A large, faint, light-green graphic is centered on the page. It features a water drop shape at the top left, which transitions into a drainage pipe structure extending towards the bottom right.

# **A GUIDE FOR WATER SENSITIVE URBAN DESIGN**

**Stormwater management for small-scale development**



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## Urban stormwater design

The aim of this document is to provide a user-friendly guide to assist with the design of stormwater systems on small-scale developments (up to 5000 m<sup>2</sup>) and to introduce the Water Sensitive SA online stormwater assessment tool, InSite Water, which is available at <https://www.watersensitivesa.insitewater.com/>

This guide assists stormwater professionals and other building designers to understand stormwater targets and how they can be met on private land.

As the area of impermeable surfaces connected to a drainage system increases, additional burden is placed on existing infrastructure. Existing pipe systems are designed for a specific purpose, such as for drainage for low density housing. As an area develops into higher density development, and more impervious surfaces are connected, piping systems no longer function well and are more frequently flooded. Additional stormwater runoff volumes and increased flooding frequency scour downstream watercourses and pollute coastal environments. Strategies to reduce this impact should be included as part of the development design process.

Stormwater design needs to consider the specific needs of a site, the conditions of the surrounding catchment, and the capacity of receiving waterways or drainage system. Water sensitive urban design (WSUD) promotes the sustainable management of water in new developments, and considers water from all sources including rainwater, stormwater, groundwater, mains water and waste water. WSUD measures can be applied to residential, commercial and industrial developments, including retention and detention storages, infiltration systems, at-source water quality treatments, and other systems as described on the South Australian Government Information and services website<sup>1</sup> SA.GOV.AU.

Efficient stormwater management in new developments has multiple social, economic and environmental benefits including:

- reduced supply costs for potable water where retention storages are incorporated for supplying toilets, hot water services, laundry washing and cold-water outlets, and irrigation systems
- reduced impervious surfaces resulting in reduced heat and stormwater runoff
- improved effectiveness and extended life of existing stormwater infrastructure.
- reduced flood risk and resultant damage
- improved stormwater quality to protect coastal environments from pollution
- protect the integrity of urban water courses from erosion
- creating greener urban environments with high visual amenity

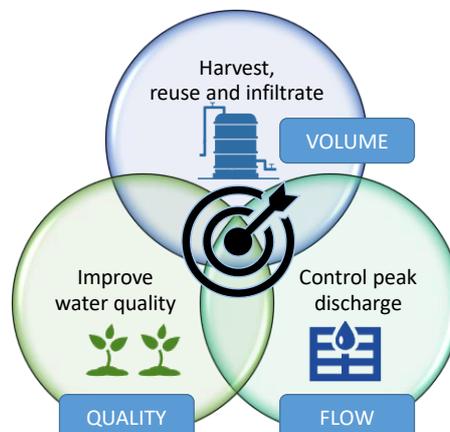


Figure 1 . Developments must target multiple criteria

<sup>1</sup> <https://www.sa.gov.au/topics/planning-and-property/land-and-property-development/planning-professionals/water-sensitive-urban-design>



## 1 Design and performance criteria

Urban stormwater design has traditionally focused on peak flow management only, however, design standards have evolved and now require stormwater design to consider the changes in catchment conditions that are created by urbanisation. Engineers Australia<sup>2</sup> now recommends the design and installation of volume reduction facilities and water quality improvement systems as part of stormwater drainage design. In addition, water efficiency and drought proofing is important in South Australia.

Developments must incorporate measures to address each of the following objectives:

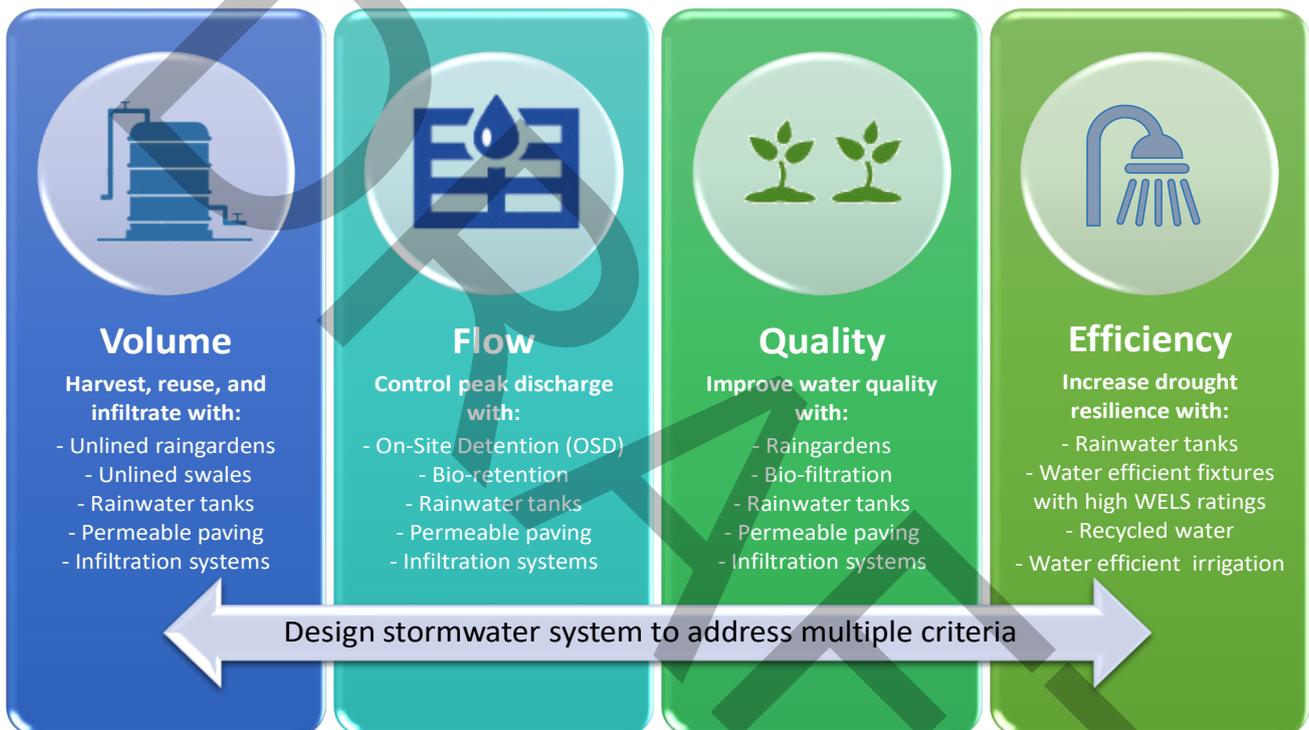


Figure 2. Stormwater management design objectives and potential management options

<sup>2</sup> Adapted from *Australian Rainfall and Runoff Guide – ARR 2016*, Engineers Australia 2016, see Chapter 9 (Urban Drainage)



## 1.1 Volume – harvest and re-use or infiltrate stormwater

**Performance Objective 1: Development sited and designed to ensure the average annual runoff volume increases by no more than 10%.**

This volume management objective is adapted from *Australian Rainfall and Runoff Guide* (ARR 2016)<sup>3</sup>, and removes excess stormwater runoff volume from a catchment for re-use or to recharge groundwater to provide the following benefits:

- increase soil moisture to support trees and canopy cover and benefit urban cooling
- maintain waterway stability and reduce scour
- maintain hydrologic behaviour in catchments including natural runoff regimes
- increase volume of water stored in an aquifer
- increase availability of water for harvesting and use

Average annual volume reduction can often be achieved through the implementation of permeable pavement systems, retention and/or infiltration systems. See *Water Sensitive SA Fact Sheet WSUD 02* for further information. Please note that this VOLUME objective is not directly related to peak stormwater discharge events (flooding), which is addressed by the next objective – FLOW. Average annual volume is a separate measure from peak discharge flows.

## 1.2 Flow – control peak stormwater discharge flows or volume

**Performance objective 2:**

### 2.1 Stormwater flow management performance measure – residential development

- **Post development peak rate of runoff from the development site for the critical design storm shall not exceed that from the pre-development site from a 5-year ARI (0.2 EY) storm event.**

### 2.2 Stormwater flow management performance measure – commercial, industrial and institutional development

- **Post development peak rate of runoff from the development site for the critical design storm shall not exceed that from the pre-development site from a 20 year ARI (5% AEP) storm event.**

This objective is to limit peak flood flows from minor flooding events is to provide the following benefits:

- reduce property flood damage
- reduce personal safety risks due to flood
- reduce infrastructure damage
- reduce upgrade requirements for council and stormwater authority infrastructure.

The capacity of the existing drainage system should not be exceeded. Ultimately the design storm event used for the design of the on-site drainage system should reflect the importance of a facility and the consequences of failure<sup>4</sup>. Note: in-ground drainage systems are usually only useful for minor flooding events in line with the above performance objectives. A comprehensive drainage plan must also address major flooding from rare rainfall events, and ensure overland flow paths are considered, and that buildings and assets are placed above major flood levels. Major flooding events are outside the scope of this guide, and professional design advice should be sought for your particular circumstances.

<sup>3</sup> Adapted from *Australian Rainfall and Runoff Guide – ARR 2016*, Engineers Australia 2016, see Chapter 9 (Urban Drainage)

<sup>4</sup> Adapted from *Australian Rainfall and Runoff Guide – ARR 2016*, Engineers Australia 2016, See Chapter 9 (Urban Drainage)



### 1.3 Quality – improve stormwater runoff water quality

#### Performance objective 3:

Development sited and designed to improve the quality of stormwater and minimise pollutant transfer to receiving waters by incorporating measures that reduce annual pollutant loads by:

- a) **80% for total suspended solids**
- b) **60% for total phosphorous**
- c) **45% for total nitrogen**
- d) **90% for gross pollutants.**

**compared with untreated stormwater runoff.**

This objective reduces urban runoff contamination to:

- maintain aquatic health and biodiversity
- maintain amenity of waterways
- protect coastal environments.

Stormwater quality and sediment control devices should typically be sized to treat the peak discharge that is generated during a design storm event. Design storm event for quality and sediment control devices should be between a 4 EY (3-month ARI) and a 1 EY (1-year ARI) storm event (see ARR 2016, Book 9, Chapter 3). The device should be designed with sediment control and for larger flows to bypass the device to reduce damage.

### 1.4 Water conservation and water-use efficiency

#### Objective 4:

Development designed to achieve **25% potable (mains) water reduction compared to a building that has no water saving features<sup>5</sup>**.

This objective reduces potable water demand to:

- reduce the risk of communities running low on water and improve drought resilience
- adapt to population growth and climate change
- reduce the need for new reservoirs and desalination plants
- allow for more environmental flows for aquatic ecosystems.

## 2 Rainwater tanks

The purpose of rainwater tanks is to: capture and use rainwater to conserve potable mains supplies; reduce stormwater runoff volumes; and to reduce pollutants reaching downstream waterways. Rainwater tanks are suitable on all developments, however they are most effective on developments that incorporate large roof areas (to maximise capture), and have high water demand such as residential dwellings or apartments, offices and public buildings, or developments with large gardens areas that require irrigation.

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<sup>5</sup> See Water Sensitive Urban Design (December 2010) – Greater Adelaide Region Technical Manual, Chapter 4 (Demand reduction)



Figure 3. Common rainwater (retention) tank installations (Source: A King)

### Design and application

To maximise rainwater re-use and reduce potable water supply, it is recommended that rainwater tanks be plumbed to all toilets, washing machines, laundry cold water outlets, and irrigation systems for any landscaped areas of the site. Rainwater tanks can also be connected to hot water services that include a water storage component, however these systems must comply with the National Construction Code (NCC) of Australia<sup>6</sup>. Considerations for connecting rainwater to hot water services are:

- ensure hot water is uniformly heated to 60° to “sterilise” it for contact use.
- install a fine mesh filter prior to hot water service inlet pipe to improve water quality – periodic maintenance is required
- ensure good quality pump is used to prevent fluctuation of water pressure and hence maintain a constant shower temperature
- install backflow prevention valve(s) as per NCC requirements.

Additional treatment is generally required when rainwater is to be used as a drinking water supply.

To ensure clean water supply in your rainwater re-use system, it is recommended that gutters are fitted with appropriate leaf guards, rainheads are fitted to downpipes, first flush diverters are fitted prior to the tank storage and mosquito screens fitted at the end of all pipes.

It is important that all engineering and architectural plans and specifications for new developments state the above requirements to ensure WSUD measures are implemented at the time of construction.

Rainwater tanks can include stormwater detention capabilities. These systems are referred to as combination retention/detention systems. The detention storage component is typically located at the top of the tank, with a restricted outlet orifice provided at a calculated height above the base of the tank to control peak flows. The detention component remains empty except during a rain event. The retention component is the permanent volume of stormwater stored at the bottom of the tank (below the restricted outlet orifice) that is available for use. Further information regarding detention systems is below.

<sup>6</sup> See NCC Plumbing Code of Australia PCA (Volume Three), Australian Building Codes Board, latest version at <https://www.abcb.gov.au/>

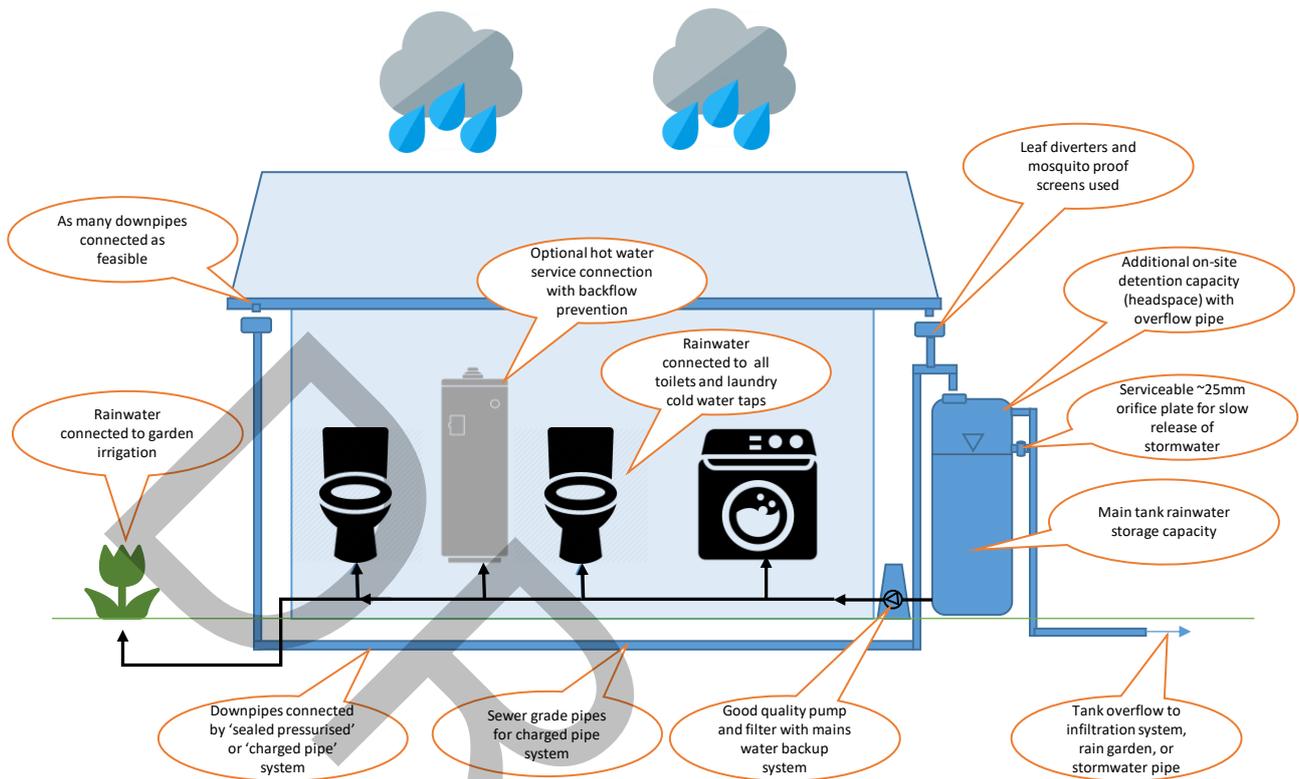


Figure 4. Schematic drawing of common rainwater tank installations

### 3 Infiltration systems

Infiltration systems consist of a shallow excavated trench, soakage well or tank, designed to retain a certain volume of stormwater runoff. The stored water permeates into surrounding soils, significantly reducing runoff volumes, having provided a pathway for treated runoff to recharge local groundwater aquifers and, in turn, surface water resources.

There are several different types of infiltration systems that are available to the designer, each of which suit different sites and applications. These are:

- infiltration trenches
- infiltration basins
- soakage wells or pipes
- permeable pavement
- infiltration swales.

Infiltration systems function best when high-infiltration soil types are present (sand or mildly reactive clays). Many suburbs within the metropolitan Adelaide area are characterised by reactive clays not suited to these systems. An estimation of a sites soil type can be determined by referring to the Department of Environment and Water Nature Maps at <https://data.environment.sa.gov.au/NatureMaps/Pages/default.aspx> and the *Soil Association Map of the Adelaide Region, Adelaide Geological Survey of South Australia 1972*. Alternatively, for more accurate results, a geotechnical engineer can be engaged to undertake site soil classification and percolation testing.



## Design and application

Guidance for the use of infiltration trenches and infiltration wells is outlined in *WSUD: Basic procedures for “source control” of stormwater – a handbook for Australian practice*<sup>7</sup>.

The use of on-site gravel trenches or soakage well infiltration systems in proximity to buildings and other structures is restricted to soil types classified as class A (Stable, non-reactive), Class S (Slightly reactive clay), class M (Moderately reactive clay) or class M-D (Deep moderately reactive clay).

To protect nearby footings, slabs and other structures from cracking due to movement, the surface movement due to soils should be equal to or less than 25 mm, as defined in AS 2870 and where the following conditions exist:

- The slope of the natural ground does not exceed 1 in 10;
- The depth to rock is 1.2 m or greater; and
- The groundwater table is permanently below 1.5 m from the natural ground surface or the final ground surface, whichever is the lowest.

Pre-treatment of water for removal of debris and sediment is essential. Pre-treatment measures include leaf filters for roof runoff, and sediment sumps, vegetated swales, bioretention systems or sand filters for surface runoff.

The use of on-site infiltration devices is not usually recommended on sites classified as reactive soils of type H / H-D, H1 / H1-D, H2 / H2-D, E / E-D and P as defined in AS 2870, unless in accordance with advice from a structural engineer. For a description of these soil types see the Glossary.

Table 1 - Infiltration characteristics of common soil types

Soil type	AS 2870 Classification	Soil Hydraulic Conductivity ( $K_h$ ) <sup>8</sup>	Minimum clearance from structures and boundaries <sup>9</sup>
Sandy soils and sandy loam	Class A	$5 \times 10^{-5}$ m/s (180 mm/hr) or greater	1 metre
Sandy clay	Class S	between $1 \times 10^{-5}$ and $5 \times 10^{-5}$ m/s (36–180 mm/hr)	2 metres
Weathered or fractured rock	Class A	between $1 \times 10^{-6}$ and $1 \times 10^{-5}$ m/s (3.6–36 mm/hr)	2 metres
Medium clay	Usually Class M / M-D	between $1 \times 10^{-6}$ and $1 \times 10^{-5}$ m/s (3.6–36 mm/hr)	4 metres
Heavy clay	Usually Class M / M-D	between $1 \times 10^{-8}$ and $1 \times 10^{-6}$ m/s (0.036–3.6 mm/hr)	5 metres

<sup>7</sup> Argue JR (2004/2013) *WSUD: Basic procedures for “source control” of stormwater – a handbook for Australian practice*. Urban Water Resources Centre, University of South Australia.

<sup>8</sup> Water, Melbourne. *WSUD Engineering Procedures: Stormwater: Stormwater* (Kindle Locations 6606-6609). CSIRO PUBLISHING. Kindle Edition.

<sup>9</sup> Argue JR (2004/2013) *WSUD: Basic procedures for “source control” of stormwater – a handbook for Australian practice*. Urban Water Resources Centre, University of South Australia.



## Infiltration pit sizing

A guide to sizing infiltration pits to capture the storm volume for a 1-in-5-year ARI 30 minute storm event in Adelaide is:

- 0.9 m diameter x 1.2 m high infiltration pit can connect up to 50 m<sup>2</sup> of roof (~1 downpipe)

Details for sizing an infiltration pit can be found in:

- *WSUD: Basic procedures for “source control” of stormwater – a handbook for Australian practice*<sup>10</sup>
- *Minister’s Specification SA 78AA - On-Site Retention of Stormwater*<sup>11</sup>

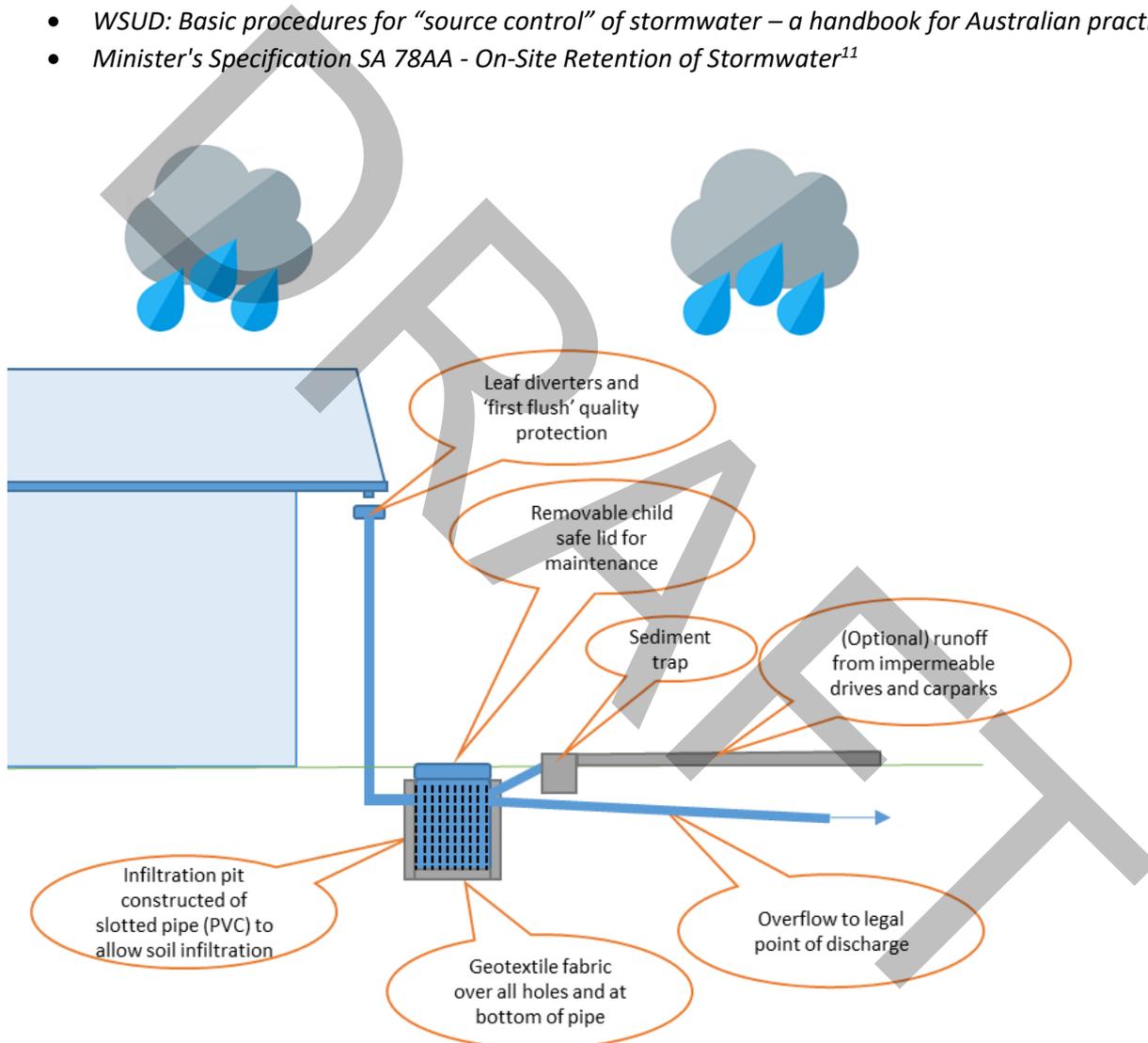


Figure 5. Example infiltration pit

<sup>10</sup> Argue JR (2004/2013) *WSUD: Basic procedures for “source control” of stormwater – a handbook for Australian practice*. Urban Water Resources Centre, University of South Australia.

<sup>11</sup> Minister’s Specification SA 78AA September 2003 *On-Site Retention of Stormwater* is available online at [https://www.sa.gov.au/\\_data/assets/pdf\\_file/0017/7046/SA\\_78AA\\_Onsite\\_retention\\_of\\_stormwater.pdf](https://www.sa.gov.au/_data/assets/pdf_file/0017/7046/SA_78AA_Onsite_retention_of_stormwater.pdf)



## Infiltration trench sizing

A guide to sizing infiltration pits to capture the storm volume for a 1-in-5-year ARI 30 minute storm event in Adelaide is:

- 0.9 m wide x 1.2 m high x 2.2m long infiltration pit trench connect up to 50 m<sup>2</sup> of roof (~1 downpipe)

Details for sizing an infiltration pit can be found in:

- *WSUD: Basic procedures for “source control” of stormwater – a handbook for Australian practice*<sup>12</sup>
- *Minister’s Specification SA 78AA - On-Site Retention of Stormwater*<sup>13</sup>

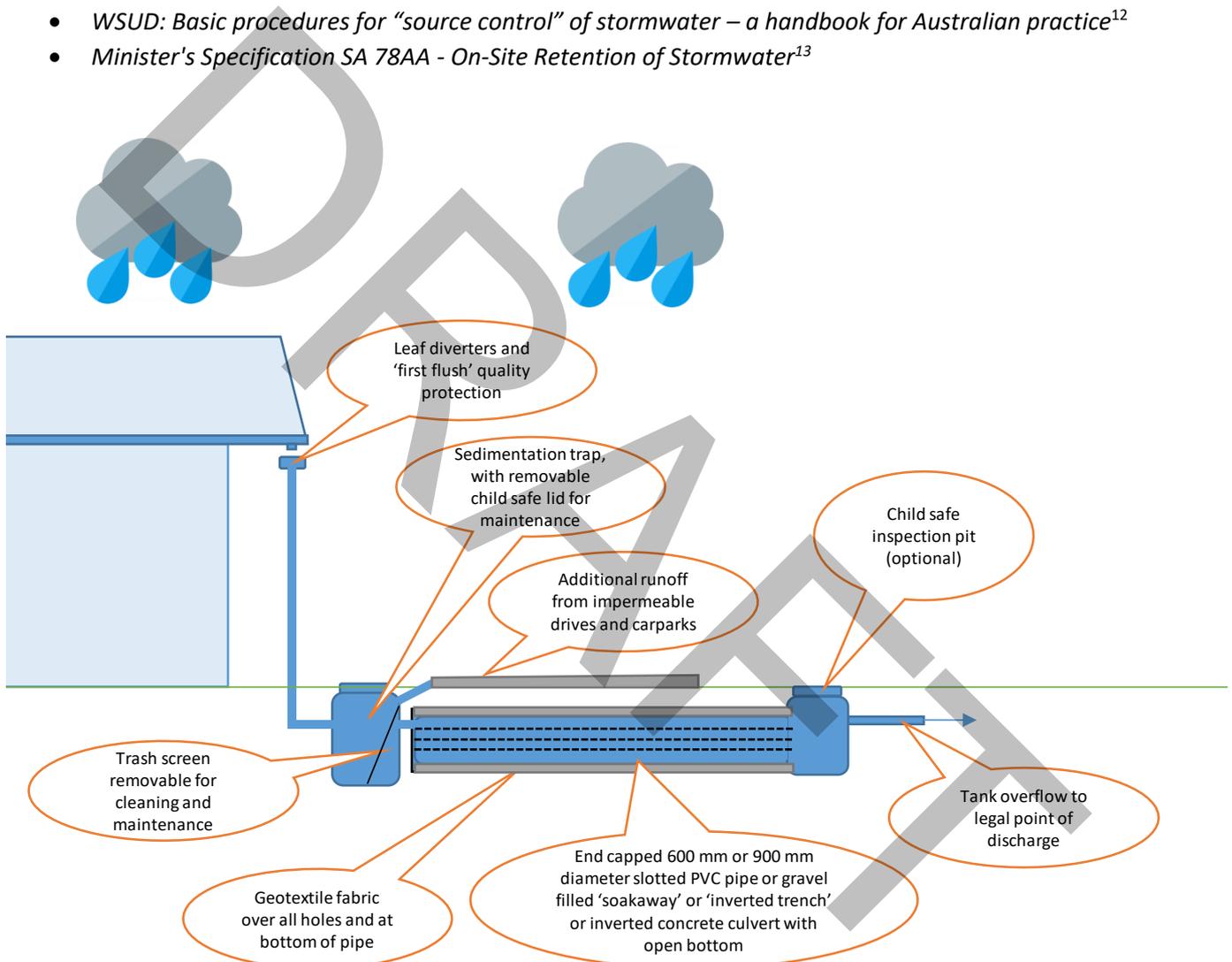


Figure 6. Example infiltration trench

<sup>12</sup> Argue JR (2004/2013) *WSUD: Basic procedures for “source control” of stormwater – a handbook for Australian practice*. Urban Water Resources Centre, University of South Australia.

<sup>13</sup> Minister’s Specification SA 78AA September 2003 *On-Site Retention of Stormwater* is available online at [https://www.sa.gov.au/\\_data/assets/pdf\\_file/0017/7046/SA\\_78AA\\_Onsite\\_retention\\_of\\_stormwater.pdf](https://www.sa.gov.au/_data/assets/pdf_file/0017/7046/SA_78AA_Onsite_retention_of_stormwater.pdf)



## 4 Permeable pavement systems

### Overview

Permeable pavement systems are pavement systems that allow stormwater to percolate through to a sub-surface course, from where it either infiltrates to the soil or is filtered back to the drainage system to subsurface soils or storages to reduce stormwater runoff. Underlying pavement layers can also include perforated pipes that allow the release of stormwater runoff into the receiving drainage system.

Permeable pavement systems provide two main advantages over regular impervious pavements: Improved water quality through filtering, interception and providing biological treatment; and reduced stormwater flow through infiltration and storage.

Permeable pavement systems commonly include interlocking block paving, porous concrete or plastic grids that provide structural stability to gravel or grassed paths, driveways and car parks. Single-sized gravel can also be used as an effective method of reducing stormwater runoff in low-traffic footpath and driveway areas.



Figure 7. Permeable paving (Source: A King)

### Design and application

Pervious pavement systems fall into two distinct categories:

- Porous surfaces: Comprising a layer of highly porous material (e.g. specially designed concrete or asphalt).
- Permeable pavements: Comprising a layer of interlocking paving blocks (either made with porous material or specially shaped to allow the ingress of water by way of vertical slots) to allow runoff through to the underlying surface.

Interlocking pavements or other systems rated to handle traffic are recommended where high traffic loads can be expected

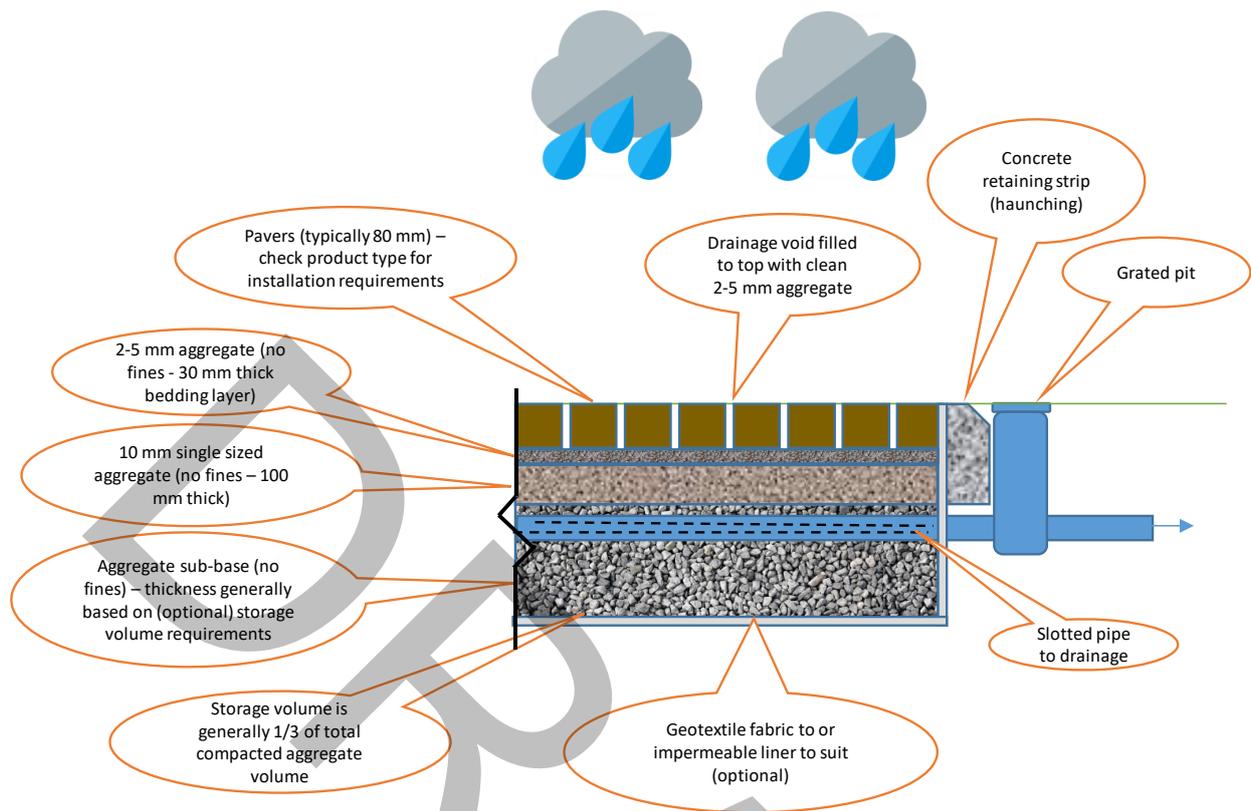


Figure 8. Example cross section of porous pavers

## 5 Bioretention systems (raingardens, bioswales and bioretention)

### Overview

Bioretention systems are also known as raingardens, biofilters, bio-infiltration systems and bioremediation systems. Common types of bioretention systems are:

**Raingardens** improve stormwater water quality by slowly filtering water through the soil layer to the drainage pipe at the base. Stormwater flows are diverted and pollutants removed through the processes of settlement (sedimentation) binding with components in the filter media, and by the action of specially selected plants and the associated microbial community.

**Bioretention basins** are shallow planted depressions that assist in redistributing excess rain and stormwater runoff from the roof of a development, as well as pervious and impervious surfaces. The process assists the rainwater and stormwater runoff to infiltrate the underlying soil, recharge the groundwater and reduce peak flows from the development.

**Bioretention swales and bioretention buffer strips** serve an identical purpose as bioretention basins in that they reduce the volumetric flow of stormwater and improve stormwater quality. Bioretention swales usually include gravel storage volume. The void spaces in gravel helps store runoff from impervious areas (i.e. a carpark or driveway).



Figure 9. Typical raingarden barrel/tank (top left), bioretention basin/raingarden (top right) and bioretention swale (bottom) installations.

### Design tips

For South Australian conditions, a rule of thumb guide is for the area of your raingarden to be between 0.5-2.0% of the area of the contributing catchment (e.g. area of roof or other impervious surfaces draining to the raingarden). For more information and tools for sizing and designing a raingarden see [www.watersensitivesa.insitewater.com](http://www.watersensitivesa.insitewater.com).

For guidance on plantings in a raingarden or bioretention system see the Water Sensitive SA [Guide to raingarden plant selection and placement](#)<sup>14</sup>

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<sup>14</sup> See Water Sensitive SA Guide to raingarden plant selection and placement <http://www.watersensitivesa.com/resources/publications-2/guidelines/bioretention/>

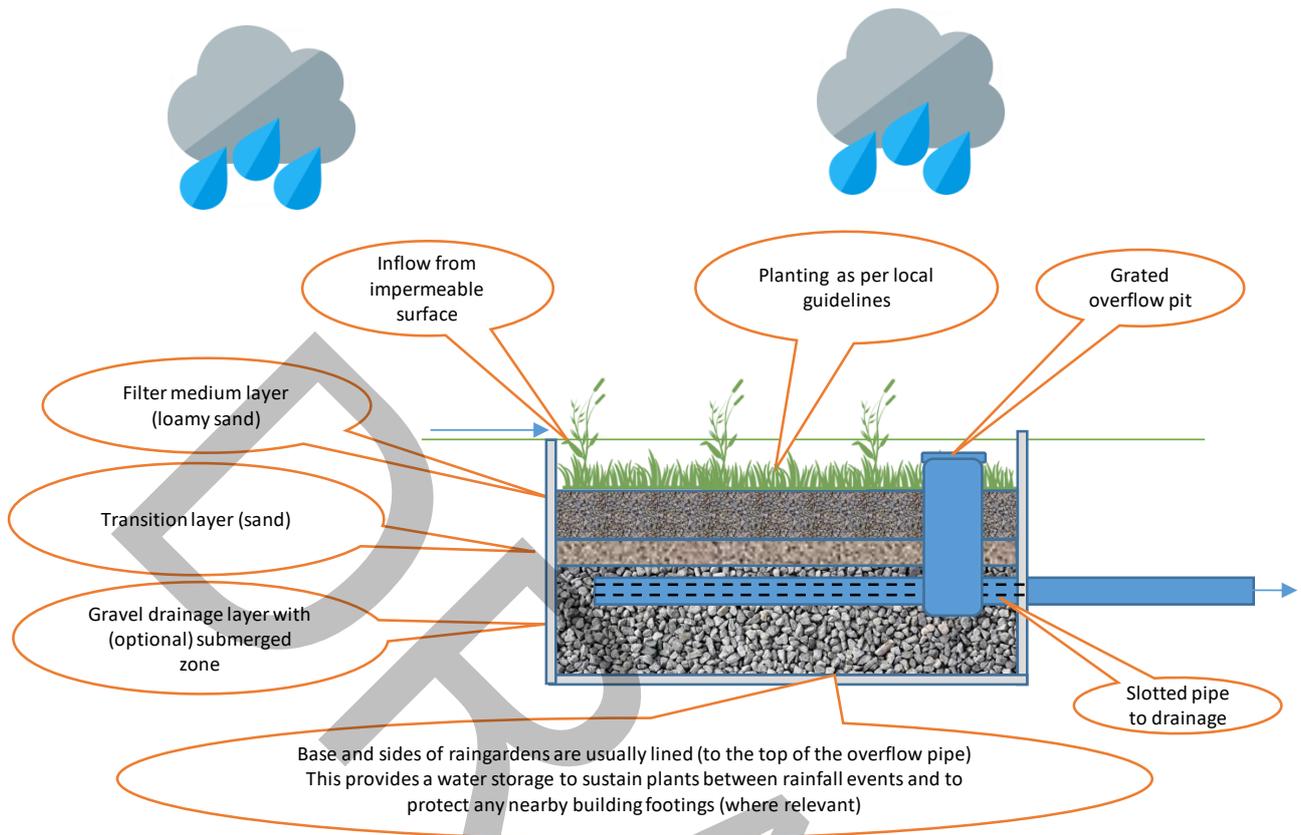


Figure 10. Bioretention raingarden.

## 6 Grass buffers and swales

**Grass buffers** are vegetated strips that convey hard runoff from an impermeable surface to a downstream drainage system. Buffers are effective in removing coarse and medium sized sediment from stormwater.

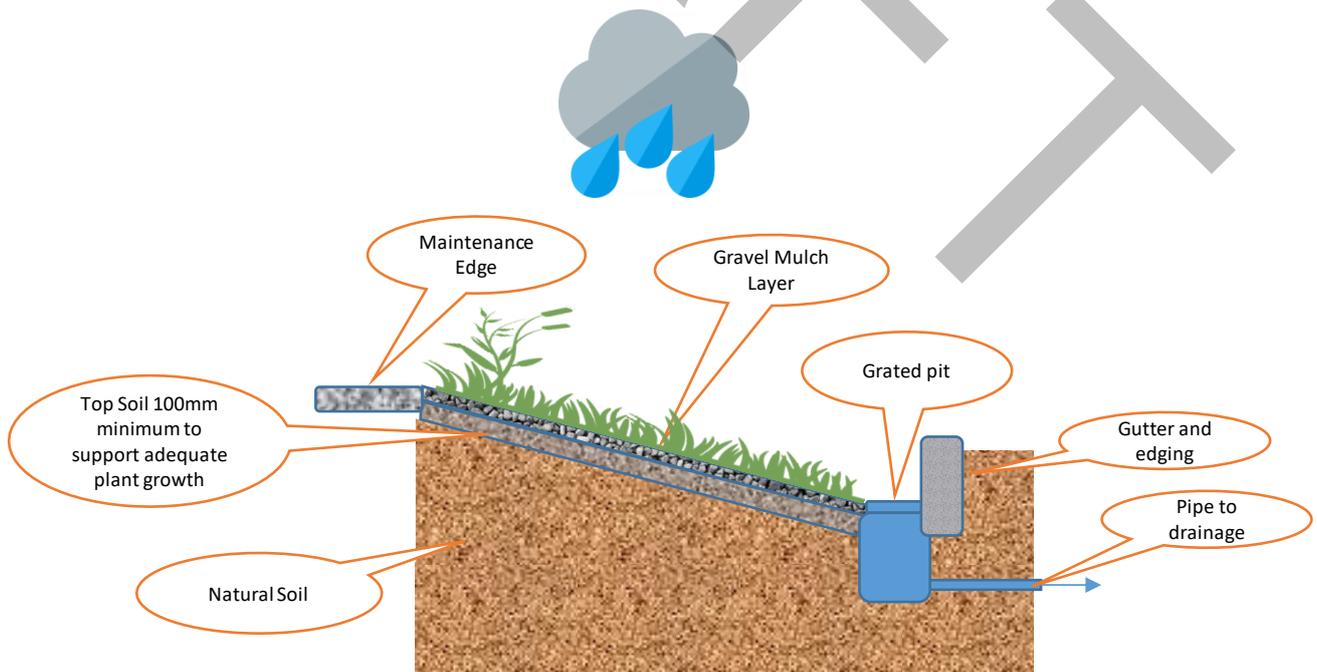


Figure 11. Grass Buffer simplified diagram



**Grass swales** are formed, vegetated channels that are used to convey runoff from impervious areas. They are typically shallow, linear, and wide. Grass swales can become features in the landscape, require minimal maintenance once established, and are hardy enough to withstand large flows. Grass swales differ from bioretention swales in that they normally have no underlying gravel and drainage layers.

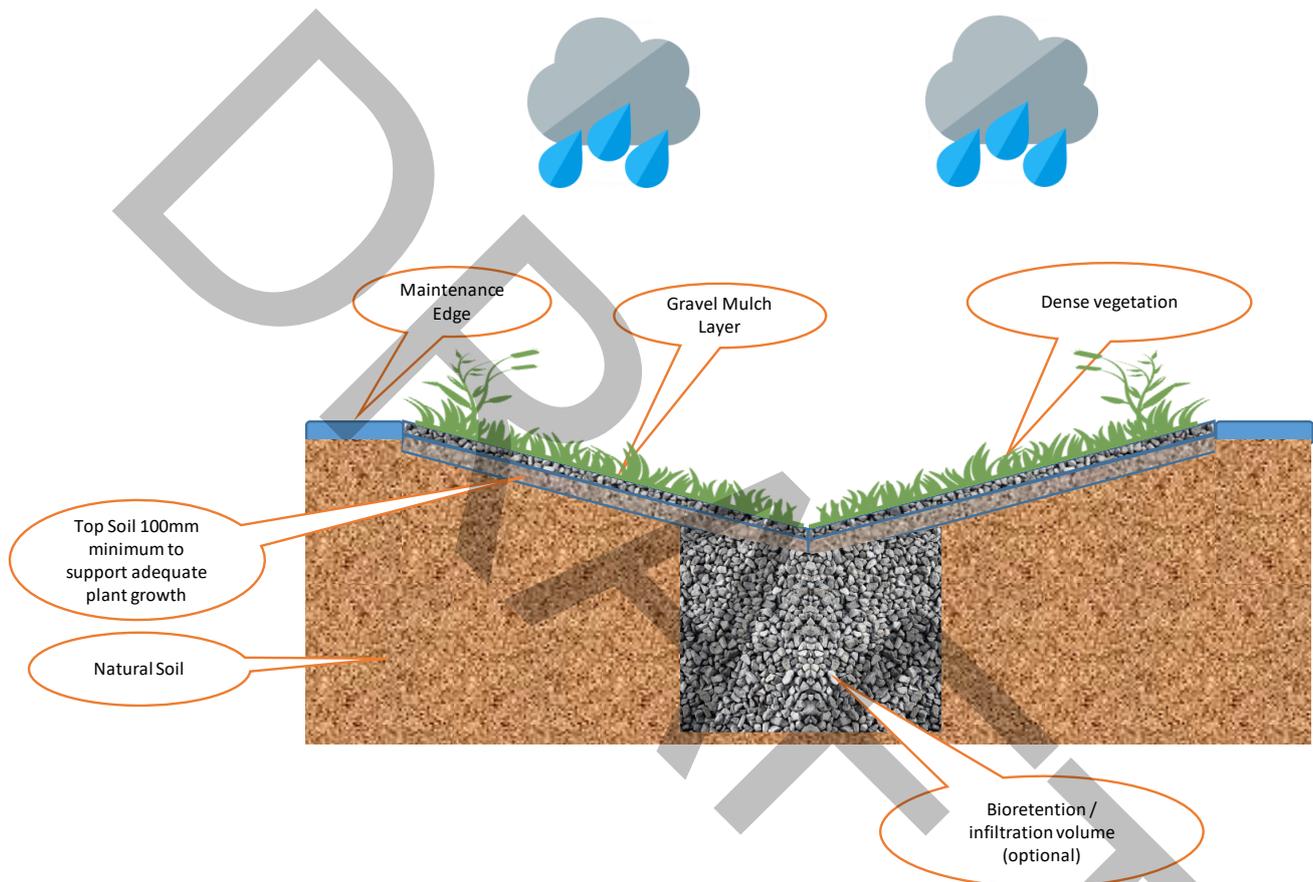


Figure 12. Swale simplified diagram

### Design tips

Ensure levels are correct so that runoff can enter the buffer unimpeded. Buffer strips are typically grassy areas although a range of species could be used. More detailed technical advice on the design on these systems can be found in *Water Sensitive Urban Design – Greater Adelaide Region Technical Manual*, Chapter 11 (Swales and Buffer Strips) and the *WSUD Engineering Procedures: Stormwater*, which can be purchased at [www.publish.csiro.au/book/4974](http://www.publish.csiro.au/book/4974)



## 7 Green roofs and living walls

### Overview

Green roofs and living walls can provide reduced energy costs, natural insulation, establish peaceful areas for individuals and a place for wildlife, as well as, absorb and treat stormwater. Additionally, green roofs improve air quality and aid in reducing the urban heat island effect; a condition in which cities and suburban developments absorb and trap heat.

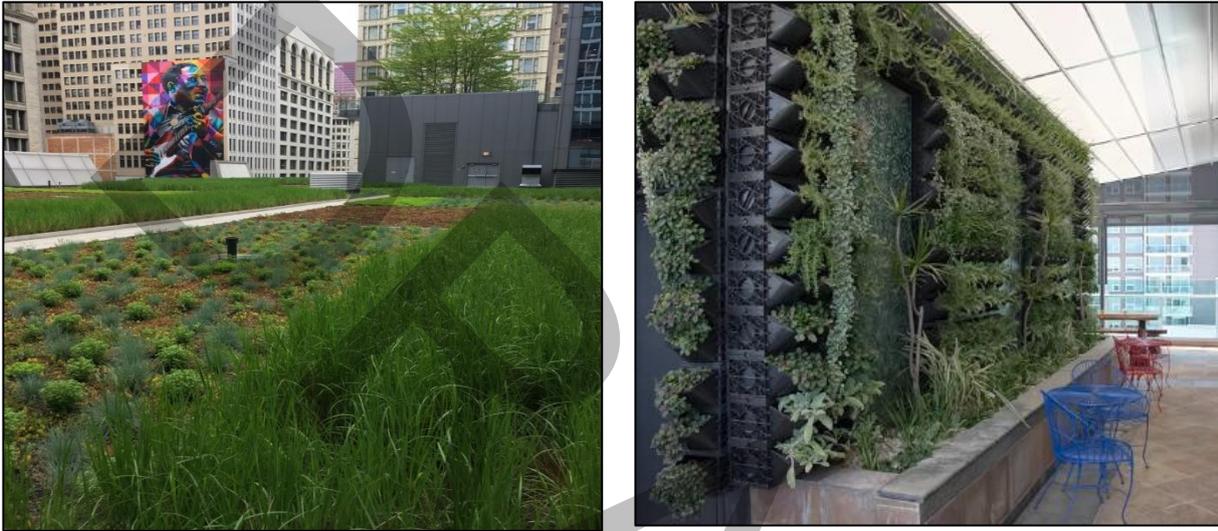


Figure 13. Example rooftop garden and living wall

### Design and application

Green roofs and living walls consist of a series of substrate layers to support drainage on top of built structures, provide thermal insulation, and can ameliorate the urban heat island effect<sup>15</sup>. The layers incorporated within green roofs and living walls must accommodate drainage and protect the built structure from moisture and water ingress. This is achieved through the inclusion of a waterproof membrane in the design. High-quality root repellent systems are also required for green roofs and living walls to further protect the surrounding structures. A typical cross section of a green roof is shown in Figure 14.

The most appropriate green roof for the Greater Adelaide region is a deeper substrate, which consists of depths between 150 and 600 millimetres of growing medium. Care should be taken that a structural engineer certifies that the building design can support a green roof, and that the design is resistant to heatwaves, as green roofs can “cook” in high temperatures, killing the vegetation. Design responses to improve performance in high temperatures can include deeper growing medium; water storage crystals; effective irrigation; partial shading with vegetation or structures, e.g. solar panels; and the use of annual native grasses and other summer heat resistant species.

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<sup>15</sup> For more information see the Growing Green Guide: A guide to green roofs, walls and facades in Melbourne and Victoria <http://www.growinggreenguide.org/>

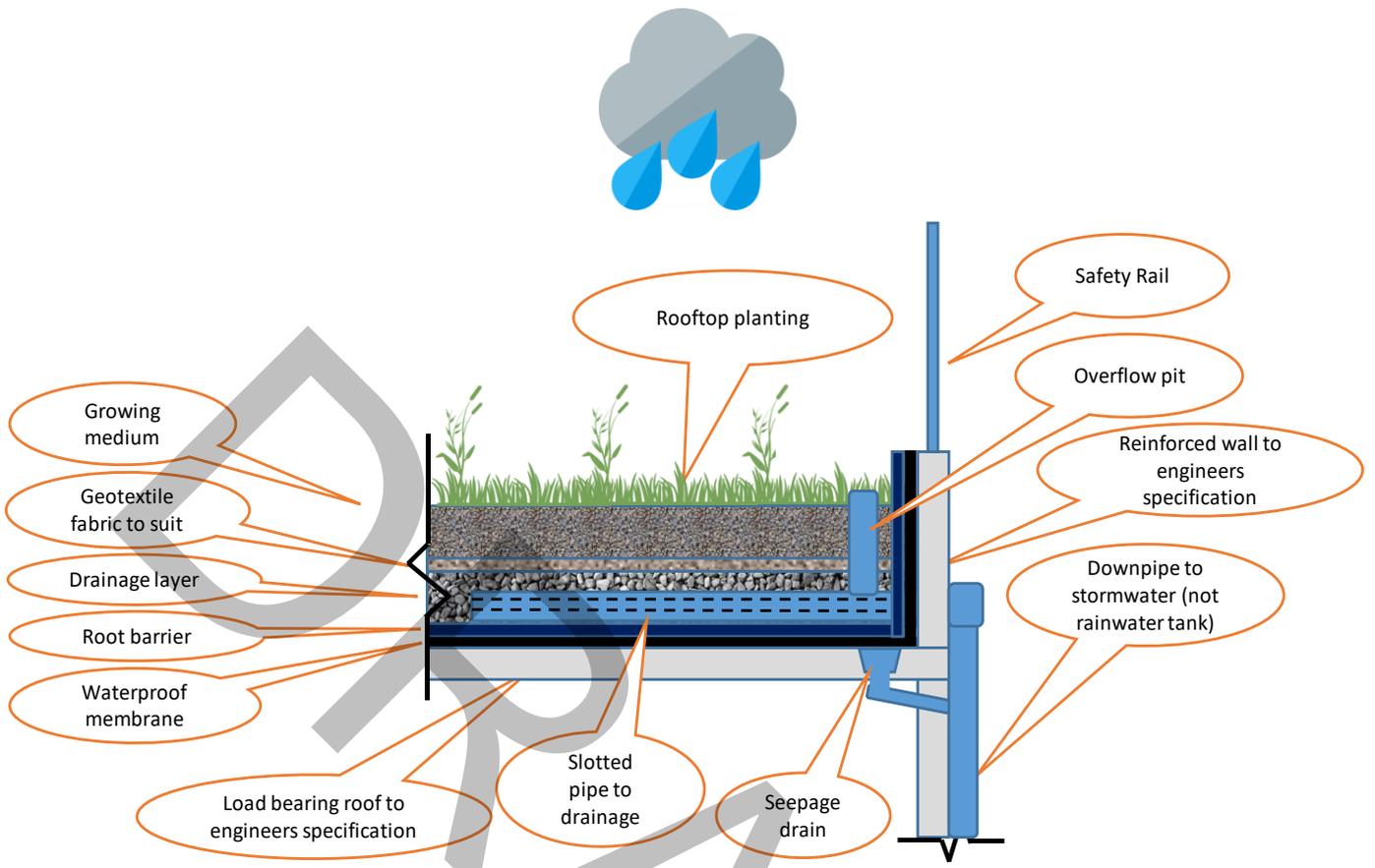


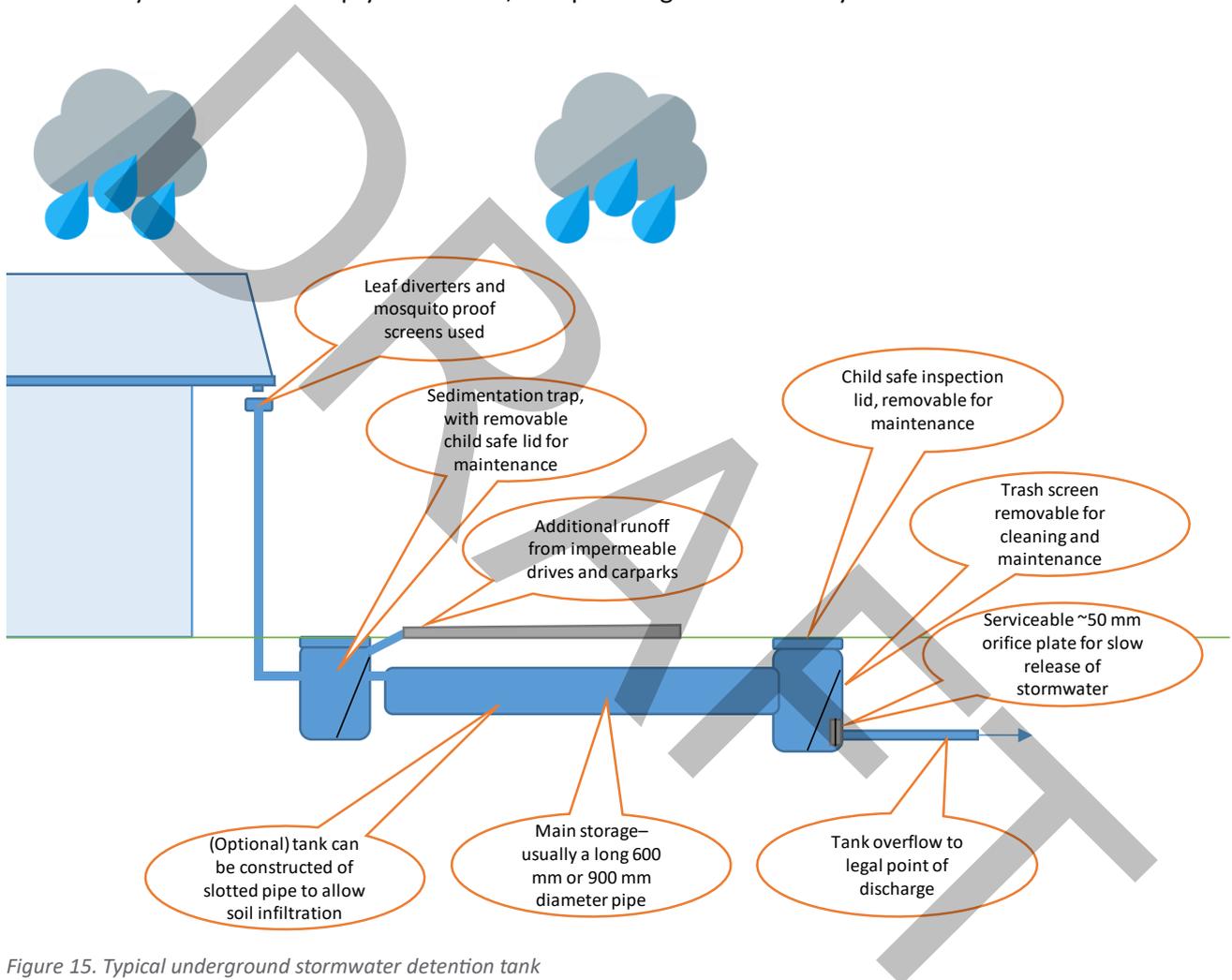
Figure 14. The various layers constituting a green roof design



## 8 On-site detention (OSD) tanks

### Overview

Detention systems are similar to retention systems, however the captured stormwater runoff is only temporarily “detained” for a short period of time, with stormwater discharged at a controlled (reduced) outflow rate. This helps to limit impacts on the capacity of the receiving drainage system. Stormwater detention systems remain empty at all times, except during or immediately after a rain event occurs.



### Design and application

Detention tanks are useful in areas where current stormwater infrastructure has aged – particularly where urban areas have densified over time, increasing impermeable areas connected to existing drainage systems. The installation of a detention tank aims to reduce local drainage overcapacity in existing infrastructure.

The effect is usually only locally beneficial, with overall catchment flood volumes remaining the same. The flow rate from the tank may be regulated by the size of the tank and orifice outlet. Onsite detention tanks must be designed to suit the requirements of the proposed building development and its location in the catchment. For more information see local Council and stormwater authority guidelines and AS/NZS 3500.3 (Stormwater Drainage).



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## 9 Water efficient fixtures and appliances

### Overview

Developments must incorporate water efficient appliances and fixtures such as showerheads, dishwashers, washing machines, basins, kitchen taps and toilets. The Australian Water Efficiency Labelling and Standards (WELS) scheme is an Australian Federal system established to rate appliances based on their water efficiency. It works by assigning a relevant WELS rating (WELS Star rating) label to certain products.



### Design and application

Projects should aim to meet best practice water efficiency standards wherever possible. The below recommended WELS ratings performance criteria has been specified in comparison with the industry benchmark.

Table 2 Water efficient appliances and fixtures – WELS Rating and associated water savings against industry benchmark, performance criteria and best practice

Typical fixture	Minimum requirements (used in InSite tool)	Best practice
Basins	4 Star WELS	5 Star WELS
Kitchen taps	4 Star WELS	5 Star WELS
Toilets	4 Star WELS	5 Star WELS
Showerheads	3 Star WELS (with flow between 7.5–9 litres/minute)	3 Star WELS (with flow between 6–7.5 litres/minute)
Urinals	4 Star WELS	5 Star WELS
Dishwashers	3 Star WELS	5 Star WELS
Washing machines	3 Star WELS	5 Star WELS
Baths	Medium Sized Contemporary Bath	Small square tub/combined shower

The 25% potable (mains) water reduction performance target compared to a building that has no water saving features can generally be met by using a combination of efficient water fittings and a rainwater tank to supply water for appropriate household uses. This section provides recommended fitting specifications in accordance with the Australian Water Efficiency Labelling and Standards (WELS) for water efficiency of fittings<sup>16</sup>.

See *Water Sensitive SA Fact Sheet WSUD 02* for recommended rainwater tank sizes to meet both water saving and stormwater objectives.

<sup>16</sup> See <http://www.waterrating.gov.au/> for more information on WELS ratings



## Disclaimer

This guide is of a general nature only. Advice from a suitably qualified professional should be sought for your particular circumstances. Depending on each unique situation, there may be occasions where compliance is not achieved. The following is outside the scope of this guide, however it is critical that all designers consider the following:

- Manage expectations and risks around occasional surface water and ponding.
- Ensure that uncontrolled stormwater does not flow over property boundaries or otherwise cause a nuisance.
- Plan for major flood pathways – locate away from, adapt (raise floors above predicted flood levels) and defend buildings against potential major flooding.
- Plan to reduce annual average damages and safety risks.
- Take into account local conditions such as slope, topography and soils (type, reactivity, permeability, water table level, salinity, dispersiveness, acid sulphate soils, etc.).
- Ensure that soil moisture and building clearance is considered in areas of reactive clays or where varying soil moisture levels could damage buildings.
- For steeper sites, ensure the design includes geotechnical considerations such as slope stability with varying soil saturation levels.
- Compliance with other Australian Standards, regulations and Council requirements.



## Glossary of common stormwater design terms

Term	Definition
AEP	<b>Annual exceedance probability</b> is defined as: The probability that a given rainfall total accumulated over a given duration will be exceeded in any one year. With ARI expressed in years, the relationship is: $AEP = 1 - \exp(-1/ARI)$ . Further discussion of stormwater terminology can be found in Book 1; Chapter 2; Section 2.2 Terminology of ARR 2016 <a href="http://arr.ga.gov.au/arr-guideline">http://arr.ga.gov.au/arr-guideline</a>
ARI	<b>Average recurrence interval</b> is defined as: The average, or expected, value of the periods between exceedances of a given rainfall total accumulated over a given duration.
ARR 2016	<b>Australian Rainfall and Runoff</b> (Engineers Australia 2016, published at <a href="http://arr.ga.gov.au">http://arr.ga.gov.au</a> ) is a national guideline document, data and software suite that is the default national standard for the estimation of design flood characteristics in Australia.
Deemed to satisfy	A simplified checklist approach to achieving compliance targets (as opposed to a custom designed or software modelled approach).
ESD	<b>Environmentally sustainable development</b>
EY	<b>Exceedances per year</b> The number of times an event is likely to occur or be exceeded within any given year.
Infill growth	Growth occurring through densification of existing developed areas.
InSite Water	An integrated water cycle management design toolkit focused on Council approvals for infill growth <a href="http://www.insitewater.com.au">www.insitewater.com.au</a>
IFD	<b>Intensity-frequency-duration</b> Data generated for engineers and hydrologists to understand design rainfall events <a href="http://www.bom.gov.au/water/designRainfalls/ifd/">http://www.bom.gov.au/water/designRainfalls/ifd/</a> . The 2016 Intensity–Frequency–Duration (IFD) design rainfalls are provided for use in conjunction with the 2016 edition of <i>Australian Rainfall and Runoff</i> (ARR 2016)
Integrated water management	A multi-disciplinary and multi-objective approach for the sustainable use of available resources with the objectives of environmental protection, and minimising water demands, wastewater discharges and stormwater runoff.
$K_h$	<b>Saturated Hydraulic Conductivity.</b> If no data is available for a site, field hydraulic conductivity tests must be undertaken to confirm assumptions of soil hydraulic conductivity adopted during the concept design stage. Field soil hydraulic conductivity ( $K_h$ ) can be determined using the falling head auger hole test method.
OSD	<b>On site detention</b> A common practice of slowing down stormwater release rates into stormwater drains by using a detention tank with a known outflow rate.
Rainwater	Rainfall collected from the roofs of buildings.
Rainwater tank	A water tank that is used to collect and store rainwater runoff, typically from rooftops via rain gutters.



Soil site classification	<p>Soils site classification is according to <i>Australian Standard AS 2870/2011 - Residential slabs and footings</i></p> <p>Site classifications and movement are based on soil reactivity</p> <p><b>Class A (0-10mm)</b> Stable, non-reactive. Most sand and rock sites. Little or no ground movement likely as a result of moisture changes.</p> <p><b>Class S (10-20mm)</b> Slightly reactive clay sites. May experience slight ground movement as a result of moisture changes.</p> <p><b>Class M / M-D (20-40mm)</b> Moderately reactive clay or silt sites. May experience moderate ground movement as a result of soil conditions and moisture changes.</p> <p><b>Class H1 / H1-D (40-60mm)</b> Highly reactive clay sites. May experience a high amount of ground movement as a result of soil conditions and moisture changes.</p> <p><b>Class H2 / H2-D (60-75mm)</b> Highly reactive clay sites. May experience very high ground movement as a result of soil conditions and moisture changes.</p> <p><b>Class E / E-D (75mm+)</b> Extremely reactive sites. May experience extreme amounts of ground movement as a result of soil conditions and moisture changes.</p> <p><b>Class P</b> (this is approximately 70% of building sites in Australia) Problem sites. Sites may be classified as 'Class P' as a result of mine subsidence, landslip, collapse activity or coastal erosion (e.g. dunes), soft soils with a lack of suitable bearing, cut and/or filled sites, or creep areas. Ground movement as a result of moisture changes may be very severe. If you are building on a Class P site you will need to consult a structural engineer.</p> <p>The 'D' inclusion (i.e M-D, H1-D, H2-D or E-D) The 'D' in these classifications refers to 'deep' movements in soil due to deep variances in moisture. These classifications are mostly found in dry areas.</p>
Stormwater	Rainfall that runs off all urban surfaces such as roofs, pavements, car parks, roads, gardens and vegetated open space.
$t_c$	$t_c$ – “time of concentration” reserved for SITE-ONLY (runoff) travel time
$T_c$	$T_c$ – “critical storm duration”, a CATCHMENT-WIDE PROPERTY
TN	<b>Total nitrogen</b> The sum of the nitrogen present in all nitrogen-containing components in a given water sample at certain temperature over a specific time period. Best practice is a 45% reduction target of typical urban annual load.
TP	<b>Total phosphorus</b> The sum of the phosphorus present in all phosphorus-containing components in a given water sample at certain temperature over a specific time period. Best practice is a 45% reduction target of typical urban annual load.
TSS	<b>Total suspended solids</b> A water quality measurement of the mass of fine inorganic particles suspended in a given water sample at a certain temperature over a specific time period. Best practice is an 80% reduction target of typical urban annual load.
WELS	Australian Water Efficiency Labelling Standards scheme.
WSUD	<b>Water sensitive urban design</b> Design principles that aim to reduce the impact of interactions between the urban built form and the urban water cycle including surface water, potable water, groundwater, urban and roof runoff, wastewater and stormwater.

## Guide for water sensitive urban design – Stormwater Management

### Residential development – small scale, deemed-to-satisfy solutions

This guide provides simple options to meet stormwater management requirements. Simplified options are called deemed-to-satisfy (DTS) solutions. If implemented, these designs will satisfy the stormwater management performance objectives for runoff volume, flow and quality and water conservation for your Council. The options provided will suit the majority of applicants to:

- increase the efficiency of development application and approval processes
- achieve better outcomes for flood risk, stormwater quality, amenity and microclimate (where possible).

The design solutions are suitable for smaller sites up to 600 m<sup>2</sup> per dwelling as indicated.

For larger sites (allotments above 600 m<sup>2</sup> and less than 2,500 m<sup>2</sup>) and for sites where the DTS solutions are unsuitable, compliance with the stormwater management performance objectives can be demonstrated by applying [InsiteWater](http://www.watersensitivesa.insitewater.com/) (<http://www.watersensitivesa.insitewater.com/>) instead of this guide.

Councils will require that the approach chosen must be supported by the design details for a development and with subsequent construction, commissioning, and maintenance. Prior to construction the design must be checked by a qualified professional.

This guideline offers two DTS approaches:

- rainwater tank approach – retention only or combined retention and detention
- infiltration approach

Residential dwellings include single allotments and townhouse subdivisions. If more than one dwelling per lot, the allotment size for the purpose of this DTS guideline is the area of each residential land parcel post land division (e.g. a 700 m<sup>2</sup> block divided equally into two land parcels would each have an allotment size of 350 m<sup>2</sup>).

## 9.1 Infiltration and urban cooling

Infiltration approach	Council objectives
<p>The approach uses <u>infiltration systems only</u> to meet Council flow, volume and quality targets.</p> <p>This will maximise the infiltration of stormwater to the soil to help sustain the health of trees, shrubs and grassed areas in private landscaped areas and adjacent street verges. Increasing the moisture in the soil available for plants will also keep outdoor areas cooler.</p> <p><b>Design criteria</b></p> <ul style="list-style-type: none"> <li>☑ Sedimentation trap, a grass filter strip or swale must be built before any infiltration pits.</li> <li>☑ Infiltration pits and pipes are sized to allow the volume outlined as per the below table.</li> <li>☑ The final design will be a product of contributory area, quality and quantity of runoff, soil infiltration capacity, and the geometry and void space of the infiltration device used and soil characteristics.</li> <li>☑ Wrapping infiltration devices in geotextile will prevent the ingress of fines.</li> <li>☑ An overflow must be provided to direct excess flows to Council’s stormwater drainage system.</li> <li>☑ Consideration of soil type and swell is important when locating gravel trenches near buildings and other structures.</li> </ul> <p><b>Notes</b></p> <ol style="list-style-type: none"> <li>1. Impervious surfaces including roofs, parking bays and driveways should be used to calculate the percentage imperviousness.</li> <li>2. To reduce the percentage imperviousness, install permeable paving for the driveway / parking area.</li> <li>3. Volumes in the below table are calculated in accordance with <i>WSUD: Basic procedures for “source control” of stormwater – a handbook for Australian practice</i><sup>17</sup></li> <li>4. Additional guidance is provided within the: <ul style="list-style-type: none"> <li>• <a href="#"><i>Minister’s Specification SA 78AA Onsite retention of stormwater</i></a><sup>18</sup></li> <li>• <i>WSUD: Basic procedures for “source control” of stormwater – a handbook for Australian practice</i><sup>19</sup></li> <li>• <i>Soil classification is according to Australian Standard AS 2870 - Residential slabs and footings</i></li> </ul> </li> </ol>	 <p>FLOW</p>  <p>VOLUME</p>  <p>QUALITY</p>

<sup>17</sup> Argue JR (2004/2013) *WSUD: Basic procedures for “source control” of stormwater – a handbook for Australian practice*. Urban Water Resources Centre, University of South Australia.

<sup>18</sup> Minister’s Specification SA 78AA [\*Onsite retention of stormwater\*](#)

<sup>19</sup> Argue JR (2004/2013) *WSUD: Basic procedures for “source control” of stormwater – a handbook for Australian practice*. Urban Water Resources Centre, University of South Australia.



Table 2. Infiltration systems approach for Sand or Sandy Loam soils (Soil Class A) and for Sandy Clay soils (Soil Class S) – deemed-to-satisfy solutions

		Allotment size (m <sup>2</sup> )				
		Less than 200 m <sup>2</sup>	Less than 300 m <sup>2</sup>	Less than 400 m <sup>2</sup>	Less than 500 m <sup>2</sup>	Less than 600 m <sup>2</sup>
Site percentage imperviousness	70%	Infiltration Volume 1.9 m <sup>3</sup>	Infiltration Volume 2.9 m <sup>3</sup>	Infiltration Volume 3.8 m <sup>3</sup>	Infiltration Volume 4.8 m <sup>3</sup>	Infiltration Volume 5.7 m <sup>3</sup>
	80%	Infiltration Volume 2.2 m <sup>3</sup>	Infiltration Volume 3.3 m <sup>3</sup>	Infiltration Volume 4.4 m <sup>3</sup>	Infiltration Volume 5.4 m <sup>3</sup>	Infiltration Volume 6.5 m <sup>3</sup>
	90%	Infiltration Volume 2.4 m <sup>3</sup>	Infiltration Volume 3.7 m <sup>3</sup>	Infiltration Volume 4.9 m <sup>3</sup>	Infiltration Volume 6.1 m <sup>3</sup>	Infiltration Volume 8.2 m <sup>3</sup>
	100%	Infiltration Volume 2.7 m <sup>3</sup>	Infiltration Volume 4.1 m <sup>3</sup>	Infiltration Volume 5.4 m <sup>3</sup>	Infiltration Volume 6.8 m <sup>3</sup>	Use InSite Water toolkit or reduce impermeable surface area

Table 3. Infiltration systems approach for Medium Clay soils (Soil Class M / M-D) – deemed-to-satisfy solutions

		Allotment size (m <sup>2</sup> )				
		Less than 200 m <sup>2</sup>	Less than 300 m <sup>2</sup>	Less than 400 m <sup>2</sup>	Less than 500 m <sup>2</sup>	Less than 600 m <sup>2</sup>
Site percentage imperviousness	70%	Infiltration Volume 2.2 m <sup>3</sup>	Infiltration Volume 3.2 m <sup>3</sup>	Infiltration Volume 4.3 m <sup>3</sup>	Infiltration Volume 5.4 m <sup>3</sup>	Infiltration Volume 6.5 m <sup>3</sup>
	80%	Infiltration Volume 2.5 m <sup>3</sup>	Infiltration Volume 3.7 m <sup>3</sup>	Infiltration Volume 4.9 m <sup>3</sup>	Infiltration Volume 6.2 m <sup>3</sup>	Infiltration Volume 7.4 m <sup>3</sup>
	90%	Infiltration Volume 2.8 m <sup>3</sup>	Infiltration Volume 4.2 m <sup>3</sup>	Infiltration Volume 5.5 m <sup>3</sup>	Infiltration Volume 6.9 m <sup>3</sup>	Infiltration Volume 8.3 m <sup>3</sup>
	100%	Infiltration Volume 3.1 m <sup>3</sup>	Infiltration Volume 4.6 m <sup>3</sup>	Infiltration Volume 6.2 m <sup>3</sup>	Infiltration Volume 7.7 m <sup>3</sup>	Use InSite Water toolkit or reduce impermeable surface area



## 9.2 Rainwater tank approach

Rainwater tank approach	Stormwater objectives met
<p>To meet stormwater runoff volume, peak flow reduction and water quality targets this approach uses rainwater tanks, incorporating combined retention (usable rainwater tank volume) <u>and</u> detention (tank volume with a slow release orifice that will gradually empty),.</p> <p>Potential tank size and integrated detention volume is indicated in Table Table 2 based upon allotment size and percentage imperviousness available.</p> <p><b>Design criteria</b></p> <ul style="list-style-type: none"> <li><input checked="" type="checkbox"/> Rainwater tanks are connected to at least 60% of the roof area.</li> <li><input checked="" type="checkbox"/> The rainwater tank is connected to all toilets, external irrigation (if applicable) and all washing machine cold taps. Rainwater can also be connected to the How Water System (optional).</li> <li><input checked="" type="checkbox"/> Slow release orifice at the bottom of the detention component of the tank should be 20-25 mm in diameter.</li> <li><input checked="" type="checkbox"/> Impervious surfaces including roofs, carparks and driveways should be used to calculate the percentage imperviousness of the site.</li> </ul> <p><b>Notes</b></p> <ol style="list-style-type: none"> <li>To reduce the percentage impervious, install permeable paving for the driveway/parking areas</li> </ol>	 <b>FLOW</b>  <b>VOLUME</b>  <b>QUALITY</b>

Table 4. Rainwater tank (combined retention and detention) approach – Deemed-to-satisfy solutions

		Allotment size (m <sup>2</sup> )				
		Less than 200 m <sup>2</sup>	Less than 300 m <sup>2</sup>	Less than 400 m <sup>2</sup>	Less than 500 m <sup>2</sup>	Less than 600 m <sup>2</sup>
Site percentage imperviousness	70%	Retention: 1000 L Detention: 1000 L	Retention: 1000 L Detention: 1000 L	Retention: 1000 L Detention: 1000 L	Retention: 2000 L Detention: 1000 L	Retention: 3000 L Detention: 1000 L
	80%	Retention: 1000 L Detention: 1000 L	Retention: 1000 L Detention: 1000 L	Retention: 2000 L Detention: 1000 L	Retention: 2000 L Detention: 1000 L	Retention: 4000 L Detention: 1500 L
	90%	Retention: 1000 L Detention: 1000 L	Retention: 1000 L Detention: 1000 L	Retention: 2000 L Detention: 1000 L	Retention: 3000 L Detention: 1500 L	Retention: 4000 L Detention: 2000 L
	100%	Retention: 1000 L Detention: 1000 L	Retention: 2000 L Detention: 1000 L	Retention: 3000 L Detention: 1500 L	Retention: 3000 L Detention: 2000 L	Use InSite Water toolkit or reduce impermeable surface area

In addition to the deemed to satisfy solutions it is desirable to:

- choose pervious surface options for driveways, paths, and courtyards where appropriate
- direct stormwater runoff from paths and driveways to landscaped areas.

## Guide for water sensitive urban design – Stormwater Management

### Residential development – compliance with the InSite Water toolkit

A water sensitive urban design (WSUD) approach can be applied at a range of scales from the individual allotment to townhouses developments and apartment buildings. To meet stormwater runoff volume reduction, peak flow, and quality targets and water use efficiency targets solutions may include the use of raingardens, infiltration pits, rainwater (retention and re-use) tanks, small water tank-based and underground detention systems, green roofs, swales and permeable paving

The [InSite Water](#) toolkit provides a mechanism to demonstrate compliance of your development with South Australia’s WSUD performance-based planning policy objectives, for residential development with site areas up to 2,500 m<sup>2</sup>.

All four WSUD performance-based policy objectives must be met to achieve a complying development.



#### Volume

No more than 10% increase in average annual runoff volume



#### Flow

Maintain peak stormwater discharge flows



#### Quality

Reduce annual stormwater runoff pollutant loads



#### Efficiency

Achieve greater than 25% potable water use reduction

A development application to your local Council using the InSite Water toolkit:

- Should be undertaken by a suitably qualified professional
- Must include:
  - An InSite Water compliance certificate and associated report
  - Drawings showing the WSUD features of the design and how they are integrated into the site

Refer to *Water Sensitive SA Fact Sheet WSUD 01* for a comprehensive list of WSUD features to consider when integrating your stormwater management with your overall site design.

#### Site examples

The following case studies have been provided to show compliant WSUD approaches for:

- Example 1. A single dwelling
- Example 2. Two townhouses on a lot
- Example 3. Three townhouses on a lot
- Example 4. 10 townhouses
- Example 5. An apartment development

Examples of WSUD solutions for commercial developments can be found in the Water Sensitive SA Fact Sheet WSUD 04

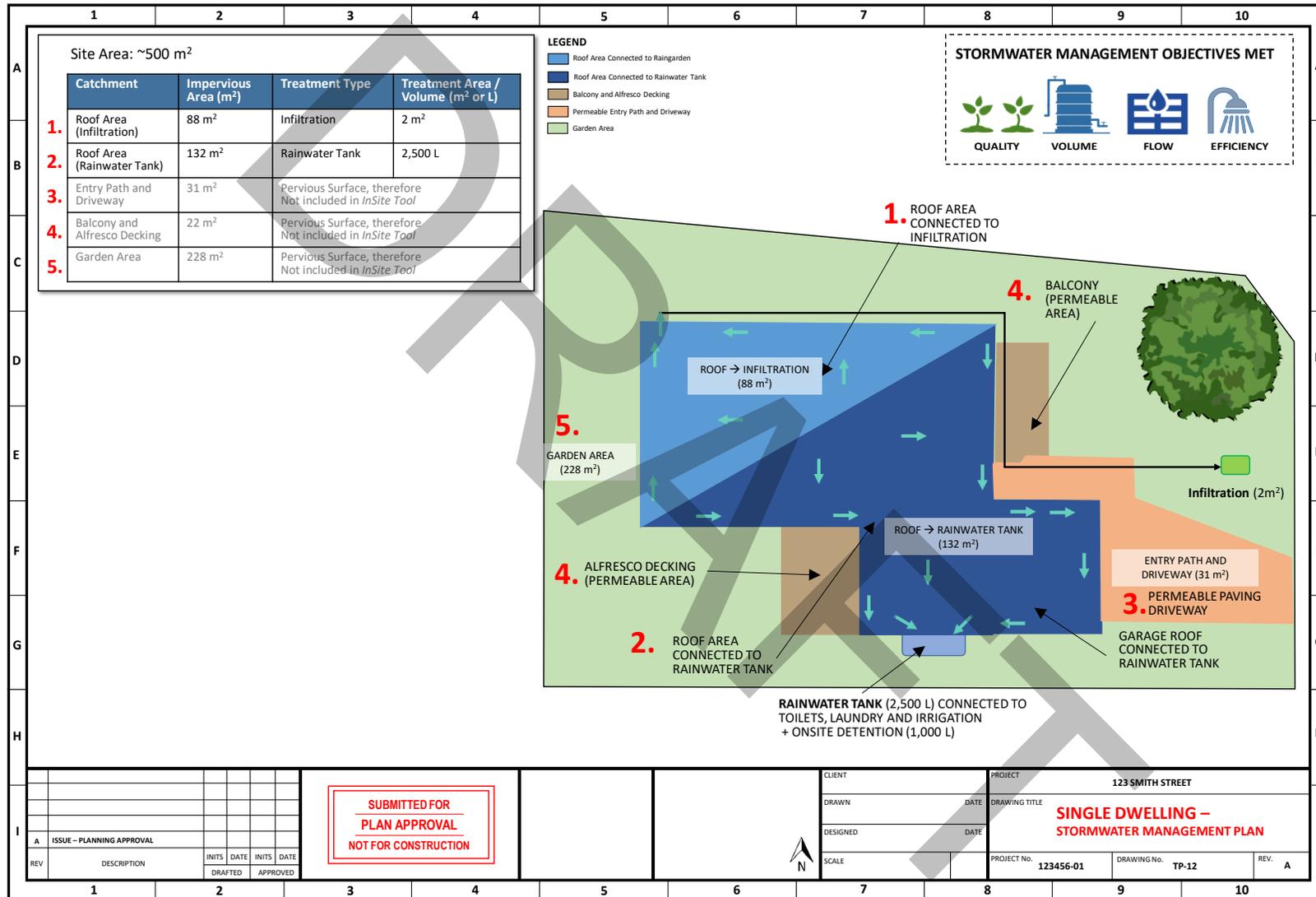


Figure 16. Single dwelling development to integrate WSUD - One side of the property drains into a rainwater tank, which is connected to all toilets, the washing machine cold tap and outdoor taps for irrigation. The driveway is constructed of permeable paving to reduce the impermeable are of the development.

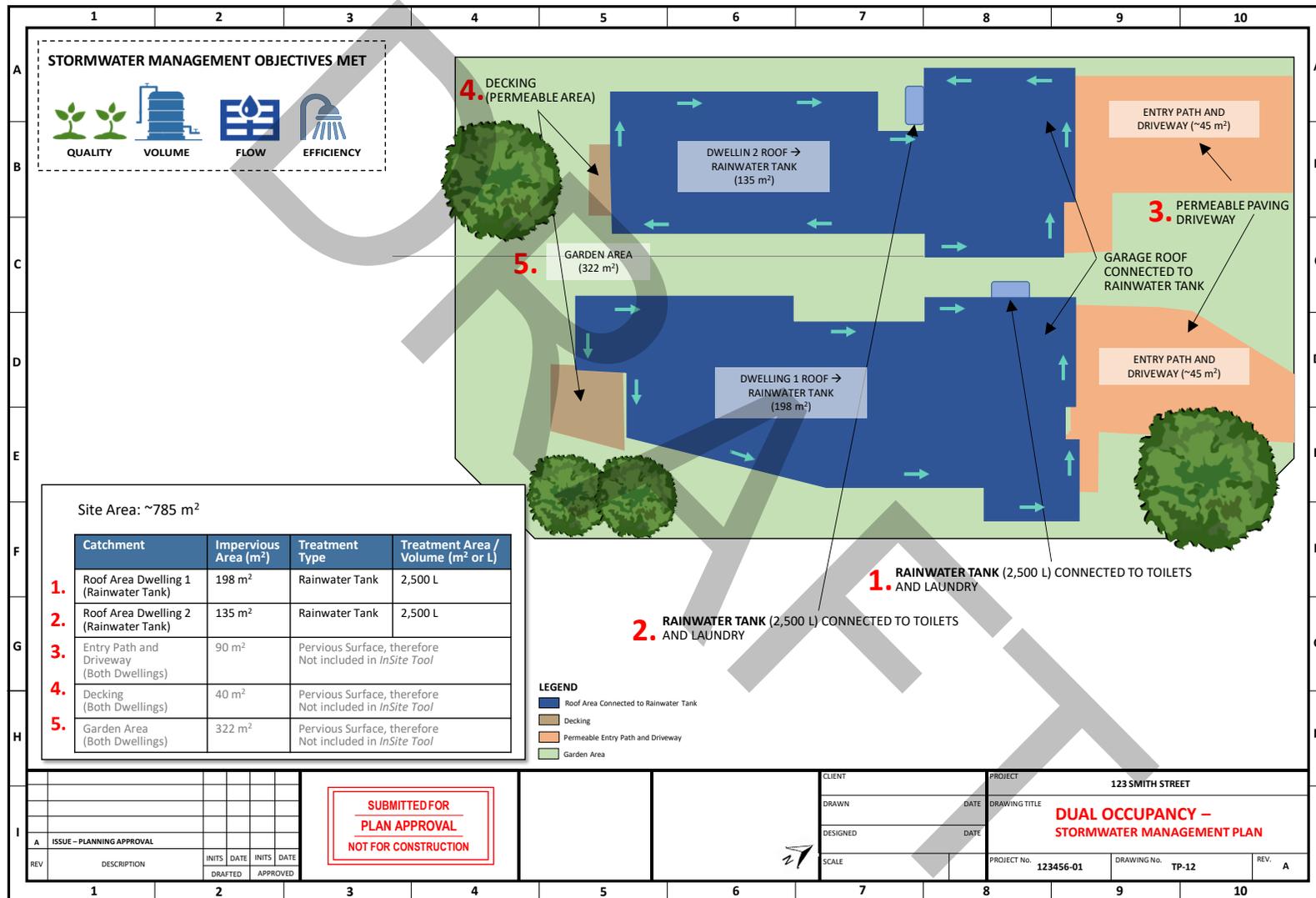


Figure 17. Dual occupancy - This diagram shows a WSUD strategy where the entire roof of both units is connected to rainwater tanks. Permeable paving is used for driveways to reduce the impermeable surface area of the development.

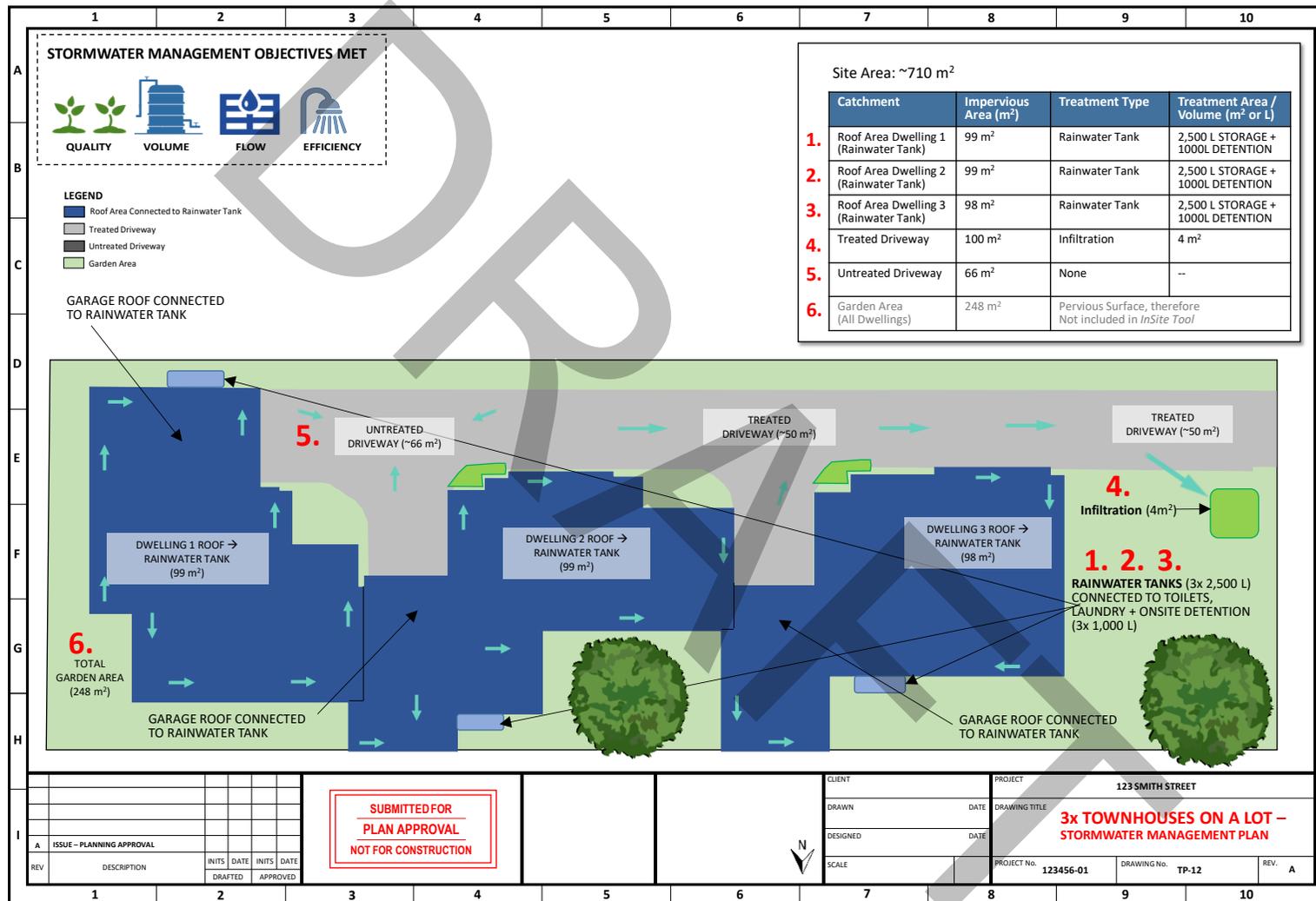


Figure 18. Three townhouses on a lot - This development has used an infiltration system to treat driveway runoff, and water tanks for the roof. The water tanks are connected via a charged pipe system to all downpipes. Internally, rainwater used for all toilets and washing machine cold water taps.

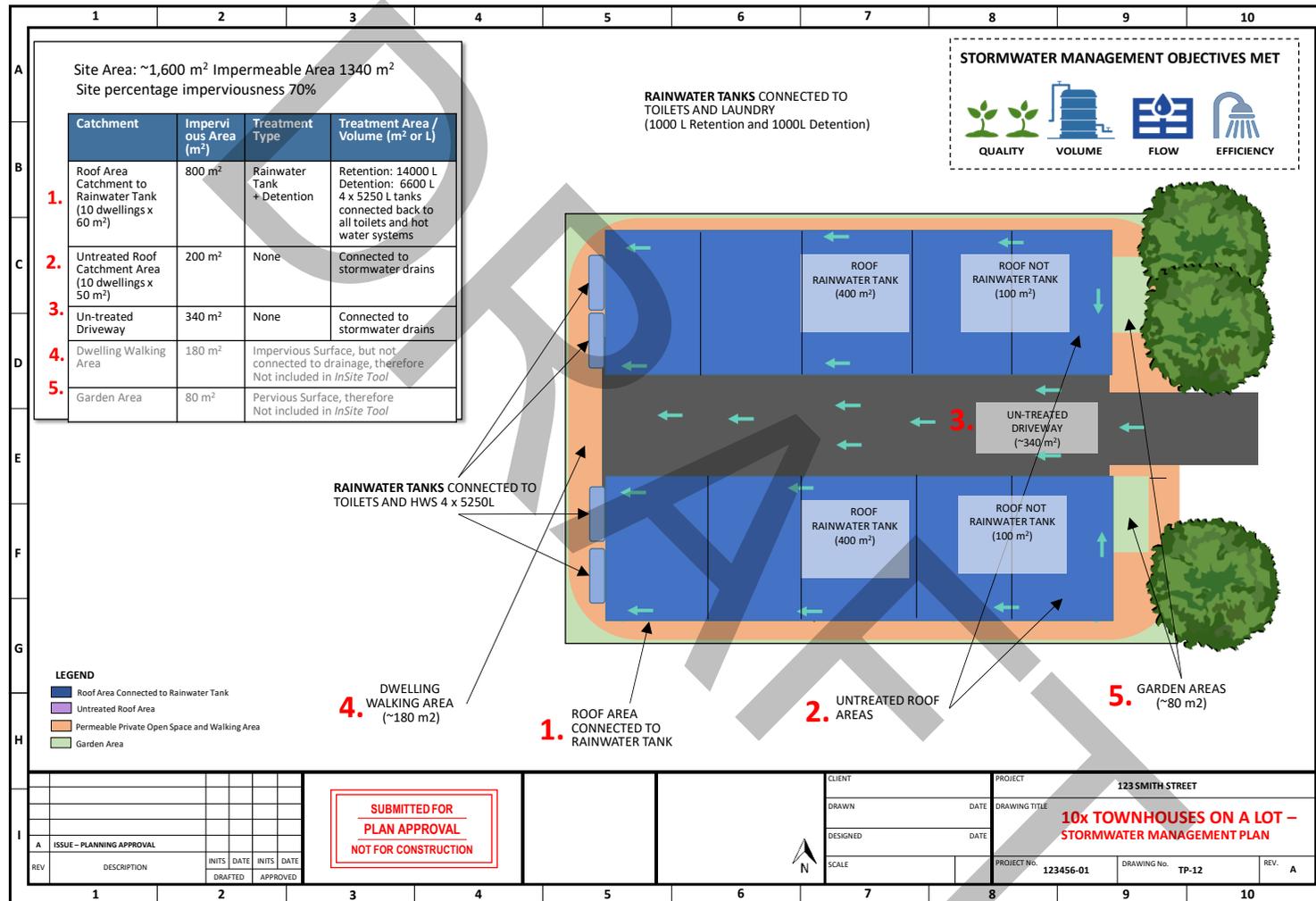


Figure 19. 10 townhouses on a lot - This development has connected just over half of the roof area to individual rainwater tanks. In addition, the driveway runoff is treated with raingardens.

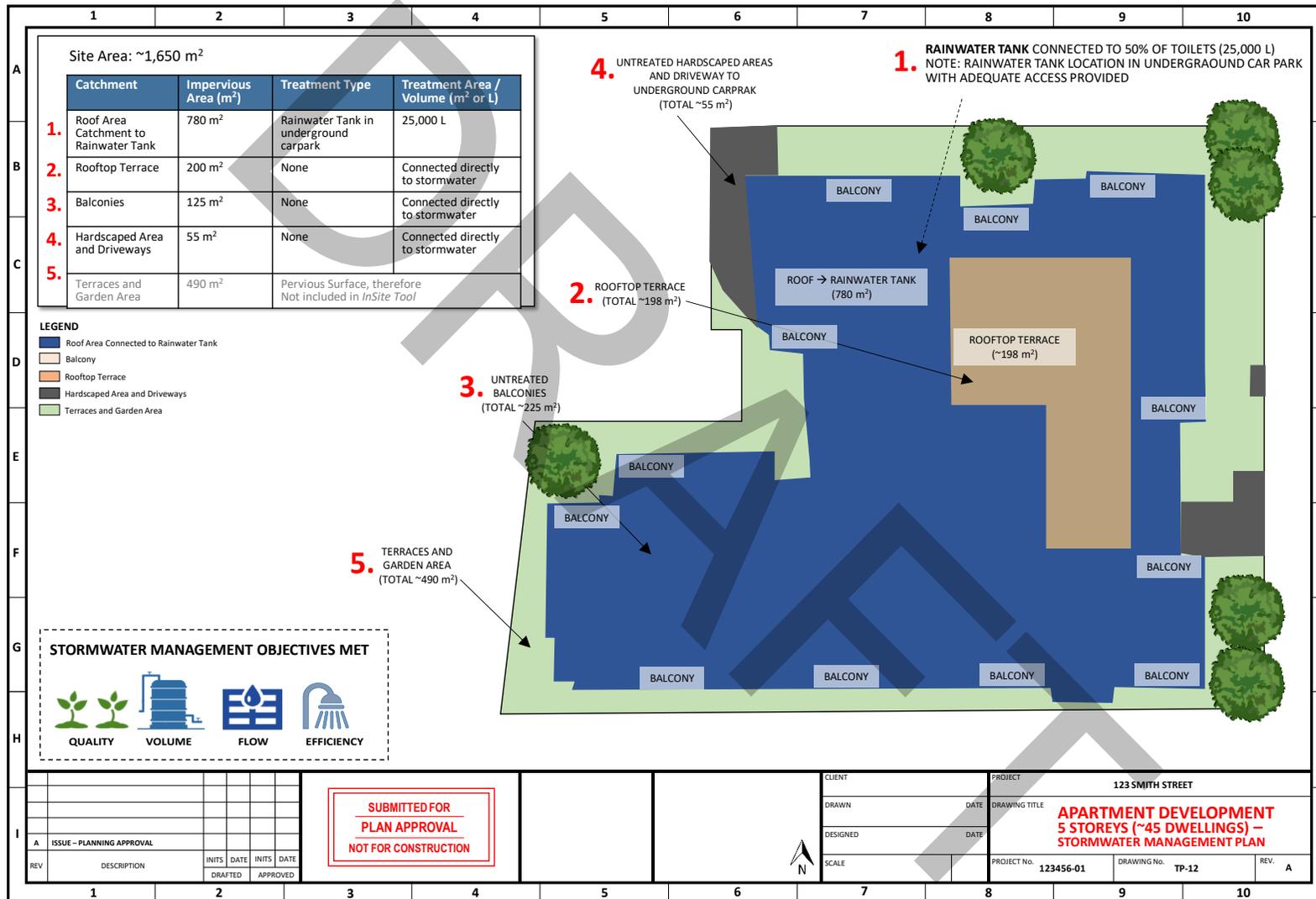


Figure 20. In this apartment development, most of the stormwater is captured in a basement rainwater tank, and re-used in the building, meeting all stormwater objectives.

## Guide for water sensitive urban design – Stormwater Management

### Commercial development - compliance with the InSite Water toolkit

Commercial developments present many opportunities for WSUD techniques.. To meet stormwater runoff volume reduction, peak flow, and quality targets and water use efficiency targets solutions may include the use of raingardens, infiltration pits, rainwater (retention and re-use) tanks, small water tank-based and underground detention systems, green roofs, swales and permeable paving.

The [InSite Water](http://www.watersensitivesa.insitewater.com) toolkit ([www.watersensitivesa.insitewater.com](http://www.watersensitivesa.insitewater.com)) provides a mechanism to demonstrate compliance of your development with the South Australia’s WSUD performance-based planning policy objectives, for commercial residential development sites with areas up to 5,000 m<sup>2</sup>.

All four WSUD performance-based policy objectives must be met to achieve a complying development.



#### Volume

No more than 10% increase in average annual runoff volume



#### Flow

Maintain peak stormwater discharge flows



#### Quality

Reduce annual stormwater runoff pollutant loads



#### Efficiency

Achieve greater than 25% potable water use reduction

A development application to your local Council using the [InSite Water](http://www.watersensitivesa.insitewater.com) toolkit:

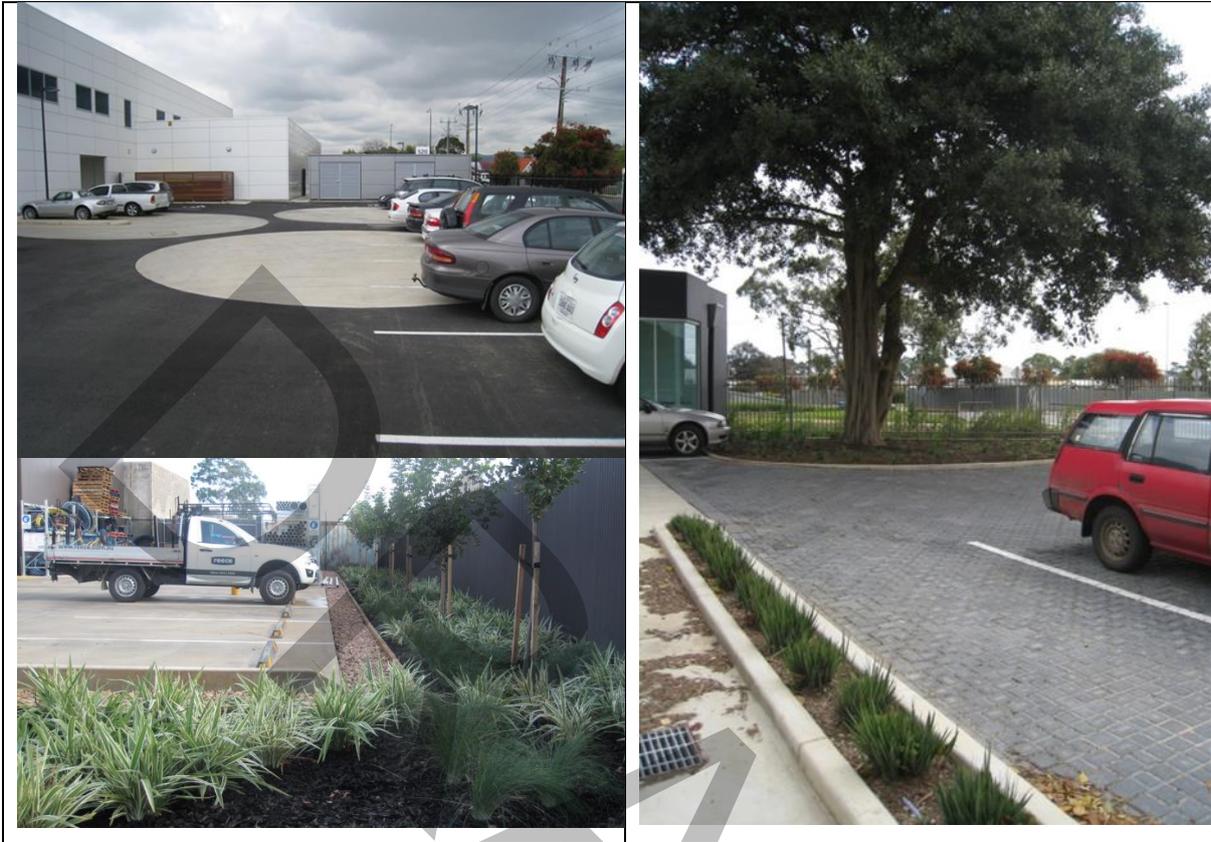
- should be undertaken by a suitably qualified professional.
- must include:
  - an [InSite Water](http://www.watersensitivesa.insitewater.com) compliance certificate and associated report
  - drawings showing the WSUD features of the design and how they are integrated into the site.

Refer to *Water Sensitive SA Fact Sheet WSUD 01* for a comprehensive list of WSUD features to consider when integrating your stormwater management with your overall site design.

#### Site examples

The following case studies have been provided to show compliant WSUD approaches for:

- Example 1. A commercial and retail development
- Example 2. A warehouse development



Source: Andrew King

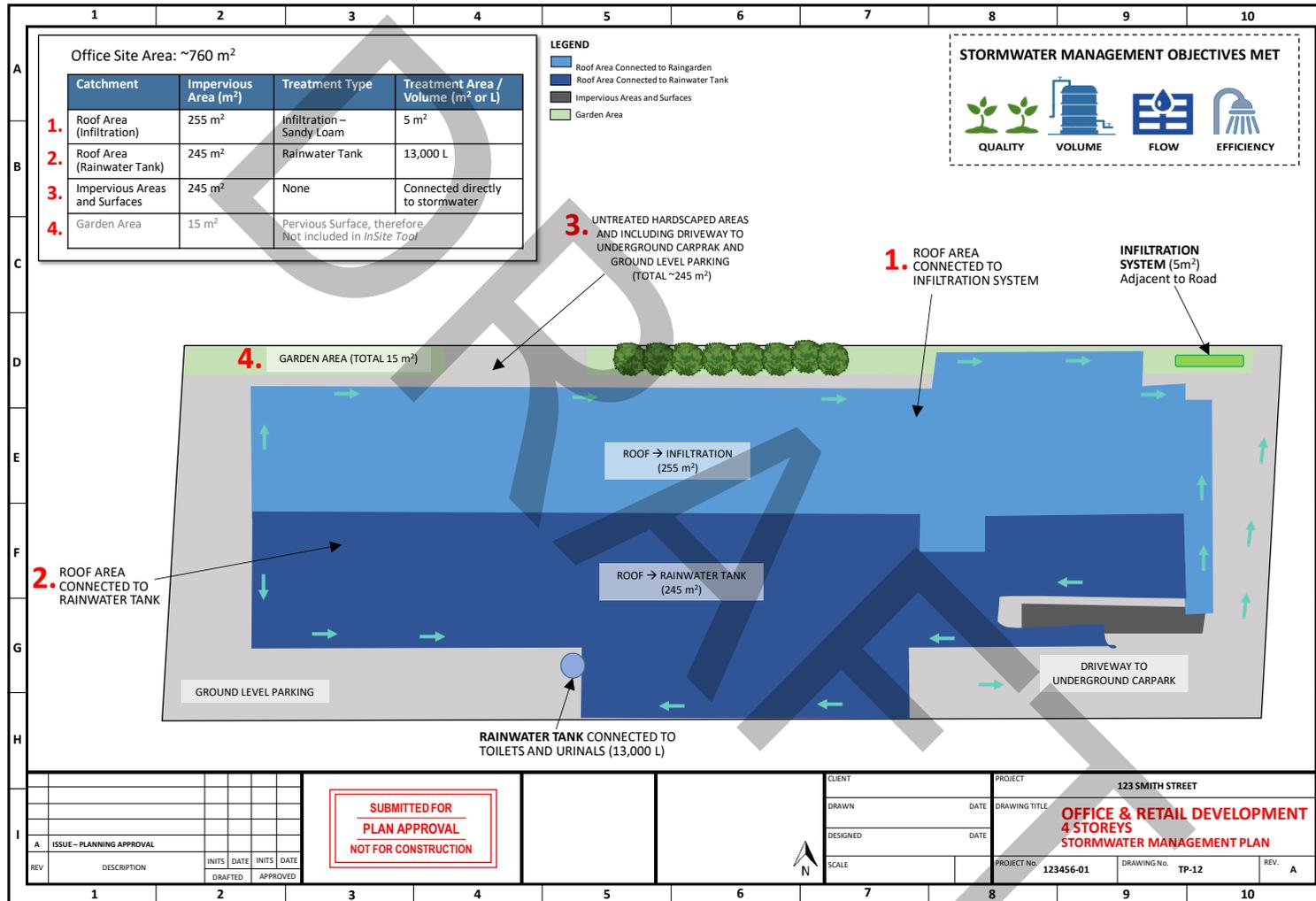


Figure 21. Commercial and retail development. - This development collects rainwater from half the roof into a 13,000 L rainwater tank connected to toilet and urinal flushing. In addition, water is infiltrated into the ground using an infiltration system. In this case, permeable paving for car parking areas is not required to meet stormwater objectives.

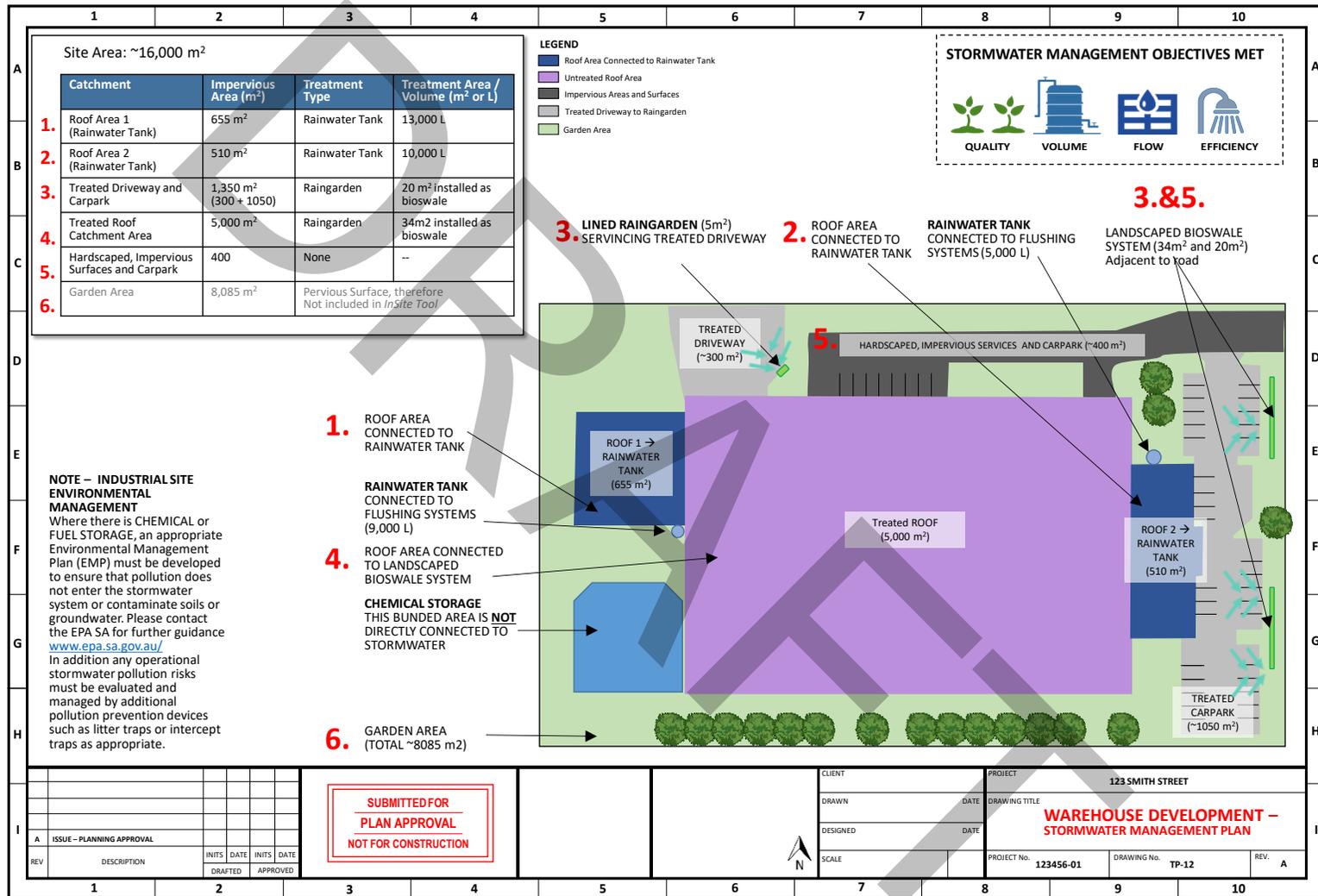


Figure 22. Warehouse development - This site uses the available space and clearance to install raingardens and bioswales as part of the site's landscaping. Two separate rainwater tanks are installed to supply rainwater for non-potable water uses including toilet flushing, fire pump testing and in washdown bays. The site does not use permeable paving as it receives heavy vehicle traffic.

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