Government of **Western Australia**
Department of **Water and Environmental Regulation**

Decision process for stormwater management in Western Australia

November 2017

A component of Chapter 4:
Integrating stormwater management approaches,
Stormwater management manual for Western Australia
(the former Department of Water 2004–07)

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For more information about this report, contact Urban Water Branch.

The Department of Water and Environmental Regulation was established by the Government of Western Australia on 1 July 2017. It is a result of the amalgamation of the Department of Environment Regulation, Department of Water and the Office of the Environmental Protection Authority. This website/publication may contain references to previous government departments and programs. Please contact the Department of Water and Environmental Regulation to clarify any specific information.

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1 Introduction

1.1 Why is this document needed?

Urban development should be designed to ensure that liveable, resilient, sustainable and productive cities and communities are created by interconnecting the built, social and natural environments. Water sensitive urban design is a significant component of water sensitive cities and communities. It is a planning and design approach that incorporates the sustainable management and integration of stormwater, groundwater, wastewater and water supply into the built form of houses, streets, suburbs and master-planned communities. Stormwater is therefore one aspect of water sensitive urban design.

This document provides an approach and outcome criteria for planning and designing stormwater management systems for urban (greenfield, infill and brownfield) developments and when planning and designing existing stormwater management system retrofits. This document does not require that one type of design or method be used, as there are many ways of achieving the desired outcomes. Example designs and stormwater systems are provided to demonstrate some options for achieving the approaches and criteria. Innovation is encouraged, especially at constrained and challenging sites. Innovation can produce new types of stormwater systems that will achieve the desired outcomes.

The desired outcomes of the *Decision process for stormwater management in Western Australia (WA)* are for urban stormwater management systems to be planned and designed to:

- protect public health and safety
- protect public and private infrastructure and buildings from flooding
- protect and enhance sensitive receiving environments by managing the water cycle, water quality, habitat diversity and biodiversity
- enable economically sustainable construction, maintenance and renewal/replacement costs
- achieve good urban amenity.

These outcomes can be achieved by:

- designing urban stormwater management systems that reduce risk to people and property from flooding to within acceptable levels
- designing urban stormwater management systems that mimic natural hydrological processes for that catchment
- retaining natural water bodies as the receiving environments for runoff of suitable quality from minor and major rainfall events
- retaining and planting vegetation (preferably local native species) wherever possible to reduce stormwater runoff volumes and peak flow rates, reduce

urban temperatures, improve water quality, increase urban biodiversity, and improve aesthetics and urban amenity

- implementing stormwater management systems and site management, maintenance and other practices to prevent, reduce and treat pollutants
- designing urban stormwater management systems that achieve good urban amenity and provide multiple functions.

This document is the third edition of the *Decision process for stormwater management in WA*, which was originally published in 2005 and previously updated in 2009. We developed this edition based on feedback from local governments, state government agencies and the urban development industry on how the process could be improved.

This update was developed to:

- apply current best practice international approaches and criteria for small rainfall event management
- review requirements for the north-west and north of WA when applying the 1-year, 1-hour average recurrence interval rainfall event criterion to avoid over-sized systems
- consider shallow groundwater management at the beginning of the stormwater management decision process
- strengthen the case for small rainfall event management to be considered early in the design of urban stormwater management systems
- incorporate the new rainfall event terminologies from the Australian Government's review of *Australian rainfall and runoff: a guide to flood estimation* (2016)
- explain how to include natural hydrological processes in stormwater management
- provide an explanation of stormwater management relating to management of receiving water bodies and their buffers
- consider urban liveability and amenity in the design of stormwater and shallow groundwater management systems
- provide updated information on stormwater management in the land and water planning process.

The decision process is a standalone document that complements the objectives, principles and delivery approach outlined in the *Stormwater management manual for WA* (Department of Water 2004–07). It is a component of Chapter 4: *Integrating stormwater management approaches* of the *Stormwater management manual for WA*. Detailed information about stormwater management – including structural and non-structural controls, retrofitting and case studies – is provided in the *Stormwater management manual for WA*.

1.2 Who should use this document?

State and local governments, water service providers and the urban development industry should use this document to design urban stormwater management systems in WA. State and local government officers should refer to it when reviewing proposed urban stormwater management systems.

1.3 How to use this document

The document includes two key figures. Figure 1 shows the process of integrating stormwater management into the land and water planning process. Figure 2 provides the criteria and main approaches for stormwater management in WA, to assist those designing and assessing the urban form. Figure 2 can be printed on A3 paper as a quick reference tool. The remainder of the document provides more detail and references.

New to this document is a suite of conceptual diagrams (figures 3–10) that visually represent the logic of stormwater management for different site conditions and at the lot and estate scales. These diagrams provide some of the options available and are not intended as one-size-fits-all solutions.

Section 2 provides information on stormwater management roles in WA.

Section 3 explains the stormwater management approach.

Section 4 explains the new stormwater quantity criteria for small, minor and major rainfall events, with explanations as to why those criteria were selected and comparisons with the criteria published in the 2009 edition of the *Decision process for stormwater management in WA*.

2 Stormwater management roles

The Department of Water and Environmental Regulation is WA's water resource management agency. For stormwater management, we:

- provide floodplain mapping for major river systems
- prepare drainage and water management plans
- provide WA stormwater management criteria and guidelines
- provide water management and design advice on the state government's strategic and special projects
- assess water management strategies and plans prepared under *Better urban water management* (Western Australian Planning Commission 2008).

Local government is the service provider of local drainage systems throughout WA. This includes the design, construction and maintenance of local road and drainage systems. Local government assesses and approves urban development proposals (including water management strategies and plans prepared under *Better urban water management*). See the *Local government guidelines for subdivisional development* (Institute of Public Works Engineering Australia WA Division Inc. 2012) for local government subdivision and drainage management guidelines.

The Water Corporation is the service provider of urban main drainage systems in some parts of the Perth metropolitan region and arterial rural drains in some parts of the south-west of WA. This includes the design, construction and maintenance of main drainage systems. The Water Corporation assesses urban development proposals when they are in a drainage catchment containing their drainage infrastructure.

Other drainage service providers include Main Roads WA, Public Transport Authority, and facilities such as Perth Airport and university campuses.

The Department of Biodiversity, Conservation and Attractions is the custodian of the wetland mapping layers, including the Geomorphic Wetlands Swan Coastal Plain data set. The department also works to ensure land use, development and other permitted works, acts or activities within or affecting the Swan Canning Development Control Area:

- do not result in further water quality degradation of the Swan Canning river system, and where possible, improve the situation
- protect and enhance the ecological health, community benefits and amenity of the river system.

Stormwater management is addressed in urban development planning. The Department of Planning, Lands and Heritage is responsible for planning sustainable communities in WA. The Department of Water and Environmental Regulation provides advice to the Department of Planning, Lands and Heritage to inform its recommendations to the Western Australian Planning Commission and the Minister for Planning who make decisions relating to the planning and development of communities throughout WA. The Western Australian Planning Commission's responsibilities include considering total water cycle management when making decisions, to ensure that development is consistent with current best management practices and best planning practices for the sustainable management of water resources, including stormwater.

For more detailed information on the roles of various stakeholders in stormwater management, see Section 6, Chapter 2, *Stormwater management manual for WA* (Department of Water 2004).

3 Stormwater management approach

When land is urbanised, the area of impervious ground increases and the vegetation typically decreases, resulting in additional runoff, less infiltration and less evapotranspiration. If not managed appropriately, these hydrological changes can:

- increase risks to people and properties from flooding
- increase the volume of runoff that needs to be managed in the urban landscape
- increase water quality contamination risk
- impact the ecology of receiving water bodies.

Lots, roads, parks, public spaces and water bodies are all locations where stormwater is managed. When designing stormwater management systems, it is important to focus on what occurs most often, while understanding and planning for what occurs less frequently.

Design for the small, then minor, then major rainfall events and aim to replicate how water moves in the natural landscape.

The important elements of the stormwater management approach are:

- Mimic natural hydrological processes to achieve best economic, social and environmental outcomes (see section 3.1).
- Prevent and reduce pollution through the application of non-structural and structural controls and the management of runoff from small rainfall events(see section 3.2).
- Integrate stormwater management systems in the urban form to enhance urban amenity (see section 3.3).
- Integrate stormwater management in the land and water planning process so that the necessary investigations are undertaken to inform decisions at each stage of the land and water planning stage (see section 3.4).
- Design site-responsive stormwater management systems that respond to constraints or challenging parameters and that reflect the economic, social and environmental outcomes sought for the site (see section 3.5).

3.1 Mimic natural hydrological processes

When designing or assessing a stormwater management system, think about how rainfall and runoff behave in a natural catchment and aim to mimic that hydrology in the constructed stormwater system. Scientific and case study investigations find that when stormwater management systems mimic natural hydrological processes, the best economic, social and ecological outcomes are achieved. These natural processes are influenced by the site's geology, topography, climate and vegetation cover and include:

- minimal runoff during small rainfall events
- high evapotranspiration
- significant groundwater recharge on sites with medium and high permeability soils
- overland runoff during minor and major rainfall events.

How to mimic natural hydrological processes

- *Retain and protect water bodies with environmental and social values*.

  Why?

  Natural water bodies are integral components of natural hydrological processes and are receiving environments for runoff from minor and major rainfall events. Water bodies and their buffers or foreshore areas reduce the risk of flooding houses and infrastructure due to their capacity to store runoff from large rainfall events.

  How?

  Retain natural water bodies with high conservation significance. Consider incorporating parts of multiple use (and other degraded) wetlands into landscaped stormwater management systems with similar storage capacity and hydrologic function.

  Locate stormwater management systems outside of conservation category wetlands, resource enhancement category wetlands, other wetlands of high conservation significance, and their buffers, and waterways, coastal marine areas, and their foreshore areas. This will reduce the impacts on receiving water bodies, such as altered hydrology, declining water quality and introduction of weed seeds.

- *Retain and plant vegetation wherever possible.*

  Why?

  Trees (particularly trees that maintain a canopy during the wet season), understorey vegetation and leaf litter reduce the volume of stormwater runoff and reduce peak flow rates. This is because leaves and branches capture rainfall before it falls to the ground, rainfall is used by trees via transpiration and evaporation, rainfall infiltration rates are increased due to root channels, and runoff velocity is reduced due to a rougher surface. Vegetation reduces soil erosion by slowing down flow rates, absorbing the impact of raindrops on the soil surface and by holding the soil together. Vegetation reduces temperatures and the urban heat island effect, improves water and air quality, increases urban biodiversity and improves people's mental and physical health.

How?

Prepare and implement urban forest strategies and plans.

Incorporate vegetation within gardens, carparks, verges, medians, traffic management devices (such as roundabouts), public spaces (such as plazas) and public open space.

Incorporate vegetation wherever possible within stormwater management systems. This includes gardens designed to receive stormwater runoff, tree pits, biofilters, vegetated swales, green roofs/walls, living streams, infiltration basins/areas, detention basins/areas and constructed wetlands.

Integrate stormwater management systems wherever possible within the landscaped areas of carparks, road reserves and gardens. For example, use flush kerbs or kerbs with openings around carpark garden beds and trees, and install pervious paving in parking bays, traffic islands and footpaths. Integrating landscaped areas and stormwater management systems will provide multiple functions to the land area. The increased water input from the stormwater flows can improve vegetation vigour and resilience.

Use local native vegetation where possible. The benefits of local native vegetation include: reduced need for irrigation water, fertiliser and pesticides; increased biodiversity; and less nutrient inputs to receiving water bodies (as opposed to deciduous plants that drop leaves).

Vegetated stormwater management systems can be designed to increase resilience to dry seasons. For example, saturated zones can be installed within biofilters. Structural cells can be installed with roadside and carpark tree pits to increase tree root coverage and consequently tree vigour and health. Fit-for-purpose irrigation sources can be used during the dry season, where appropriate.

Implement protection zones around vegetation that has been identified for retention when constructing stormwater management systems. Apply Australian Standard: AS4970-2009 *Protection of trees in development sites*.

See *Draft State planning policy no. 7.3: Apartment design* (Western Australian Planning Commission 2016) for guidance on retaining vegetation and deep root zones in apartment and multiple residential developments.

Apply the *Planning and development (local planning scheme) amendment regulations 2015* and *State planning policy no. 3.7: Planning in bushfire prone areas* (Western Australian Planning Commission 2015a) within areas designated as bushfire prone by the Fire and Emergency Services Commissioner.

- *Minimise the 'effective imperviousness' of a development area*.

  Why?

  Effective imperviousness is the proportion of a catchment that consists of impervious surfaces directly connected to receiving water bodies by pipes (Ladson et al. 2006).

  Minimising effective imperviousness reduces the changes to pre-development hydrology and reduces the transport of pollutants to receiving water bodies (Burns et al. 2014), by providing locations to retain runoff and treat pollutants before entering a conveyance system. Chapter 2 of the *Stormwater management manual for WA* (Department of Water 2004) provides more information about the effects of stormwater runoff.

  How?

  Retain and install pervious surfaces wherever practical.

  Use at-source retention and overland flow wherever practical to disconnect constructed impervious surfaces from receiving water bodies (by preventing direct stormwater discharge via pipes and drains) and from piped drainage systems.

  See the *Stormwater management manual for WA* (Department of Water 2004–07) for more information about managing the quantity and quality of stormwater runoff. See *Draft State planning policy no. 7.3: Apartment design* (Western Australian Planning Commission 2016) for guidance on retention and installation of pervious surfaces in apartment and multiple residential developments.

- *Manage small rainfall event runoff at-source*.

  Why?

  Managing small rainfall events at-source mimics the hydrology (infiltration, evaporation and transpiration processes) that occurs pre-development at most sites. Managing the runoff from small rainfall events at-source also prevents the collection and downstream transportation of pollutants. At-source management allows for increased losses and treatment opportunities close to where the rain falls.

  If water throughout the catchment is collected and transported to a point some distance downstream for retention and treatment, often impractically large areas would be required to allow sufficient infiltration or evaporation (Walsh et al. 2004; Burns et al. 2012).

  Ladson et al. (2004) stated that retaining stormwater from small rainfall events is the critical factor in reducing urban runoff impacts on receiving water bodies. They stated that increased total catchment imperviousness would still generate higher volumes from larger rain events than those from the pre-urban state but the frequency of discharge would be more in line with the pre-urban runoff characteristics. The ecological impacts of these larger events may be relatively small because they are closer to the type of disturbances that aquatic plants and animals have adapted to. Whereas, if runoff from small rainfall events was discharged directly to receiving environments, the increased frequency, volume and rates of flow would result in detrimental ecological impacts.

By managing stormwater runoff from small rainfall events throughout the catchment, the distributed infiltration and evapotranspiration systems help to reduce urban temperatures.

How?

Treat (if required), infiltrate, use, evaporate or detain small rainfall event runoff at-source or as close to the runoff source as possible. Less development space is required for small rainfall event management when runoff is managed closer to source. See the *Stormwater management manual for WA* (Department of Water 2004–07) for more information.

If pre-development hydrology consisted of only a small percentage of small rainfall events infiltrating or evapotranspirating at-source, mimic this in the constructed stormwater management system.

For developments with a stormwater harvesting or managed aquifer recharge scheme, small rainfall event runoff from parts of the development will be collected and conveyed to the harvesting or recharge system, instead of infiltrated, evaporated or detained at-source.

- *Provide overland flow paths wherever practical*.

  Why?

  Overland flow paths slow down and reduce the volume of runoff, improving water quality. When the overland flow path contains understorey vegetation, these effects are enhanced. By slowing and reducing runoff, people and property are more protected from minor and major rainfall events. Additional benefits of more overland flow, and consequent reduced piped flow, include: reduced chances of pipe blockages, reduced capital expenditure, and easier inspections.

  How?

  Include vegetated overland flow paths to water bodies instead of pipes or drains wherever practical. Consider swales, living streams and vegetated buffers. See Chapter 9 of the *Stormwater management manual for WA* (Department of Water 2007a) for more information.

- *Incorporate the forms and processes of natural water bodies within stormwater management systems.*

  Why?

  This improves the stormwater management system's biodiversity values, water quality treatment capabilities, amenity values and resilience to extreme weather events.

  How?

  For example, living streams mimic natural watercourses due to their intermittent flooding and their meandering course. Vegetated swales can be designed to mimic ephemeral streams and constructed wetlands can be designed to mimic natural wetlands.

  For more information about the issues associated with conventional conveyance drainage management systems, as well as the water sensitive approaches to stormwater management, see the *Stormwater management manual for WA* (Department of Water 2004–07), *Australian runoff quality – a guide to water sensitive urban design* (Engineers Australia 2006), Burns et al. (2012 and 2014), Melbourne Water (2013) and United States Environmental Protection Agency (2014).

3.2 Prevent and reduce water pollution

Stormwater management involves preventing and reducing water pollution through the implementation of non-structural controls (see Chapter 7, *Stormwater management manual for WA*, Department of Water 2005). It also involves the implementation of structural controls throughout the catchment to prevent and treat pollution (see Chapter 9, *Stormwater management manual for WA*, Department of Water 2007a). Implement erosion prevention and sediment control practices (non-structural and structural) during the construction of urban developments, housing/buildings and public works (such as roads). See Section 2.1.1 of Chapter 7, *Stormwater management manual for WA* (Department of Water 2005) for more information.

Manage runoff from small rainfall events at-source to prevent the collection and downstream transportation of pollutants and to reduce the size of downstream stormwater quality treatment systems. At many sites, retention or detention systems will be sufficient to manage water quality. However, at-source treatment in a stormwater quality treatment system may be required at some sites, depending on the pre-development environment and the post-development land uses. Determine if at-source stormwater quality treatment is required based on:

- the quality of pre-development surface water and groundwater
- the quality of post-development stormwater and groundwater (mobilised or discharged)

- potential pathways towards receiving environments, by considering factors such as soil types, depth to groundwater and horizontal distance to receiving environments
- the requirements of receiving environments.

See section 4.1 for the criteria for management of runoff from small rainfall events.

Field investigations may be required to measure pre-development water quality of receiving environments. Water quality objectives should be based on applicable state and local government water management plans and the requirements of receiving environments. In the absence of already established local catchment targets, the *Australian and New Zealand guidelines for fresh and marine water quality* (ANZECC/ARMCANZ 2000) provide a guide for water quality objectives. Demonstration of compliance with water quality targets that have been set by water quality improvement plans or similar plans will depend on the scale and nature of the proposed development.

The Urban Nutrient Decision Outcomes (UNDO) tool has been developed by the Department of Water and Environmental Regulation to assess the export of nitrogen and phosphorus from urban developments on the Swan Coastal Plain in south-west WA. This allows urban developers to quantify the magnitude of structural and non-structural controls required to reduce nutrient exports to within guideline values.

3.3 Integrate stormwater management systems in the urban form to enhance urban amenity

Achieving good urban amenity is another important component of stormwater management systems. This can be accomplished by:

- integrating stormwater management systems within the design of road reserves, public spaces and public open space
- managing stormwater and retaining and planting vegetation (preferably local native species) throughout the urban landscape
- establishing a connection between people, water and nature in the urban landscape.

Stormwater management is a significant component in the planning and delivery of public open space. The *Public parkland planning and design guide* (Government of Western Australia 2014) was developed to assist planners to develop parkland with sustainable water management practices.

See Figure 2 for more information about achieving good urban amenity.

3.4 Integrate stormwater management in the land and water planning process

To ensure that stormwater management is integrated with urban water management and land-use planning, stormwater management system design is included in the land and water planning process.

Better urban water management (Western Australian Planning Commission 2008) was developed to assist the land development industry to demonstrate compliance with the policies and principles of *State planning policy no. 2.9: Water resources* (Western Australian Planning Commission 2006). A series of guidance notes were developed by the Department of Water and Environmental Regulation to assist with its implementation.

Water management strategies and plans are prepared in accordance with:

- *Better urban water management* (Western Australian Planning Commission 2008)
- *Guidelines for district water management strategies* (Department of Water 2013d)
- *Interim: Developing a local water management strategy* (Department of Water 2008a)
- *Urban water management plans – guidelines for preparation and compliance with subdivision conditions* (Department of Water 2008b).

Figure 1 shows the steps for stormwater management planning in relation to *Better urban water management* (Western Australian Planning Commission 2008).

Further guidance on the integration of urban water planning and management with land-use planning and development can be found in *Draft Liveable neighbourhoods* (Western Australian Planning Commission 2015b) and *State planning policy: Design WA* (Western Australian Planning Commission, in development).

3.5 Design stormwater management systems based on the local site parameters

With an understanding of the stormwater management approach, site-specific stormwater management systems can be designed.

The design of stormwater management systems should be based on adequate investigations to ascertain the site conditions, because site-specific solutions are often required. Innovation is encouraged, especially at constrained and challenging sites.

The approaches and criteria to apply to the site-specific design are outlined in Figure 2. Variations to these criteria could be considered if it can be demonstrated that there is a more sustainable approach to achieving the criteria outcomes. Consult with the Department of Waterand Environmental Regulation and the relevant local government early in the design process if modifications to the criteria are being considered.

Teams that design and assess stormwater management systems should be multidisciplinary, comprising disciplines such as engineers, landscape architects, planners, environmental scientists, hydrologists and maintenance staff. Collaborate with others in local and state government, universities, industry associations and natural resource management groups to discuss past and proposed approaches.

Consider the management of shallow groundwater (where present) early in the stormwater management design process. The process and considerations for a groundwater management system are detailed in *Water resource considerations when controlling groundwater levels in urban development* (Department of Water 2013e). For guidance regarding separation distances to controlled groundwater levels, see the *Specification: separation distances for groundwater controlled urban development* (Institute of Public Works Engineering Australia 2016).

Chapters 6, 7 and 9 of the *Stormwater management manual for WA* (Department of Water 2004–07) outline how to select and design individual components of stormwater management systems.

4 How should rainfall events of different sizes be managed?

Figure 2 provides the process and criteria for water-sensitive stormwater management. Further detail on the stormwater quantity criteria outlined in Figure 2 is provided below.

4.1 Small rainfall events – ecological protection

Ecological protection is the main outcome to seek when managing runoff from 'small rainfall events'.

Manage water quality

- *Manage — retain and/or detain, and treat (if required) — stormwater runoff from constructed impervious surfaces generated by the first 15 mm of rainfall at-source as much as practical.*
    - At-source means that lot runoff is managed within lots and road runoff is managed within road reserves and the stormwater has not entered a piped or lined channel conveyance system.
    - Where site conditions do not allow for the full runoff to be managed at-source, manage as much as practical at-source, subject to the pre-development hydrology. Convey the remaining runoff from the lot or road reserve via overland flow wherever practical.
    - At-source treatment using a stormwater quality treatment system may be required depending on the pre-development environment and the post-development land uses. Determine if at-source stormwater quality treatment is required based on the:
        - quality of pre-development surface water and groundwater
        - quality of post-development stormwater and groundwater (mobilised or discharged)
        - potential pathways towards receiving environments, by considering factors such as soil types, depth to groundwater and horizontal distance to receiving environments
        - requirements of receiving environments.
- *Install off-line stormwater quality treatment systems at the outlet of pipes or lined channels that directly convey small rainfall event runoff from constructed impervious surfaces.*
- *Ensure the emptying time of stormwater management systems is based on the type of system, requirements for prevention of disease vector and breeding of nuisance insects, and amenity requirements for useability of systems post-rainfall.*

Note that the *Building Code of Australia: Volume 1: Class 2–9 buildings* and the *Volume 2: Class 1 and 10 buildings* (Commonwealth of Australia and States and Territories of Australia 2016) provide sizing requirements for gutters and downpipes.

The code does not specify how to manage the stormwater that is discharged from a downpipe.

Runoff generated from the first 15 mm of rainfall can mobilise substances such as soluble materials, fine dusts and silts, oils, grease and other non-volatile hydrocarbons from constructed impervious surfaces (New South Wales Environmental Protection Authority 2013).

Managing this runoff 'at-source' will prevent the transport of pollutants downstream. It will also reduce the volume of stormwater requiring treatment downstream, which reduces the size of the stormwater quality management system required. If all runoff from lots was conveyed for management in road reserves or public open space, the stormwater quality management system would need to occupy a much larger area of the road reserve or public open space. This would mean that capital and maintenance costs would be transferred to systems managed by local governments, rather than by the lot owners.

A review of national and international approaches found that many jurisdictions adopted a rainfall depth value — rather than a rainfall event value — to categorise the volume that needs to be managed at-source, as well as first flush interception. See Department of Water (2013f), Department of Environment and Resource Management (2010), Christchurch City Council (2012) and United States Environmental Protection Agency (2011) for more information.

Comparison to the previously published criterion

The criterion we published in the 2009 *Decision process for stormwater management in WA* was 'retain or detain stormwater runoff from constructed impervious surfaces generated by up to 1-year, 1-hour average recurrence interval (ARI) events on-site (i.e. as high in the catchment and as close to the source as possible)'.

The criterion we published in the 2011 *Stormwater design considerations* was 'retain or detain stormwater runoff from constructed impervious surfaces generated by up to the 1-year, 1-hour ARI event at its source, preferably in lots and road reserves'.

The 15 mm criterion replaces the previous 1-year, 1-hour ARI rainfall event criterion. The 1-year, 1-hour ARI criterion resulted in over-sized systems for water quality management for areas in the north-west and north of Western Australia. For example, 37 mm of rainfall would need to be managed at-source in Kununurra under the 1-year, 1-hour ARI criterion, which is much larger than the volume required to achieve water quality management. In Perth, Busselton and Carnarvon, the 1-year, 1-hour ARI criterion resulted in 16 mm of rainfall to be managed at-source.

The 15 mm criterion enables initial water quality objectives to be met under more practical circumstances.

Maintain form and hydrology of sensitive receiving environments

- *Maintain pre-development peak flow rates and total volume runoff from the outlets of the development area for the critical 1 exceedance per year (EY) event.*

This will assist with protecting the ecological values of sensitive receiving environments, by maintaining the pre-development hydrological regime and maintaining the stability and form of waterway channels.

The criterion for managing the runoff from the first 15 mm of rainfall at-source also assists with maintaining the pre-development hydrology of the site. This is because small rainfall events in natural catchments generally do not produce overland flow and runoff. Instead, the rainfall infiltrates into the ground (subsequently recharging the groundwater at some sites) or evaporates. Managing small rainfall events at-source will significantly reduce the frequency of flows that affect downstream receiving environments.

Comparison to the previously published criterion

The criterion we published in the 2009 *Decision process for stormwater management in WA* was 'detention systems should preserve the pre-development critical 1-year ARI peak flow rate and discharge volume for the catchment'.

The criterion we published in the 2011 *Stormwater design considerations* was 'maintain pre-development peak flow rates and total volumes runoff from the whole sub-catchment at outlets from the site at the critical 1-year ARI event'.

As a proponent usually has limited or no control over the stormwater management systems for a whole catchment or sub-catchment, use of the term 'catchment' was deemed inappropriate. Additionally, 'development area' replaces 'site' due to varying interpretations of the meaning of 'site'. Some interpret 'site' as meaning 'lots', while others interpret 'site' as meaning 'development area'. This criterion was intended to apply to the development area.

The critical 1 EY event replaces the use of the critical 1-year ARI rainfall event. This reflects the new methodology and terminology in *Australian rainfall and runoff* (Ball et al. 2016).

4.2 Minor rainfall events — serviceability, amenity and road safety

Provision of serviceability, amenity and road safety are the main outcomes to seek when managing runoff from 'minor rainfall events'.

Provide serviceability, amenity and road safety

- *Design stormwater management systems to provide serviceability, amenity and road safety during minor rainfall events.*

Once the small rainfall event management systems and areas have been designed, assess the effects of minor rainfall events on transport networks, public open space and drainage networks.

Consult with service providers at the beginning of the design process. Providers of transport networks (local government, Main Roads WA and Public Transport Authority), public open space (local government) and drainage networks (local government, Water Corporation and other private drainage providers) will define the relevant design exceedance per year (EY) or the annual exceedance probability (AEP), as well as the peak allowable discharge into the service providers' drainage networks during minor rainfall events.

Refer to *Australian rainfall and runoff: a guide to flood estimation* (Ball et al. 2016) for information on how to design minor rainfall event management systems.

Comparison to the previously published criteria

The criterion we published in the 2009 *Decision process for stormwater management in WA* was 'design for greater than 1-year and less than/equal to 5-year (residential/rural-residential) or 10-year (commercial/industrial) ARI events'.

The criteria we published in the 2011 *Stormwater design considerations* were 'greater than 1-year ARI and up to 5-year ARI events for residential and rural-residential, and 10-year ARI events for commercial and industrial areas; attenuate critical 5-year event flows to the capacity of downstream natural channels or constructed drainage infrastructure; and maintain serviceability of roads and infrastructure'.

As it is the type of infrastructure that determines the applicable design rainfall event, it is the infrastructure provider that should specify the design rainfall event value.

4.3 Major rainfall events — flood protection

Flood protection is the main outcome to seek when managing runoff from 'major rainfall events'.

Manage catchment flooding

- *Implement the flood regime documented in relevant Department of Water and Environmental Regulation catchment plans (e.g. drainage and water management plans).*
- *Maintain the 1 per cent annual exceedance probability (AEP) pre-development flood regime (flood level, peak flow rates and storage volumes) for catchments that do not have a published catchment plan. Alteration to the pre-development flood regime depends on the constraints of the catchment and the receiving environments. Any proposed alterations to the flood regime will require assessment and/or modelling of the capacity of the entire system and the cumulative impacts from the change, to the satisfaction of the Department of Water and Environmental Regulation and other relevant agencies.*

Once the small and minor rainfall event management systems have been designed, examine how runoff from major rainfall events moves through the urban landscape.

The 'manage catchment flooding' criteria will help protect people and property from flooding, identify safe evacuation routes and prevent increased flood levels upstream and downstream of the development area.

Comparison to the previously published criteria

The criterion we published in the 2009 *Decision process for stormwater management in WA* was 'maintain the pre-development annual discharge volume and peak flow, unless otherwise established through determination of ecological water requirements for sensitive receiving environments'.

The criteria we published in the 2011 *Stormwater design considerations* were 'identify flow paths during urban design; and reduce risk of flooding and manage flow rates'.

Flood level was added to the major rainfall events criteria because it is the critical aspect for managing the impacts of flooding on the urban development. The 2009 criterion also required modification to specify the rainfall event size, because maintenance of the pre-development regime should not be applied to all rainfall event sizes.

Prevent building and critical infrastructure flooding

- *Protect people and property from flooding by constructing residential, commercial and industrial building habitable floor levels with the following minimum clearances above the 1 per cent annual exceedance probability (AEP) flood level:*
    - *road drainage systems: 0.3 m*
    - *terminal retention or detention areas with no overflow relief: 0.5 m*
    - *major drainage system and waterways: 0.5 m.*

We recommend that critical infrastructure and important community facilities (such as hospitals) have a higher level of flood protection. We recommend a risk-based approach is used to determine the acceptable level of flood protection for these facilities and their access routes, to ensure they remain operable during major flood events. See *Australian emergency management handbook series: Handbook 7: Managing the floodplain: a guide to best practice in flood risk management in Australia* (Attorney-General’s Department 2013).

Comparison to the previously published criterion

The 1 per cent AEP event replaces the use of the 100-year ARI rainfall event. This reflects the new methodology and terminology in *Australian rainfall and runoff: a guide to flood estimation* (Ball et al. 2016). The types of drainage systems have been clarified.

Figure 1

Stormwater management and the land and water planning process

DWMS — *Site and water assessment*

Initial assessment of water management issues by reviewing management plans, and identifying water quality and quantity objectives, indicative land form and water resource constraints, indicative areas for accommodating 1% annual exceedance probability (AEP) urban stormwater and preliminary analysis of catchment flood regime and shallow groundwater regime

↓

Investigate climate, climate change, topography, soil, and characteristics and values of groundwater, surface water (wetlands, waterways and their estuaries, constructed drains, coastal marine areas) and sensitive receiving environments (including drinking water source areas)

↓

LWMS — *Spatial requirements for water management*

Set shallow groundwater management (if required) outlet locations and levels and determine land requirements

↓

Calculate the flow paths, flood level, peak flow rates and storage volumes for the 1% AEP for catchment flood management and urban stormwater management

↓

Allocate land for accommodating the 1% AEP flow paths and flood level (within road reserves, public open space (POS) and drainage reserves)

↓

Determine land requirements for small rainfall event management (within lots, road reserves and/or POS) [a] and minor rainfall event management (within road reserves and/ or POS)

↓

Develop conceptual stormwater management design

↓

UWMP — *Detailed design*

Shallow groundwater management (if required)

↓

Small rainfall event management: ecological protection → Minor rainfall event management: serviceability, amenity & road safety [b] → Major rainfall event management: flood protection [c]

a Off-lot management might require land allocated in wider road reserves or larger POS. See *Draft Liveable neighbourhoods* (WAPC 2015b) and **Public parkland planning and design guide** (Government of Western Australia 2014). Other options include collecting and conveying the runoff for a harvesting scheme.

b See *Australian rainfall and runoff: a guide to flood estimation* (Ball et al. 2016) and service provider design AEPs for development and building categories.

c Design AEPs for vulnerable infrastructure, such as hospitals and emergency evacuation routes, may be larger than the 1% AEP.

Figure 2

Stormwater management process and criteria for urban developments and retrofit projects

Consult with stakeholders
Consult with local government authorities, Department of Water and Environmental Regulation (DWER), Department of Biodiversity, Conservaton and Attractions (DBCA), Water Corporation or other water service provider, local indigenous groups and other relevant stakeholders prior to and throughout the design process.

Review policies and guidelines
Review local and state government land and water management policies and guidelines.

Identify water resources
Identify water resources that may require management in the proposed development or project.

Conduct desktop investigation
Conduct a preliminary desktop investigation by reviewing published management plans and reports[1].

Conduct a detailed investigation and evaluation of water resources, groundwater, surface water flows, sensitive receiving environments[2], soil characteristics (e.g. infiltration rates) and contaminant/nutrient levels. This should include desktop and field investigations and monitoring of groundwater and surface water quality and quantity in accordance with DoW (2012b), including seasonal groundwater levels and surface water-groundwater interactions, and a total water cycle balance (especially in shallow groundwater areas).

Manage shallow groundwater
- Assess the groundwater regime, including the impact of urban development on groundwater levels and of groundwater levels on the urban form.
- Assess if groundwater level management is required. Design a controlled groundwater level system in accordance with *Water resource considerations when controlling groundwater levels in urban development* (2013e).

Manage contaminated soil and groundwater
1. Is the proposal completely or partly within a known contaminated site either listed on the contaminated sites register (request a DWER Basic Summary of Records Form 2 to check) or identified through adequate field investigations, or completely or partly within Class 1 high to moderate risk of acid sulfate soil occurrence as depicted on a DWER acid sulfate soils risk map?
2. Does the soil or groundwater contain elevated contaminant/nutrient levels? Review applicable state and local government water management plans[1] and the requirements of sensitive receiving environments[2] for acceptable contaminant/nutrient levels. In the absence of already established local catchment targets, the ANZECC/ARMCANZ (2000) guidelines provide a guide for water quality targets.

Avoid mobilisation or disturbance of in-situ contaminants
1. Refer to the relevant guidance documents for assessing and managing contaminated sites and the disturbance of acid sulfate soils online at www.dwer.wa.gov.au.
2. Seek further advice from DWER and DBCA (where applicable).

Manage stormwater quantity	**Manage water quality**	**Protect and manage water bodies**	**Achieve good urban amenity**

Manage stormwater quantity
Manage runoff from small rainfall events for ecological protection
- Minimise effective imperviousness by installing pervious surfaces and diverting runoff to pervious surfaces wherever practical.
- Manage — retain and/or detain[3], and treat (if required) — stormwater runoff from constructed impervious surfaces generated by the first 15 mm of rainfall at-source as much as practical. At-source means that lot runoff is managed within lots and road runoff is managed within road reserves and the stormwater has not entered a piped or lined channel conveyance system. Where site conditions do not allow for the full runoff to be managed at-source, manage as much as practical at-source, subject to the pre-development hydrology. Convey the remaining runoff from the lot or road reserve via overland flow wherever practical. Designs should be site-specific. Determine if at-source stormwater quality treatment is required based on the: quality of stormwater/ surface water; quality of mobilised/discharged groundwater; potential pathways towards receiving environments, by considering factors such as soil types, depth to groundwater and horizontal distance to receiving environments; and requirements of receiving environments.
- Install off-line stormwater quality treatment systems at the outlet of pipes or lined channels that directly convey small rainfall event runoff from constructed impervious surfaces.
- Ensure the emptying time of stormwater management systems is based on the type of system, requirements for prevention of disease vector and breeding of nuisance insects, and amenity requirements for useability of systems post-rainfall.
- Maintain pre-development[4] peak flow rates and total volume runoff from the outlets of the development area for the critical 1 exceedance per year (EY) event.
- Manage runoff from minor rainfall events for serviceability, amenity and road safety
- Provision of serviceability, amenity and road safety are the main outcomes to seek when managing runoff from ‘minor rainfall events’. Once the small rainfall event management systems and areas have been designed, assess the effects of minor rainfall events on transport networks, public open space and drainage networks. Consult with service providers at the beginning of the design process. Providers of transport networks (local government, Main Roads WA and Public Transport Authority), public open space (local government) and drainage networks (local government, Water Corporation and private drainage providers) will define the relevant design exceedance per year (EY) or the annual exceedance probability (AEP), as well as the peak allowable discharge into the service providers’ drainage networks during minor rainfall events. Refer to *Australian rainfall and runoff: a guide to flood estimation* (Ball et al. 2016) for information on how to design minor rainfall event management systems.

Manage runoff from major rainfall events for flood protection
- Implement the flood regime documented in relevant DWER catchment plans (e.g. drainage and water management plans).
- Maintain the 1 per cent annual exceedance probability (AEP) pre-development flood regime (flood level, peak flow rates and storage volumes) for catchments that do not have a published catchment plan. Alteration to the pre-development flood regime dependents on the constraints of the catchment and the receiving environments. Any proposed alterations to the flood regime will require assessment and/or modelling of the capacity of the entire system and the cumulative impacts from the change, to the satisfaction of the Department of Water and Environmental Regulation and other relevant agencies.
- Protect people and property from flooding by constructing residential, commercial and industrial building habitable floor levels with the following minimum[6] clearances above the 1 per cent annual exceedance probability (AEP) flood level: road drainage systems: 0.3 m; terminal retention or detention areas with no overflow relief: 0.5 m; major drainage system and waterways: 0.5 m.
- Safely convey the critical 1 per cent AEP event flow through natural water bodies and constructed stormwater conveyance systems (e.g. providing overland flow from lots to road reserves; overland flow along roads and road reserves; public open space detention and conveyance systems; and living streams).

Infrastructure design
- Incorporate the methodology of *Australian rainfall and runoff: a guide to flood estimation* (Ball et al. 2016) for hydrologic and hydraulic analyses, safety analyses, modeling and design, including accounting for losses and hydraulic structure blockage.
- Refer to *Stormwater management manual for Western Australia* (DoW 2004–2007) and the stormwater page on the DWER website for guidance.
- Prevent breeding of disease vector and nuisance insects by designing and maintaining stormwater management systems to contain no standing water for more than 96 hours. Essential maintenance practices include the removal of accumulated sediment and the management of vegetation growth and weeds. Stormwater management systems designed to contain standing water, such as rainwater tanks, detention systems and constructed wetlands, must be designed and maintained to prevent breeding of mosquitoes and nuisance insects. Contact the local government environmental health officer or the medical entomology team of Department of Health for information about mosquito breeding risk seasons in different regions in WA.

Manage water quality

- Install water quality treatment systems at controlled groundwater level subsoils and drains and/or at outlet points, unless investigations demonstrate that treatment is not required. See *Water resource considerations when controlling groundwater levels* (DoW 2013e) for guidance.
- Use a combination of non-structural and structural controls in a treatment train to prevent, reduce and treat pollutants. Manage land development and construction activities to reduce erosion and prevent sediment transport. See the *Stormwater management manual for WA* (DoW 2004–07) for guidance.
- Refer to the first three dot points under 'Manage runoff from small rainfall events for ecological protection' for management of runoff from small rainfall events to assist with water quality management.
- Convey stormwater runoff overland through understorey vegetation, where practical.
- Field investigations may be required to measure pre-development water quality of receiving environments. Water quality objectives should be based on applicable state and local government water management plans, and the requirements of receiving environments. In the absence of already established local catchment targets, the *Australian and New Zealand guidelines for fresh and marine water quality* (ANZECC/ARMCANZ 2000) provide a guide for water quality objectives. Demonstration of compliance with water quality targets that have been set by water quality improvement plans or similar plans will depend on the scale and nature of the proposed development. The Urban Nutrient Decision Outcomes (UNDO) tool has been developed by the Department of Water and Environmental Regulation to assess the export of nitrogen and phosphorus from urban developments on the Swan Coastal Plain of south-west WA. This allows urban developers to quantify the magnitude of structural and non-structural controls required to reduce nutrient exports to within guideline values.

Protect and manage water resources

- Identify all water resources (wetlands, waterways and their estuaries, coastal marine areas, shallow groundwater aquifers and public drinking water source areas) within the catchment of the proposed development area.
- Retain, protect and, where possible, restore high conservation significance[2] water bodies within the development area. For waterways, the approach should be consistent with *Operational policy: identifying and establishing waterways foreshore areas* (DoW 2012a) and *River restoration – a guide to the nature, protection, rehabilitation and long-term management of waterways in Western Australia* (Water and Rivers Commission/Department of Environment 1999–2003), and in the Swan Canning Catchment, it should also be consistent with *Corporate policy statement no. 49: Planning for stormwater management affecting the Swan Canning Development Control Area* (Department of Parks and Wildlife and Swan River Trust 2016). For wetlands, the approach to protection and management should be guided by and consistent with Chapter B4 of *Guidance statement no. 33: Environmental guidance for planning and development* (EPA 2008) and the approach to restoration should be guided by *A guide to managing and restoring wetlands in Western Australia* (DEC 2013).
- Maintain pre-development surface water flow rates, runoff volumes and flood level and shallow groundwater recharge rates for receiving water bodies, unless otherwise established in an approved management strategy or plan[1] and subject to the advice of the relevant agency[5].
- Locate stormwater management systems (including pipes, constructed drains, detention areas and vegetated swales) outside of conservation category wetlands, resource enhancement category wetlands, other wetlands of high conservation significance[2], and their buffers, and waterways, coastal marine areas, and their foreshore areas. For multiple use category wetlands, stormwater management should be consistent with Chapter B4 of *Guidance statement no. 33: Environmental guidance for planning and development* (EPA 2008).
- Manage stormwater within public drinking water source areas in accordance with *Water quality protection note no. 25: Land use compatibility tables for public drinking water source areas* (DoW 2016).
- Creation of ornamental lakes will not be supported. Refer to *Interim position statement: constructed lakes* (DoW 2007b) for further guidance.

Achieve good urban amenity

- Maintain or improve urban function, form and aesthetics by integrating urban design and stormwater management.
- Investigate stormwater and discharged controlled groundwater as a potential fit-for-purpose water source for irrigation and other water uses (see *Guideline for the approval of non-drinking water systems in Western Australia – urban developments,* DoW 2013c).
- Establish a connection between people, water and nature, especially highlighting the ephemeral and variable characteristics of rainfall and runoff, by incorporating art, interpretive signage and vegetation within stormwater management systems.
- Incorporate vegetation wherever possible on buildings, on lots (gardens), in road reserves, in carparks, in public open space and in stormwater management systems. This should include trees (particularly trees that maintain a canopy during the wet season) and understorey vegetation.
- Incorporate stormwater management systems throughout the urban landscape, to assist with urban temperature reduction.
- Integrate stormwater management systems within public open space to protect and enhance public open space function (sport, recreation and nature) and hierarchy. Manage runoff from small rainfall events within lots and road reserves as much as practical, to reduce the size of stormwater quality treatment systems within parkland. See *Public parkland planning and design guide WA* (Government of Western Australia 2014) and *Draft Liveable neighbourhoods* (Western Australian Planning Commission 2015b) for more information.

Footnotes for Figure 2

[1] Water management plans include: water quality improvement plans, drainage and water management plans, district water management strategies, local water management strategies, urban water management plans, drinking water source protection reports, river actions plans, waterway management plans, wetland management plans, natural resource management strategies, and environmental protection policies.

[2] Sensitive receiving environments include the following environments, as defined in *Guidance statement no. 33: Environmental guidance for planning and development* (Environmental Protection Authority 2008): natural areas of high conservation significance (chapter B1.2.1), native vegetation and flora of high conservation significance (chapter B2.2.2), areas of high conservation significance for native terrestrial fauna (chapter B3.2.2), wetlands of high conservation significance (chapter B4.2.2), waterways of high conservation significance (chapter B5.2.2), waterways conservation areas and the Swan River Management Area (attachment B5-5), public drinking water source areas (chapter B6-1), landscapes and landforms of high conservation significance (chapter B8.2.1), and karst
areas of high conservation significance (chapter B9.2.2).

[3] Retention systems prevent stormwater runoff, up to the design rainfall event. The water may infiltrate into the soil, be used as a water source, evaporate, or evapotranspirate. Detention systems reduce the rate of stormwater runoff by temporarily holding rainfall runoff (up to the design rainfall event) and then releasing it slowly.

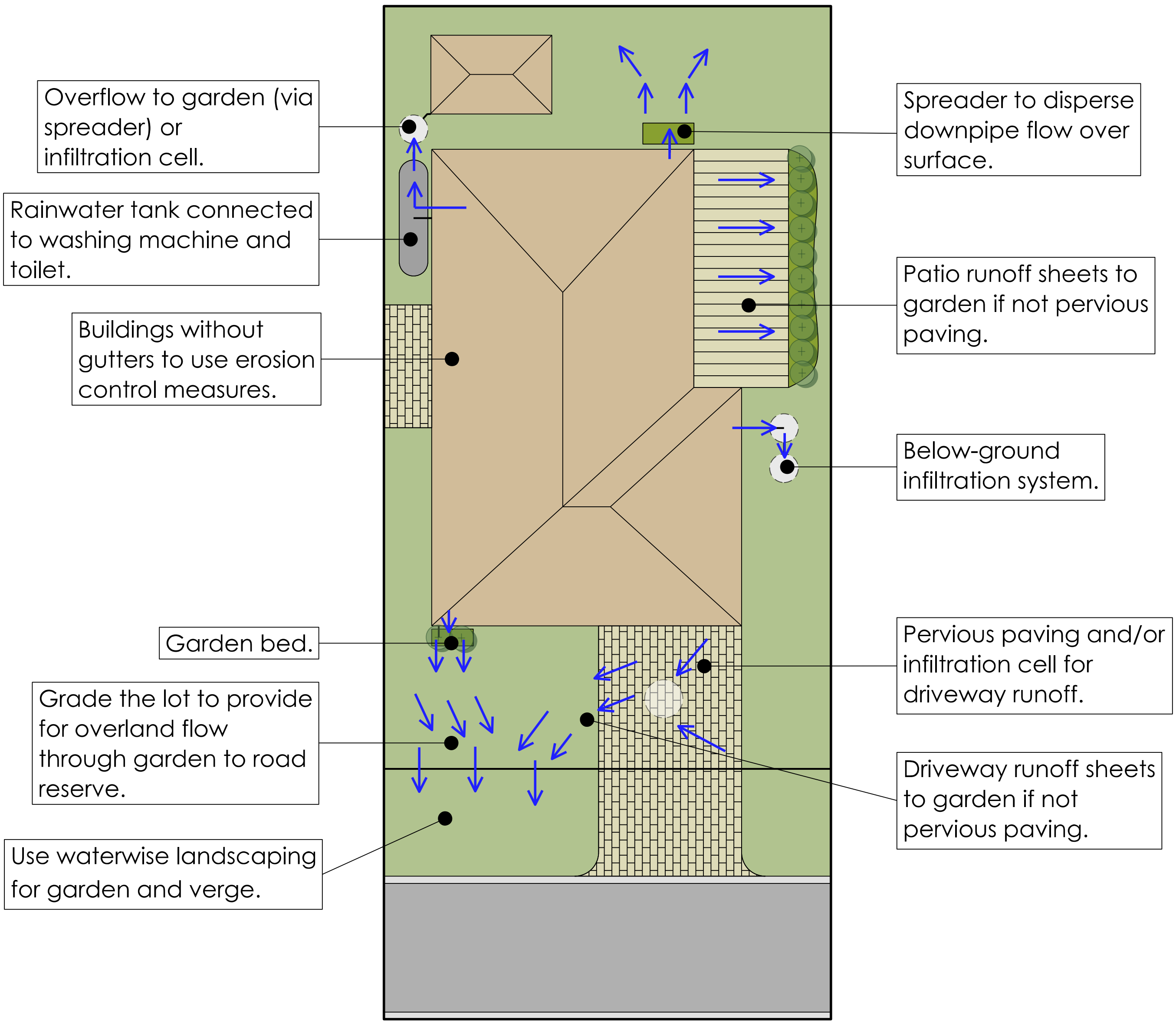
[4] Pre-development refers to the conditions at the site immediately preceding the proposed development.

[5] Consult with the: Department of Biodiversity Conservation and Attractions regarding changes to waterway management, when in the Swan Canning Catchment, and changes to wetland management; Department of Water and Environmental Regulation regarding changes to waterway and wetland management and to seek guidance on stormwater management criteria; local government regarding changes to stormwater flows to a local drainage network; and water service provider (e.g. Water Corporation) regarding changes to stormwater flows to a main drainage network

[6] Critical infrastructure and important community facilities, such as hospitals, require a higher level of flood protection based on the flooding consequences. A risk-based approach is recommended to determine the acceptable level of flood protection for these facilities and their access routes to ensure they remain operable during major flood events. See *Australian emergency management handbook series: Handbook 7: Managing the floodplain: a guide to best practice in flood risk management in Australia* (Attorney-General's Department 2013).

Figure 3

Example management options for residential lots with medium and high permeability soil – small rainfall event runoff



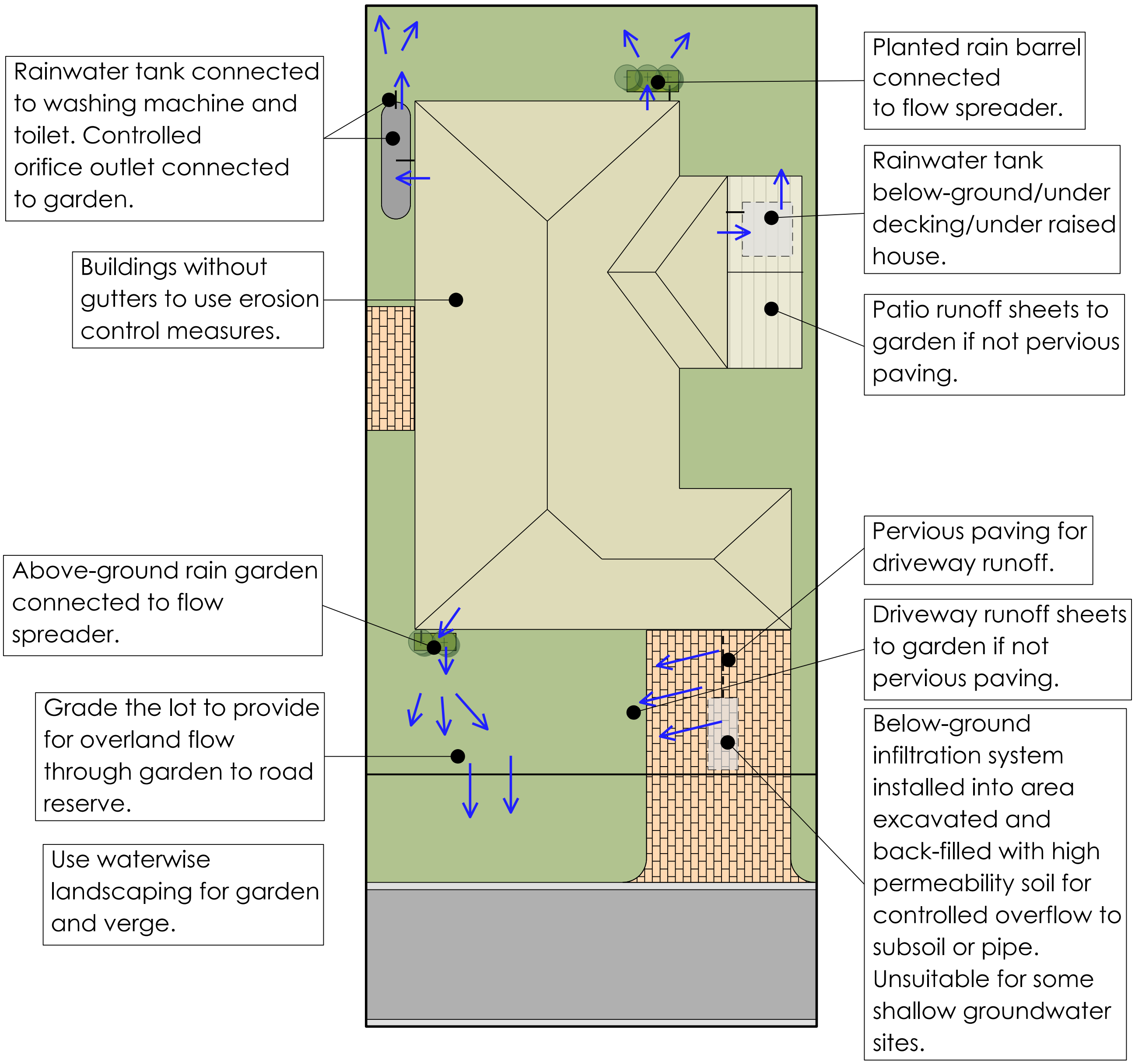
Note:

1. Sites with medium to high permeability generally have sand soil with a low fines content.

Diagrammatic to represent a variety of options. Not all options need occur in one site.
Apply site-responsive design. Not to scale

Figure 4

Example management options for residential lots with low and very low permeability soil/shallow groundwater – small rainfall event runoff



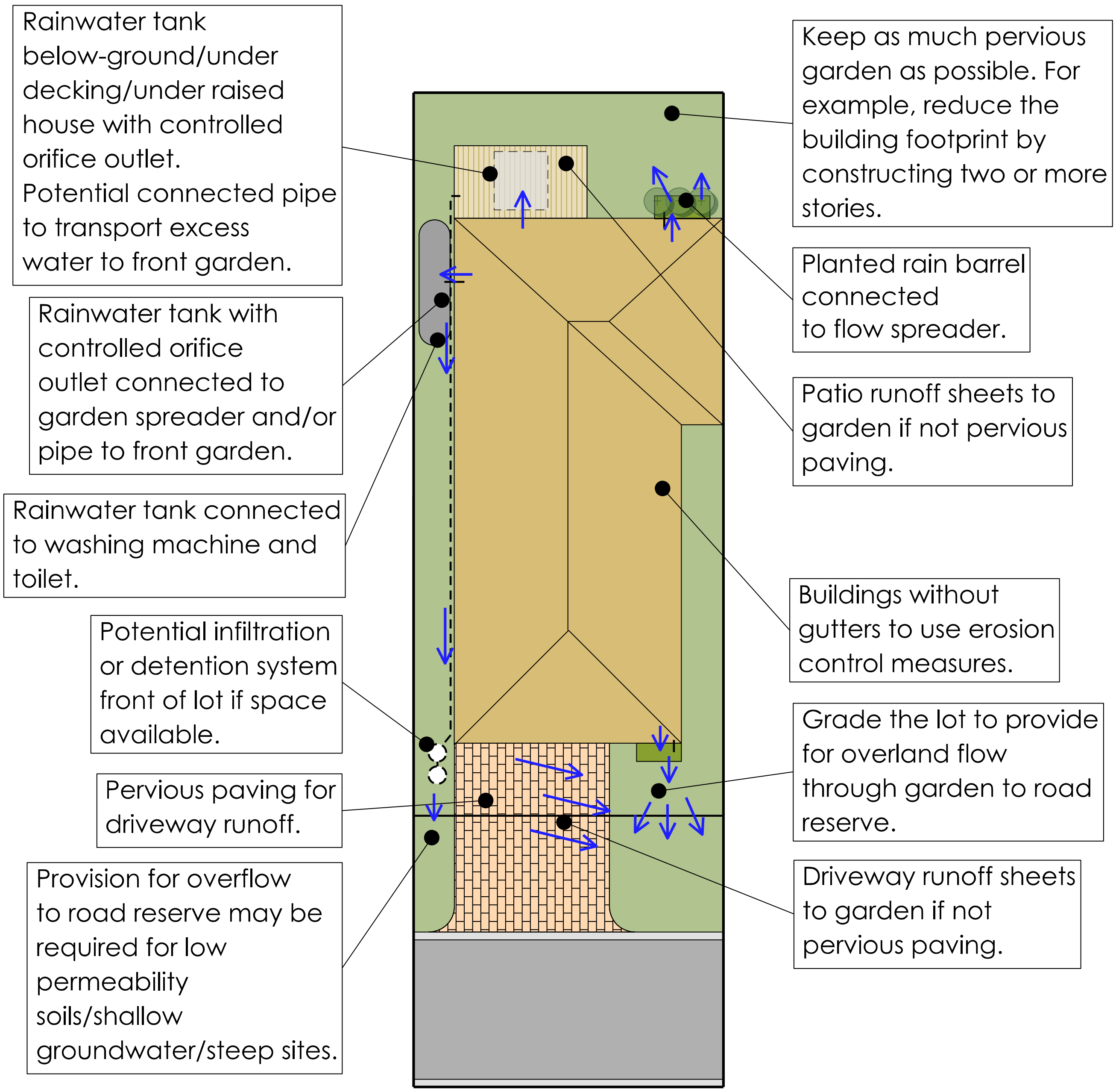
Note:

1. Includes sites with clay soil or a thin layer of sand over clay.

2. Flow spreaders and below-ground infiltration systems should be located as far as practical away from house footings, particularly when moisture barriers have not been installed. *See Foundation maintenance and footing performance: a homeowner's guide (CSIRO) for more information.*

Diagrammatic to represent a variety of options. Not all options need occur in one site.
Apply site-responsive design. Not to scale

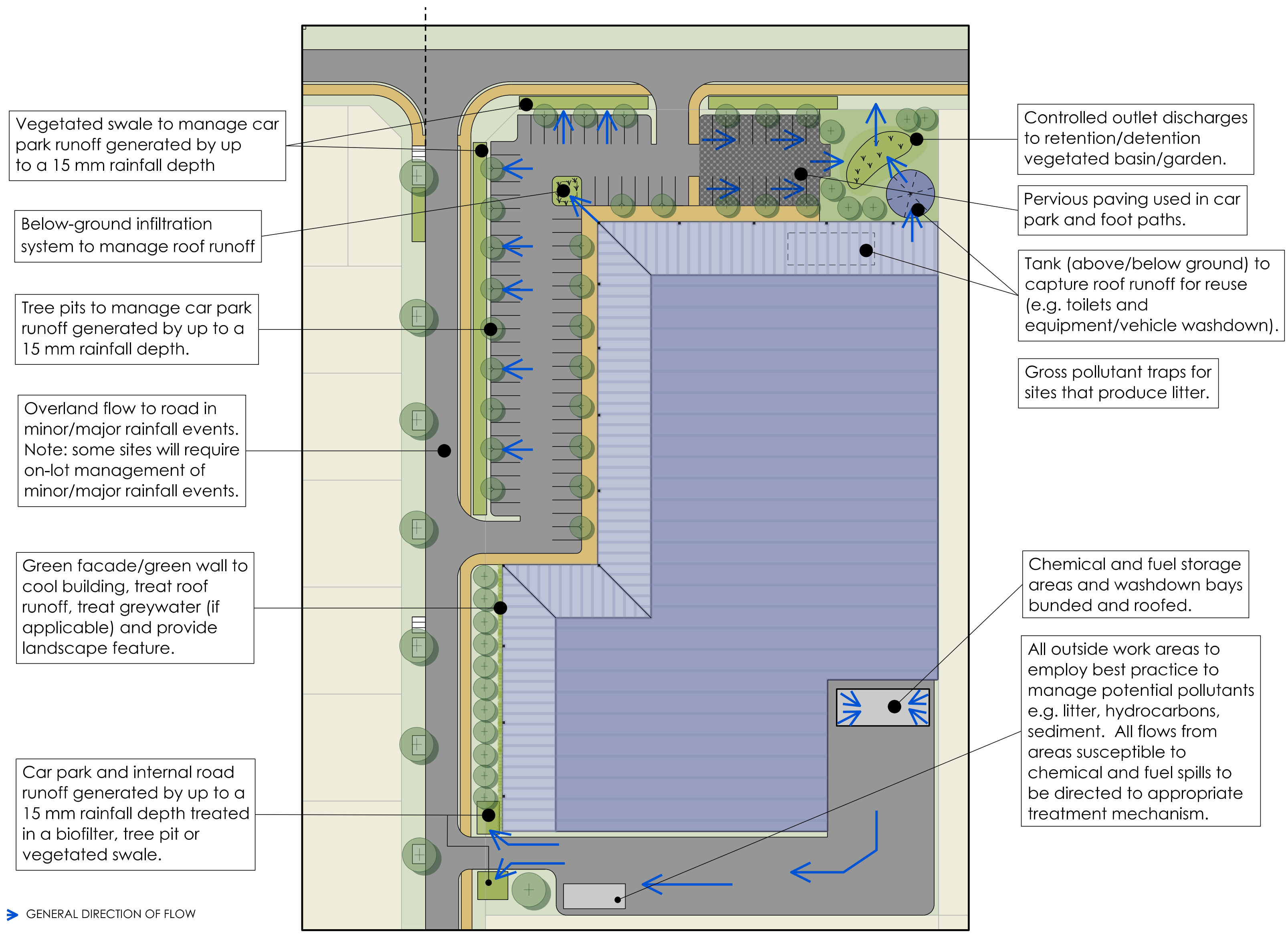
Figure 5
Example management options for residential lots on small sites – small rainfall event runoff



Diagrammatic to represent a variety of options. Not all options need occur in one site.
Apply site-responsive design. Not to scale

Figure 6

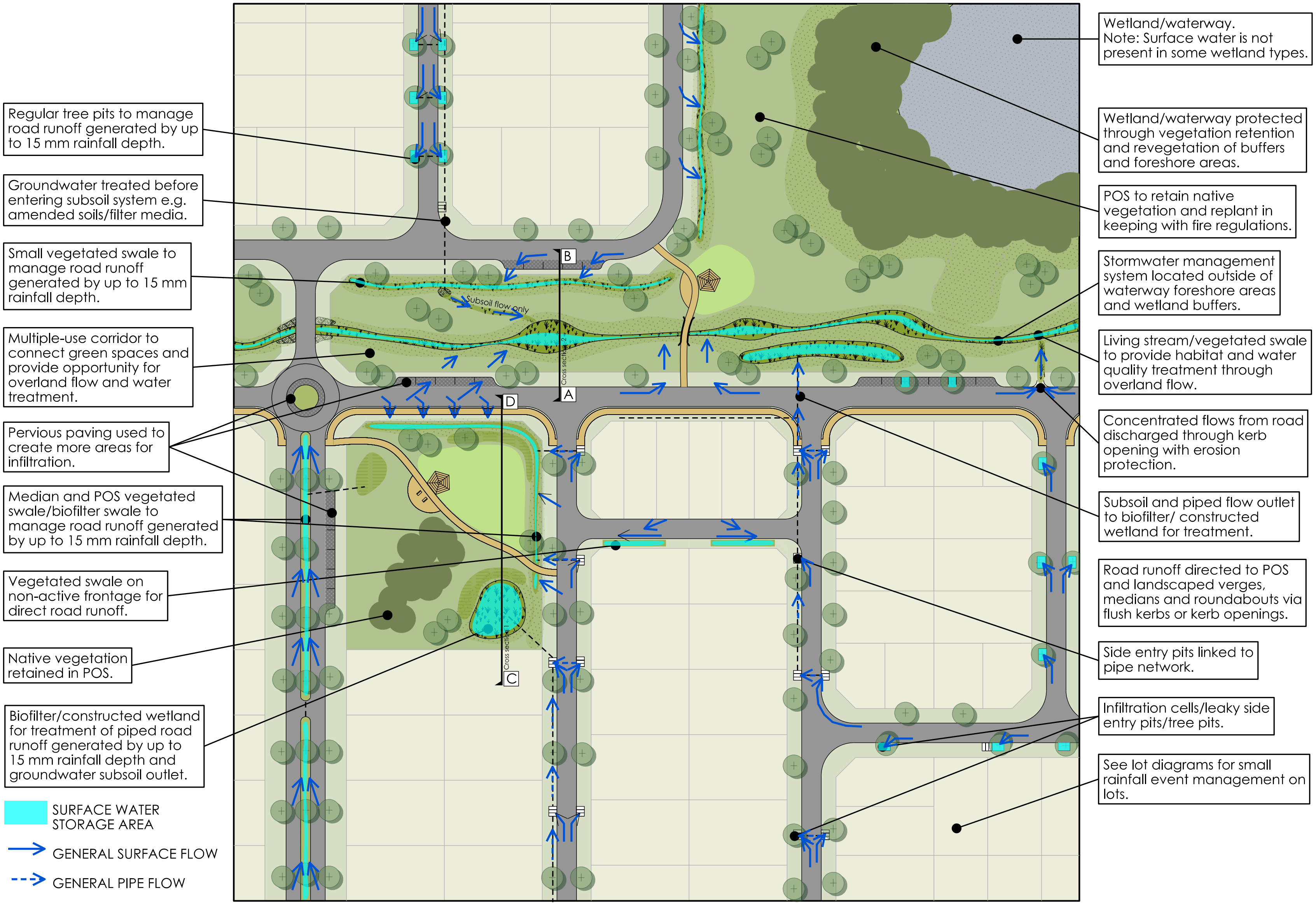
Example management options for commercial/industrial lots – small rainfall event runoff



Diagrammatic to represent a variety of options. Not all options need occur in one site.
Apply site-responsive design. Not to scale

Figure 7

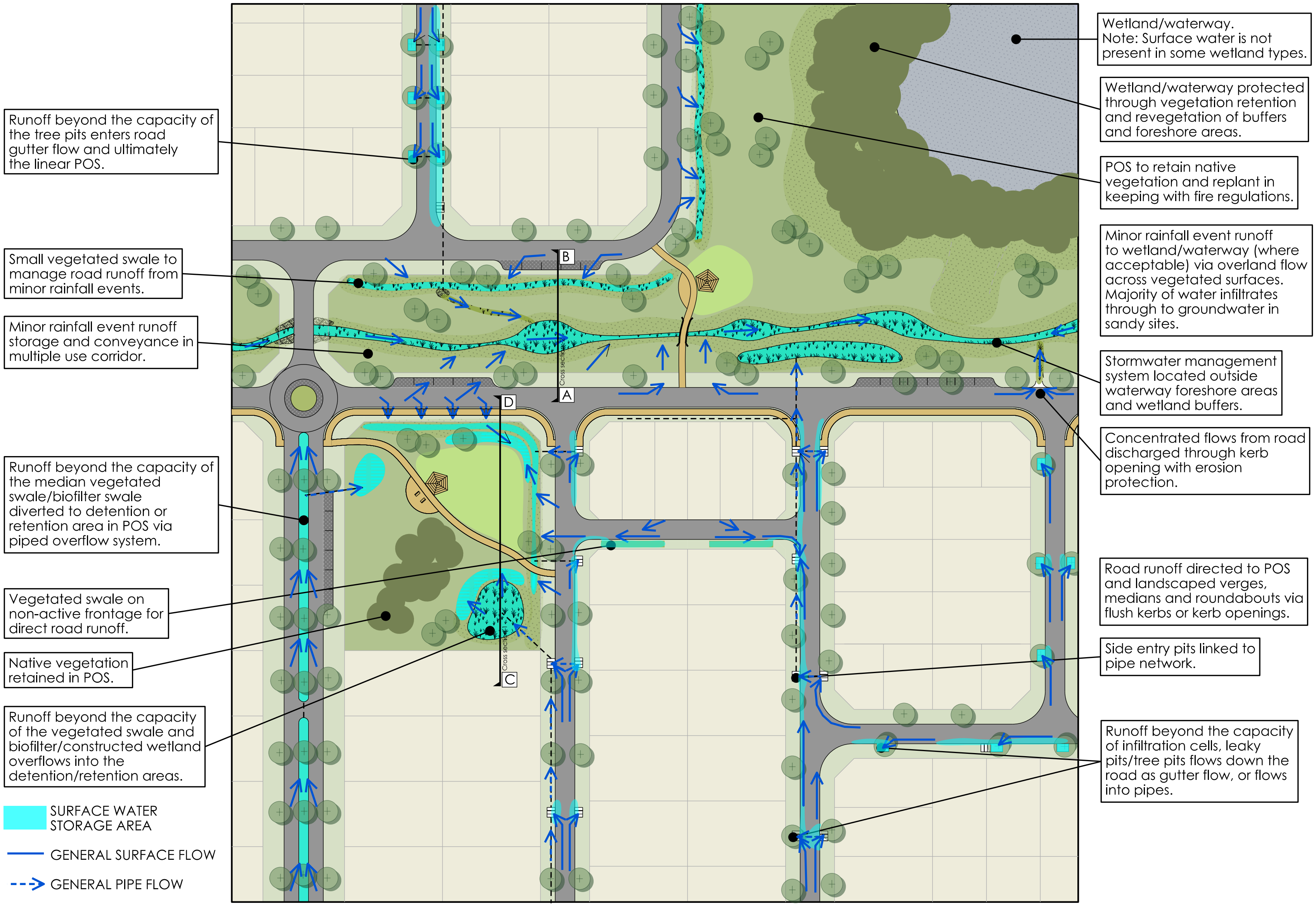
Example management options for estate scale – small rainfall event runoff



Diagrammatic to represent a variety of options. Not all options need occur in one site. Apply site-responsive design. Not to scale

Figure 8

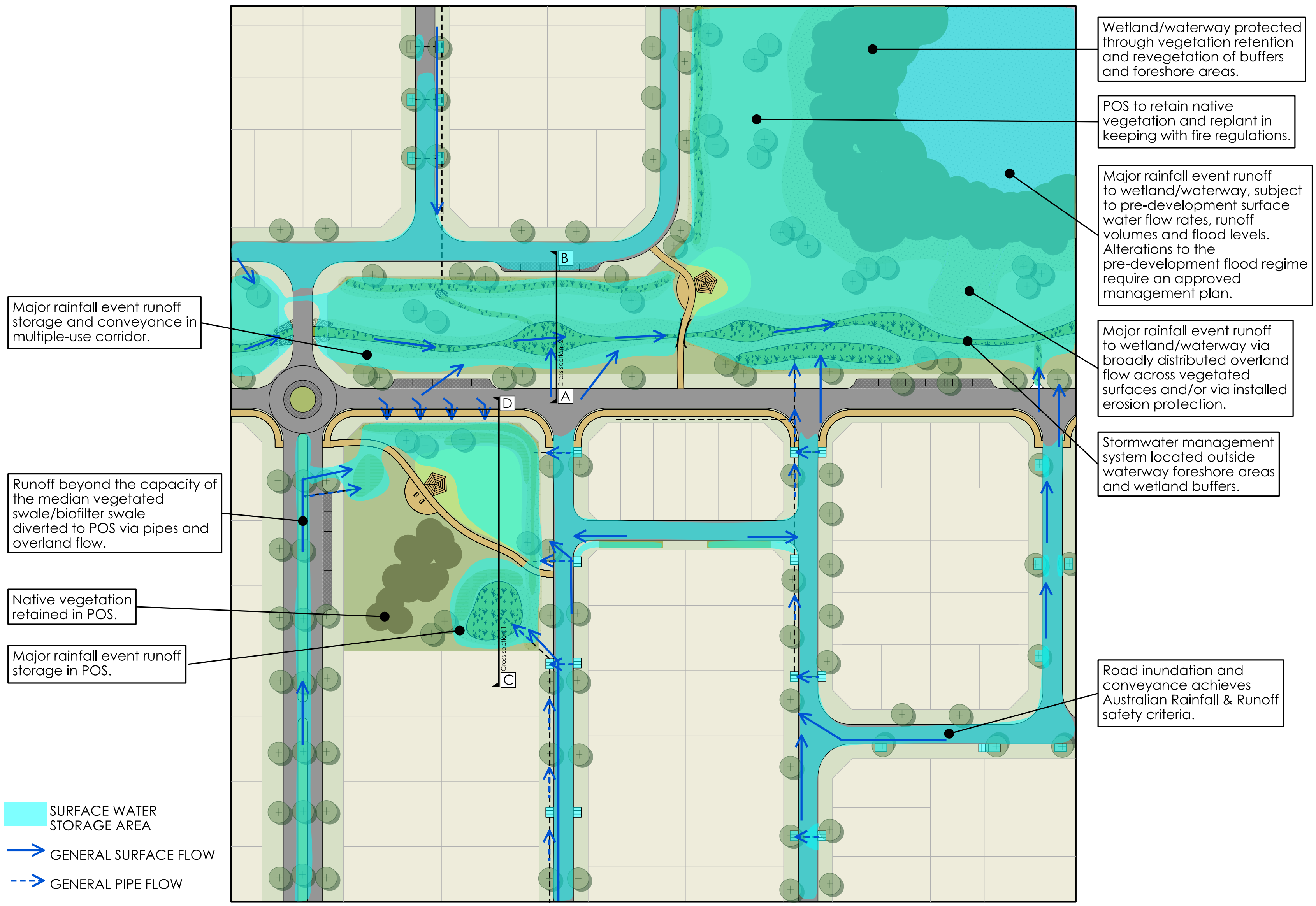
Example management options for estate scale – minor rainfall event runoff



Diagrammatic to represent a variety of options. Not all options need occur in one site. Apply site-responsive design. Not to scale

Figure 9

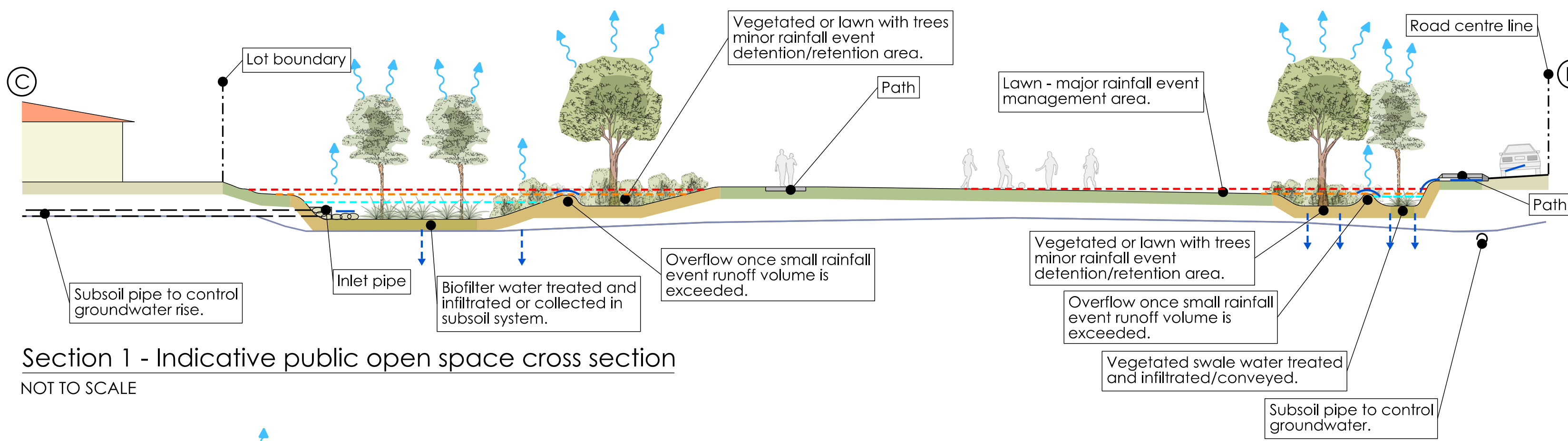
Example management options for estate scale – major rainfall event runoff



Diagrammatic to represent a variety of options. Not all options need occur in one site.
Apply site-responsive design. Not to scale

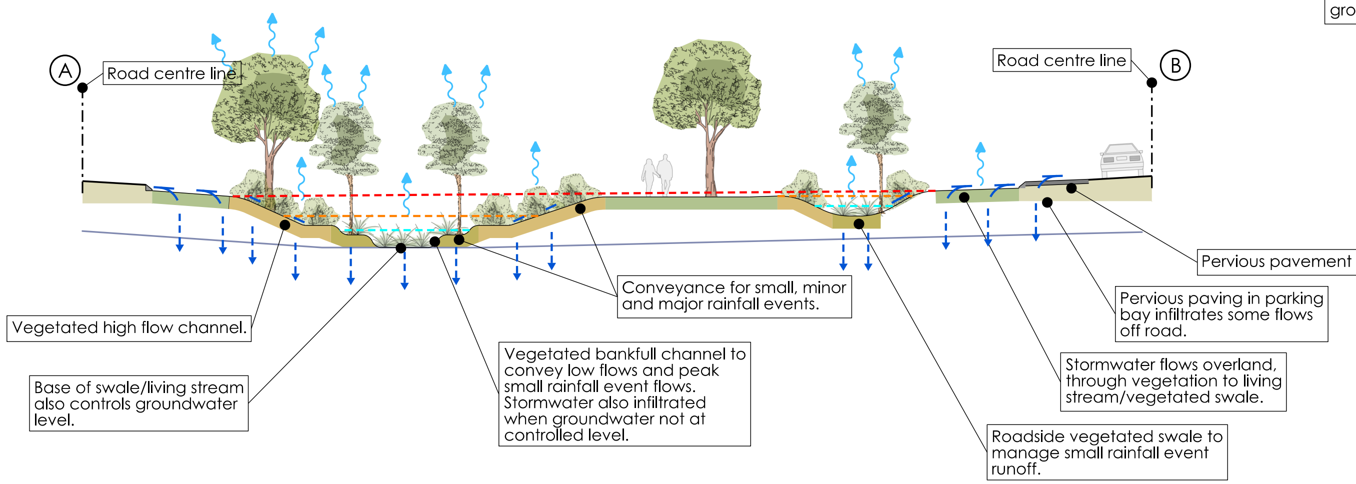
Figure 10

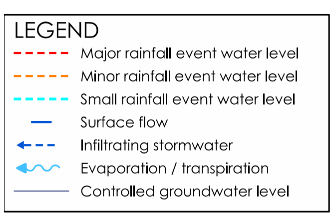
Cross-sections for public open space – all rainfall events



Section 1 - Indicative public open space cross section

NOT TO SCALE





Diagrammatic to represent a variety of options. Not all options need occur in one site.
Apply site-responsive design. Not to scale

5 Conclusion

Stormwater management is a significant component of water-sensitive urban design and of a water sensitive city or community. If designed, constructed and maintained well, stormwater systems provide multiple functions. When designing stormwater management systems, it is important to consider site-specific features, including how water moves in the natural landscape and the desired outcomes of the site. Multidisciplinary design and assessment teams are key to implementing water-sensitive stormwater systems.

The *Decision process for stormwater management in WA* provides the state government's approaches and criteria for managing runoff from small, minor and major rainfall events. It should be used in conjunction with local, state and federal government policies and guidelines for urban development, catchment management and integrated water and land use planning.

The overarching approach to water sensitive stormwater management is to think about how runoff behaves in a natural catchment and mimic that hydrology in the constructed stormwater system.

Shortened forms

AEP	Annual exceedance probability
ARI	Average recurrence interval
DWER	Department of Water and Environmental Regulation
DBCA	Department of Biodiversity, Conservation and Attractions
EY	Exceedance per year
POS	Public open space
WAPC	Western Australian Planning Commission

Glossary

Annual exceedance probability (AEP)	Expresses the probability of an event being equalled or exceeded in any year in percentage terms. For example, the 1 per cent AEP design flood discharge (Ball et al. 2016).
At-source	The site where stormwater runoff is created. This equates to on-lot for lot runoff and within road reserve for road runoff. If runoff enters a pipe or lined channel and is conveyed, the stormwater runoff is not being managed at-source.
Average recurrence interval (ARI)	The average time period between occurrences equalling or exceeding a given value (Ball et al. 2016).
Connected systems	All of the runoff from constructed impervious surfaces generated by the first 15 mm of rainfall directly enters a piped/lined channel system and is conveyed off the lot or off the road reserve.
Detention system	Reduces the rate of stormwater runoff by temporarily holding rainfall runoff (up to the design rainfall event) and then releasing it slowly.
Disconnected systems	All of the runoff from constructed impervious surfaces generated by the first 15 mm of rainfall flows onto pervious soil areas or into devices that provide for losses via infiltration, use and evaporation/transpiration and that achieve either retention and/or detention.
Effective imperviousness	The proportion of a catchment that consists of impervious surfaces directly connected to receiving water bodies by pipes (Ladson et al. 2006).
Exceedance per year (EY)	Expresses the probability of how many times in any year that event will occur. Events more frequent than 50 per cent AEP should be expressed as X exceedances per year (EY) (Ball et al. 2016).
Major rainfall event	Includes events greater than the minor rainfall event and up to and including the 1 per cent annual exceedance probability event.
Minor rainfall event	Rainfall events greater than small rainfall events and less than major rainfall events.
Non-structural controls	Institutional and pollution-prevention practices designed to prevent or minimise contaminants from entering stormwater runoff and/or reduce the volume of stormwater requiring management.
Pre-development	The conditions at the site immediately preceding the proposed development.
Relevant agency	Consult with: • Department of Biodiversity, Conservation and Attractions regarding changes to waterway management, when in the Swan Canning Catchment, and changes to wetland management

	• Department of Water and Environmental Regulation regarding changes to waterway management and to seek guidance on stormwater management criteria and changes to waterway and wetland management • Local government regarding changes to stormwater flows to a local drainage network • Water service provider (e.g. Water Corporation) regarding changes to stormwater flows to a main drainage network.
Retention system	Prevents stormwater runoff, up to the design rainfall event. The water may infiltrate into the soil, be used as a water source (e.g. by vegetation or for toilet flushing), evaporate, or evapotranspirate.
Sensitive receiving environments	Include the following environments, as defined in *Guidance statement no. 33: Environmental guidance for planning and development* (Environmental Protection Authority 2008): natural areas of high conservation significance (Chapter B1.2.1), native vegetation and flora of high conservation significance (Chapter B2.2.2), areas of high conservation significance for native terrestrial fauna (Chapter B3.2.2), wetlands of high conservation significance (Chapter B4.2.2), waterways of high conservation significance (Chapter B5.2.2), waterways conservation areas and the Swan River Management Area (attachment B5-5), public drinking water source areas (Chapter B6-1), landscapes and landforms of high conservation significance (Chapter B8.2.1), and karst areas of high conservation significance (Chapter B9.2.2).
Small rainfall event	The first 15 mm of a rainfall event.
Stormwater	Water that is 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 and insoluble) mobilised in its path of flow (Department of Water 2004).
Stormwater management system	A stormwater management system retains, detains, conveys and sometimes treats all stormwater runoff. Stormwater management systems can be structural controls, as well as the natural flow paths and receiving environments.
Stormwater quality treatment systems	Structural controls for treatment of small rainfall event runoff from constructed impervious surfaces that directly enters a piped/lined channel conveyance system. Examples are vegetated stormwater management systems, such as vegetated swales, biofilters and constructed wetlands, or proprietary water quality treatment devices. Water quality treatment for subsoil drains may also be achieved by placing appropriate soil media underneath and to the sides of the pipe filter pack to treat the groundwater before entering the pipe.

Structural controls	Engineered devices implemented to manage runoff quality and quantity, to control, treat or prevent stormwater pollution and/or reduce the volume of stormwater requiring management.
Urban development	Residential, rural-residential, commercial and industrial development (includes regional towns). It does not include heavy industrial development.
Water bodies	Wetlands, waterways and their estuaries, coastal marine areas and shallow groundwater aquifers.
Water management plans	Water quality improvement plans, drainage and water management plans, district water management strategies, local water management strategies, urban water management plans, drinking water source protection reports, river actions plans, waterway management plans, wetland management plans, natural resource management strategies, and environmental protection policies.
Waterway	Any river, creek, stream or brook, including its floodplain and estuary. This includes systems that flow permanently, for part of the year or occasionally; and parts of the waterway that have been artificially modified.
Water sensitive city	A water sensitive city combines physical infrastructure (water sensitive urban design and integrated urban water management) with social systems (governance and engagement) to create a city in which the connections that people have with their water infrastructure and services enhances their value and quality of life (Wong et al. 2013).
Water sensitive urban design	A planning and design approach that incorporates the sustainable management and integration of stormwater, groundwater, wastewater and water supply into the built form of houses, allotments, streets, suburbs and master planned communities.
Wetland	An area of seasonally, intermittently or permanently waterlogged or inundated land, whether natural or otherwise, and includes a lake, swamp, marsh, spring, dampland, tidal flat or estuary.

Guidelines and policies

Australian rainfall and runoff: a guide to flood estimation. Ball, J, Babister, M, Nathan, R, Weeks, W, Weinmann, E, Retallick, M and Testoni, I (Editors),Commonwealth of Australia (Geoscience Australia), Canberra. Available http://arr.ga.gov.au/arr-guideline.

Better urban water management. Western Australian Planning Commission, Perth available phone (08) 6551 9000.

Guidelines for district water management strategies. Department of Water, Perth. Available www.dwer.wa.gov.au or phone (08) 6364 7000.

Interim: Developing a local water management strategy. Department of Water, Perth. Available www.dwer.wa.gov.au or phone (08) 6364 7000.

Liveable neighbourhoods. Western Australian Planning Commission, Perth. Available by phone (08) 6551 9000.

Local government guidelines for subdivisional development. Institute of Public Works Engineering Australia (WA Division Inc.), Perth. Available www.ipwea.asn.au or phone (08) 9321 5306.

State planning policy no. 2.9: Water resources. Western Australian Planning Commission, Perth available phone (08) 6551 9000.

Stormwater management manual for Western Australia. Department of Water, Perth. Available www.dwer.wa.gov.au or phone (08) 6364 7000.

Urban water management plans – guidelines for preparing plans and for complying with subdivision conditions. Department of Water, Perth. Available www.dwer.wa.gov.au or phone (08) 6364 7000.

Water resource considerations when controlling groundwater levels in urban development. Department of Water, Perth. Available www.dwer.wa.gov.au or phone (08) 6364 7000.

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