Stormwater Management Manual for Western Australia

2

Understanding the context

Department of Environment

Cover photograph: Bannister Creek Drain Restored to a Living Stream, Lynwood

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Consultation and guidance from the Stormwater Working Team

Department of Environment

February 2004

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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 Catchment Management Branch of the Department of Environment.

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

This chapter explains why stormwater management is important and the issues that face stormwater managers. Stormwater management requires careful design, planning and implementation to avoid a number of potential problems in the quality of the receiving natural and built environment. It is also important that stormwater management is considered in the context of the catchment and sub-catchment, rather than focusing on the site level. This manual focuses on best management practice techniques that address these issues. An understanding of the following potential issues will help in the decision making for appropriate policy and planning, source controls and in system management measures:

- water quality in the receiving environment
- water quantity in the receiving environment
- healthy ecological communities
- flood management
- total water cycle management, and
- quality of life.

Considering this wide range of issues, an holistic approach to stormwater management is needed. The water cycle has complex interactions between surface flows, groundwater hydrology, water quality, channel form, aquatic habitat and riparian vegetation characteristics of a watercourse. The impact that the hydrological relationships in turn have on human health, recreation and quality of life are all factors to consider when determining what the community wants to achieve when managing stormwater. Effective management of stormwater means managing social, economic and environmental values in built environments (ARMCANZ/ANZECC, 2000). This chapter also discusses the key roles and responsibilities for stormwater management in Western Australia.

Understanding the concepts of the Stormwater Manual for WA

1 Why are built environments drained?

When rain falls on undeveloped land, most of the water will soak into the topsoil and slowly find its way to the nearest receiving waterway, wetland or groundwater. A small portion of rainfall in undeveloped catchments, around 10–15%, will become direct surface runoff and most of this will be generated by only a few intense rainfall events a year. Runoff moves slowly through the catchment because the ground surface is rough due to the presence of vegetation. This means that the effect of rainfall is spread out over hours and even days. Short, heavy storms have little impact on flow rates in surface receiving waters because the major movement of water to receiving surface waters is through groundwater. For example, the rate of groundwater movement through the sandy sediments of the superficial aquifer of the Swan Coastal Plain ranges from about 50 to 150 m/year depending on location.

When a catchment is developed, the proportion of land covered by impervious surfaces (roads, parking areas, compacted soils, roofs, driveways and pavements) is increased and this can reduce the area available for stormwater infiltration. Where stormwater has been traditionally managed through open drains and piped drainage, up to 80% of the rainfall volume can become direct runoff. However, new approaches in stormwater management aim to prevent pollution at the source, maximise infiltration to reduce stormwater runoff, recharge groundwater and minimise change to the natural water balance. The removal of catchment vegetation cover contributes to increased runoff, as there is reduced transpiration rates and less removal of water from the soil by plants. Therefore, retaining native vegetation is an important feature of stormwater management.

In traditionally drained built environments, there is a reduction in natural water catchment storage when floodplains and natural wetlands are in-filled for development. At the same time, paved surfaces are smoother than natural surfaces, so water can travel faster across the surface and will reach the receiving waters more quickly. In traditional stormwater management systems, peak flow rates can increase by a factor of up to ten. In these conditions, waterways have to hold larger and often sudden or rapidly peaking runoff flows.

Groundwater is naturally very close to the surface over much of the Perth metropolitan area. To enable development and prevent seasonal inundation when groundwater levels rise in winter, drains have been installed to intercept and lower the peak groundwater table. In these areas, stormwater and groundwater management is inseparable and techniques to minimise the risk of pollution to stormwater will be different in areas where low groundwater levels allow stormwater infiltration close to the surface.

The effects of catchment urbanisation, using a traditional drainage approach on stormwater runoff characteristics, can be summarised as follows:

- increased peak discharges, runoff volume and velocity
- decreased response time
- increased frequency and severity of flooding, and
- change in characteristics of urban waterways from ephemeral to perennial systems (Wong *et al*, 2000).

Figure 1 shows the components of the water cycle or hydrological cycle. Figure 2 shows the changes in the water cycle as a result of urbanisation and demonstrates that infiltration is greatly limited in urban, industrial, commercial and residential catchments, and that runoff is greatly increased.

The changes in stream hydrology geometry in response to urbanisation are shown in Figures 2 and 3. The figures show that the increase in imperviousness results in greater runoff, and that receiving surface water volumes are likely to be greater.

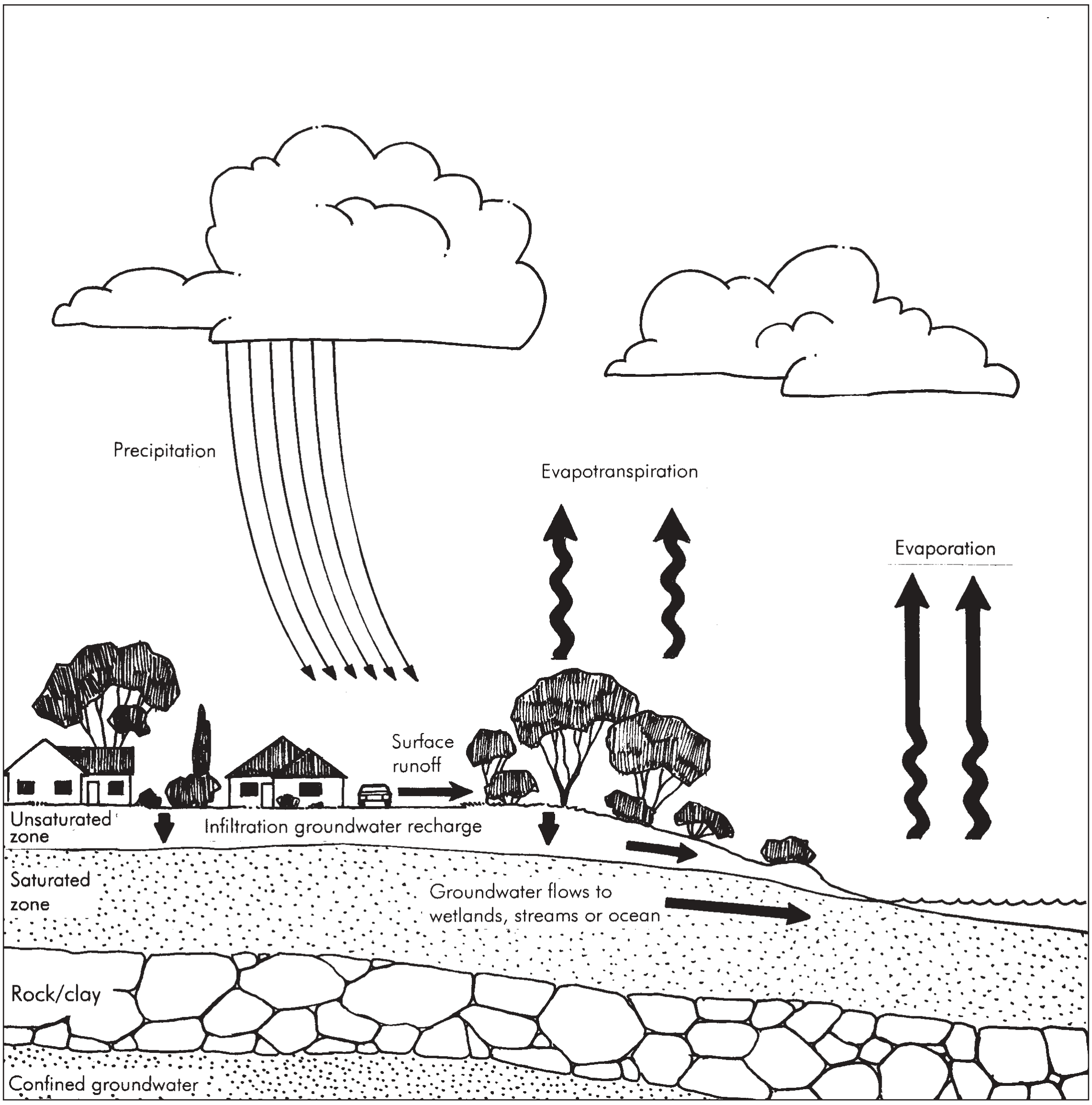

Figure 1: The hydrological cycle

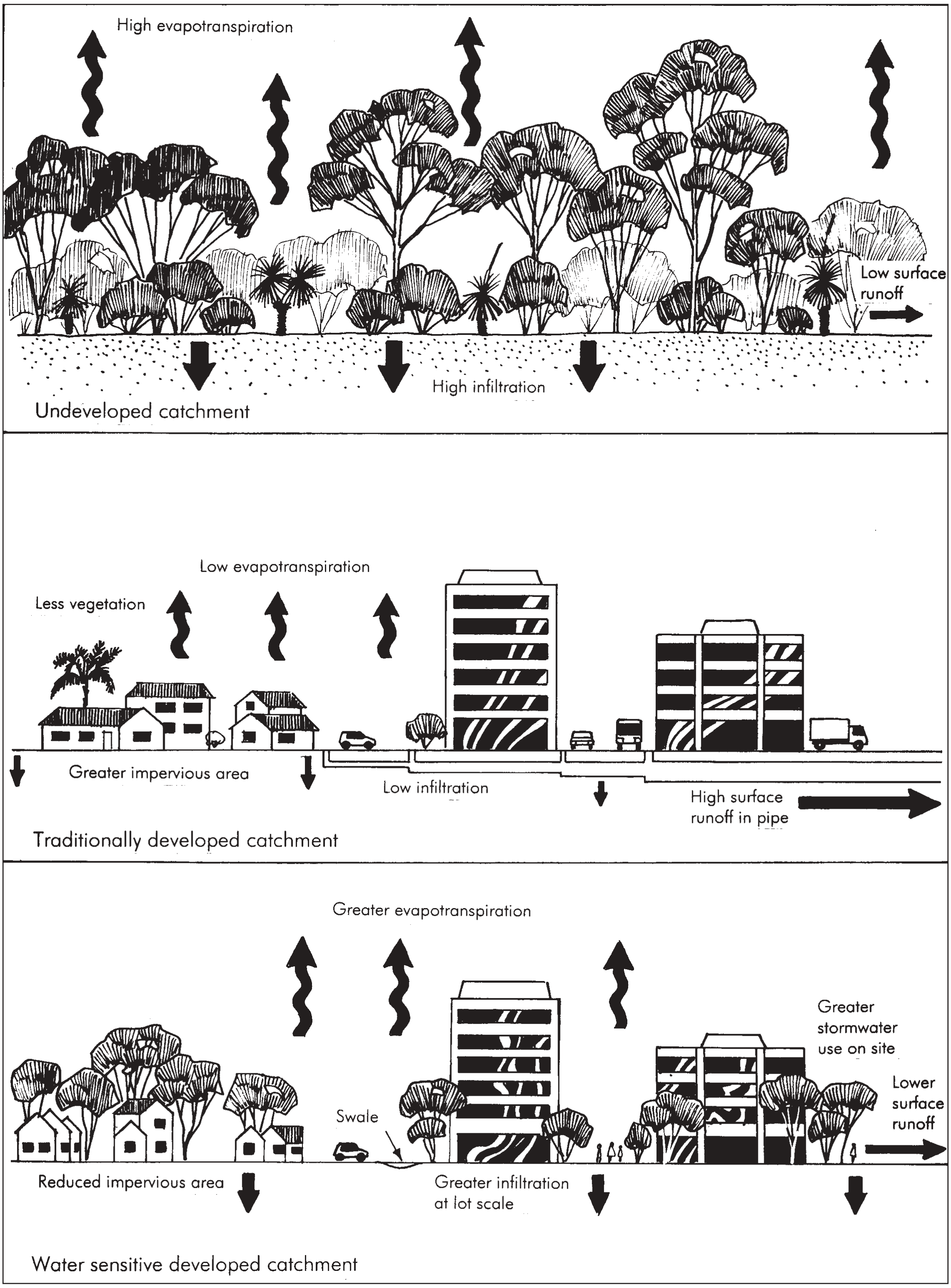

Figure 2: Effect of development on the catchment hydrology for low intensity rainfall events

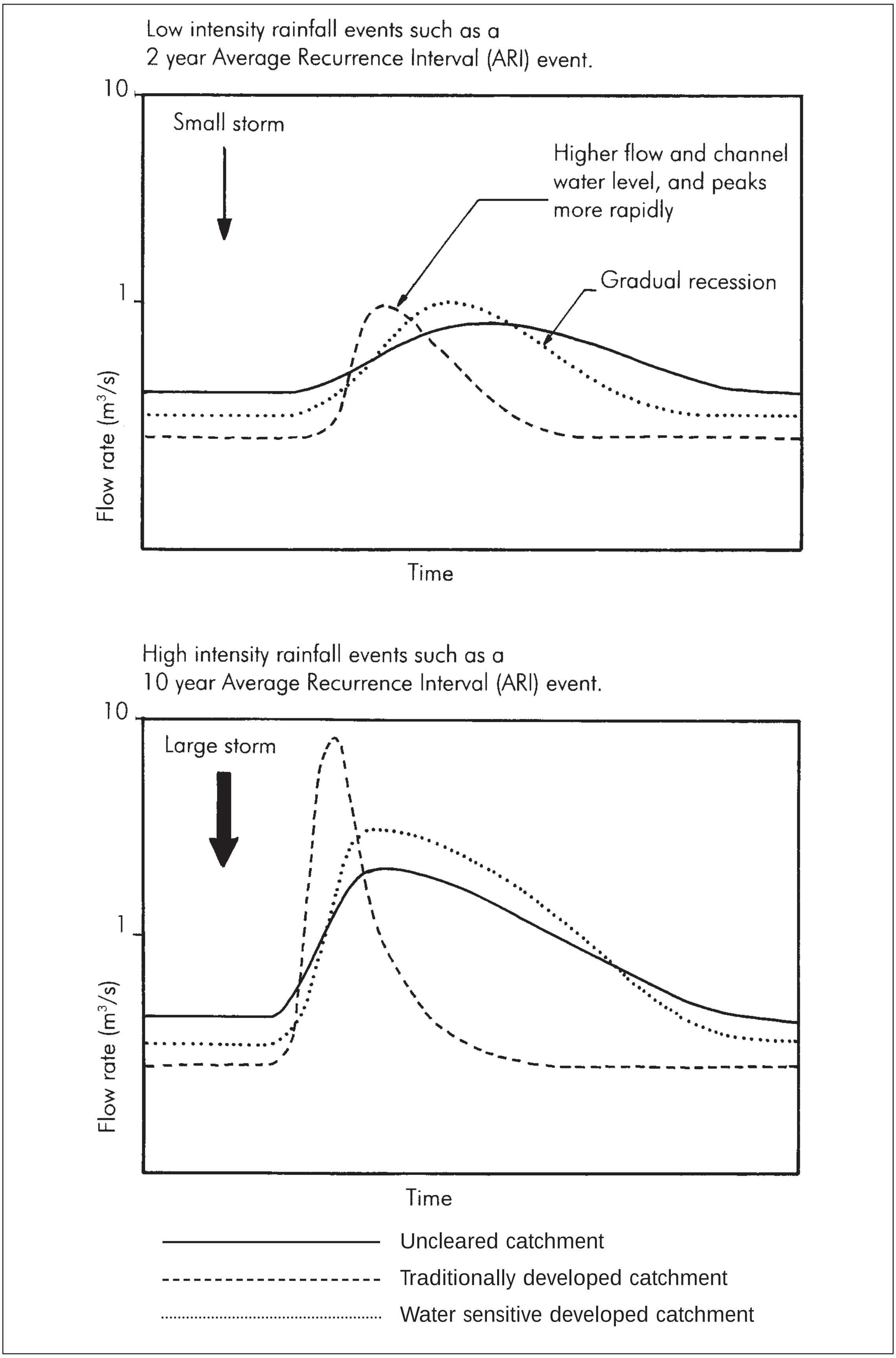

Figure 3: Differences in stream flow hydrographs between traditional land development and water sensitive development

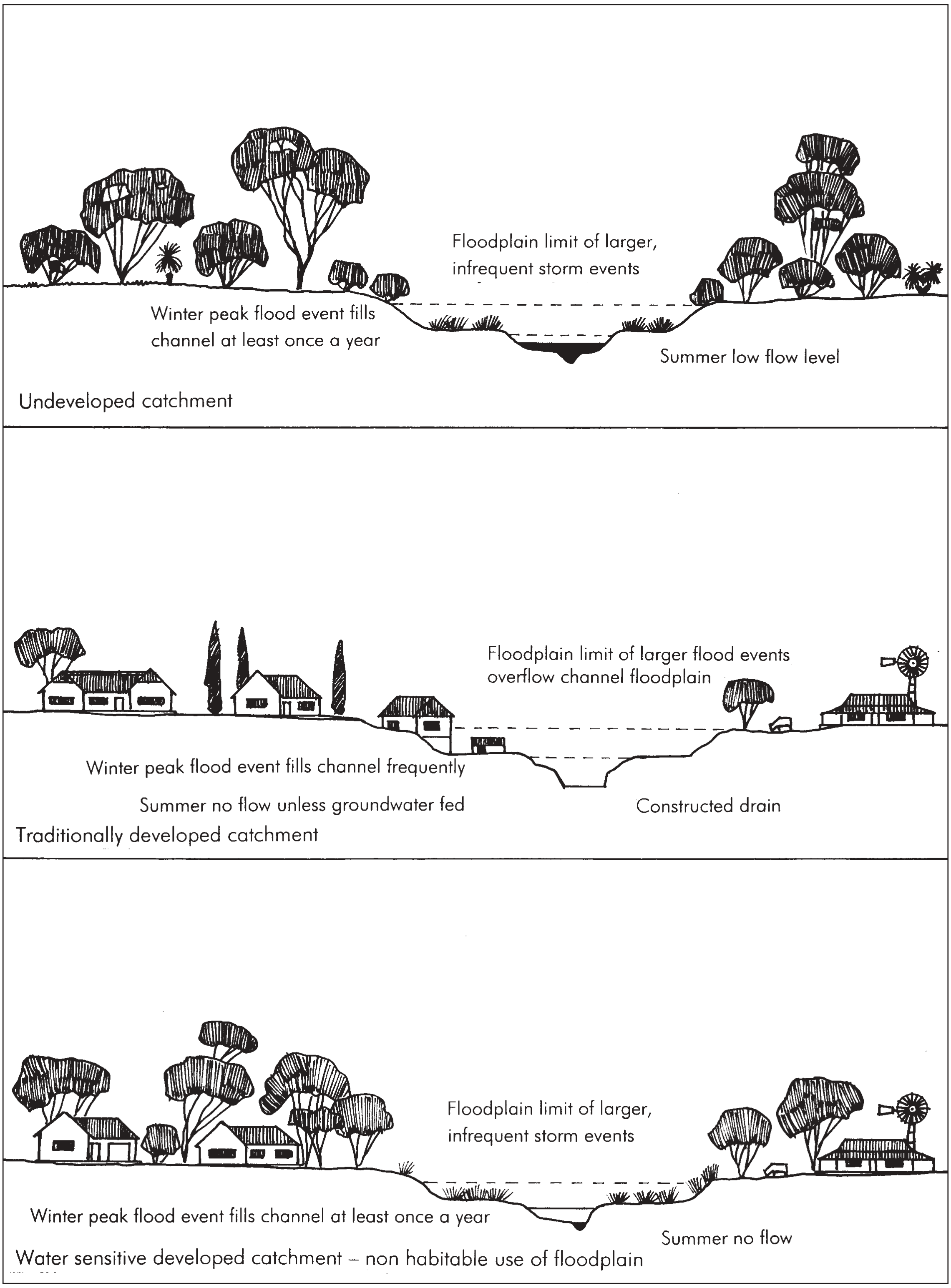

Figure 4: Response of stream geometry to traditional land development and water sensitive development

2 How are built environments drained?

Stormwater systems in WA were originally developed in response to flood prevention, to control groundwater levels and to enable development to occur. Consequently, the traditional emphasis of stormwater management has been one of efficiently collecting and conveying runoff and groundwater from residential, commercial and industrial areas into nearby lower areas such as natural waterbodies, wetlands, streams, rivers, estuaries and the marine environment. Conveyance has employed a combination of underground pipes and linear 'engineered' overland flow paths. Little or no consideration has traditionally been given to the 'downstream' consequences of a conveyance-dominated approach.

Residential development on the Swan Coastal Plain has differed from other areas in Australia, in that there has been a requirement for all rainwater that falls on a property to be retained and infiltrated using soakwells where soil conditions are appropriate. In addition, dry flood detention basins were often scattered across suburbs, usually one in every few streets throughout residential areas, which allowed stormwater to be stored throughout the catchment rather than in a single, end-of-catchment storage system. The stormwater then penetrates the soil and recharges the superficial aquifer. These approaches have resulted in significant benefits to the quality and quantity of stormwater, however, they are not enough to protect stormwater quality because there are still significant areas of urban surfaces such as roads and commercial areas that direct stormwater to drains and waterways.

A new approach termed 'Water Sensitive Urban Design' (WSUD) was developed in the late 1980s for urban planning and design. WSUD provides a framework that incorporates stormwater related issues in urban areas for water quality, water quantity and water conservation, plus broader environmental and social objectives as explicit design objectives and criteria (Water and Rivers Commission, 1998a). The emphasis of WSUD has been on stormwater as a valuable resource rather than the conveyance and disposal of traditional systems. The WSUD experience gained in Western Australia over the last decade has been incorporated into this manual, and in particular in Chapter 4.

Contemporary stormwater management is aimed at reducing the impacts of development on the natural water cycle (Victorian Stormwater Committee, 1999; ARMCANZ/ANZECC, 2000; Institution of Engineers Australia, 2003). Stormwater management now emphasises stormwater quality, health of aquatic ecosystems and public amenity, in addition to managing stormwater quantity. By necessity, stormwater management needs to be broadly based, requiring multi-disciplinary inputs.

A notable shift has also occurred in the reduced emphasis on 'end of pipe' water quality treatment solutions, and an increased emphasis on the application of 'preventative' measures (Victorian Stormwater Committee, 1999; ARMCANZ/ANZECC, 2000). These include:

- retention of existing natural drainage lines (ie. natural bio-chemical treatment processes)
- 'at-source' non-structural controls (e.g. education, Council maintenance practices), and
- use of small-scale infiltration systems (e.g. distributed infiltration to address small frequent runoff events at little additional cost: ie. down to less than 1:1 Average Recurrence Interval events).

3 What are the issues?

Stormwater management requires careful design, planning and implementation to avoid a number of potential problems in the quality of the receiving natural and built environment. It is also important that stormwater management is considered in the context of the catchment and sub-catchment, rather than focusing on the site level. This manual focuses on best management practice techniques that help address these issues and it is important to note that some of these issues are also associated with traditional conveyance systems. An understanding of the following potential issues will help in the decision making for appropriate policy and planning, source controls and in system management measures:

- water quality in the receiving environment
- water quantity in the receiving environment
- groundwater management
- flood management
- healthy ecological communities
- quality of life, and
- total water cycle management.

3.1 Water quality in the receiving environment

The conveyance stormwater drainage system was designed on the assumption that stormwater would remain benign in nature as it passed through the urban catchment. However, the built environment has many sources of pollutants that can contaminate the runoff as it passes through the catchment. The runoff can become contaminated with metals, oils and petrol from vehicles; organic debris, litter, silt and dust, fertilisers, animal waste, pesticides from gardens and detergents from car washing. In conveyance drainage systems, the contaminated water is then discharged directly into waterways and other receiving water bodies.

There are many reasons to ensure that stormwater quality remains clean. In Western Australia, a large portion of our drinking water is harvested from beneath urban environments. Hence, it is in the community's interest to ensure that the stormwater is kept clean and infiltrated as close as possible to the point where it falls as rain, before it becomes contaminated. Present methods of treatment do not remove all contaminants that may leach from suburbia into the water table. With over 130 000 private bores in Perth, the quality of infiltrated stormwater will affect extracted water used on gardens and other sources if not properly managed (Water and Rivers Commission, 1998c). The importance of protecting the biodiversity of our urbanised environments is fundamental for healthy environments and society. Ensuring that best management practices are in place is essential. For example, if detergents and oils enter our drains and waterways, they can cause damage to the water proofing on birds feathers or prove toxic to birds when preening. They can also deplete water oxygen levels as the oils and detergents break down, causing fish deaths and changes in algal communities.

Increased volumes, peak discharges and velocities usually associated with traditional conveyance in stormwater management results in significant mobilisation of pollutants and their consequent accumulation in receiving water bodies. Polluted runoff has been identified as the most significant contributor to the deterioration of water quality in natural and artificial waterways in many parts of Western Australia (Welker, 1995).

There are three major categories of pollutant mobilisation, transport and interception pathways and processes, having major implications for the selection and design of management measures. They relate to porous deep soil, clay/loam shallow soil and impervious areas (e.g. rooves and pavements). The first category is porous sands, commonly found on the Swan Coastal Plain. This soil type rapidly infiltrates rainfall at source, filtering out particulate material but facilitating through-flow of fine colloidal organic material and dissolved forms of nutrients and toxicants to groundwater. Discharges for these areas will be predominantly via groundwater. The primary pollutant interception mechanism will be through biofilm on sediments of soaks, natural waterways or ephemeral wetlands. The second category is the podsolic loam soils over heavy clay subsoils (very common in the Eastern States cities but having similar properties to iron podzols, peats and clays found at Hazelmere and Helena Valley in Perth). These systems have limited rates of infiltration and lead to a high incidence of surface overflow. Nutrients, metals and organic material are rapidly adsorbed onto the surfaces of suspended solids and are transported to the receiving waterways and wetlands. The primary pollutant mechanism is sedimentation of suspended solids and oxidation of organic materials. The third category is the impervious areas common to all urban areas. These systems have extreme peak discharge rates and high rates of delivery of pollutants to receiving waters in the absence of natural interception components. They are high in suspended solids, heavy metals and vehicle emissions. The primary pollutant interception mechanism is sedimentation of suspended solids and oxidation of organic material and nutrients in the sediments (Breen & Lawrence, 2003).

More than 70% of urban pollution (apart from trace metals) generally comes from diffuse (non-point) sources dispersed over large areas, with the remainder coming from point sources such as effluent outlets (Chiew *et al*, 1997). With urbanisation, pollutant concentration levels have generally increased. For example, the amount of phosphorus applications on 1 ha in a typical Perth residential area is estimated to be 40 kg/ha/yr (Gerritse *et al*, 1990). Transport related surfaces (roads, driveways and carparks) comprising up to 70% of the impervious surface area in built catchments, represents a significant contributor of suspended solids, trace metals, polycyclic aromatic hydrocarbons and nutrients. Urban commercial activities have been identified as the main source of litter generation (Wong *et al*, 2000).

Stormwater pollutants originate from a variety of non-point sources, including motor vehicles, construction activities, erosion and surface degradation, spills and leachates, miscellaneous surface deposits and atmospheric deposition. Table 1 summarises the common sources of the various potential pollutants. In terms of ecological impact, the most significant potential pollutants are suspended solids/sediment, oxygen demanding material (ie. organic material, including leaf litter), nutrients and micro-organisms. Oils, surfactants and litter also have ecological impacts in addition to a more immediate aesthetic impact (Wong *et al*, 2000).

While substances such as suspended solids and nutrients are important in the healthy functioning of the aquatic ecosystem, excessive concentrations of these substances in natural waterbodies is detrimental. An increase in suspended solids results in a decrease in the availability of light through the water column. Large inputs of nutrients can cause excessive algal growth, which will lead to decreased oxygen levels and light availability. The resultant bloom’s algal species could be toxic, leading to closure of the waterbody (Hosja *et al*, 1994). Other forms of aquatic flora and fauna are affected by decreases in light and oxygen levels, gradually causing an overall deterioration of the waterbody. The short-term impact of toxic contaminants such as heavy metals is organism mortality, while the long-term impacts are associated with chronic exposure and bio-accumulation of contaminants through the food chain (Wong *et al*, 2000).

As significant amounts of organic and inorganic pollutants are bound to sediment, the minimisation and control of sediment in runoff, principally by minimising runoff as close to its source as possible, is now a fundamental component of effective stormwater quality management (Wong *et al*, 2000).

Dry weather flows in stormwater systems can originate from groundwater, garden watering, commercial/industrial processes and associated activities, leaking water or reticulated sewerage pipes and illegal discharges. Dry weather flows tend to be less prevalent in sandy soils, except in sandy areas where drainage systems are cut into the groundwater table and therefore flow all year. Overflow from septic tanks also becomes a part of flows via groundwater input during wet and dry weather conditions. Water from these sources has a higher potential to contribute to pollutant loading and steps to deal with these flows need to be taken separately, but in conjunction with, measures to manage flows from rainfall events.

Table 1. Common sources of pollutants and pressures to stormwater (ARMCANZ/ANZECC, 2000).

Potential pollutant/pressures	Common source
Sediment	Soil erosion during land development, building Stream bed/bank erosion Particulates from pavement and vehicle wear Re-suspension of previously sedimented material Atmospheric deposition of particulates Spillage/illegal discharge of particulates Discharge of organic matter (e.g. leaf litter, grass) Particulates from car washing Particulates from the weathering of buildings/structures
Nutrients	Weathering of bedrock Erosion of soils having adsorbed nutrients Release from sediments as a result of decomposition of organic material Washoff of fertiliser Sewer overflows/septic tank leaks Animal/bird faeces emissions and washoff Detergents from car washing Spillage/illegal discharge Atmospheric deposition Algae and plant decomposition Leaching of excessive nutrients from agricultural and horticultural landuses
Oxygen demanding substances	Washoff of organic matter from urbanised environments and agriculture Atmospheric deposition Sewer overflows/septic tank leaks, sewage effluent discharge Animal/bird faeces emissions and washoff Spillage/illegal discharges

pH (acidity)	Atmospheric deposition Industrial spillage/illegal discharge Washoff of organic material and decomposition Erosion of roofing material Mobilisation of acid sulfate soils as a result of drainage or soil stripping
Micro-organisms (including pathogens)	Animal/bird faeces emissions and washoff Sewer overflows/septic tank leaks, sewage effluent discharge Washoff of organic material and decomposition
Toxic organics	Washoff, drift of pesticides, erosion of soil having adsorbed herbicides Spillage/illegal discharge Sewer overflows/septic tank leaks, sewage effluent discharges
Heavy metals	Atmospheric deposition of particulates Particulates from vehicle wear and emissions Sewer overflows/septic tank leaks, sewage effluent discharge Particulates from weathering of buildings/structures Release from sediments as a result of decomposition of organic material Industrial spillage/illegal discharge
Gross pollutants (litter and debris)	Pedestrians and vehicle emissions, wear, littering Spills from waste collection systems Leaf-fall from trees Disposal of lawn clippings Spills and accidents
Oils and surfactants	Weathering of asphalt pavements, release from sediments, spillage/illegal discharges, emissions, leaks from vehicles, surfactants from car washing Discharge of organic matter high in natural oils Organic matter Contaminated runoff from light industrial areas and service stations
Increased water temperature	Removal of riparian vegetation
Runoff from impervious surfaces	Discharge of groundwater that is high in salinity as a result of drainage, or elevation of the groundwater level as a result of urbanisation.
Salinity	Wastewater effluent discharges

3.2 Water quantity in the receiving environment

If runoff from built environments is not correctly managed there can be an increase in the volume and rate of water flowing into and through natural waterways, causing erosion of stream banks and vegetation. There may be a change in urban waterways from ephemeral to perennial systems, which will have consequences on its ecology and channel form. Increased erosive forces caused by increased water quantity and velocities may change the waterway channel form. This can result in deeper or wider channels and erosion of banks and the channel bed. The channel may also move laterally to accommodate the flows. Undermining of the banks by the changed hydrology can cause a loss of riparian vegetation that holds the banks and exacerbate the problems. The erosion of bank material also leads to sedimentation of downstream waterways and estuaries that can cause ecological loss and in some cases may cause problems to our use of waterways for navigation. Engineered infrastructure can also cause changes in hydrology, flow regimes and sediment movements.

A summary of the effect of increased imperviousness on waterway ecology and systems are highlighted in Table 2.

Table 2. The effect of increased imperviousness on waterway ecology and system processes.

Increased imperviousness leads to:	Flooding	Habitat loss	Erosion	Channel widening	Stream bed alteration
Increased volume	✓	✓	✓	✓	✓
Increased peak flow	✓	✓	✓	✓	✓
Increased peak duration	✓	✓	✓	✓	✓
Increased stream temperature		✓			
Decreased base flow		✓			
Sediment loading changes	✓	✓	✓	✓	✓

In some cases, the efficiency of conveyance drainage systems results in less water being received by waterways and wetland environments. Natural flows may be diverted away from receiving waters or the efficiency of the drainage system means that the water is removed too quickly from the environment. Many waterways and wetlands receive water from groundwater as well as overland flow. Removal of water from a catchment through traditional piped drainage systems can result in less groundwater contribution due to the reduced recharge of the groundwater. As a result, the groundwater contribution or base flow in the waterbodies is reduced. This may have an effect on the geomorphological processes such as the ability of the waterway to retain its form (such as pools and riffles), as well as ecological impacts. Maintaining the natural hydrology of waterways and wetlands in the urban environment is an important factor in stormwater management.

3.3 Groundwater management

Groundwater is the water that is held in fully saturated pore spaces and fractures of soil and rock. The sandy soils around Perth may contain from 10 to 35% water by volume. Under natural conditions groundwater moves very slowly and flows under the influence of gravity, moving from where the rainfall soaks into the groundwater, in some case into wetlands and rivers and eventually out to sea. The top of the saturated groundwater level is known as the watertable. The depth to the watertable varies according to location, geology, season and long-term climate variations. Regional groundwater levels are mapped in the Perth Groundwater Atlas (Water and Rivers Commission, 2003). However, the Atlas was developed for bore construction and is not of sufficient level of accuracy for land development design.

During the dry summer season on the Swan Coastal Plain, the watertable drops in response to reduced recharge by rainfall, the increased rate of evapotranspiration by plants and general evaporation from groundwater fed wetlands. In winter, rainfall replenishes the groundwater and the watertable rises, coming to the surface in some low-lying areas. Many wetlands in south-west WA are surface expressions of the watertable. Water levels in these wetlands rise and fall seasonally with the watertable (Figure 5). Seasonal drying is natural for many wetlands and the flora and fauna has adapted to these ephemeral cycles. Larger variations than the normal seasonal fluctuations can damage groundwater-dependent ecosystems. The watertable and wetlands also respond to longer-term climate trends. For example, a long run of unusually dry years from 1976 to 1990 in the South West lowered the watertable, leaving many previously 'permanent' lakes dry (Water and Rivers Commission, 1997).

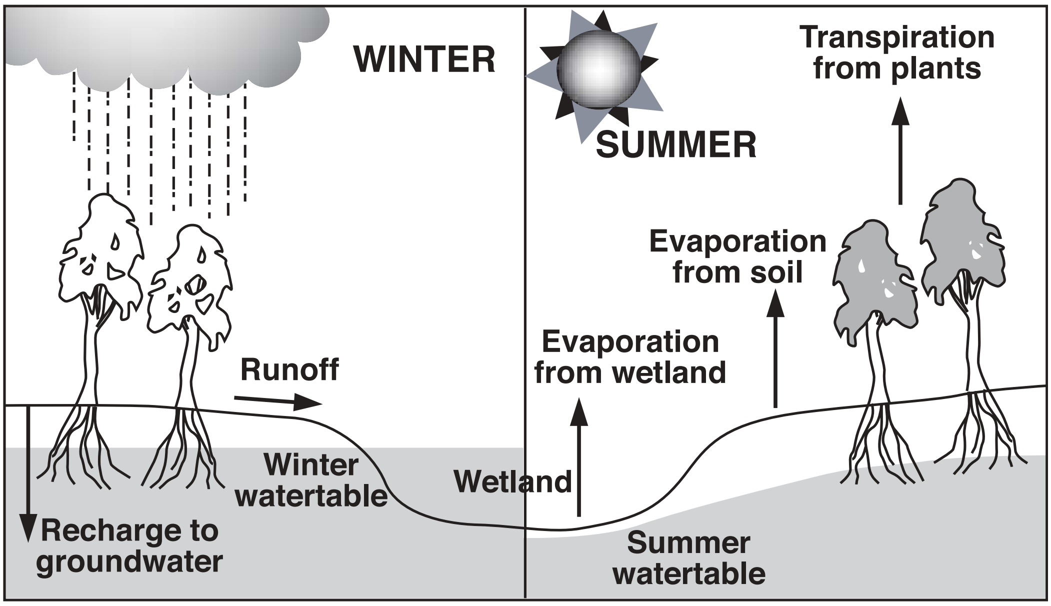

Figure 5: The seasonal groundwater cycle.

The watertable is naturally very close to the surface in some areas of the Swan Coastal Plain, where the aquifer is full and levels are regulated by evaporation of wetlands. Traditionally, to facilitate development in areas of high groundwater, drains were constructed to remove the groundwater when it reached a predetermined level, to reduce the risk of damage to infrastructure through inundation or flooding. These drains typically have flow in winter as the groundwater level rises, while in summer, the lower watertable levels mean that only a very small amount of groundwater enters these drains. These drains were directed to the nearest watercourse, however, due to impacts on receiving water bodies this practice is no longer acceptable.

Fortunately, there are many options available to ensure that stormwater remains clean and the groundwater dependent ecosystems are not damaged. The Water Sensitive Urban Design (Chapter 4), Non-structural Controls (Chapter 7) and Structural Controls (Chapter 9) chapters look at appropriate planning, bioretention, water reuse and the location of infiltration and retention systems, which provide alternatives to groundwater interception strategies.

3.4 Flood management

Flooding is a natural feature of our environment and is essential to maintain the physical form and ecological health of our waterways. In a highly impervious built environment, stormwater that would infiltrate the soil in an uncleared catchment, instead remains on the surface and increases the risk of flooding. Instead of optimising the rate of infiltration, the traditional way of dealing with the risk of local flooding has been to move the water quickly from the area of risk. While the traditional drainage system has reduced the risk of flooding over time, it has become apparent that there are many other stormwater management issues and impacts emerging through poor catchment management and/or the traditional piped drainage systems. The magnitude and nature of these impacts and issues are specific to individual catchments and can be influenced by other factors such as pre-development landuses.

Preferred ways to manage stormwater are discussed extensively in Chapters 7 and 9. By maximising infiltration of stormwater, the social and economic benefits increase because flooding can cause significant damage to property, infrastructure and can even present a risk to our health and lives. In summary, the benefits of controlling flooding are:

- reduced damage to property and associated financial and personal costs
- reduced risk of loss of life and health risks
- reduced risk of water pooling in sealed or heavy clay areas causing mosquito breeding sites and other health hazards, and
- increased potential for land development in low-lying areas.

3.5 Healthy ecological communities

It is important to note that flooding is a natural part of our waterway environment. The periodic changes in water level are crucial to the flora and fauna in floodplain rivers and are the primary source of productivity. Nutrients and particulate material are laterally exchanged between the floodplain and channel. Reproduction and other life cycles are also linked to this regular flooding.

Aquatic habitats may be lost through changes to the natural hydrology, changes in the bed material and bed shape of waterways, removal of in-stream objects such as snags and aquatic plants, and drainage of wetlands and floodplains. Damage to aquatic habitats causes a decrease in biodiversity.

Collecting and exporting the rainfall off site results in less groundwater recharge. This can result in the decline of some waterways and groundwater dependent wetlands.

Urbanisation has traditionally reduced the diversity of flora and fauna in receiving water bodies. This in turn has brought about a change in the composition of the ecological communities with some sensitive species being less abundant or being lost from that area. The change in ecological community structure may also allow pest species tolerant to the altered conditions to proliferate. Problems with drainage infrastructure such as bridges and culverts, may also alter flow patterns and fauna movement (ARMCANZ/ ANZECC, 2000).

In the Perth metropolitan area, there is about 260 000 ha of remnant native vegetation. The State Government *Bush Forever Plan* (2000) identifies about 51 200 ha (nearly 20%) as regionally significant. A further 114 000 ha (almost 44%) is managed by the Department of Conservation and Land Management or as water catchments for potable water supply. The remaining 96 000 ha (37%) are local biodiversity areas which are in private ownership, other State Government ownership or in Local Government reserves.

Approximately 14 400 ha of the local biodiversity areas have been zoned urban or for other intensive landuses under the Metropolitan Regional Scheme and are likely to be cleared (Perth Biodiversity Project, undated). It is important that as much remnant vegetation is retained for biodiversity and water quality values during the planning phase of subdivisions. Management plans can help ongoing maintenance in built areas. Retaining vegetation can help maximise infiltration, act as buffers to our waterways and wetlands and ensure the structural integrity of the waterways. Retaining as much vegetation as possible will contribute to the water quality of the Swan-Canning River system and other waterways and wetlands in the State.

3.6 Quality of life

The quality of an environment can be greatly influenced by the way stormwater is managed. Carefully designed stormwater systems can help contribute to attractive and livable communities. Chapter 4 provides ideas on how stormwater can be managed in an urban environment to achieve multiple outcomes, such as natural streams, multiple use corridors and attractive public open space. If stormwater is managed poorly, it can affect our lifestyle and health. Specific design elements that help minimise health and safety risks are discussed in Chapters 7 and 9.

Inadequate catchment and stormwater management can pose a public health risk. Stormwater treatment systems that have water for more than three to four days can harbour mosquitoes and midges. Mosquitoes are normally just a nuisance, but occasionally may be a health hazard due to mosquito borne diseases such as Ross River Virus and Murray Valley encephalitis. Chapter 3 discusses the issue of adequate planning to ensure that buffers are provided around waterways and wetlands. Design criteria to ensure that stormwater systems minimise the risk of mosquito breeding are discussed in Chapter 9. When forming stormwater management plans for an area, decisions will need to be made on the risks of mosquito borne diseases, flooding, social and environmental factors.

Traditional drainage can have potential public hazard risks, due to the often steep sides of trapezoidal drains and detention basins and sumps, requiring fencing or other protective measures.

Collecting and exporting the rainwater off-site results in less groundwater recharge in built up areas. A drop in groundwater levels can affect the performance of domestic and public supply bores. A recharge of stormwater close to source ensures a replenishment of this valuable resource.

There is a loss in the variety of uses available to the community (e.g. recreation) if the water quality is degraded or stormwater treatment systems detract from the aesthetics of an area.

3.7 Total water cycle management

Stormwater management requires consideration of the whole water cycle. Water supply, sewerage and stormwater activities have traditionally been managed separately in water authorities. This limits the ability to see them as resources and to achieve the benefits gained from their consideration as a whole. Total water cycle management, or integrated water cycle management, recognises that water supply, stormwater and sewage services are interrelated components of catchment systems, and therefore must be dealt with using an holistic water management approach that reflects the principles of ecological sustainability. Water efficiency, re-use and recycling are integral components of total water cycle management and should be practised when any water is extracted from river and groundwater systems.

The water cycle is an endless global process of water circulation that involves:

- precipitation (rainfall)
- flows, including infiltration into aquifers
- interception and storage (dams and aquifers)
- treatment and supply
- water use
- management, treatment and transfer of stormwater or wastewater
- discharge to rivers and oceans
- evaporation and transpiration, and
- cloud formation (then the cycle begins again with precipitation).

The cycle is a continuous whole, yet utilities have historically separated management of water supply systems from wastewater and stormwater systems. Recent advances in water treatment technology and urban planning have increased the number of water supply options available to utilities and consumers. Furthermore, the scarcity of water in some areas has meant that solutions must be found beyond augmenting the traditional nineteenth century water supply infrastructure to satisfy end-use requirements. A sustainable water supply needs to consider the entire global process of the water cycle'. The technology now exists to shortcut the total water cycle and capture and re-use previously harvested water resources, such as wastewater and stormwater, without waiting for the cycle of evaporation and precipitation to be completed. Essentially, water conservation calls for an holistic appreciation of the total water cycle. Water conservation is therefore inextricably linked to water re-use.

Stormwater and domestic water recycling present the more accessible options for re-use (Government of Western Australia, 2003). A hypothetical model of a decentralised stormwater and wastewater residential supply system predicted a 72% decrease in the average annual water supply imported from an external source, a 25% decrease in average annual stormwater discharge and a 100% decrease in average annual wastewater discharge (Speers & Mitchell, 2000).

Stormwater is also a valuable water resource that, if managed appropriately, can be utilised to supplement household, commercial/industrial, streetscape and parkland water supply needs, while ensuring the maintenance of the groundwater aquifer supply and surface water ecosystems. Appropriate total water cycle management will consider the seasonality of rainfall. For example, winter rain in Perth would need to be stored for irrigation over summer when little rainfall is received. In most cases in Perth, recharge to groundwater on site acts as a suitable storage for rainfall that can be drawn over summer and does not present problems of loss of water through evaporation that would occur through storage ponds.

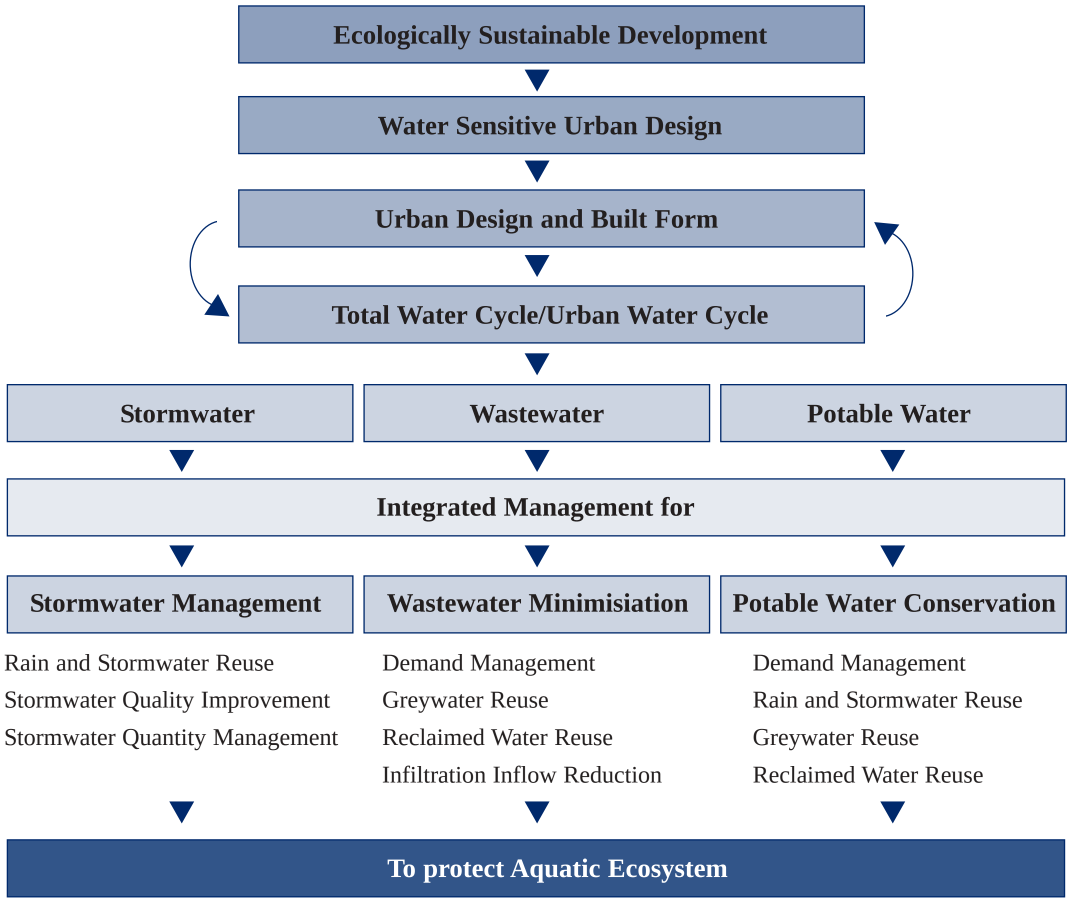

Figure 6: Interactions between ESD, WSUD and the Urban Water Cycle (Institution of Engineers, 2003)

4 What do we want to achieve when managing stormwater?

Considering the wide range of issues that arise when managing stormwater in the environment, an holistic approach needs to be taken in stormwater management. The water cycle has complex interactions that exists between surface flows, groundwater hydrology, water quality, channel form, aquatic habitat and riparian vegetation characteristics of a watercourse. The impact that the hydrological relationships in turn have on human health, recreation and quality of living are all factors to consider when determining what the community wants to achieve when managing stormwater. Effective management of stormwater means managing social, economic and environmental values in built environments (ARMCANZ/ANZECC, 2000).

4.1 Stormwater management objectives for WA

A multiple objective approach has been adopted to stormwater management in Western Australia in line with the *National Water Quality Management Strategy* (ARMCANZ/ANZECC, 2000). Aims with the following issues include:

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 which 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 community 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.

Water quality

Stormwater managers should aim to maintain or improve the surface and groundwater quality within development areas relative to pre-development conditions. The stormwater should be protected as close to source as possible, by infiltration to the groundwater where the soil conditions and depth to groundwater permit. If this is not possible, water quality should be protected via in-system treatment approaches before it enters the receiving water bodies.

Water quantity

Stormwater managers should aim to maintain the total water cycle balance within development areas relative to the pre-development conditions. By managing the quantity and rate of delivery of surface flow, water quality and the impact on groundwater aquifers and other receiving waterbodies is reduced.

Water conservation

Stormwater managers should aim to have effective use of water in the urban system. Reducing demand and maximising the efficiency of water use contribute to water conservation. Re-use of stormwater runoff for supplementing water requirements by the household, commercial premises, street landscaping and parklands should be factored into stormwater management design and planning. The recharge of groundwater aquifers with stormwater also needs to be maximised as a water conservation objective, to ensure long-term sustainable supply of groundwater for domestic and public use.

Ecosystem health

Stormwater management should protect, maintain and restore waterway, wetland, estuarine and coastal biodiversity. Managers need to enhance ecosystem health and protect existing values of waterways, wetlands, estauries, marine and associated vegetation from development impacts.

Economic viability

It is important that the long-term economic viability of a stormwater management system is considered in the development of a stormwater management strategy. If the ongoing maintenance costs of treatment devices are difficult to afford on an ongoing basis, this may detract from the effectiveness of devices in the long-term (ARMCANZ/ANZECC, 2000). In many cases, the perceived cost of alternative stormwater treatment systems results in reluctance to change. However, in reality or when demonstrated, the long-term costs may be significantly lower than conventional systems. In addition, the value of stormwater in the built environment is taken into account and reflects its true social, environmental and economic contributions.

Public health

One of the key roles of stormwater management is to improve the safety of our urban environment. There are a number of issues that may be considered to minimise risk to public health and safety. These include the risk to:

- public health from mosquitoes from constructed wetlands and wetland systems
- the community and property from flooding
- of injury to the public and operational personnel from structural controls infrastructure, and
- people caught in waterways during floods.

Protection of property

One of the key reasons for stormwater management arising was to protect the built environment from flooding and waterlogging. The cost of damage to property includes financial and personal costs and it is important to ensure that our urban environments have minimal risk of damage from water.

Social values

To ensure that community social, aesthetic and cultural values are recognised and maintained when managing stormwater. Changes in community values and expectations has meant that in terms of stormwater management, it is no longer adequate to consider flood protection alone. Community values now encompass concern for improved access to open space and a variety of recreation opportunities, quality of life, aesthetic living environment, conservation of Aboriginal heritage sites, environmental protection and ecologically sustainable development.

This evolution of community values is addressed by the multiple objective approach that is being taken in stormwater management. The standard of environmental and amenity quality now needs to be considered equally with that of flood protection.

Development

The way we manage new developments and maintain existing areas is important to ensure that our environment and communities are sustainable. Cost effective and best management practice stormwater management should be implemented through planning and development in accordance with sustainability and precautionary principles.

5 How will we achieve these stormwater management objectives?

5.1 The stormwater management framework

This chapter looks at how the objectives for stormwater management in Western Australia are achieved. The stormwater management framework has a number of components that make up the policy and planning context and the delivery framework for achieving the objectives for stormwater management in Western Australia. The principles and objectives are implemented through three key areas: the State planning framework, the State policy framework and the delivery approaches which together contribute to sustainable stormwater management.

The stormwater management framework components that contribute to the desired **stormwater management objectives** are:

- stormwater management principles
- delivery approaches
- policy framework, and
- State planning framework.

5.2 Principles for stormwater management in Western Australia

In Western Australia, there are a number of principles that underpin the objectives for stormwater management. These principles should be addressed when undertaking the planning and implementation of stormwater management. They should:

- incorporate water resource issues as early as possible in the landuse planning process;
- address water resource issues at the catchment and sub-catchment level;
- ensure stormwater management is part of the 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 and conservation and reuse; and
- recognise the need for site specific solutions and implement appropriate non structural and structural solutions.

5.3 The approaches for stormwater management

The approaches provide planners, developers and government with a guide to implementing the objectives and principles of stormwater management. These eight approaches are the checklist for on-ground implementation and are based on the objectives for Water Sensitive Urban Design (CSIRO, 1999). Some example techniques showing how they can be achieved are also given. Details on design guidelines for Source Controls, Non Structural and Structural Techniques are presented throughout the manual.

Protect water quality

Stormwater remains clean and retains its high value

Implement best management practice on-site.

Implement non-structural controls, including education and awareness programs.

Install structural controls at source or near source.

Use in-system management measures.

Undertake regular and timely maintenance of infrastructure and streetscapes.

Protect infrastructure from flooding and inundation

Stormwater runoff from infrequent high intensity rainfall events is safely stored and conveyed

Safe passage of excess runoff from large rainfall events towards watercourses and wetlands.

Store and detain excess runoff from large rainfall events in parks and multiple use corridors.

Safely convey excessive groundwater to the nearest watercourse.

Minimise runoff

Slow the migration of rainwater from the catchment and reduce peak flows

Retain and infiltrate rainfall within property boundaries.

Use rainfall on-site or as high in the catchment as possible.

Maximise the amount of permeable surfaces in the catchment.

Use non-kerbed roads and carparks.

Plant trees with large canopies over sealed surfaces such as roads and carparks.

Maximise local infiltration

Fewer water quality and flooding problems

Minimise impervious areas.

Use vegetated swales.

Use soakwells and minimise use of piped drainage systems.

Create vegetated buffer and filter strips.

Recharge the groundwater table for local bore water use.

Make the most of nature's drainage

Cost effective, safe and attractive alternatives to pipes and drains

Retain natural channels and incorporate into public open space.

Retain and restore riparian vegetation to improve water quality through bio-filtration.

Create riffles and pools to improve water quality and provide refuge for local flora and fauna.

Protect valuable natural ecosystems.

Minimise the use of artificial drainage systems.

Minimise changes to the natural water balance

Avoid summer algal blooms and midge problems and protect our groundwater resources

Retain seasonal wetlands and vegetation.

Maintain the natural water balance of wetlands.

No direct drainage to conservation category wetlands or their buffers, or to other conservation value wetlands or their buffers, where appropriate.

Recharge groundwater by stormwater infiltration.

Integrate stormwater treatment into the landscape

Add value while minimising development costs

Public open space systems incorporating natural drainage systems.

Water sensitive urban design approach to road layout, lot layout and streetscape.

Maximise environmental, cultural and recreational opportunities.

Convert drains into natural streams

Lower flow velocities, benefit from natural flood water storage and improve waterway ecology

Create stable streams, with a channel size suitable for 1 in 1 year ARI rainfall events, equivalent to a bankfull flow.

Accommodate large and infrequent storm events within the floodplain.

Create habitat diversity to support a healthy, ecologically functioning waterway.

A stormwater management hierarchy approach for managing urban stormwater is taken in Western Australia. The hierarchy will help guide which approaches are appropriate for specific situations and is an evolution of the stormwater management hierarchy in the National Water Quality Management Strategy (ARMCANZ/ANZECC, 2000) to meet local conditions.

The stormwater management hierarchy applied in WA is to:

i. **Retain and restore natural drainage lines** – retain and restore existing valuable elements of the natural drainage system, including waterway, wetland and groundwater features and processes.

ii. **Implement non-structural source controls** – minimise pollutant inputs principally via planning, organisational and behavioural techniques to minimise the amount of pollution entering the drainage system.

iii. **Minimise runoff** – infiltrate or re-use rainfall as high in the catchment as possible. Install structural controls at or near the source to minimise pollutant inputs and the volume of stormwater.

iv. **Use in-system management measures** – includes vegetative measures, such as swales and riparian zones, and structural quality improvement devices such as gross pollutant traps.

These steps require the preservation of the valuable features of the water environment, control of the pollution at the source, and only proposes management measures within stormwater systems for residual impacts that cannot be cost-effectively mitigated by source or near source controls.

5.4 Related State and National strategies

One of the key mechanisms for achieving the outcomes for stormwater management is to ensure that the stormwater objectives meet and contribute to other natural resource management policies and strategies.

These strategies in turn assist in the implementation of the desired stormwater management outcomes. A brief discussion of national, State and regional strategies that are relevant to stormwater management follows.

5.4.1 National strategies

National strategy for Ecologically Sustainable Development

The *National Strategy for Ecologically Sustainable Development* (Commonwealth of Australia, 1992) sets out national objectives and principles for development that improves the total quality of life while maintaining the ecological processes on which life depends. The principles of Ecologically Sustainable Development (ESD) are listed as:

- The precautionary principle – if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.
- Inter-generational equity – the present generation should ensure that the health, diversity and productivity of the environment are maintained or enhanced for the benefit of future generations.
- Conservation of biological diversity and ecological integrity – conservation of biological diversity and ecological integrity should be a fundamental consideration.

- Improved valuation, pricing and incentive mechanisms – environmental factors should be included in the valuation of assets and services.

The application of ESD to management of stormwater therefore aims "*to develop and manage in an integrated way, the quality and quantity of surface and groundwater resources and to develop mechanisms for water resource management which maintain ecological systems while meeting economic, social and community needs*" (ARMCANZ/ANZECC, 2000).

National Water Quality Management Strategy

The National Water Quality Management Strategy is comprised of a suite of papers providing guidance on aspects of the water cycle, including ambient and drinking water quality, monitoring, groundwater, rural land and water, stormwater, sewage systems and effluent management for specific industries. The principle objective of the Strategy is:

> *'To achieve sustainable use of the nation's water resources by protecting and enhancing its quality while maintaining economic and social development'*.

The strategy emphasises a number of overarching principles for application to water quality management. These are:

- ecologically sustainable development
- integrated/total catchment management
- best management practices, including the use of acceptable modern technology and waste minimisation and utilisation, and
- the role of economic measures and application of the user pays and polluter pays principles.

Australian Guidelines for Urban Stormwater Management

The Australian Guidelines for Urban Stormwater Management (ARMCANZ/ANZECC, 2000), a component of the National Water Quality Management Strategy, provides a nationally consistent approach for managing urban stormwater in an ecologically sustainable way. The Guidelines outline current best practice in stormwater planning and management in Australia.

The broad principles leading to effective stormwater management, as listed in the 'Australian Guidelines' are:

- hydrology – minimise the impact of urbanisation on the hydrology of a catchment, including base and peak flow
- water quality – minimise pollution entering the stormwater system and remove any residual pollution
- vegetation – maximise the value of indigenous riparian, floodplain and foreshore vegetation, and
- aquatic habitat – maximise the value of physical habitats to aquatic fauna within the stormwater system.

5.4.2 State strategies

Draft State Sustainability Strategy

The Western Australian State Sustainability Strategy '*Focus on the Future (Consultation Draft September)*' (Government of Western Australia, 2002) defines sustainability as meeting the needs of current and future generations through simultaneous environmental, social and economic improvement. The Strategy outlines actions to promote and encourage long-term progress towards sustainability, including new initiatives, policy and legislative change and institutional reform. Additionally, the Water Corporation and Department of Environment operate a number of programs directed at water conservation. The Strategy has a vision that water is used with care and is provided sustainably to meet needs and recommends the following objectives to:

- reduce water consumption
- extend responsibility for water supply to the planning system (water sensitive design) and to local government (regional councils) for groundwater supplies
- achieve significant wastewater reuse, and
- investigate long-term innovative water supply options that have broad sustainability outcomes.

A State water strategy for Western Australia – *Securing Our Water Future*

This Strategy recognises that Western Australia has reached a critical point in the way in which we use and reuse our precious water resources. The current water shortage experienced by the Perth community has shown that the efficient use of water is no longer a response to the current drought but in fact an essential step in learning to live with less water without compromising our way of life. The State Water Strategy was formed embracing a wide range of input from community members, including those who took part in a series of Water Forums across WA in 2002 and delegates to the Water Symposium at Parliament House (October 7-9, 2002).

The Strategy has five main objectives:

i. Improving water use efficiency in all sectors.
ii. Achieving significant advances in water reuse
iii. Fostering innovation and research.
iv. Planning and developing new sources of water in a timely manner.
v. Protecting the value of our water resources.

State Water Quality Management Strategy

The National Water Quality Management Strategy guidelines are supported in WA via the State Water Quality Management Strategy (Government of Western Australia, 2001). The State Water Quality Management Strategy requires that the series of National Water Quality Management Strategy guidelines be implemented via development of relevant strategies and plans in WA.

The guiding principles and general strategies outlined in the State Water Quality Management Strategy establish the philosophical base and approach for water quality management in WA and will be applied by all government agencies involved in water quality management (Government of Western Australia, 2001).

Draft Statewide Waterways Management Strategy

The Statewide Waterways Management Strategy is currently being prepared. It will be a management framework that will enable available resources to be used wisely while allowing for the protection and enhancement of the State's many waterways for the next 20 years. A Draft Policy *Statewide Policy No. 4 Waterways WA: A policy for statewide management of waterways in Western Australia 2000* has already given a statement of the vision, guiding principles and objectives of Statewide waterways management. The Vision for statewide waterways management is:

‘*Healthy waterways that provide for a range of environmental and human needs*.’

The economic, environmental and social guiding principles outlined in the Policy for statewide management of waterways form the context of stormwater management in relation to waterways. The key aims in the draft strategy are to:

- identify waterway condition, values and pressures;
- safeguard our significant waterways;
- restore and maintain waterway health;
- improve the way we manage waterways;
- balance values, expectations, ecology and uses; and
- challenge what we do in the future.

Wetland protection policies

The Government’s objectives applying to all wetlands on the Swan Coastal Plain (Water and Rivers Commission, 2001) are for the management and restoration of degraded wetlands, and preservation of ‘Conservation Category Wetlands’. The statutory basis for protection of permanently inundated wetlands (lakes) on the Swan Coastal Plain is the *Environmental Protection (Swan Coastal Plain Lakes) Policy* (EPA, 1992). Conservation Category Wetlands and wetlands protected under the *Environmental Protection (Swan Coastal Plain Lakes) Policy* (EPA, 1992) shall not be used in stormwater management systems. Policy direction is guided by the Wetlands Conservation Policy for Western Australia (Government of Western Australia, 1997).

5.4.3 Regional strategies

Natural resource management strategies

Natural resource management (NRM) is “*The ecologically sustainable management of the State’s land, water, air and biodiversity resources for the benefit of existing and future generations, and for the maintenance of the life support capability of the biosphere*” (Government of Western Australia, undated). Natural resource management has been adopted across Australia, in recognition of the complex set of inter-related systems, natural and human, that comprises the catchment environment. NRM embraces:

- a holistic approach to natural resource management within catchments, marine environments and aquifers, with linkages between water resources, vegetation, landuse, and other natural resources recognised;
- integration of social, economic and environmental issues;
- cooperation and coordination between landholders, community groups, government agencies and other natural resource users and managers within the catchment; and
- community consultation and participation (Government of Western Australia, undated).

Within an NRM framework, the potential exists for using non-engineered solutions to manage stormwater that has complementary benefits such as protection of native biodiversity, enhanced value of ecosystem services and improved quality of life for residents. An NRM approach provides the means to assess the biophysical impacts of water management and the interactions of these impacts with social and cultural aspects of urban life. In Western Australia, there are formal arrangements between State government agencies and community-based regional groups to prepare Natural Resource Management Strategies for whole regions.

Six Natural Resource Management strategies are being developed for regions around the State. The Commonwealth and State expectations for regional natural resource management strategies is for them to set out the partnership between the community and government in managing natural resources at a regional scale. The purpose of the strategies is to ensure that key National and State environmental policies and programs are addressed in the regions. The strategies will contribute to the overall stormwater management outcomes.

5.5 The planning framework and stormwater management

Western Australia's planning system is relatively complicated, with many levels and processes functioning to administer various aspects of landuse planning and related legislation. The planning framework is a significant avenue through which development aspects such as drainage, stormwater management and other infrastructure are designed and submitted.

The planning system in Western Australia is administered at three main levels. The first level is the Minister for Planning and Infrastructure who has the ultimate authority for planning in the State. The second level is the Western Australian Planning Commission, supported by the Department for Planning and Infrastructure, that has the responsibility for urban, rural and regional landuse planning and land development matters. The third level is Local Government, which is responsible for town planning in local communities (WAPC, 1996).

The town planning system in Western Australia comprises two key components. The first component is the strategic and policy development planning level that focuses on the 'big picture' or broad planning for future landuse infrastructure and service provision, integrating a wide range of economic, social and environmental considerations. Stormwater management policies and objectives can be incorporated in such instruments as Statements of Planning Policy, Regional Schemes and Structure Plans.

The statutory planning level is the legal arm of the planning system and makes use of the legislation and regulations to ensure appropriate processes of landuse, land supply and urban development. Key areas where stormwater management objectives can be incorporated into more specific controls include Local Government Town Planning Schemes, subdivision proposals and development applications.

Details on the range of planning instruments that affect how stormwater is implemented in the built environment are discussed in Chapter 3 of this manual.

6 Who is responsible for achieving these management objectives?

Stormwater management in Western Australia is currently under the jurisdiction of a number of organisations. The Department of Environment is responsible for policy development, setting environmental criteria and strategic planning. Local Governments are responsible for and manage stormwater within their jurisdiction. The Water Corporation has been licensed to provide drainage services for main or arterial drains in some *declared* areas of Western Australia. In rural areas, a 'Notice of Intention to Drain or Pump Water from Land' has to be sought from the Commissioner of Soil and Land Conservation for landholders proposing to construct a deep drain, an evaporation basin or to pump groundwater. A review of the institutional arrangements is currently being undertaken and a whole of government approach is being developed. The responsibilities for stormwater management may change pending the outcome of *A White Paper on Drainage Reform in WA*. In addition to the stormwater management system, there are additional responsibilities for all stakeholders in the built environment and it is essential that they employ best management planning and practices in their day-to-day activities as well as over the long-term. There are a range of roles and responsibilities that contribute to stormwater planning, construction and management.

Key players in stormwater management

Who benefits from best practice stormwater management?	The community The environment All stakeholders
Who regulates stormwater management?	Environmental Protection Authority Western Australian Planning Commission The Commissioner of Soil and Land Conservation (rural) Department of Environment Swan River Trust Water Corporation (main drainage only)
Who manages stormwater?	Local Government with assistance from the community Landowners, individuals and community groups Commercial and industrial users Infrastructure Service Providers (including Water Corporation)
Who creates stormwater infrastructure?	Landholders Local Government Developers Water Corporation

Landowners, individuals and community groups

Lot scale water management, reuse and conservation has the most significant impact on the quantity and quality of our water resources. Many of the management practices outlined in this manual can be implemented at the lot scale. Individual consumer behaviour has the greatest impact on minimising stormwater pollution and the volume of runoff generated. Consumer demands also drive the urban development industry and influence design for land development.

Pollutants generated from lot scale activities include:

- fertiliser and pesticides leached from crops, gardens and lawn areas
- litter and dumped refuse
- detergents, oil and grease wash from paved areas
- bacteria and organic matter from stock and pets
- nutrients from on-site wastewater disposal (eg. septic tank systems)
- organic matter, leaf litter and lawn clippings
- surfactants from car washing, and
- sediment from building/landscaping activities.

Multiplied by hundreds or thousands of land holdings in a catchment area, the cumulative effect of polluted runoff can be devastating to the receiving waters downstream.

Commercial and industrial landusers have a role to ensure that their activities do not contribute to the pollution of stormwater. The Department of Environment has a range of guidelines, policies and regulations to guide best practice that aim to ensure employers, landowners and employees operate with sound environmental practice.

Urban residents can also help conserve water resources by implementing water efficient household appliances, water reuse in households and alternative supplies to scheme water, such as rainwater tanks and garden bores.

Community awareness of the activities that they can undertake is heavily dependent on State and Local Government education and awareness programs. Activities that Local Governments and State agencies can undertake to support the community groups, landowners and individuals are covered in the Education and Awareness Chapter of this manual.

Key stormwater roles for landowners, individuals and community groups

- work with local governments and community groups to help prepare catchment/stormwater management plans
- ensure that day-to-day activities protect and conserve stormwater as a valuable resource
- ensure that activities do not contribute to the pollution of stormwater through applying best practice, and
- implement site management plans to guide activities.

Local Government

Local government authorities have the responsibility for landuse planning and therefore a significant ability to affect stormwater management, through the design, construction and maintenance processes for the provision of local infrastructure.

Suitable consideration of stormwater management during the location and conceptual planning of urban, commercial and industrial areas has the potential to minimise many of the impacts of land development on stormwater. Local government planners can help protect stormwater quality by ensuring the land is capable of sustaining urban development and follows the principles of water sensitive design to minimise the extent of impervious surfaces and provide adequate space for stormwater management and integrate stormwater quality treatment measures with public open space. New stormwater infrastructure should be designed to ensure the impact of stormwater on receiving environments is minimal.

Local government is responsible for the management of various parts of the built environment that may discharge directly into the stormwater system. These include local stormwater drains, roads, reserves, parks and car parks. Adopting a best practice environmental management approach in regard to the operation and maintenance of these resources is an essential element for improved stormwater management.

Key stormwater roles for Local Government

- plan for new development and assess development applications
- ensure inclusion of stormwater management objectives and principles in Town Planning Schemes, Outline Development Plans, rezoning applications, subdivision plans and development plans.
- implement total water cycle management principles as a requirement within new developments
- assess and plan operational activities that have potential to affect stormwater quality or quantity
- lead the development of catchment-based stormwater management plans
- plan and design new water management infrastructure, and
- help identify opportunities to upgrade existing natural and built infrastructure to improve environmental performance.

Development industry

Development affects stormwater quality, during the construction period and as a result of the increased areas of impervious surface.

Managing runoff in a water sensitive manner not only helps prevent problems associated with stormwater up front, but can also enhance the social and environmental amenity of the landscape. Developers have an important role to play in the adoption of a water sensitive approach to urban planning, design and development.

Management of stormwater is crucial during construction, as soil is often removed and left exposed to erosion. Massive sediment loads reaching receiving waters can be a consequence of poor site management. It is essential that construction activities are undertaken in such a way that contaminated runoff is not discharged off-site.

The level of impact on stormwater following construction depends on the site's specific landuse and layout. By minimising impervious areas and using water sensitive urban design concepts, the impact of development on stormwater quality can be minimised.

Key stormwater roles for the development industry

- ensure planning and design of new developments meet State and Local government policies and manual objectives
- ensure water management infrastructure, proposed in new and retrofitted developments, are innovative, cost effective and meet stormwater management objectives and principles, and
- encourage demand for developments that meet stormwater management objectives and principles.

Environmental Protection Authority

The Environmental Protection Authority (EPA) is responsible for the protection of Western Australia's environment by application of statutory powers described in the *Environmental Protection Act 1986*. This Act overrides planning legislation. A major role of the EPA is to ensure that the environment is protected when development decisions are made. It does this by providing independent environmental advice to the Minister for the Environment so that environmental considerations are taken into account in the decision–making process. Another key instrument used by the EPA is the development of Environmental Protection Policies (EPPs). EPPs most often address area-specific environmental concerns but can also be used for statewide issues. The EPA is also responsible for developing a *State Monitoring and Evaluation Framework for Natural Resource Management* and *State of the Environment* reporting.

Key stormwater roles for the EPA

- assess development proposals, and
- establish and review Environmental Protection Policies (EPP's)
- set conditions and provide advice on environmental management of stormwater, and
- assess the environmental performance of stormwater management.

Swan River Trust

The Swan River Trust was set up in 1989 to coordinate the work necessary to balance the use and protection of the waterways and shorelines, and to restore degraded environments of the Swan and Canning rivers. The Trust was established under the *Swan River Trust Act 1988*. Under this Act, approval from the Swan River Trust is required to undertake developments within the Trust management area. The Trust supports the development of management plans for sensitive parts of the river system and provides advice to the Minister for the Environment, the Western Australian Planning Commission and local governments to guide the development of one of Perth's most precious natural features. It works with local government and landowners to control shoreline erosion. It also works to prevent pollution, clean up contamination and keep the waterways and shorelines clear of refuse and reduce the frequency and extent of nuisance algal blooms and prevent toxic algal blooms.

Key stormwater roles for the Swan River Trust

- plan for the conservation, enhancement and appropriate development of the Swan-Canning river system
- prepare standards, guidelines, development control policies and management plans for the environmental protection of the Swan and Canning rivers
- provide advice to developers and undertake education and information programs for industry and key stakeholders, and
- guide the development approval process.

Department of Environment

Under the *Environmental Protection Act 1986*, the Department of Environment (DoE) is responsible for the protection of Western Australia's environment by application of statutory powers. Under the *Rights in Water and Irrigation Act 1914*, DoE is responsible for ensuring that the State's surface and groundwater resources are managed to support sustainable development and conservation of the environment for the long-term benefit of the community. Under the *Metropolitan Water Authority Act 1982*, DoE is responsible for strategic planning for stormwater in the metropolitan regional area.

Key stormwater roles for the Department of Environment

- develop strategies, policies, guidelines and management plans to protect water resources
- application of Best Management Practice principles for stormwater management to the assessment and guidance of development/planning proposals
- facilitate the implementation of Ministerial conditions and enforcement, where necessary
- encourage adoption of Best Management Practice principles for stormwater management through other non-regulatory opportunities
- support sustainable development and conservation of the State's water resources
- protect wetlands, waterways and water supplies through promoting adoption of best management practice principles for stormwater management in landuse planning and management
- provide advice and information to the development industry and stakeholders on the management of stormwater
- assess statutory planning documentation at the regional and local scale, and
- assess stormwater management plans.

Western Australian Planning Commission

The Western Australian Planning Commission is the statutory authority with powers vested in it by the *Western Australian Planning Commission Act 1985*. The Commission prepares policies on many planning matters such as *Statements of Planning Policy* under *Section 5AA of the Town Planning and Development Act 1928-1986*. Less formal Development Control Policies are also prepared by the Commission and these are important for stormwater management planning as they can guide subdivision of land, development control, public open space and residential road planning.

Key stormwater roles for Western Australian Planning Commission

- ensure that stormwater management principles and objectives are incorporated into the State Planning Strategy
- ensure that the Perth Metropolitan Region Scheme incorporates and supports stormwater management principles and objectives
- ensure that stormwater management principles and objectives are met when preparing and implementing country region schemes
- ensure that development control policies developed by WAPC meet stormwater management principles and objectives
- ensure that all subdivisions and development applications that are assessed by the DPI and decisions made by the WAPC meet stormwater management principles
- ensure that there is a Statement of Planning Policy, which incorporates stormwater management planning principles and objectives, and
- ensure inclusion of stormwater management principles and objectives in strategic guidelines, Structure Plans, Outline Development Plans, rezoning applications and subdivision plans.

Water Corporation

The Water Corporation provides water supply and wastewater services to the metropolitan area, regional centres and communities. One of the key roles of the Corporation is to work with the Department of Environment to ensure that current water supply sources are sustainable and to source alternative and innovative supplies for water. Improved stormwater management can be seen as a potential source of water through both stormwater reuse and recharge of the groundwater system. The Corporation also provides drainage and irrigation services to households, businesses and farms throughout the State. In the metropolitan area, the Corporation manages main drains in some areas that receive stormwater from the extensive local government stormwater drains.

Key stormwater roles for Water Corporation

- operational responsibilities for the management and implementation of water quality and environmental objectives in main drain stormwater systems
- maximise the recovery and reuse of stormwater as a cost effective and reliable source of water
- implement effective environmental management systems across the Corporation’s planning, business and management process
- develop awareness of stormwater management requirements and responsibilities among employees, stakeholders and contract partners
- set standards for planning and design of stormwater infrastructure to protect the receiving environments from the impacts of urban development and to reduce the risks of flooding, and
- work with local government and developers to plan new sustainable drainage infrastructure in developing urban areas.

Infrastructure providers

There are a number of infrastructure providers, such as Main Roads Western Australia and the Public Transport Authority, that need to take into account stormwater management when delivering and managing infrastructure and services to the community. One of the key guideline documents published by Main Roads WA is the Austroads, 2002, *Guidelines for Treatment of Stormwater Runoff from the Road Infrastructure*.

Key stormwater roles for infrastructure providers

- ensure inclusion of stormwater management principles and objectives when designing and implementing infrastructure
- implement effective environmental management systems across their planning, business and management process
- ensure that environmental impact assessments are undertaken and management plans are prepared, implemented and address stormwater management issues and objectives, and
- develop awareness of stormwater management requirements and responsibilities among their employees, stakeholders and contract partners.

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Stormwater Management framework for Western Australia

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 urban 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.

Delivery Approach

- Protect Water Quality
- Protect infrastructure from flooding and inundation
- Minimise runoff
- Maximise local infiltration
- Make the most of natures drainage
- Minimise changes to the natural water balance
- Integrate stormwater treatment into the urban landscape
- Convert drains into natural streams

Stormwater Management Hierarchy

1. Retain and Restore Natural Drainage lines
2. Implement non structural source controls
3. Minimise Runoff
4. Use in-system management measures

Policy Framework

National Strategies

- Ecologically Sustainable Development
- National Water Quality Management Strategy
- Australian Guidelines for Water Quality Management

State Strategies

- State Sustainability Strategy
- State Water Strategy
- Water Quality Strategy
- Wetlands Policy
- Waterways Strategy

Regional

- NRM regional strategies

State Planning Framework

Strategic Planning

- State Planning Strategy
- Statements of Planning Policy (SPPs)
- Region Schemes
- Regional Structure Plans
- District Structure Plans
- Local Structure Plans
- Local Planning Strategies

Statutory Planning

- Town Planning Schemes
- Outline Development Plans
- Local Structure Plans
- Subdivision
- Development Control Guidelines
- Development Approvals

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