management issues paper has been sent to Project Working Group, Project Steering Committee, senior local government officers and Councillors.

☑ The Project Working Group and Project Steering Committee have reviewed and endorsed the priority management issues. These priority management issues should form the basis for developing management actions.

☑ A range of structural and non-structural control options that would address the priority management issues have been identified.

☑ Management actions that are clearly linked to priority management issues have been identified.

☑ Responsibilities for implementation of management actions have been agreed.

☑ An implementation plan has been prepared.

☑ A draft plan, preferably in two volumes (with extra details and supporting documentation included in volume two), has been prepared.

☑ A draft plan has been submitted to stakeholders for review and comment.

☑ The plan has been finalised and made available for public access.

5.14 Stormwater management plan implementation

To assist project implementation, a project tracking system could be created to follow the status of individual projects from concept to completion. The purpose is to store essential data on the design, construction, maintenance and performance of individual projects. The tracking system should be designed to store data that is needed to brief key managers and stakeholders, such as the current status of all projects. As discussed in Center for Watershed Protection (2005), three tasks are used to create a project tracking system:

1. **Determine key project management information to track.** This can include information on cost, location, type of device/project, installation date, inspection schedule and maintenance performed.

2. **Continuously update project information into tracking system.** The tracking system should be updated several times per year to include new project information.

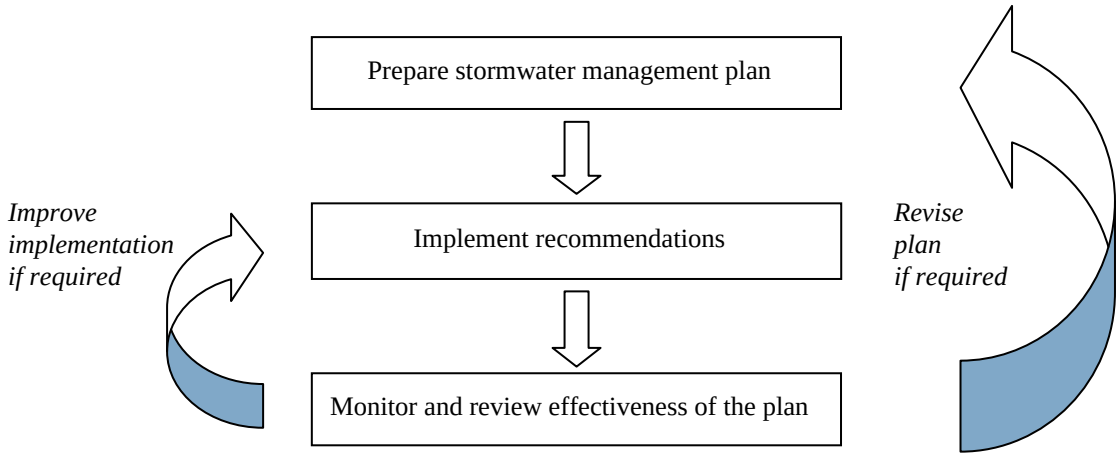
3. **Periodically report on status of project implementation.** The tracking system should be reviewed at least once a year to make sure project data is current. A short report should be prepared that summarises the status of implementation, with an emphasis on project successes and failures that can be used to adjust future project implementation.

A local government implementation team should be formed. This team should include operational (e.g. maintenance staff) and management staff, to ensure that practical implementation issues are considered, as well as ensuring there is upper management support and sufficient funding for projects. The implementation team might include the same people as the local government team formed for development of the plan.

An external group should be involved in the review of implementation of the stormwater management plan. It is recommended that a group be created that meets regularly (e.g. quarterly or bi-annually) to plot progress of the plan. Public reporting can include both a progress report on the plan's implementation and reporting on the outcomes achieved by the plan's actions (ARMCANZ & ANZECC 2000).

5.15 Performance monitoring and review

Stormwater management plans should be viewed as live documents that are actively consulted, reviewed and revised. Implementation of the actions should be reviewed annually. The timing of the annual review should allow for review outcomes to be incorporated within budget planning cycles. The stormwater management plan should also specify when the whole plan should be reviewed (e.g. in 5 years).



Specific milestones, objectives and outcomes should be identified in the stormwater management plan, which enable monitoring and review of the implementation process. The following could be monitored:

- If actions have been implemented.
- Changes in stormwater management practices.
- Reductions in stormwater threats.
- Changes in stormwater quality.
- Changes in the quality/health of receiving water bodies.
- Changing or new priorities.

Actions should be reviewed to determine if they require alteration due to acquisition of further information or recognition that the original actions were not entirely appropriate (Water and Rivers Commission 2001).

The effectiveness of the plan could be assessed by asking the following evaluation questions (adapted from Water and Rivers Commission 2001):

- What worked in relation to helping achieve the objectives?
- What did not work?
- Were the project objectives met?
- Did anything change as a result of the action?
- Were there any unexpected results from the plan?

- What would be done differently next time?
- What evidence is there that the plan made a difference?
- Have people changed their management practices?
- Are the problem areas getting better?
- Have community values / expectations changed?

See Chapter 10 for information about how to monitor and evaluate structural and non-structural stormwater management devices.

6 References

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7 Further reading and useful websites

Planning:

Center for Watershed Protection 2005, *Urban Subwatershed Restoration Manual No. 2: Methods to Develop Restoration Plans for Small Urban Watersheds, Version 2.0*, Center for Watershed Protection, United States of America. Available via <http://www.cwp.org>.

Derwent Estuary Program 2005, *A Model Stormwater Management Plan for Hobart Regional Councils – a Focus on the New Town Rivulet Catchment*, Derwent Estuary Program, DPIWE, Tasmania. Available via <http://www.derwentriver.tas.gov.au>. This provides detailed information about the process of preparing an example stormwater management plan (including questionnaires used to survey stakeholders).

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Websites:

Bureau of Meteorology website: <http://www.bom.gov.au>.

Bush Forever web page via the Western Australian Planning Commission's website: <http://www.wapc.wa.gov.au>, search for Bush Forever.

Department of Agriculture website: <http://www.agric.wa.gov.au>.

Department of Environment and Conservation website: <http://www.dec.wa.gov.au>.

Department of Environment and Conservation's Florabase website: <http://florabase.dec.wa.gov.au>.

Department of Water website: <http://www.water.wa.gov.au>.

Landgate (formerly Department of Land Information) website: <http://www.landgate.wa.gov.au>.

Urbanwater.info website: <http://www.urbanwater.info>.

SLIP website: <https://www2.landgate.wa.gov.au/slip/portal/home/home.html>.

WALIS website: <http://www.walis.wa.gov.au> for general queries about spatial information.

WALGA website: <http://www.walga.asn.au>.

Western Australian Museum's Faunabase website: <http://www.museum.wa.gov.au/faunabase>.

8 Acronyms

ARI	Average recurrence interval
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
ANZECC	Australian and New Zealand Environment and Conservation Council
GIS	Geographic information system
ICLEI	Local Governments for Sustainability Australia/New Zealand
NRM	Natural resource management
SLIP	Shared Land Information Platform
WALGA	Western Australian Local Government Association
WALIS	Western Australian Land Information System

Appendix A — Example process for defining priority management issues

Some factors to be considered are:

- Risk assessment needs to determine if a risk is inherent (i.e. based on general risks from that type of activity) or managed (e.g. site management practices may reduce the risk – however, managed risk can only be determined if information on management actions for that site is available).
- Viv Read & Associates (2005) recommended the following regarding risk assessment:
  - The scale of the current risk (providing a sense of proportion between each of the threat types).
  - The locations of highest risk.
  - The trend of the risk (increasing, decreasing or stable).
  - The estimated time to full impact (or cessation) of the risk.
  - The responsiveness to intervention (works to reduce the risk).

The following process has been copied from the CSIRO (2000) *Urban Stormwater: Best Practice Environmental Management Guidelines*. However, it is a very complicated process that has most value in catchments that are complex and where obviously high priority threats are already undergoing management.

The approach adopted for prioritising stormwater management issues is based on risk assessment. Risk assessment involves estimating potential risks from stormwater threats to local and receiving environment values. The assessment should consider the magnitude of each threat and value, as confirmed by the Project Working Group, and the sensitivity of a particular value to a given threat.

Within each sub-catchment, each threat type is assigned a significance rating of Low, Moderate, High or Very High. These qualitative ratings will be translated to a quantitative rating on a 1 to 4 scale as part of the risk assessment. In arriving at a significance rating, consideration should be given to the quantity of pollutant load generated and the frequency of occurrence. Discussions should take place with key people in local government, Department of Water, Department of Environment and Conservation, the catchment management group, Water Corporation and others. It will be necessary to justify and explain the basis for assigning a rating to a particular threat. Proposed significance ratings will be reviewed and endorsed by the Project Working Group and Project Steering Committee before their final adoption.

Risk magnitudes should be calculated for all combinations of values and threats within each sub-catchment by assigning a numerical score for each qualitative rating (i.e. 1 = Low, 2 = Moderate, 3 = High and 4 = Very High). A sensitivity score from 1 to 4 is also assigned depending on the influence of the threat on the specific value. Values that are very highly sensitive to a given threat should be assigned a score of 4, while values that are not sensitive should be assigned a score of 1. For example, if visual amenity in a specific sub-catchment is highly ranked, it will be sensitive to stormwater threats that produce pollutants that directly impact on aesthetics of the receiving water body (e.g. litter). Alternatively, a particular stormwater threat within a sub-catchment may occur downstream of a specific value. Therefore, the value will not be sensitive to the threat.

Using this approach, the risk magnitude for each combination of value and threat should be calculated as follows:

$$Risk = Value \times Threat \times Sensitivity$$

For each sub-catchment, the combination of specific threats, values and their sensitivities can be expressed as a matrix. Figure 5 provides an example of a risk matrix for a sub-catchment, where sensitivity is shown

in the top right corner of each risk cell. Risk cells have been shaded in accordance with magnitude, with darker cells representing higher risks.

By listing specific risks from all sub-catchments in order of their magnitude, management priorities can be defined for different threats and locations across the study area. The identification of management priorities from this list should focus on specific risks that generate the highest risk magnitude (e.g. the top 25 risks).

City of Hume - Lower Moonee Ponds Creek				Stormwater Threats							
				Waterway Degradation	Residential Runoff	Industrial Runoff	Commercial Runoff	Arterial Road Runoff	Developing Industrial	Developing Residential	Building Site Runoff (Lot Scale)
				3	2	3	4	4	3	2	2
Receiving Values	Environmental	In-Stream Habitat	1	9 (3)	6 (3)	12 (4)	8 (2)	16 (4)	12 (4)	8 (4)	8 (4)
		Riparian Flora/Habitat	3	9 (1)	6 (1)	9 (1)	12 (1)	12 (1)	9 (1)	6 (1)	6 (1)
	Cultural	European Heritage	3	18 (2)	6 (1)	9 (1)	12 (1)	12 (1)	9 (1)	6 (1)	6 (1)
		Aboriginal Heritage	4	36 (3)	8 (1)	12 (1)	16 (1)	16 (1)	12 (1)	8 (1)	8 (1)
	Amenity	Recreational	3	18 (2)	12 (2)	18 (2)	24 (2)	24 (2)	18 (2)	12 (2)	18 (3)
		Visual/Landscape	2	18 (3)	12 (3)	18 (3)	24 (3)	24 (3)	12 (2)	8 (2)	12 (3)
	Stormwater	Flood Protection & Conveyance	1	3 (1)	6 (3)	6 (2)	8 (2)	4 (1)	3 (1)	2 (1)	2 (1)
		Water Quality Treatment	1	9 (3)	6 (3)	9 (3)	8 (2)	8 (2)	9 (3)	6 (3)	4 (2)
	Economic	Tourism	3	18 (2)	12 (2)	18 (2)	24 (2)	24 (2)	18 (2)	12 (2)	12 (2)
		Property Value	2	12 (2)	8 (2)	12 (2)	16 (2)	8 (1)	12 (2)	8 (2)	8 (2)

Sensitivity = 2

Threat(2) x Value(2) x Sensitivity(2) = **Risk(8)**

Figure 5. Example risk matrix. (Copied from WBM Oceanics Australia 2000, cited in CSIRO 2000.)