HUNTERS HILL COUNCIL

PART 1
CONSOLIDATED
STORMWATER MANAGEMENT
POLICY

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CONTENTS

1. INTRODUCTION

The Hunters Hill Council's Consolidated Development Control Plan 2013 (DCP 2013) was adopted on 24 June 2013 and applied to all developments after the 12 August 2013.

The document covered the requirements for all development types within the Hunters Hill Council's Local Government Area and consists of three parts covering all developments and land use. It was prepared in accordance with Section 74 of the Environmental Planning and Assessment Act and supported the Hunters Hill Local Environment Plan 2012 (LEP 2012).

The relevant sections of the Hunters Hill Council's Consolidated DCP 2013 in relation to stormwater management are covered in Part 3, Chapter 3.2.7 Concept Stormwater Plans and in Part 5, Chapter 5.6 Stormwater Management.

There are also supporting documents known as Sustainable Water Parts I, II and III. These technical documents supported the Development Control Plan, provided a zoning map showing areas in catchments for different treatment methods, provided manual calculation methods for various stormwater treatments and design guidance practice notes.

However, the Hunters Hill Council's Consolidated DCP 2013 does not make specific references to these technical documents.

These technical documents although covered different stormwater treatment methods, is overly complicated and does not provide guidance on all drainage situations, and it does not provide guidelines for the design of the public drainage system.

Because of the above reasons, the Hunters Hill Council Consolidated DCP 2013, in relation to stormwater management, needs to be revised and the technical documents will need to be updated to reflect current best practice design criteria. The relevant technical guidelines will be incorporated into this new document.

It is noted that the technical documents need to be simplified and expanded to cover both private and public drainage systems. However, the main objectives of Hunters Hill Council's Stormwater Management Policy will still be relevant and will be retained.

2. STORMWATER MANAGEMENT OBJECTIVES

The main objectives in relation to stormwater management are to:

- Promote water sensitive urban development, which provides better integrated solutions for the management of the urban water cycle.
- Reduce adverse impacts upon water quality within the Hunters Hill Council local environment, which result from urbanization, and to protect water quality in the receiving waters that surround the municipality.
- Provide guidance to professionals involved in planning, design and assessment of water cycle systems at the site level on the selection, sizing and assessment of management measures to achieve the set water cycle objectives and performance criteria for water quality and quantity.
- Provide guidance to professionals involved in planning, design and assessment of public drainage systems to benefit the community.

The above objectives can be achieved through the following actions:

- Reduce water-borne pollutants prior to discharge to Lane Cove and Parramatta. Rivers and the bushland. The main pollutants include sediments, suspended solids and nutrients.
- Control soil erosion during and after the construction phase.
- Reduce stormwater volume discharges into the existing drainage system and to bushland.
- Reduce erosion and sedimentation problems to the natural bushland.
- Conserve water and reduce mains water consumption.
- Utilize stormwater as a natural water resource.

- Reduce downstream flooding and drainage impacts.
- Reduce stormwater discharges.

3. CONCEPT STORMWATER MANAGEMENT PLANS

A *Concept Stormwater Management Plan* (CSMP) will need to be submitted with the Development Application, and which satisfies the requirements of Hunters Hill Council's Consolidated Development Control Plan 2013 (DCP 2013), Chapter 5.6 Stormwater Management in the following situations:

- The site slopes towards the rear and/or side boundary and where the downstream rear and/or side property/s is residential (that is, not a reserve, bushland or waterway) and is not benefitted by any legal drainage easement.
- The site is located in a catchment area where nuisance flooding is known.
- The site is located in a catchment area where the catchment zone requires On-site Stormwater Detention.
- The proposed development is a multi-residential development and/or sub-division.
- A public stormwater drainage conduit or easement passes through the site in development.

Although not mandatory unless the above situations apply, it is recommended that a basic CSMP be submitted to assist Council in support of the proposed development.

4. DEVELOPMENT TYPES AND STORMWATER CONTROL REQUIREMENTS

This section has been designed to assist applicants when preparing submission documents as part of a Development Application (DA) to understand what type of stormwater control is required for the proposed development and is summarized in **TABLE 4.1**.

TABLE 4.1

	Single residential	**Multi-residential (including villas, townhouses, units)**	**Commercial, industrial**	**Alterations and additions**	**Paving works**
On-site Stormwater Detention	YES (1)	YES (1)	YES (1)	(1), (2)	(1), (2)
Drainage easement through downstream property	YES (3)	YES (3)	YES (3)	YES (3)	YES (3)
Infiltration and dispersion system	(4)	(4)	(4)	(4)	(4)
Holding sump and mechanical pump-out	(5), (6)	(5), (6)	(5), (6)	(5), (6)	(5), (6)
Rainwater harvesting	YES (7)	YES (7)	YES (7)	YES (7)	NO
Erosion and sediment control plan	YES	YES	YES	YES	YES

Notes:
1. If the site is located in the catchment zone that requires On-site Stormwater Detention, it may be required.
2. Only required if the increase in impervious area is > 40sqm.

3. For sites which fall away from the street frontage, it is important to note that a legal drainage easement must be sought first before any other stormwater disposal method will be considered.
4. Infiltration and absorption systems will only be approved in the following circumstances:
    - The site falls to the rear and a stormwater drainage easement cannot be obtained, and
    - There is a supporting geotechnical report which indicates that the soil infiltration rate is high enough to dispose of the collected runoff.
5. Holding sumps and mechanical pump-out systems are permitted only in the following circumstances:
    - For draining sub-floor areas, basements and underground car parking areas.
    - Where the site falls to the rear and a stormwater drainage easement cannot be obtained, and
    - The soil infiltration rate is too low to design an absorption system, and
    - An On-site Stormwater Detention System (OSD) component is incorporated into the design.
    - Important Note: Where known flooding has been identified, the discharge of the site runoff into the catchment would be prohibited. In this regard, easement acquisition is mandatory. The applicant must seek a formal drainage easement through Section 88k of the Conveyancing Act via the Court.
6. The OSD component is generally only required where the site is in the designated catchment zone. However, if the site falls away from the street frontage, then OSD may be required to limit the site's discharge being directed to the street frontage.
7. A minimum volume for rainwater harvesting shall be provided in accordance with the greater of either the BASIX Certificate or Council's calculated rainwater re-use volume.

5. CATCHMENT ZONE MAP

This section provides guidelines for determining what type of stormwater management controls are required for a proposed development.

There are three (3) distinct zones within the local government area which specifically require On-site Stormwater Detention (OSD) to be implemented as a mandatory requirement for certain development types.

In addition, there are other stormwater management elements which also need to be satisfied. These are:

- Water conservation – which includes rainwater harvesting as a requirement.
- Control Stormwater Pollution and Erosion – which includes devices such as trash screens, sediment traps, gross pollutant traps, proprietary devices such as HumeCeptor™ units, StormFilter ™ devices, infiltration systems, grass lined swales, bioswales, on-site stormwater detention systems and the like, rainwater tanks, etc.
- Maintaining Water Balance – these also include rainwater tanks and infiltration systems.
- Preventing increased flooding – these include on-site stormwater detention systems, rainwater tanks and on-site absorption systems.

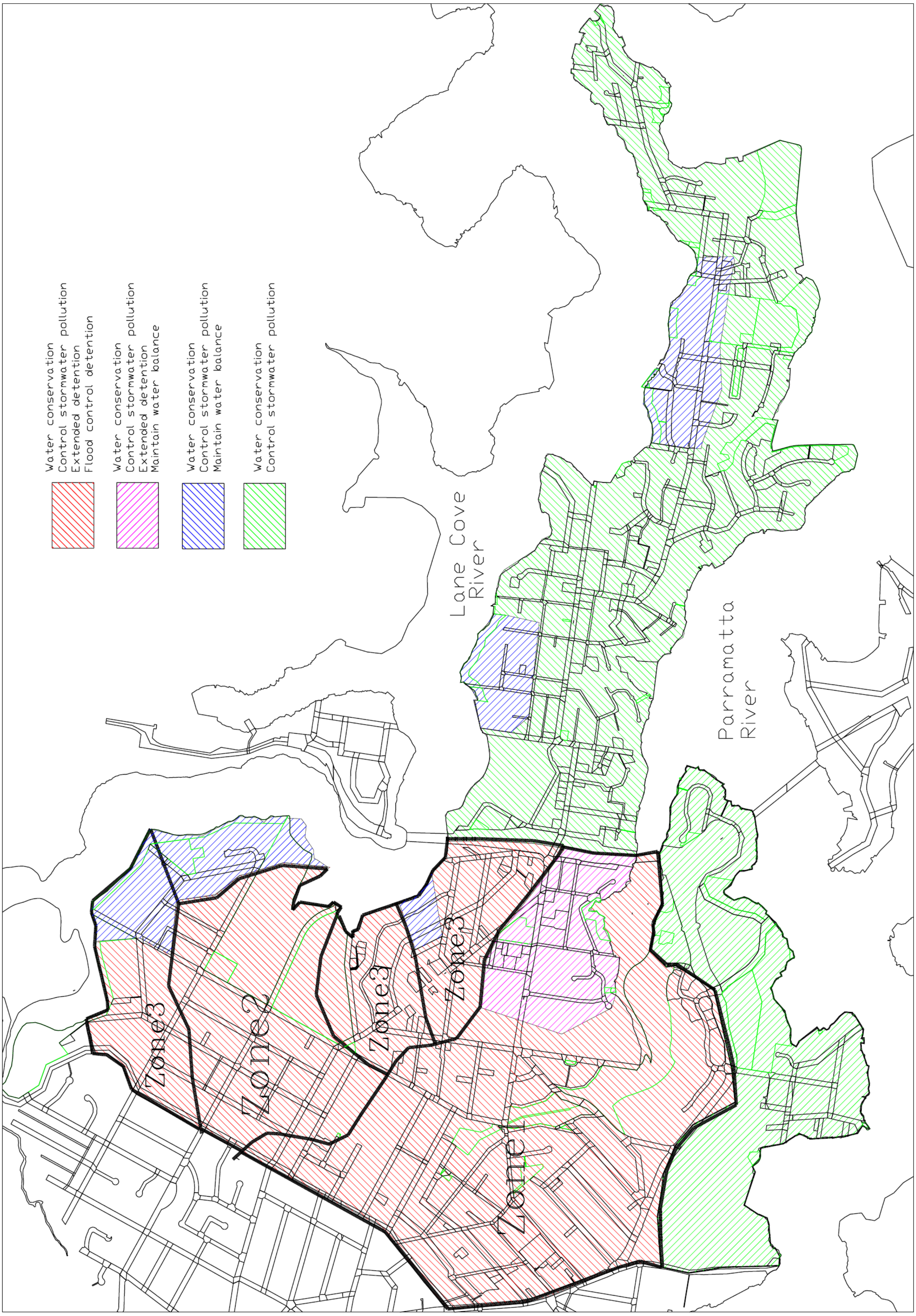
The **Zone Map** is given in **FIGURE 5.1** below.
Further description of the stormwater management controls and their required performance standards are given in the proceeding pages.

How to use the Map:

- Identify the site location from **FIGURE 5.1 – ZONE MAP**.
- Identify what the Stormwater Management Criteria is required for the proposed development.
  For example, if the site is located in **Zone 2**, the design criteria will be:
    - water conservation
    - control stormwater pollution
    - extended detention, and
    - flood control detention.

- If on-site stormwater detention is specified, check if the proposed development can be exempt – refer to **TABLE 4.1** above.
  For example, if the proposed development is an ‘alterations and additions’, with an impervious area increase of less than 40sqm, and the site slopes towards the street frontage, then OSD is not required.
- Refer to **SECTIONS 6 to 10** for the Stormwater Management design guidelines.

FIGURE 5.1 – ZONE MAP



6. MAINTAIN WATER BALANCE AND WATER CONSERVATION

Objectives:

- To ensure more efficient use of water.
- To reduce consumption of potable mains water supply.

Performance Standards:

- Rainwater harvesting shall be provided in accordance with **TABLE 6.1** below.
- Rainwater harvesting systems shall satisfy the **design criteria** as stipulated below.
- The minimum volume to be provided shall be the greater of the BASIX Certificate volume and Hunters Hill Council's volume as calculated from **TABLE 6.1**.
    - For example, the BASIX Certificate volume for an 'alterations and additions' development is 2,000L. The alterations and additions development has an impervious area of 70sqm. From **TABLE 6.1**, the Hunters Hill Council volume is 35 x 70 = 2,450L. Therefore adopt 2,450L minimum rainwater volume.
- In addition to rainwater harvesting requirements, the following shall be implemented:
    - Installation of water efficient fixtures and appliances
    - Covering over swimming pools
    - Drip irrigation systems in the garden

TABLE 6.1

	Single residential	**Multi-residential (incl. villas, townhouses, units)**	**Commercial, industrial**	**Alterations and additions**	**Paving works**
Hunters Hill Council Volume (L per sqm)	25	30	30	35	0

Rainwater re-use design criteria:

- The above table provides on average a 30% reduction in mains water usage.
- Rainwater systems must be located sympathetic to the site and the surrounding environment and <u>must not</u> be visually or sound intrusive.
- A Schematic Diagram of the rainwater harvesting system must be included on the Stormwater Management Plan and must show, at a minimum, the following:
    - the net storage volume (excluding the 'sludge' volume),
    - the 'first flush' device,
    - inlet and outlet pipes and sizes,
    - connection from roof areas only,
    - diversion switch or top-up from potable water supply,
    - signage noting "rainwater – not for human consumption',
    - connection to washing machine/s, toilet/s, and/or external tap/s, etc.
- Above-ground or below-ground tanks for storage are permitted.
- Refer to **APPENDIX A**, **FIGURES A1 and A2** for details of basic schematic layouts of above and below ground rainwater harvesting storage systems.
- It is noted that a rainwater re-use system is an enclosed 'pressure' or 'charged' system and all pipes leading into the system must be designed for pressure applications. However 'charged systems' are only permitted for rainwater re-use applications and generally operate between the roof gutters and the rainwater tank. All other systems such as OSD and OSA cannot be a 'charged system'. The outlet pipe for overflows from the rainwater re-use facility must be by gravity fall to the street, to the receiving drainage system or to the receiving waterway.
- To maintain sufficient pressure, a mechanical pump is usually installed. This is equivalent to a pressure head of 20m. A gravity height of 20m would need to be provided to achieve this same pressure.
- Pre-fabricated (manufactured) units are preferred over in-situ formed tanks. However, if in-situ formed tanks are to be used, they must be fully waterproof and certified by a qualified Structural Engineer.
- A minimum storage volume, generally achieved by mains top-up, or by toggle switch to the mains water supply when the volume drops below a designated water level,

must be specified. A simple float valve system can be installed to achieve this automatically.

- An anaerobic zone or 'sludge' level is to be provided. This is to ensure water is not drawn below this level so that sediment is not entrained.
- The rainwater storage zone comprises the total volume available for draw-down, which is between the overflow or outlet pipe and the anaerobic zone or sludge level. The air gap between the overflow pipe and the top of the tank may be used for on-site stormwater detention purposes, if required.
- Refer to **FIGURE A3** for details showing the storage components of a dual supply system.
- All rainwater systems shall include a 'first flush' device incorporated into all inlet pipe/s. This device separates the first part of the rainfall entering the rainwater tank and is required to prevent pollutants and other material captured on the roof or gutters from contaminating the tank water. The device operates by filtering roof runoff through a mesh screen to capture leaves and other debris. The first part of the runoff is captured in the chamber to slowly trickle through a small hole whilst cleaner water at the top of the chamber passes into the tank. Refer to **FIGURE A4** for simplistic detail of a 'first flush' mechanism.
- Roof and gutters shall not be painted with lead-based or tar-based paints and roofs shall not contain asbestos. Galvanized iron, Colorbond™, Zincalume™, slate or ceramic tiles are acceptable.
- Rainwater shall not be used for drinking. Therefore, appropriate signage must be installed.
- The Australian Standard **AS/NZ 3500.1.2-1998: 'National Plumbing and Drainage - Water Supply – Acceptable Solutions'** provides guidance on the design of stormwater and rainwater re-use plumbing systems. The standard categorizes cross connection between mains water supply and a domestic roof water tank as a 'low hazard' connection. This requires a non-testable backflow prevention device, such as:
    - No physical connection between the tank and the mains water system
    - An air gap
    - A reduced pressure zone device (RPZD)
- An air gap refers to a physical separation between the mains water and rainwater supplies within the tank. This is a simple, reliable and maintenance-free solution. A RPZD is a mechanical device that separates mains and other water supplies. It requires regular servicing and replacement. Under **AS/NZ 3500.1.2-1998**, dual supply systems that utilize an air gap or an RPZD can be configured as shown in **FIGURE A5**.
- Types of materials that can be used for rainwater re-use storage are:
    - Concrete – these can be pre-formed or in-situ poured and can be placed above or below ground. However, they must be fully waterproof and certified by a qualified Structural Engineer.
    - Fibreglass and plastic – fibreglass materials used would be constructed from similar materials to the manufacture of boats and can be used for above-ground storage applications. Plastic or poly tanks are constructed from food grade polyethylene that has been UV stabilized and impact modified. These tanks would have a manufacturer's warranty and are generally strong and durable.
    - Metal – galvanized iron tanks are constructed from steel with a zinc coating and can be used in above-ground installations. They are strong and durable but can be subject to corrosion if the copper pipe for the household water service is connected to the tank. The first section of the plumbing connected to the tank should therefore be uPVC or other non-metallic material to prevent galvanic reaction. Zincalume™ tanks are constructed from steel with a zinc/aluminium coating and are similar to galvanized iron tanks. Aquaplate™ are tanks made from Colorbond™ lined with a food-grade polymer. They can be used in above-ground installations. This tank is strong, durable and corrosion resistant. However, when cleaning the tank, it is important to avoid damaging the polymer lining.
- Maintenance – a rainwater tank requires minimal maintenance but generally requires the occasional cleaning. The frequency of cleaning will depend on the amount of sediment and debris that enters the tank. A 'first flush' device and adequate mesh screens on all inlets and outlets will ensure that the majority of sediment and debris

does not enter the tank. This will reduce the frequency of cleaning to approximately every 10 years. Regular maintenance tasks include:

- Cleaning the 'first flush' device every three (3) to six (6) months
- Removing leaves and debris from the inlet mesh on the tank every three (3) to six (6) months
- Removing leaves and debris from gutters every three (3) to six (6) months
- Checking the level of sediment in the tank every two (2) years.

- Clean-out Pit – some rainwater harvesting tanks (especially those that are located above-ground) continue to hold water in the sealed pipe between the roof gutter and the rainwater tank and the 'low point' in the pipe network is below the level of the inlet going into the rainwater tank. In this situation, a 'clean-out' pit must be installed at the 'low point' in the pipe network to allow for 'bleeding' of the pipe network and for general cleaning and maintenance. This 'clean-out' pit is to have a minimum 200mm deep sediment trap with weep holes installed in the base of the pit to ensure that it does not hold permanent water which would result in insect breeding. The off-line connection is to have a screw cap which can be opened to empty the water in the pipeline during regular maintenance. Screw cap inspection eyes will not be accepted.
- Refer to **FIGURE A6** showing a typical detail of a 'clean-out' pit.

7. CONTROL STORMWATER POLLUTION

Objectives:

- To capture and treat stormwater flows during regular rainfall events.
- To achieve stormwater treatment objectives as specified in the relevant stormwater management plans or other adopted plans or strategies.

Performance Standards:

- Stormwater pollution control performance standards shall be in accordance with **TABLE 7.1** below.
- This requirement applies to all residential, commercial, industrial, community service and recreational development across the whole of the local government area, as stipulated in the Catchment **FIGURE 5.1 – ZONE MAP**.
- The expected average annual post-development pollutant loads in stormwater runoff from the developed site must not exceed the values that are given in **TABLE 7.1**.

TABLE 7.1

	Single residential with impervious areas < 50%	**Single residential with impervious areas > 50%**	**Multi-residential (incl. villas, townhouses, units)**	**Commercial, industrial, community, recreational**	**Alterations and additions**
Minimum Standards to be achieved	60% TSS 30% TP 30% TN reduction of baseline annual pollutant load	80% TSS 40% TP 40% TN reduction of baseline annual pollutant load	80% TSS 45% TP 45% TN reduction of baseline annual pollutant load	80% TSS 45% TP 45% TN reduction of baseline annual pollutant load	60% TSS 30% TP 30% TN reduction of baseline annual pollutant load

Legend:
TSS = Total Suspended Solids
TP = Total Phosphorus
TN = Total Nitrogen

Control stormwater pollution design criteria:

- To achieve the above performance standards, the computer program known as the Model for Urban Stormwater Improvement Conceptualization (MUSIC), can be used to simulate various stormwater treatment methods for the site.
- Reference: **www.ewater.com.au/music**
- The **MUSIC** program is a decision support tool for stormwater designers and assists in planning and design (at a conceptual level), appropriate stormwater management systems to achieve the water quality objectives.
- The **MUSIC** modelling software was developed by researchers and practitioners of the former CRC for Catchment Hydrology and eWater CRC and represents an accumulation of the best available knowledge and research into urban stormwater management in Australia.
- The **MUSIC** program estimates stormwater pollution generation and simulates the performance of stormwater treatment devices individually and as part of a treatment train (individual devices connected in series to improve overall treatment performance).
- By simulating the performance of the stormwater quality improvement measures, **MUSIC** provides information on whether a proposed system conceptually would achieve design objectives such as water quality and hydrologic management objectives.
- Use the **MUSIC** program where the proposed development poses a medium to high risk impact on the water quality of the receiving environment.
- Where the risk is low (for example, for a residential alterations and additions development with an increase in impervious area footprint of less than 40sqm or is a first-floor addition within the building footprint), a more simplistic approach such as ‘deemed to comply solutions’ may be adopted.
- Should the designer choose to undertake manual calculations, the Hunters Hill Council’s Sustainable Water Part II, Technical Appendix can be used for guidance. A manual worked example is given in the Appendices.
- If the **MUSIC** program is to be used, the designer must, at a minimum, provide the following information:
  - Input model parameters and treatment plan,
  - Output model results,
  - Plan showing the appropriate treatment device/s or system/s used.
  - Screenshots of the above.
  - Submission of the supporting **MUSIC** digital files (.sqz).
- If manual calculations are to be undertaken, provide a spreadsheet with a summary of the input and output information and on the Stormwater Management Drawings.

7.1 Roof water tanks

- Purpose – to manage pollutants from roof and balcony runoff.
- Rainwater tanks may be used to control stormwater pollution directly from these areas to satisfy a component of the stormwater pollution objectives.
- The stormwater volume and pollutant loads need to be calculated. For a worked example, refer to **APPENDIX B**. Alternatively, apply the **MUSIC** program to model the pollutant loads and the required rainwater tank volume.
- For rainwater re-use tank volume design criteria – refer to **SECTION 5.1**.

7.2 Porous Paving

- Purpose – to manage stormwater pollutants due to runoff from on-ground areas and to reduce load from impervious surfaces. The allowable reduction in impervious surfaces is shown in **APPENDIX B, TABLE B1** and **TABLE B2**.
- Types – various types of surface treatments may be utilized, which include:
  - Concrete grid and modular paving (e.g. over gravel, sand or soil/grass). The concrete, ceramic or plastic grids provide structural integrity for vehicle traffic loads with voids to allow infiltration of runoff. These products generally contain voids that are filled with sand, gravel or soil/grass. Stormwater filters through these voids to a sand or gravel sub-base which provides the clean filtering effect – refer **APPENDIX B**, **FIGURE B1**. However, they are only

effective for 'low flows' and acts as a 'first flush' system. During larger storm events, overflows are taken to the street drainage system. Therefore, they are not intended to be used for the disposal of the site's runoff unless the design parameters of the soil infiltration are able to dispose of storms up to and including the 50-year Average Recurrence Interval (ARI) or 2% Annual Exceedance Probability (AEP) storm. A safe overland flow route is required for overflows.
    - Asphalt porous pavements. These types of pavements are laid on a sand/gravel sub-base over natural soil. Rainfall percolates through the porous asphalt layer and into the sub-base where it spreads and infiltrates into the soil. Where they are installed over impermeable ground, they require subsoil drainage which are connected to the internal or street drainage system. Again, these types of systems are used for pollution control and not generally intended to cater for large storm events and a 'fail-safe' overflow mechanism is required. These pavements are susceptible to sediment clogging and require regular maintenance such as vacuum sweeping or high pressure hosing to remove sediment and over time may revert to being an impervious surface. A typical section is given in **APPENDIX B**, **FIGURE B2**. These systems should not be located in areas where sediment deposition is likely. They should also not be designed for accessways with high vehicle traffic volumes or where heavy vehicles frequent. The installation of sediment traps, vegetated filter strips or specially designed gutter systems to remove sediments should be considered.
- Aquifer contamination – porous pavements shall not be installed over shallow aquifers because they risk contamination by transfer of toxic materials from the asphalt, vehicular traffic and general road use.
- Contaminant capture – porous pavements shall include a sand sub-base layer over a retention trench with a geotextile fabric lining to capture contaminants.
- Structural Integrity – porous pavements must be designed to handle the design vehicle traffic loads.
- Surface gradient – the finished levels of the porous pavement shall be such that the gradient of the pavement is not greater than 5%, in any direction, unless certified by the designer that a greater slope will not affect the capture/infiltration ability of the system.
- Rock and shale stratum – do not install porous pavements over rock or shale, where there is little to no permeability. Severely weathered rock such as sandstone may be acceptable but will require a Geotech Engineer to certify.
- Manufactured systems – where a porous pavement system is sourced from a manufacturer, the manufacturer's recommendations and specifications shall be adhered to. Case studies or constructed examples showing proven track record of such manufactured systems shall be provided in support of the proposed system to be used.

7.3 Bioretention Systems

- Purpose – to manage and treat stormwater pollutants due to runoff from roof and on-ground areas.
- Calculations – a worked example is given in **APPENDIX B** showing the manual method or alternatively use the **MUSIC** program to determine the required control systems.
- Functionality – water is passed through a filter medium of sand, organic matter, soil or other media. After exiting the filter device, the stormwater may be returned to the conveyance system through an underdrain or be allowed to infiltrate into the soil. Stomwater runoff from larger storm events is generally diverted past the facility to the stormwater drainage system. They are designed to incorporate many of the pollutant removal mechanisms that operate in forested ecosystems. They are usually very effective in treating stormwater pollution and are applied to land use with a high percentage of impermeable surfaces. Stormwater is conveyed to the filtering device as piped flow or as overland flow. Many of these overland flow paths can be integrated into the landscaping for the site. Bioretention can also be used as a stormwater retrofit-management measure put into place after development has occurred- by modifying existing landscaped areas, or if a parking lot is being resurfaced.

- Types – various types of bioretention systems may be utilized. A typical detail showing a bioswale system is given in **APPENDIX C**, **FIGURE C1** and **FIGURE C2**. Bioretention systems are landscaped areas adapted to treat stormwater runoff. Types of systems which fall into this category include the following:
    - Sand filters – a surface sand filter consists of a sand bed that can be covered by a layer of topsoil, allowing grass to cover the filter medium. Geotextile surrounds the filter medium on all sides. Under the filter medium is a gravel layer with an underdrain, allowing drainage of filtered stormwater. Before entering the filter medium, stormwater runoff passes through an open sedimentation chamber to remove litter and coarse sediments. Surface sand filters are the type of filter devices that can treat the largest drainage area.
    - Organic filters – a surface organic filter is similar to a sand filter but instead of sand, an organic material such as leaf compost or similar is used as the filter medium. The organic filter is used when removal of nutrients and trace metals is of major concern.
    - Planting soil filters – stormwater enters the bioretention unit by overland flow or as piped flow. The runoff should be passed through pre-treatment in the form of sedimentation ponds and/or filter strips before entering the bioretention system. The filter medium consists of a thick layer of planting soil, covered by a thinner layer of mulch. The unit is usually covered with vegetation. The filter medium may or may not be surrounded by a sand filter layer and/or gravel curtain drains. Filter fabric should line the unit. As in the case of sand and organic filters, planting soil systems are equipped with a gravel layer and a drainage pipe at the bottom. The unit should be constructed so that ponding of 150mm to 300mm of water is allowed, thus increasing the volume of water that can pass through the filter medium. At the bottom of the unit there is a drainage pipe that will convey the filtered water away from the unit.
- Design Issues – there are a number design issues which need to be considered and these include:
    - Hydraulic design - if the stormwater is delivered to the device through pipes or is along the main conveyance system, the filtering device should be designed off-line. An overflow must be provided for storms exceeding the design flow. This should be designed so that downstream erosion is prevented. Most stormwater filtering devices require 600mm to 1800mm of head. The system should be designed so that the stormwater runoff volume from regular design storms of 3 months to 1 year ARI is retained for 24 to 48 hours in the provided retention storage. The underdrain should be a 100mm perforated pipe (150mm is preferred) in a gravel layer.
    - Pre-treatment - it is necessary to have pre-treatment of the runoff entering the filter medium to remove litter and coarse sediments. This could otherwise have a negative impact on the performance of the filtering device. A sand pit, sediment bay (equivalent to at least 25% of the provided retention storage volume), or filter strips are examples of acceptable pre-treatment techniques.
    - Retention storage – the retention storage volume of the filter devices is essential for the sustainable management of the bioretention system. It evens out the flow rate through the filter and provides some measure of pre-treatment. The retention storage should be sized based on the hydraulic design criteria described earlier. A 300mm to 500mm depth is recommended. This can be increased to 1200mm provided that the side slopes of the basin are 1V:6H or more. Ponding depths in excess of these shall be fenced off.
    - Landscape design – landscaping is critical to the performance and function of bioretention areas. Therefore, details of landscaping elements and planting should be included in the Landscaping Plan required by Council. Sand and organic filters may have a grass cover to aid in pollutant adsorption. The grass should be capable of withstanding frequent periods of inundation and drought. Planting recommendations for bioretention facilities are as follows:
        - Native plant species should be specified over non-native species.
        - Vegetation should be selected based on a specified zone of hydric tolerance.
        - A selection of trees with an understory of shrubs and herbaceous materials should be provided.
        - Woody vegetation should not be specified at inflow locations.

- Filter bed – the filter medium in sand and organic filters should have a depth of about 450mm, covered by an approximately 100mm thick layer of topsoil. For planting soil systems, the filter medium should be thicker, approximately 750mm to 1200mm, covered by a 50mm to 100mm thick layer of mulch. The gravel layer should have a depth of about 150mm to 200mm. The surface area of the filtration device is determined by the permeability of the filter medium, the designed retention time of the device, design water volume to be treated, average ponding depth and the depth of the filter medium.

  The area of the filter bed is calculated based on the following equation:

  Af = (WQv) (df) / [(k) (hf + df) (tf)]

  where:

  Af = Surface area of filter bed [sqm]
  WQv = water quality volume [cum]
  df = filter bed depth = 0.46 [m]
  k = coefficient of permeability of filter media [m/day]:
  1.07 m/day for sand
  0.6 m/day for peat
  0.15 m/day for planting soil
  hf = average height of water above filter bed = 0.4 [m]
  tf = design filter bed drain time = 1.5 [days]

- Maintenance – sediment should be cleaned out of the pre-treatment device when it accumulates to a depth of more than 150mm. When the filtering capacity of the filter diminishes substantially (e.g. when water ponds on the surface of the filter bed for more than 72 hours), the top discoloured material shall be removed and be replaced with fresh material. The removed sediments should be disposed of in an acceptable manner (e.g. landfill). Silt/sediment should be removed from the filter bed when the accumulation exceeds 25mm. Organic filters or sand filters that have a grass cover should be mowed a minimum of 3 times per growing season to maintain maximum grass heights less than 300 mm. Trash and debris shall be removed as necessary. For additional information, refer to the document **Guidelines for the Maintenance of Stormwater Treatment Measures, dated January 2022, prepared by Stormwater NSW**, which will provide more guidance for the maintenance of Water Sensitive Urban Design (WSUD) devices.

7.4 Grass lined swales

- Purpose – to manage, divert and treat stormwater pollutants due to runoff from roof and on-ground areas.
- Calculations – use the manual method as shown in **APPENDIX B** or the **MUSIC** program.
- Functionality – grassed swales are conveyance systems for stormwater in which removal of pollutants can be achieved by filtration through the grass and by infiltration into the ground. The purpose of a grassed swale is to:
  - Convey stormwater
  - Divert stormwater around potential pollutant sources
  - Reduce runoff volumes and peak flows by attenuating runoff velocities and provide an opportunity for infiltration
  - Reduce sediments and other pollutants in runoff, and hence provide pretreatment of stormwater for other treatment measures.
- System overview – vegetated swales are most applicable in residential areas where the percentage of impervious cover is relatively small such as low density urban areas. Typical details are given in **APPENDIX D**, **FIGURE D1** and **FIGURE D2**. Swales are usually located in a drainage easement at the back or side of a residential lot. They can also be part of a treatment train, i.e. in conjunction with other measures for stormwater treatment or used along roads in place of curb and gutter. Stormwater is directed to the swale through pipes or overland flow. If stormwater is piped to the swale, energy dissipaters and flow spreaders must be installed, so as to not cause scouring. The swale itself consists of a grass-lined, trapezoid channel, in which the

stormwater is conveyed. As the water passes through the channel, pollutants are removed through filtration by the vegetation of the swale. Swale vegetation could be local native grasses and ground covers and not necessarily lawns. If properly maintained, a grassed swale can be expected to have a high removal rate of sediments, oil and grease and bacteria, while the removal rate for litter and nutrients will be relatively low.

- Design Issues – there are a number of design issues which need to be considered and these include:
    - Hydraulic design – a 1-year ARI storm event can be used as a guideline when designing the swale. The maximum velocity in the swale should not exceed 0.3m/s to 0.5m/s and the swale's depth is preferably between 0.3m to 0.5m. Manning's Equation can be used to design the swale with the following 'n' values:
        - n = 0.2 for mowed grass.
        - n = 0.24 for natural or infrequently mowed grass.

      Sump overflows to the pipe system can be used to bypass major storms (exceeding the design storm) away from the grassed swale. If no overflow arrangement is considered, swales should be designed to safely convey the 10-year ARI or 10% AEP storm with a 75mm freeboard. The 100-year ARI or 1% AEP design storm should also be considered and all habitable floor levels need to be set a minimum of 300mm above the maximum water surface level during the 1% AEP storm.
    - Slope – grassed swales can be constructed on longitudinal slopes of 5% or less. If small check dams are installed, swales can be constructed on slopes up to 6%. The purpose of these dams is to decrease velocity, and by doing so, making pollutant removal more efficient. For slopes of less than 2%, a subsoil drainage system shall be installed to ensure effective drainage and minimize the risk of standing water that can have a negative impact on vegetation establishment and growth. For steeper ground, swales shall be installed parallel to the contour lines. The swale shall have a uniform longitudinal grade to ensure a constant non-scouring flow.
    - Dimensions – a trapezoid shape is recommended for the swale, due to ease of maintenance and construction. The bottom width should be between 0.6m and 2.5m. The sides of the swale are to be constructed with a grade of 3H:1V or less, or if permanent stabilization is adopted, 2H:1V.
    - Retention storage – retention storage will be increased if check dams are installed. This will also promote infiltration. If this approach is chosen it is important that the dams are constructed of durable material so that they will not erode. The area downstream from the check dams should also be protected from erosion. Further, the dams should be constructed so that ponded water will infiltrate within 24 hours or less.
    - Landscape design – a grassed swale is more aesthetically appealing than kerb and gutter, and can easily be integrated into the landscape design. It is important that soil stabilization measures are taken into account during the establishment of a vegetation cover. If not, water entering the swale might cause scouring and increased sediment loads in the stormwater runoff. Mats, blankets or mulch can be used to cover the swale while vegetation cover is established. Native grasses and groundcovers are encouraged to be used for vegetating the swale and not necessarily just lawns.
- Maintenance – a swale will demand more maintenance than kerb and gutter. The vegetation has to be cut to maintain the effectiveness of the swale, and litter and sediment must be removed. Further, any erosion that has occurred must be repaired. Grassed swales can be maintained solely by mowing and trimming. However, it is best to allow swale grasses to grow and develop a healthy sward. The vegetation cover should not be higher than 300mm, as high grass is more likely not to remain upright during a storm event. This will significantly reduce the effectiveness of the swale. It is recommended that the height of the vegetation be kept between 150mm to 200mm to ensure effective filtration. Any spraying undertaken shall only be spot spraying, where required, of plant pest species. Any chemicals used shall be applied in accordance with the manufacturer's recommendations.

8. FLOOD MITIGATION AND EROSION CONTROL

Objectives – the objectives in relation to flood mitigation and erosion control are to:

- Ensure that developments do not contribute to increased risk of flooding during moderate rainfall events with an average recurrence interval of up to 1.5-years.
- Ensure that developments are compatible with the design and capacity of existing stormwater systems.
- Avoid damage to stream banks, adjacent bushland and aquatic habitat due to stormwater that is discharged in a large volume or at a high velocity.

Performance Standards – to achieve the above objectives, On-site Stormwater Detention (OSD) systems shall be used for flood mitigation and erosion control. On-site Absorption systems (OSA) may also be used and is covered in **SECTION 9 INFILTRATION AND ABSORPTION SYSTEMS**. The following standards are applicable:

- The requirement for OSD applies to all developments across the whole of the local government area, as stipulated in **TABLE 4.1** and the site location in **FIGURE 5.1 – ZONE MAP**.
- The minimum OSD site storage volume (SSV) to achieve the required stormwater control performance standards shall be in accordance with **TABLE 8.1**.
- The maximum permissible site discharge (PSD) to achieve the required stormwater control performance standards shall be in accordance with **TABLE 8.2**.

TABLE 8.1

ZONE (FIGURE 5.1)	Flood Mitigation SSV (m^3 per $100m^2$ of impervious area)	Erosion Control SSV (m^3 per $100m^2$ of impervious area)
1	3.04	1.2
2	2.63	1.1
3	2.47	1.0

TABLE 8.2

ZONE (FIGURE 5.1)	Flood Mitigation PSD (L/s per $100m^2$ of impervious area)	Erosion Control PSD (L/s per $100m^2$ of impervious area)
1	1.80	0.41
2	2.20	0.57
3	2.40	0.64

On-site Stormwater Detention Design Criteria:

- Types – OSD systems may be designed as a ‘stand-alone’ system or incorporated into the rainwater re-use tank. It may also be combined with the infiltration, absorption and bio-retention systems.
- Orifice – an orifice is to be fitted to the outlet. Two types of orifice outlet controls are acceptable. For orifice plate fixtures, these must be dyna-bolted into the wall to prevent their removal. Refer to **APPENDIX E**, **TABLE E1** for orifice coefficient values. The size of the orifice shall not be less than 30mm in diameter, to minimize blockages.
- Offsets – there will be no volume offsets for rainwater harvesting.
- Control types – the centre-line of the orifice must be set at least 50mm above the top of the kerb level at the point of discharge into the gutter. If a lower level is to be adopted (e.g. when connecting into a drainage inlet pit), a hydraulic grade line (HGL) analysis, to determine the water level, must be provided. The HGL analysis shall be determined for the 20-year ARI or 5% Annual Exceedance Probability (AEP) storm.
- Areas to drain into the OSD system – If practical, the area of the whole site shall be routed through the OSD system. If site constrained, at least all impervious areas are routed through the OSD system.
- Sediment trap – a minimum 600mm (W) x 600mm (L) x 200mm (D) sediment trap will be required in the OSD control pit in front of the orifice outlet. This sediment trap shall have weep holes in the base for drainage to prevent holding permanent water.

- Trash Screens – trash screens must be installed over the outlet orifice in all OSD systems, generally in the control pit. The minimum requirements for trash screens are:
    - Be of rust proof material. Lysaght maxi-mesh RH3030 or equivalent may be used.
    - Be removable for inspections and routine maintenance.
    - Must completely cover the outlet conduit at not less than 200mm away from the outlet.
    - Orientated such that the incoming flows are across the face of the mesh.
    - Shall include a lifting handle for ease of removal.
- Under-ground OSD systems shall comply with the following:
    - Are not to be located in an overland flow path or in a public drainage easement.
    - Must be located external to all buildings. This includes basements and garages. However, dispensation may be permitted if there is no other alternative. In this situation, the inspection grates must be external to the building footprint so that it can be inspected external to the building.
    - If located in landscaped areas, it must have at least 300mm of topsoil cover on top of the tank, to satisfy minimum landscape requirements.
    - Must be located in common areas and not in private courtyards.
    - Must be located outside of tree root zones.
    - For strata subdivisions and community title developments, it must be located in common areas and have unimpeded access for external personnel to carry out routine inspections and maintenance.
    - Must include a safe formal surcharge path for overflows out of the OSD system to cater for the 1% AEP storms.
    - Must be designed for structural and soundproof adequacy. In this regard, a Structural Engineer must provide a certification.
    - The base of the tank must be graded to fall towards the outlet at a minimum 1% gradient.
    - Must have an access grate over the control outlet with a second access at the extreme corners of the tank. Additional access points may be required for irregular shaped tanks or large tanks.
    - Must comply with **AS2865 'Safe Working in a Confined Space'**.
    - Must have step irons for internal access where the tank is deeper than 1.0m (measured from the top of the grate to the floor of the tank).
    - OSD tanks must have an internal depth of not less than 300mm.
- On-ground OSD systems in landscaped areas shall comply with the following:
    - Must not be located in an overland flow path, in a public drainage easement or across boundaries of allotments.
    - Must be located external to all buildings including basements. Where the OSD system is near sub-floor areas, adequate waterproofing of the underlying building structure must be provided.
    - Must be located where they can be accessible by external personnel for routine inspections and maintenance.
    - Must be located in common areas and not located in private courtyards.
    - Must include a safe formal surcharge path to cater for overflows out of the OSD system for the 1% AEP storms.
    - Must have a minimum fall towards the control outlet at 1% gradient.
    - The perimeter barrier around the OSD system shall be constructed of masonry type or solid material which is durable and impermeable to enable the containment of the design storage volume.
    - Subsoil drainage is to be installed to avoid soil saturation where gradients are less than 3%.
    - In landscaped areas, ponding depths must not exceed 300mm around the perimeter of the OSD system and not more than 350mm near the control pit. If the ponding depth around the perimeter exceeds 300mm, then a pool type fence is to be installed. Refer to **TABLE 8.3** for allowable ponding depths for various locations.
    - Embankment slopes 1V:4H desirable, 1V:3V absolute.
    - A minimum freeboard of 300mm is to be provided between the maximum design water level in the OSD system and the finished floor level of all

residential habitable floors and a minimum freeboard of 150mm for garages. Refer to **TABLE 11.2** for freeboard requirements.

- Calculations – refer to **APPENDIX E** for a worked example for sizing of an under-ground OSD tank.

TABLE 8.3

On-ground Detention System	Maximum ponding depth (mm)
Soft Landscaping (without fencing)	300
Soft Landscaping (with fencing)	1200
Tennis Courts (any surface)	200
Car Parking Areas	150

- Outlets – the outlet conduit from the OSD system connecting to the kerb, receiving drainage system or receiving waterway must not have a negative slope. Only one outlet point to the street kerb and gutter, receiving drainage system or receiving waterway is allowed. This outlet point can consist of double, triple or quadriple outlets. If the property draining to the street has a frontage width greater than 30m, a second outlet point may be permitted but the spacing of the outlet points must be at least 15m or greater. Where cover over the conduit cannot be achieved, the outlet is to be replaced with equivalent conduit/s.
  Conduit equivalencies are given in **TABLE 8.4**. The outlet conduit must be taken directly to the kerb face at not more than 45 degrees angle to the boundary. Private pipes can only be allowed to be laid within the verge and must not be laid parallel with the kerb. If it is necessary to lay the pipe further downslope to enable efficient fall, then a standard kerb inlet pit with lintel (min. 1.2m length) shall be installed at the kerb and gutter and then a minimum 375mm-dia reinforced concrete pipe (RCP), shall be laid under the road pavement and connecting to the nearest downstream public drainage line.

TABLE 8.4

Pipe	Equivalent Conduit
150mm-dia	100mm (D) x 200mm (W) x 6mm (thick) RHS
225mm-dia	Twin 100mm (D) x 200mm (W) x 6mm (thick) RHS
300mm-dia	4 x 100mm (D) x 200mm (W) x 6mm (thick) RHS

Note: All rectangular hollow sections (RHS) are to be hot dipped galvanized.

- Gravity System – all pipes leading to and out of the OSD system shall be by gravity fall to enable the conduit to self-drain after a storm event. A ‘charged’ network is generally not permitted for OSD systems.
- Discharging to a different catchment – stormwater runoff must be disposed of in the same direction of fall. That is, if the site falls away from the street frontage, then a legal drainage easement will be required. Only if genuine attempt at easement acquisition has been unsuccessful, will an alternative disposal method be considered. This may require a catchment analysis if the proposal is to drain the site’s stormwater runoff to a different catchment (or sub-catchment).
- Legal Obligations – all OSD systems must have a “**Positive Covenant**” and a “**Restriction on the Use of Land**” imposed on the title of the property. The purpose of the Covenant is to ensure that the registered proprietor of the land is made aware and takes responsibility for the control, care and maintenance of the OSD system. The purpose of the Restriction on the use of land is to ensure that the system cannot be tampered with or altered in any manner, shape or form. For newly created parcels of land, the Terms are to be created under Section 88B of the Conveyancing Act 1919. For existing properties, the Terms are to be created by an application to the Lands Department using Forms 13PC and 13RPA. Standard wording is given in **APPENDIX F**.
- Design Submission - A Stormwater Management Plan (SMP) showing the OSD system must be submitted with the Development Application. The minimum OSD information to be included on the SMP, shall be:
  - Summary Sheet with the site address, designated stormwater control zone, calculated impermeability value of the proposed development, minimum

storage volume/s and corresponding permissible site discharge/s (for both erosion and flood control), orifice size/s,
- Control pit showing configuration of the trash screen, sediment trap, orifice, inlet and outlet pipe with overflow weir and dimensions,
- pit grate dimensions, finished surface levels and invert levels,
- size and gradients of all pipes,
- plan dimensions of the OSD system,
- finished design levels with gradients (for above-ground OSD),
- maximum design water level,
- pool fencing (if required).

9. INFILTRATION AND ON-SITE ABSORPTION SYSTEMS

Objectives – the objectives in relation to flood mitigation and erosion control are to:

- Provide an alternative solution for the disposal of stormwater runoff from low-lying sites in development, where the site is not benefitted by any legal drainage easement.
- Avoid damage to stream banks, adjacent bushland, and aquatic habitat due to stormwater that is discharged in a large volume or at a high velocity.

Definitions – for the purpose of this document, the term used for ‘infiltration systems’ refers to basic devices such as porous pavements and modular paving where the purpose of which is to reduce the impermeability of the site and to provide a water treatment option as described and covered in **SECTION 7.2 POROUS PAVING**, to satisfy the water quality objectives. The term used for ‘On-site Absorption (OSA) Systems refers to a complete system which is used to manage the majority of the development site’s runoff as an alternative to off-site stormwater disposal, collected from impermeable and permeable surfaces, and where off-site disposal of the site’s runoff may not be practical.

Performance Standards – to achieve the above objectives, On-site Absorption (OSA) systems may be used in combination with a fail-safe dispersion device. In some situations, an OSD system may be required immediately upstream of the OSA system to enable effective soil infiltration. The OSA may only be considered in the following circumstances:

- A formal drainage easement cannot be obtained through downstream property/s to enable legal rights of drainage for the proposed development site. To assist the applicant in pursuing a legal drainage easement, the generic letter given in **APPENDIX G**, can be used.
- A Geotechnical Report, prepared by a qualified Geotech Engineer, has been undertaken for the site and the recommendations of the Geotechnical Report indicate that an OSA system can be used to safely dispose of the site’s runoff.
- The requirement for OSA can be applied to all developments across the whole of the local government area, where the site drains away from the street frontage and the above circumstances exist. Typical details and a worked example of an OSA system is given in **APPENDIX H**.

Design Criteria – the following design criteria applies to all OSA systems:

- Subject to the recommendations as given in the Geotechnical Report, the Mass Curve Method of calculating the size of the OSA system can be used.
- OSA systems may be located in soft landscaped or hard landscaped areas. It shall not be located in an area where there will be vehicle loads such as under a driveway.
- OSA systems shall not be located under or over a sewer system without Sydney Water approval.
- OSA systems shall not be located in rock (this includes sedimentary rocks such as shale and some unsuitable non-sedimentary rock), which have zero to near zero permeability.
- If the Geotechnical Report allows the OSA system to be constructed over rock, the OSA shall be at least 500mm above the rock.
- OSA systems shall follow the line of contours.
- Access chambers shall be provided at each end of the OSA system for routine inspections and maintenance.

- The design storm shall be the 100-year ARI or 1% AEP storm.
- Soil type must not be predominantly loose aeolian sands or clays.
- Suitable soils must have a uniform depth or thickness of at least 2.0m.
- The hydraulic conductivity of the soil must be greater than 1×10^{-6} m/s.
- The minimum clearance to any downstream structure or building shall be 3.0m and to the rear boundary it shall be 1.5m.
- The minimum clearance to sewer lines shall be 1.0m without a report from Sydney Water allowing the OSA system to be in closer proximity.
- OSA will not be permitted for site slopes greater than 5% (unless supported by the Geotechnical Report).
- OSA will not be permitted where a high-water table is encountered. The base of the OSA trench must be at least 500mm above the water table.
- The inspection pits into the OSA system must have a 200mm deep sediment traps with trash screens.
- A dispersion system shall be provided downslope of the OSA system to prevent concentrated runoff should the system overflow during higher storm events.

10. MECHANICAL PUMP-OUT SYSTEMS

Objectives – the objectives in relation to stormwater management is to:

- Provide an alternative solution for the disposal of stormwater runoff from low-lying sites in development, where the site is not benefitted by any legal drainage easement and the soil condition does not allow it to be considered for on-site disposal such as an absorption system.
- Have a method for the disposal of subsoil drainage water in sub-floor areas.
- Provide a method for the safe disposal of the site's stormwater runoff where alternative disposal methods cannot be achieved.

Performance Standards – where drainage is to be directed to a different catchment, to achieve the above objectives, it may be necessary to incorporate an On-site Stormwater Detention (OSD) system to minimize the discharge to the street.

Important Note: Where known flooding has been identified, the discharge of the site runoff into the catchment would be prohibited. In this regard, easement acquisition is mandatory. The applicant will need to seek a formal drainage easement through Section 88k of the Conveyancing Act, via the Court.

Design Criteria – the following design criteria applies to mechanical pump-out systems:

- For the sizing of the storage sump and mechanical pump-out system, the Australian standards **AS/NZS 3500.3:2003 "Plumbing and Drainage Part 3: Stormwater Drainage"** Code, **Section 9 Pumped Systems**, and **Appendix L**, shall be used. However, where there is conflict between the Code and this document, the design criteria given in this document takes precedence.
- Step irons are to be installed where the tank depth exceeds 1.0m, measured from the top of the grate to the floor of the holding tank.
- A holding sump and mechanical pump-out system is generally to be used for the temporary storage and conveyance of seepage water in sub-floor areas and runoff collected from sections of the driveway that cannot be graded away from the low-lying area.
- The maximum on-ground driveway area allowed to be directed into the holding sump is 50sqm, unless otherwise approved by Council.
- Without a known seepage water inflow rate, the minimum area to be adopted for calculating the minimum size of the holding sump is 25sqm.
- Dual mechanical pumps, connected in parallel shall be used, with each pump capable of emptying the holding tank at a rate equal to the 100-year ARI, 2-hour duration storm event.
- Pumps shall be arranged such that they operate alternately, and both pumps shall operate simultaneously when the water level exceeds the design storage level.

- A sediment trap is to be installed on the inlet side of the holding tank. This can be provided in the inlet pits.
- The rising main from the holding sump and pump-out system shall be discharged to a junction pit within the property and then gravity fed to the receiving drainage system or receiving waterway. This junction pit shall be located such that overflows will be safely directed to the street, receiving drainage system or receiving waterway but away from structures, buildings or low-level driveways.
- The rising main outlet shall have a one-way valve installed to prevent any back surge.
- An automatic alarm system shall be provided to warn of failure of any part of the pump system. The alarm is to have visual indicators (e.g. strobe light) and an audible alarm siren.
- A rechargeable back-up battery for the alarm is to be provided in the event of power failure.
- Seepage water pumped to the street must be directed into an under-ground drainage system such as a public stormwater pit and pipe system. It cannot be drained directly to the kerb and gutter for health and safety reasons. The constant pumping of seepage water into the gutter will result in slime build-up and erosion over time.
- A worked example for sizing the holding sump and mechanical pump-out system is given in **APPENDIX I**

11. PUBLIC AND PRIVATE STORMWATER DRAINAGE SYSTEMS

Objectives – the objectives in relation to stormwater management is to:

- Provide minimum guidelines for the design of a drainage network to enable the safe conveyance of stormwater runoff from both private and public land.
- Minimize the impact of stormwater runoff by collecting and conveying stormwater safely and to control its quantity and quality.

Performance Standards – stormwater drainage systems are to be designed to safely collect and convey stormwater runoff to the receiving drainage system or waterway with minimal nuisance, danger to life and damage to properties.

Design Criteria – the following design criteria applies to all stormwater drainage networks:

- The design of the stormwater drainage network shall be in accordance with the **Australian Rainfall and Runoff Handbook** utilizing the ‘major’ and ‘minor ‘system design criteria and the Australian Standards **AS/NZS 3500.3:2015 “Plumbing and Drainage Part 3: Stormwater Drainage”** Code. Where there is discrepancy between the Codes and this document, the design criteria given in this document takes precedence.
- Roof eaves and box gutters and downpipes shall be designed in accordance with the Australian Standards **AS/NZS 3500.3:2015 “Plumbing and Drainage Part 3: Stormwater Drainage”** Code.
- Stormwater drainage pipes and other conduit types must be laid with a positive gradient, to fall towards the outlet (downstream).
- Without a known tailwater level, the top of the pit level or the ground finished surface level is to be adopted as the starting Hydraulic Grade Line (HGL) level, for calculation purposes.
- The re-direction of stormwater runoff from one catchment into another catchment is prohibited, unless supporting calculations show that this will not cause a negative impact on the receiving drainage system and is approved by Council.
- Stormwater drainage networks must have sufficient capture points to prevent stormwater entering buildings or structures and hence minimize damage to the buildings or structures, to minimize nuisance and minimize danger to persons and vehicular traffic, and to prevent long term water ponding.
- Stormwater drainage networks must include a failsafe overland flowpath, in case the design storm event is exceeded.
- Stormwater drainage networks must include provision/s for silt and sediment traps and trash screens to capture water borne pollutants.
- Stormwater drainage networks shall be designed in accordance with **SECTION 11.1** to **SECTION 11.11**.

11.1 Minor Stormwater Drainage System

- The ‘minor’ stormwater drainage system shall be accommodated in gutters, pits and pipes (conduits), to safely collect and convey stormwater runoff during the ‘minor’ design storm event.
- The ‘minor’ design storm event is given in **TABLE 11.1**.

TABLE 11.1

Location	Private Drainage System Design Storm ARI (year)	Public Drainage System Design Storm ARI (year)
Local Road		10
Collector Road		10
State and Regional Road		50
Emergency Facility Access	100	100
Road Depression (low point)	50	50
Drainage Easement	20	20
Residential – low density	10	
Residential - multi	20	
Commercial and Industrial	50	

11.2 Major Stormwater Drainage System

- The ‘major’ stormwater drainage system design storm event shall be the 100-yr ARI or 1% AEP.
- The ‘major’ stormwater drainage system shall be accommodated in pits, pipes (conduits), formal overland flow routes, roads, channels, creeks and rivers.
- If the overland flow route is through a road, it shall be located within the road carriageway and between kerbs.
- Where the overland flow route within the road carriageway or drainage easement cannot be accommodated safely, then the pit and pipe network are to be designed for the ‘major’ storm event.
- The minimum freeboard between structures and the 100-yr ARI or 1% AEP design water level are given in **TABLE 11.2**.

TABLE 11.2

Location	Freeboard (mm) (100-yr ARI or 1% AEP)
Habitable floor (residential)	300 (1)
Non-habitable floor (patio, verandah, porch)	150
Commercial or Industrial internal areas	150 (2)
Garage floor	150 (3)
Carport (open on all sides)	75 (3)
Sub-floor areas such as basements and low-level parking areas	150 (2)

Notes:
1. Freeboard to be increased to 500m if in a known flood area.
2. Freeboard to be increased to 300mm if in a known flood area.
3. Freeboard may be reduced at Council’s discretion.

11.3 Catchment Area and Runoff

- The catchment area is defined by the limits from where surface runoff will make its way towards the point of exit either by natural or man-made paths. This is usually measured in hectares (ha) or square meters (sqm).
- The impervious areas of a catchment in determination of the runoff from the catchment area is given in **TABLE 11.3a**.
- The catchment runoff shall be determined using a suitable hydrological method depending on the size and shape of the catchment area. Two (2) methods that can be employed is given in **TABLE 11.3b**. The Rational Method determines peak flows and is acceptable for

smaller sized catchment areas and for site specific applications such as a residential development lot. Where the area becomes large, then a hydrological computer model will be required. Acceptable hydrological computer models include ILSAX, DRAINS, RAFTS, and RORB. It is noted that Council does not have all these computer models available and therefore the onus is on the designer to provide sufficient supporting information so that Council can make a sound determination of the application.

TABLE 11.3a

Location	Imperviousness (%)
Site specific development	Use impermeability factor as determined in **APPENDIX B**
Road reserve	100
Residential catchment area	60
Commercial and industrial catchment areas	90

TABLE 11.3b

Method	Size of Catchment Area
Rational Method	< 1000 sqm
Hydrological Model	> 1000 sqm

11.4 Flow Widths

- For the ‘minor’ design storm event, the width of flow in the gutter shall not exceed 0.45m, that is, runoff must be fully contained within the gutter.
- For the ‘major’ design storm event, the width of flow shall be contained within the road carriageway between kerbs. If stormwater cannot be accommodated safely, then the under-ground drainage network is to be designed to cater for the ‘major’ design storm event.

11.5 Conduits

- The network of pipes, box culverts and other type of conduit capable of conveying stormwater runoff during the ‘minor’ or ‘major’ storm event.
- For determining hydraulic losses in conduits, use the Darcy-Weisbach Equation. The Colebrook-White friction factor or conduit roughness of certain conveyance systems are given in **TABLE 11.5a**.
- The minimum conduit size, slope, cover and allowable material to be used is given in **TABLE 11.5b**.
- Reinforced concrete pipes shall be rubber ring jointed.
- Domestic PVC pipes for pressure applications (e.g. rainwater system) shall be solvent welded and drinking water safe.

TABLE 11.5a

Material	Roughness factor, k_s (mm)
uPVC pipe/conduit	0.015
Vitrified clay pipe	0.15
Reinforced concrete pipe/conduit	0.60
Fiber reinforced concrete pipe	0.03
‘Blackbrute’, ‘Bluebrute’ pipe (1)	0.03

T**ABLE 11.5b**

	Shape	Material	Minimum size (mm)	Minimum Slope (%)	Min. cover to obvert (mm)
Private Systems	Circular - pipes	uPVC, concrete	50-dia	1%	450 (3)
	Rectangular - culverts	galvanized steel	100 x 100	1%	50
Public Systems	Circular – pipes (6)	reinforced concrete	375-dia (2)	1%	600 (4)
	Rectangular - culverts	reinforced concrete	300 x 300	0.75%	600 (5)

Notes:
1. If used on public land, will be subject to Council approval.
2. A 300mm diameter pipe may be acceptable subject to Council approval.
3. A cover of 300mm may be acceptable in landscaped areas not traversed by vehicular traffic.
4. A cover of 450mm may be acceptable in pedestrian only areas.
5. Less cover may be permitted if culvert is designed for vehicle traffic load.
6. Minimum Class 2 for pipes. Higher class required if cover is reduced.

11.6 Hydraulic Grade Line

- Hydraulic Grade Line (HGL) calculations are required when designing public drainage systems. This is generally not necessary for private drainage systems unless the water surface profile is critical at the point of discharge, for example, when designing an OSD system with 'free outlet' control. For private networks, a check on the slope and friction value with its capacity based on 'pipe flowing full but unpressurised' is sufficient.
- Drainage networks shall be designed to have minimal hydraulic losses. Therefore, bends in the pipe network is to be minimized, and drops in the pits (level difference between the inlet pipe and outlet pipe), and the reduction in downstream pipe sizes are to be avoided.
- Where bends in the pipe network are greater than 22.5 degrees, a junction pit is to be installed. A junction pit may also be necessary for sharper angles at Council's request.
- To avoid 'choke points', pipes will not be permitted to be installed such that a larger pipe joins into a smaller pipe downstream. However, this may be unavoidable when designing public drainage networks, where the proposed drainage line is to be connected into an existing drainage network originally designed for lower intensity storm events. In this situation, the starting water level is to be assumed to be at the top of the pit lid where the new line joins into the existing line.
- The Missouri Charts, Hare Equation, US Corps of Engineers Mitre Bend Charts and the Australian Rainfall and Runoff are to be used to determine pit losses and the Darcy-Weisbach/Colbrook-White Equation is to be used to determine the losses due to friction within the pipe network, if manual HGL calculations are to be performed. Alternatively, the computer program **DRAINS** can be used to determine the HGL when designing the drainage network. An electronic copy of the **DRAINS** (DRN) files will need to be submitted along with a summary of the design in EXCEL format.
- For uniform open channels, use the Mannings Equation, when manually calculating the size of the channel with the design water surface profile. The computer programs **DRAINS** or **HEC-Ras** can be used for non-uniform and irregular shaped channels.
- Full hydraulic calculations must be submitted for assessment to enable Council to determine the feasibility of the proposal.

11.7 Stormwater Drainage Pits

- Stormwater drainage pits in a road reserve shall be located generally along the kerb line. Inlet pits shall have grates (of minimum dimension 450mm x 900mm) and a lintel opening of not less than 1.2m long. Minimum dimensions for various types of pits are given in **TABLE 11.7**.
- Pits that are in public ownership shall have grates of minimum 450mm x 450mm. Grates that will be subject to vehicular traffic shall be heavy duty class D. Grates in landscape areas which are not subjected to vehicle traffic shall be minimum Class C. All public grates are to be galvanized, bicycle friendly with grate hinged to frame and lockable.
- Private pits may be prefabricated provided that the correct load type is specified (that is, load class for either non-vehicle trafficable or vehicle trafficable areas as per Manufacturer's specifications). Public pits can be either cast insitu reinforced concrete or precast units. If precast units are to be used, the correct load class must be specified.
- Where private pits are designed for surcharging or upwelling of stormwater, they must be hinged to frame and lockable. Solid covers over public junction pits shall be gatic type.
- Letterbox type pits may be specified but they are not to be used at or near kerb locations. In the road reserve where there are no kerb and gutter, butterfly type grates may be used but must be flush with the surrounding ground surface level.
- Pits deeper than 1.0m (measured between the finished ground level and the base of the pit) shall have galvanized or stainless steel step irons installed.

- Inlet pits shall be installed at 'low points', at intervals where the flow width in the gutter is to be maintained at 450mm. Junction pits shall be located at changes in gradients in the pipe network, changes in direction of the pipe alignment (only when > 22.5 degrees deflection for private pipes), and where there is a level difference greater than 75mm between the inlet pipe and outlet pipe.
- Kerb inlet pits shall have lintels of minimum 1.2m in length but not more than 3.6m.

TABLE 11.7

Pit Type	Minimum internal dimensions (mm)
Kerb inlet with 1.2 min. lintel and grate in the kerb and gutter	600 x 900
Grated inlet pit (no lintel) or junction pit (solid cover) in landscape area not under the kerb and gutter (public asset) < 1.0m deep	600 x 600
Grated inlet pit (no lintel) or junction pit (solid cover) in landscape area not under the kerb and gutter (public asset) > 1.0m deep	900 x 900
Grated inlet pit (no lintel) or junction pit in private property (not public asset) < 1.0m deep	300 x 300
Grated inlet pit or junction pit in private property (not public asset) between 1.0m and 1.5m deep	450 x 450
Grated inlet pit or junction pit in private property (not public asset) between 1.5m and 2.0m deep	600 x 600
Grated inlet pit or junction pit in private property (not public asset) > 2.0m deep	900 x 900

11.8 Open Channels

- Where-ever possible, an underground piped drainage network is preferred over an open channel conveyance system.
- Open channels will only be permitted to convey overland flows as part of the 'failsafe' design for the 'major' stormwater drainage system.
- Open channels shall have smooth transitions and must avoid sharp changes in direction and in levels where-ever practical, to avoid 'hydraulic jumps', which may cause instability and rise in water levels in the channel.
- Open channels shall be designed in accordance with the **Australian Rainfall and Runoff Handbook** and the **NSW Government Flood Plain Development Manual**. Where there is discrepancy between the Codes and this document, the design criteria as given in this document shall take precedence.
- Flow velocities shall not exceed the lesser value between that which would cause scour to a particular surface treatment or the safe values as given in the **NSW Government Flood Plain Development Manual**.
- Side slopes shall not exceed 1V:3H unless fully fenced.
- The Mannings Roughness coefficients shall be used for open channel design. Typical values for various types of surfaces can be obtained from the **Australian Rainfall and Runoff Handbook or AS/NZS3500.3:2015 Plumbing and Drainage – Stormwater Drainage**.
- The **HEC-Ras** or **DRAINS** program can be used to determine water surface profiles for non-uniform or irregular open channels.

11.9 Building adjacent to Stormwater Drainage Systems

- Where new buildings and structures are to be constructed, their support structures which includes foundations, piers and footings are not to load bear onto the underlying stormwater drainage network. The base of all footings and piers must be found outside of the Zone of Influence. This is the zone created by an angle of 45 degrees to the horizontal extended from the invert of the drainage conduit to the surface.
- If a new drainage pipe is to be installed in proximity to a building or structure, the exact location of the buildings or structure's foundations are to be found and the new pipe network shall be designed such that it is located outside of the Zone of Influence.
- Public drainage networks are not to be laid under buildings or structures.

- Consult with and obtain consent from Sydney Water if the proposed drainage network is to be laid under or over a sewer main.
- If a proposed development requires the relocation of a public drainage line to enable the proposed development to proceed, then a full hydrological and hydraulic analysis shall be provided to Council. This will include the HGL for the existing and proposed conditions. The HGL must not be worse for the relocated line. A plan and longitudinal section of the proposed line showing design flows (for the design ARI storm event), finished grate levels, conduit invert levels, conduit sizes, conduit gradients, crossing services, and an HGL shall be submitted to support the proposal.

11.10 Connections to the receiving Stormwater Drainage System or Waterway

- Non-return valves are not to be installed in the public stormwater drainage network.
- Where the private outlet for the conveyance of stormwater runoff from a site is to be discharged directly to the street kerb and gutter, the outlet must be connected into the back of the kerb with a minimum cover of 50mm. Equivalent conduit sizes may be required if minimum cover cannot be achieved. Alternatively, it may be necessary to connect into an existing public drainage pipe.
- Where the private outlet pipe is to convey sub-surface water, it shall be taken to the nearest downstream public stormwater drainage under-ground network.
- Where the private pipe is conveying stormwater runoff into a public pipe, a standard Council junction pit shall be installed at the point of connection. A direct pipe connection will only be permitted if the ratio between the diameter of the private pipe to the diameter of the public stormwater drainage pipe is less than one third. A flowcon™ 'conconnect' fitting device shall be installed to facilitate the connection between the private and public pipe.

11.11 Services

- Care shall be taken to ensure that there will be no clashes with any utility services.
- A 'Before You Dig' services search shall be undertaken prior to the design of the drainage system network. Where services are found to cross the line either over or under the proposed stormwater drainage conduit, a physical investigation by potholing shall be undertaken at the crossing point prior to the finalization of the construction plans.
- Public stormwater drainage lines shall generally be located under the kerb and gutter or in the road pavement adjacent to the gutter to avoid conflict with utility services in the road verge (nature strip).
- Locating the proposed public stormwater drainage conduit within the nature strip may be approved, at Council's discretion, if it is not practical to locate the new conduit within the road carriageway due to either busy traffic on a main road and/or is likely to clash with major services.
- Where private stormwater pipes are to be connected into the back of the kerb, it must be laid within the verge at the shortest possible distance between the kerb and the boundary and projected at an angle of not more than 45 degrees to the site boundary, to avoid clash with services. The laying of private stormwater pipes parallel with the kerb line is prohibited.

12. STORMWATER DRAINAGE EASEMENTS AND INTER-ALLOTMENT DRAINAGE

Objectives – the objectives in relation to stormwater management is to:

- Provide formal legal rights of access for the unhindered disposal of stormwater runoff for both private and public drainage infrastructure that must pass through private land.
- Avoid unnecessary reduction in capacity of the existing drainage system by maintaining flows within the same catchment.

Performance Standards – legal stormwater drainage easement acquisition enables the legal rights of drainage for future maintenance, upgrade and identification.

Requirements – where the site grades away from the street frontage, the creation of a formal drainage easement will be required. To enable the development to proceed, the applicant must provide evidence in the form of a Legal Agreement between the affected parties or copies of titles showing the created or intention to create an easement. The applicant must undertake a genuine attempt to acquire an easement on the downstream property/s before consideration of alternative method of drainage disposal may be considered. To assist the applicant in obtaining a legal drainage easement, the generic letter as given in **APPENDIX G**, can be used.
Although an existing public stormwater drainage conduit through a private property has the same legal rights of drainage even if there is no easement created over it, Council will take the opportunity to pursue an easement over the public drainage system when-ever possible, to enable Council full rights of access to inspect, maintain or upgrade the underlying conduit. This means that when a development is proposed on a site, which currently has a stormwater conduit passing through it, Council will require that a stormwater drainage easement be created over the line of the existing stormwater conduit as a condition of approval for the development.

Design Criteria – the following design criteria are to be followed:

- Where an easement is to be created over an existing public stormwater conduit, all legal costs including surveys and searches associated with the acquisition of the drainage easement over the public stormwater drainage conduit shall be borne by Council but there will be no compensation for the value of the land for the easement.
- A sub-division of land will not be approved unless a legal drainage easement can be obtained through the downstream property/s to enable the newly created allotments the rights of drainage in the same direction of the fall of land by gravity means.
- Buildings and structures shall not be permitted to be constructed over drainage easements. This includes any structures that may overhang the building such as balconies and eaves gutters up to a height of 4.5m.
- The creation of a public drainage easement is to allow Council reasonable access to the underlying conduit for the purpose of inspections, maintenance, or upgrade. It may be necessary to relocate the underlying stormwater conduit to enable future access to the conduit.
- Encroachments over easements are prohibited because this may impede the overland flowpath over the line of the easement.
- No load bearing structure shall be permitted to be constructed within the drainage easement. This includes any private stormwater pits, pipes and services. For existing conduits, it may be necessary to relocate the conduit prior to the creation of an easement to ensure that there will be no future structural load onto the conduit.
- The planting of trees or shrubs with invasive roots will not be permitted within the drainage easement.
- Paved surfaces may be permitted to be constructed over the easement provided that the construction joints are located along the longitudinal edge of the easement to enable ease of future access to the underlying conduit.
- An easement for the disposal of the site’s stormwater and the installation of inter-allotment drainage pipes shall be provided to enable drainage of low-lying properties where-ever possible.
- The widths of stormwater drainage easements are given in **TABLE 12.1**.

TABLE 12.1

Easement Type	**Minimum Width (m)**
Public Drainage System	External width of the conduit + 1.0m (rounded to the nearest 0.1m)
Private Drainage System (inter-allotment)	External width of the conduit + 0.5m (rounded to the nearest 0.1m)

13. DOCUMENTATION SUBMISSION

Minimum Requirements – where required by condition, at the completion of construction of the stormwater drainage system, the following minimum documentation must be submitted to Council:

- Works-as-Executed drawings, signed and dated by a Registered Surveyor.
- Compliance Certificate from the Certifying Professional Engineer, who must be a current Corporate member of the Institution of Engineers, Australia with N.E.R. standing.
- Copies of titles showing the creation of easements (where easement acquisition is required), Positive Covenant and Restriction on the Use of Land (where an OSD system is required). Refer **to APPENDIX F** for legal instruments.

APPENDIX A – RAINWATER HARVESTING SYSTEMS

FIGURE A1 – TYPICAL ABOVE-GROUND RAINWATER SYSTEM

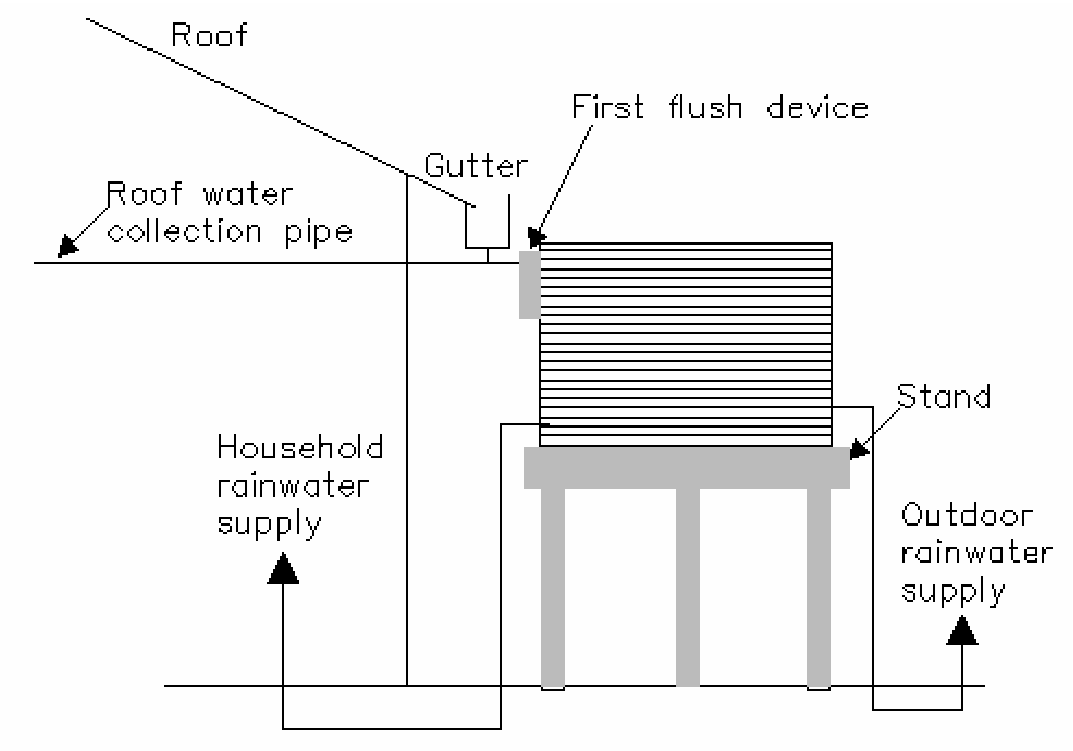


FIGURE A2 – TYPICAL BELOW-GROUND RAINWATER SYSTEM

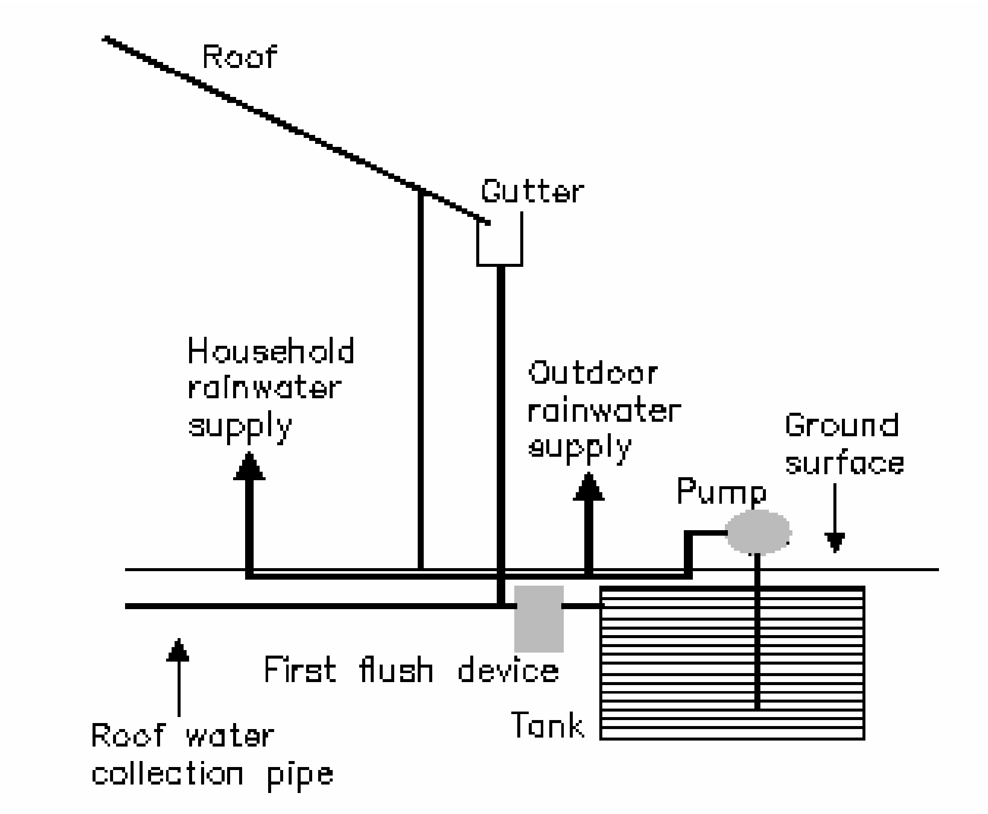
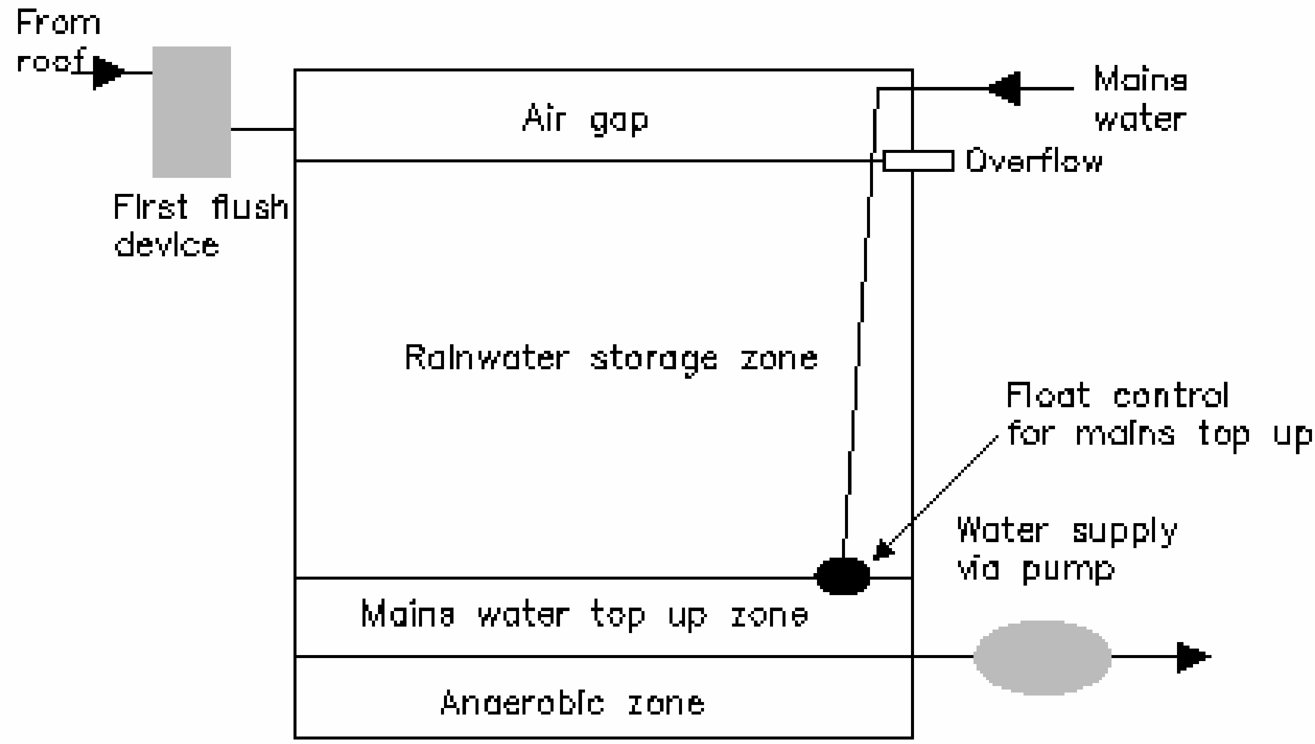


FIGURE A3 – PLAN AND ELEVATION



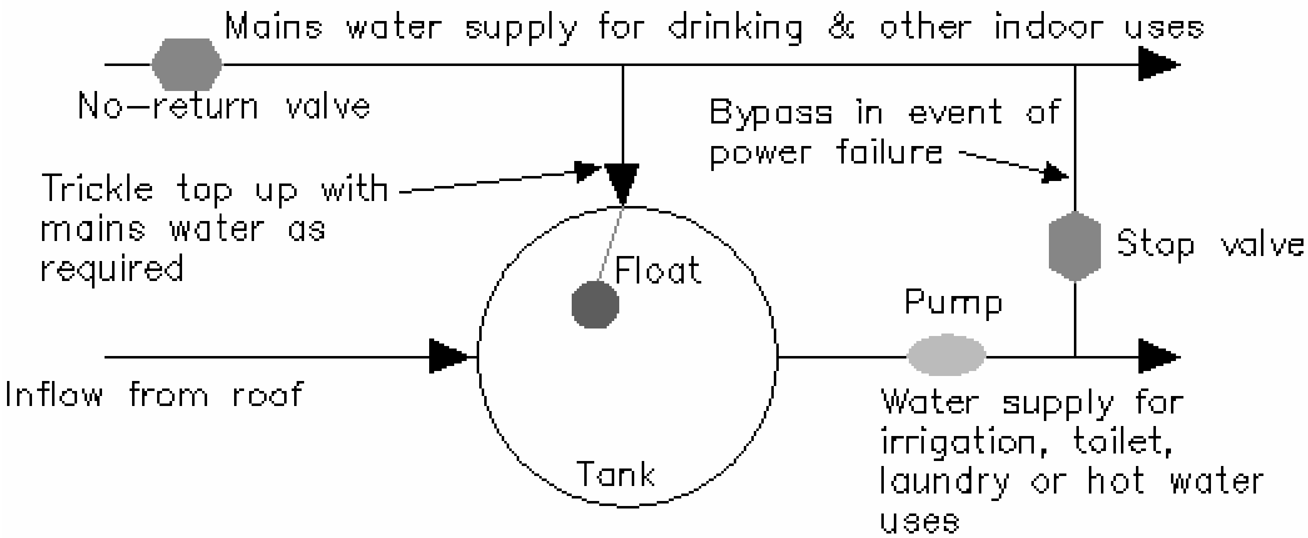


FIGURE A4 – BASIC 'FIRST FLUSH' DEVICE DETAIL

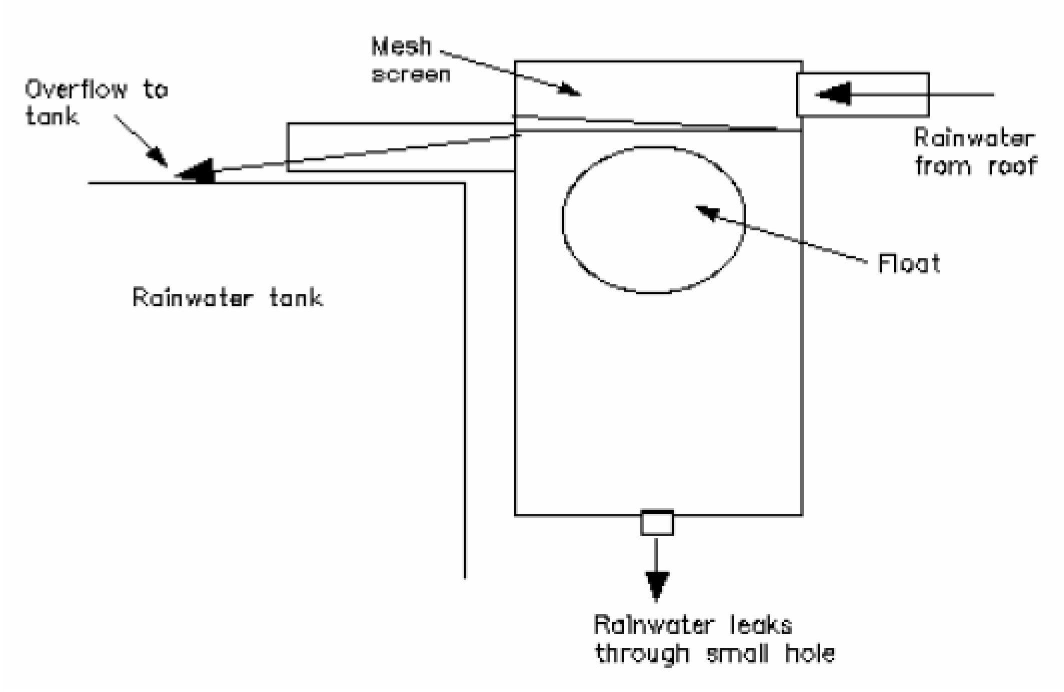
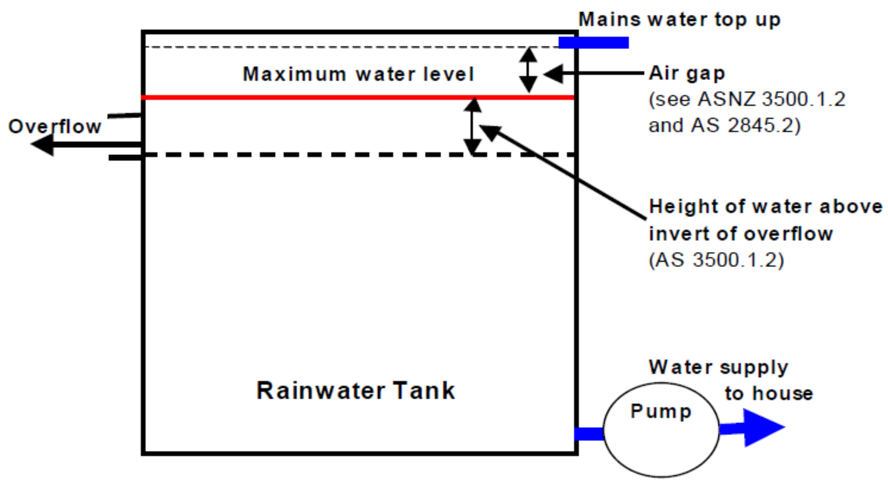


FIGURE A5 – BACKFLOW PREVENTION USING AIR GAP OR AN RPZD



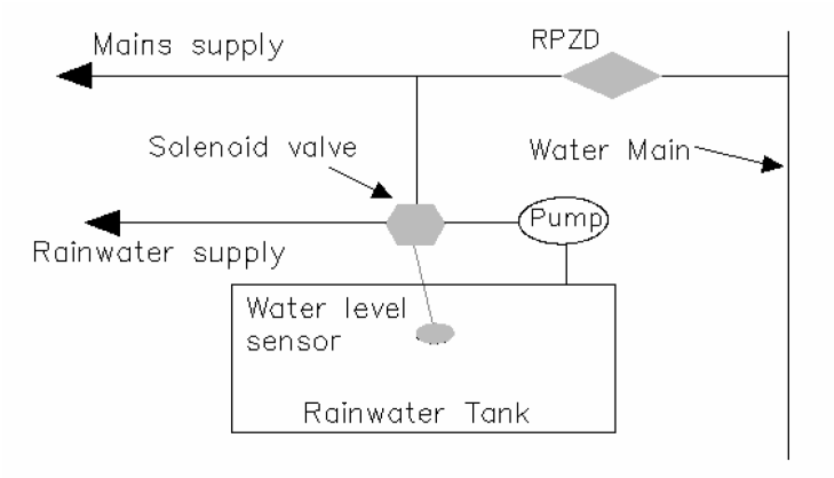
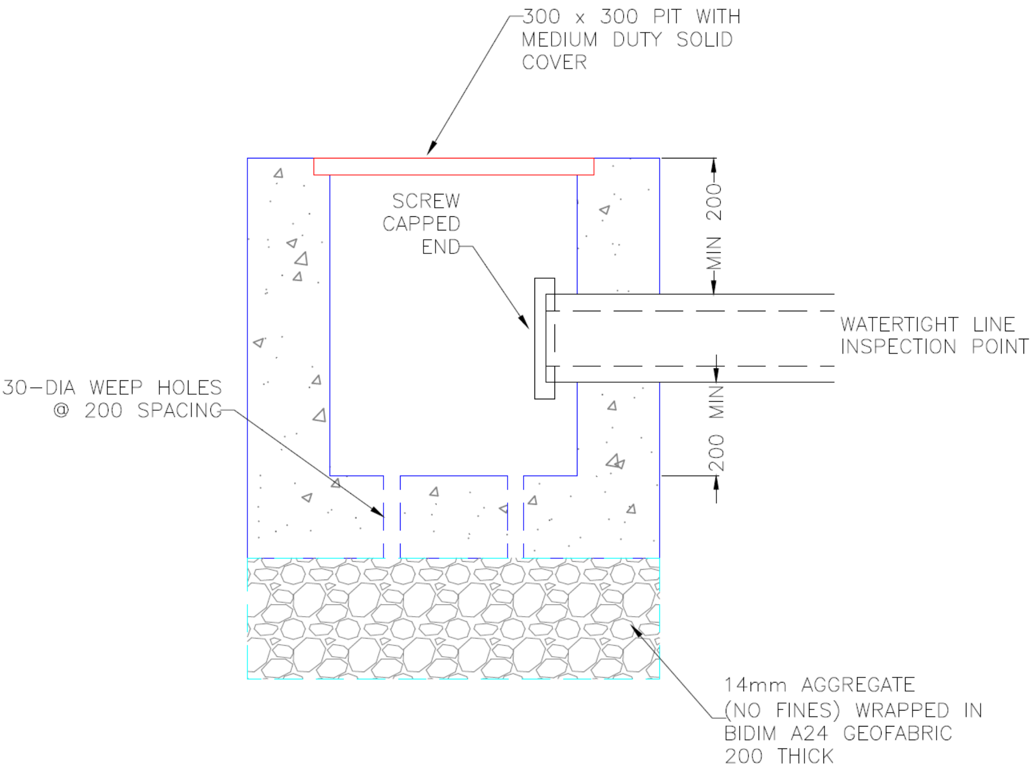


FIGURE A6 – TYPICAL 'CLEAN-OUT' PIT DETAIL



APPENDIX B – CALCULATING ROOF WATER VOLUME AND POLLUTANT LOADS

WORKED EXAMPLE

This is a manual hand calculated worked example. The designer may choose to use the **MUSIC** program to determine the required rainwater tank volume and pollution control devices required to satisfy the reduction in pollutant loads coming directly from roof areas. Where **MUSIC** is to be used, the reduction in mains potable water usage is to be specified as 30%.

STEP 1 – Calculate the impermeable areas of the site using **TABLE B1** below for guidance.

TABLE B1

SURFACE TYPE	MATERIAL	IMPERMEABILITY FACTOR (1)
Roof areas	Metal, concrete, slate, and other impermeable materials	1.00
	'Green Roofs'	0.50
Ground surfaces	Concrete, paving and other non-porous material	1.00
	Gravel	1.00 (2)
	Porous paving	0.50
	Grid pavers (e.g. 'grass-grid')	0.20
Decks and patios	Concrete, paving and other non-porous material	1.00
	Timber over natural soil	0.50
Swimming pools	All types	0.50 (3)

Notes:
1. Sourced from Maryland Design Manual (200 Ed.), Maryland Department of the Environment U.S.A.
2. Taken generally the same as for concrete for Australian conditions.
3. Overflows from swimming pools generally to be directed to the sewer system and not to the stormwater system.

Site Details

Development Type: New single residential dwelling home
Site area: 650 sqm
Proposed footprint of roof area: 300 sqm
Associate works: includes path, driveway and associated landscaping

This is tabulated in **TABLE B2** below.

TABLE B2

Surface Type	(1) Area (sqm)	(2) Impermeability Factor	Impermeable Area (1) X (2)
Roof	300	1.00	300
Driveway – concrete	100	1.00	100
Landscaped area	150	0.00	0
Path - grid pavers	100	0.20	20
Total Impermeable Site Area			**420 sqm**

Therefore, the Site Impermeability Indicator (%), **I** = 420/650 x 100 = 65%

STEP 2 – Calculating pollutant loads and runoff volumes

L = Average annual load of pollutant exported from the site through the stormwater runoff [kg/yr]
= (Vol x EMC) / 100

Where **Vol** = Average annual stormwater volume from the site
= (Rv x Rainfall x A) / 1000 [cum/yr]
Rv = Volumetric runoff Coefficient
= 0.25 + (0.0065 x I) [expressed as fraction of rainfall converted into runoff]
I = Site impermeability indicator [expressed as a percentage]

A = Total site area [sqm]
Rainfall = Average yearly rainfall for the site [mm]
EMC = Average Event Mean Pollutant Concentration [mg/L]
Where TSS = 140 mg/L
TP = 0.25 mg/L
TN = 2.00 mg/L

Note: The above values are based on the stormwater flow and quality data provided by the Cooperative Research Centre for Catchment Hydrology, undertaken by the NSW Department of Environment and Conservation.

The above worked example is shown below in tabulated summary format:

site area (m^2)	650						
roof area (m^2)	300						
impervious paved area (m^2)	100						
grid pavers area (m^2)	100						
landscaped irrigated area (m^2)	150						
average rainfall (mm)	1150						
Task							
calculate site imperviousness, % (I_{site})		65					
Refer to Table 1							
Determine WSUD performance standards							
The site is assumed to be located in Zone1-Purple							
	Mains water reduction	OSD storage	ED storage (m^3)	Volume reduction	TSS reduction	TP reduction	TN reduction
Site performance standards	30%		5.0	10%	80%	40%	40%
Select site options & assess meeting performance standards							
Rainwater tank to manage roof runoff							
roof area (m^2) to rainwater tank (A_{roof})		300					
	rainwater tank size	5					
	reuse option	toilet flushing, laundry and irrigation					
	irrigation area	100					
Calculate pollutant loads and stormwater volume for tank's roof area (refer to **Box-1**)							
Vol_{roof} (m3/yr) = 0.25+0.0065x100xRainfall (mm/yr)xA_{roof} (m^2)/1000				Vol_{roof}	TSS_{roof}	TP_{roof}	TN_{roof}
TSS_{roof} (kg/yr) = Vol_{roof}(m3/yr)x140(mg/l)/1000				310.5	43.5	0.078	0.621
TP_{roof} (kg/yr) = Vol_{roof}(m3/yr)x0.25(mg/l)/1000							
TN_{roof} (kg/yr) = Vol_{roof}(m3/yr)x2.0(mg/l)/1000							
Calculate Tank's hydraulic load							
Hydraulic load = tank's size (m^3)/Vol_{roof} (m^3/yr)		1.6%					
Estimate rainwater tank performance based on **Box-3**		OSD (m^3)	ED storage (m^3)	Volume reduction	TSS reduction	TP reduction	TN reduction
		1.8	2.9	31%	82%	59%	55%
Estimate Tank's removed volume, pollutant loads and savings in mains water							
Voltank (m3/yr) = Volroof (m3/yr) x % vol reduction				Vol_{tank}	TSS_{tank}	TP_{tank}	TN_{tank}
TSS_{tank} (kg/yr) = TSS_{roof} (kg/yr) x % TSS reduction				96	35.7	0.046	0.343
TP_{tank} (kg/yr) = TP_{roof} (kg/yr) x % TP reduction							
TN_{tank} (kg/yr) = TN_{roof} (kg/yr) x % TN reduction							

STEP 3 – Calculation for management of pollutant loads using bioretention and combined results

Bioretention to manage remaining site area runoff							
remaining site area to bioretention, m^2 (A_{Rsite})		300	assumed $100m^2$ paved $+100m^2$ grid pavers				
Remaining site imperviousness to bioretention, % (I_{Rsite})		40	+100m2 landscaped area				
It is assumed that the bioretention filter media dia. is 0.5mm and that the filter area is 10% of the retention area							
Bioretention area (m^2)		16		Bioretention depth (m)		0.5	
Bioretention size (m3)		8.0					
Calculate stormwater volume and pollutant loads for Bioretention's remaining site area							
Vol_{Rsite} (m3/yr) = (0.25+0.0065xI_{Rsite})xRainfall (mm/yr)xA_{Rsite} (m^2)/1000							
TSS_{Rsite} (kg/yr) = Vol_{Rsite}(m^3/yr)x140(mg/l)/1000				Vol_{Rsite}	TSS_{Rsite}	TP_{Rsite}	TN_{Rsite}
TP_{Rsite} (kg/yr) = Vol_{Rsite}(m^3/yr)x0.25(mg/l)/1000				175.95	24.6	0.044	0.352
TN_{Rsite} (kg/yr) = Vol_{Rsite}(m^3/yr)x2.00(mg/l)/1000							
Calculate Bioretention's hydraulic loading rate							
Hydraulic loading rate = Bioretention's size (m^3)/Vol_{Rsite} (m^3/yr)			4.5%				
Estimate Bioretention's performance based on **Box-4**			ED storage (m^3)		TSS reduction	TP reduction	TN reduction
			4		82%	74%	70%
Estimate bioretention's removed pollutant loads							
TSS_{bio} (kg/yr) = TSS_{Rsite} (kg/yr) x % TSS reduction					TSS_{bio}	TP_{bio}	TN_{bio}
TP_{bio} (kg/yr) = TP_{Rsite} (kg/yr) x % TP reduction					20.2	0.033	0.246
TN_{bio} (kg/yr) = TN_{Rsite} (kg/yr) x % TN reduction							
Estimate collective site performance for selected options							
Total site area, m^2 (A_{site})		650					
Total site imperviousness, % (I_{site})		65					
Calculate total pollutant loads and stormwater volume removed by selected management options							
Vol_{rem} (m^3/yr) = Vol_{tank} + Vol_{bio}				Vol_{rem}	TSS_{rem}	TP_{rem}	TN_{rem}
TSS_{rem} (= TSS_{tank} + TSS_{bio}				96	56.0	0.078	0.589
TP_{rem} = TP_{tank} + TP_{bio}							
TN_{rem} = TN_{tank} + TN_{bio}							
Calculate site's pollutant loads and stormwater volume for post-development conditions without controls							
Vol_{post} (m3/yr) = (0.25+0.0065xI_{site})xRainfall (mm/yr)xA_{site} (m^2)/1000							
TSS_{post} (kg/yr) = Vol_{post}(m^3/yr)x140(mg/l)/1000				Vol_{post}	TSS_{post}	TP_{post}	TN_{post}
TP_{post} (kg/yr) = Vol_{post}(m^3/yr)x0.25(mg/l)/1000				500.8	70.1	0.125	1.002
TN_{post} (kg/yr) = Vol_{post}(m^3/yr)x2.0(mg/l)/1000							
Calculate proposed site's total performance for pollutant loads and stormwater volume							
Site Volume reduction (%) = 100 x Vol_{rem}/Vol_{post}				Site Vol. reduction	Site TSS reduction	Site TP reduction	Site TN reduction
Site TSS reduction (%) = 100 x TSS_{rem}/TSS_{post}				19%	80%	63%	59%
Site TP reduction (%) = 100 x TP_{rem}/TP_{post}							
Site TN reduction (%) = 100 x TN_{rem}/TN_{post}							

FIGURE B1 – TYPICAL COMPONENT OF A GRID PAVEMENT

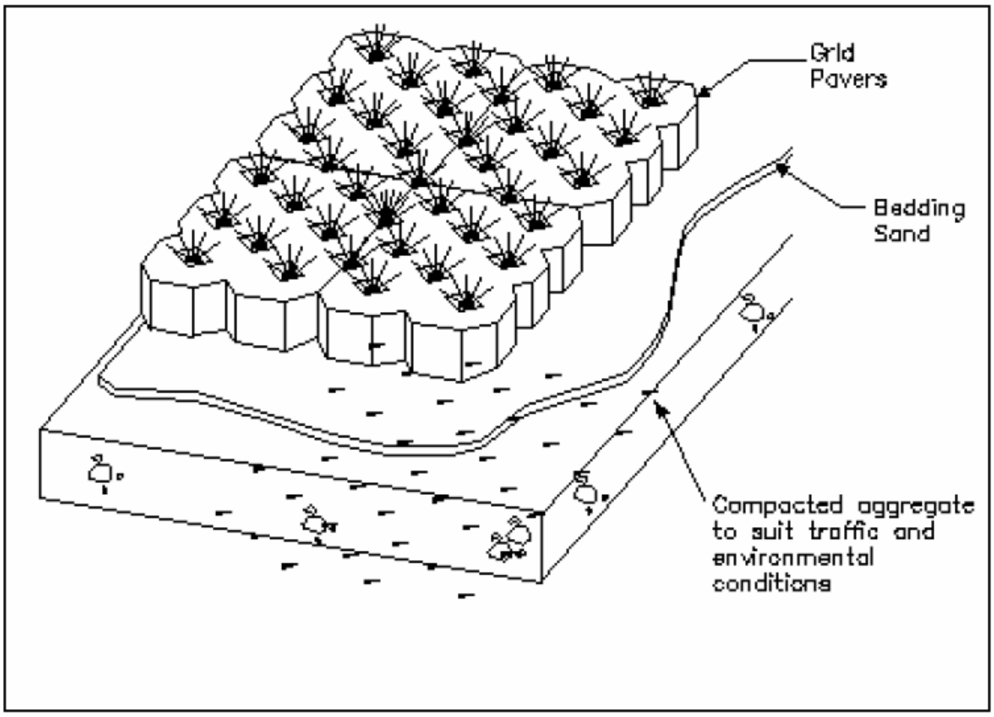
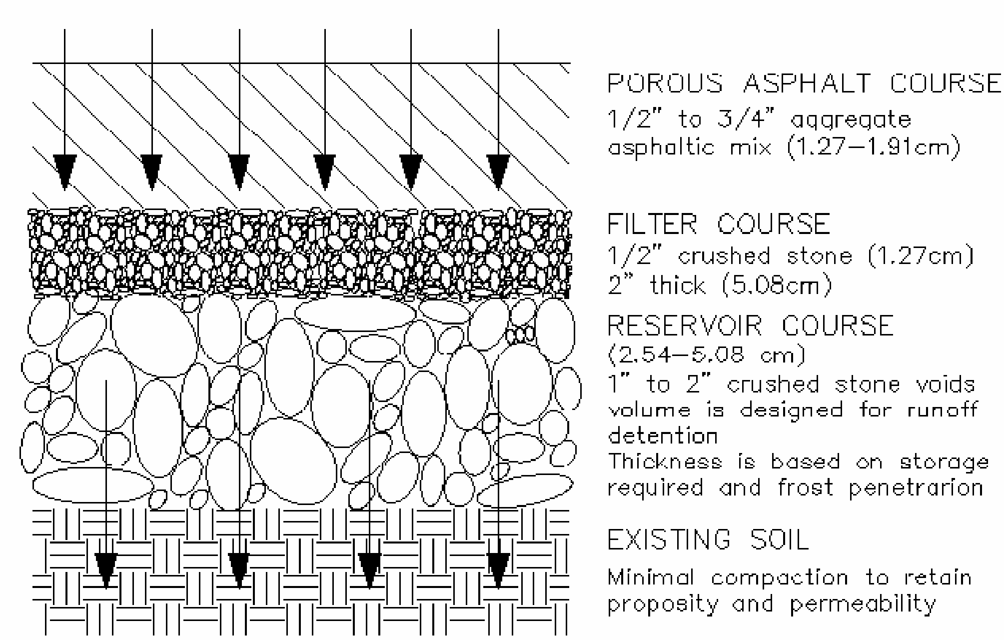


FIGURE B2 – TYPICAL SECTION THROUGH ASPHALT POROUS PAVEMENT



APPENDIX C – BIORETENTION SYSTEMS

FIGURE C1 – TYPICAL BIORETENTION SYSTEM

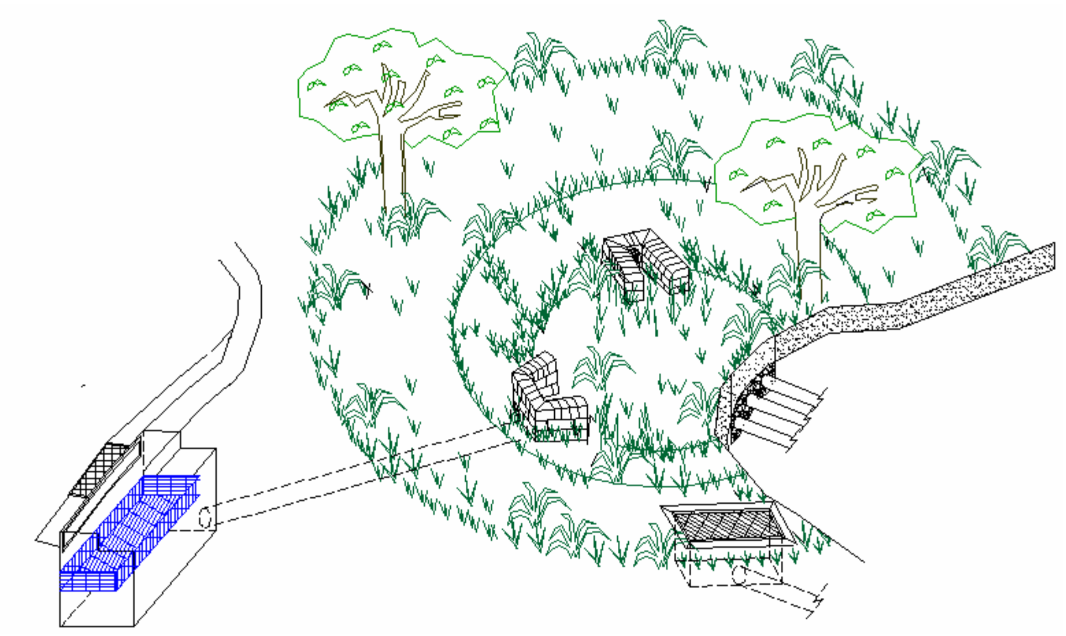
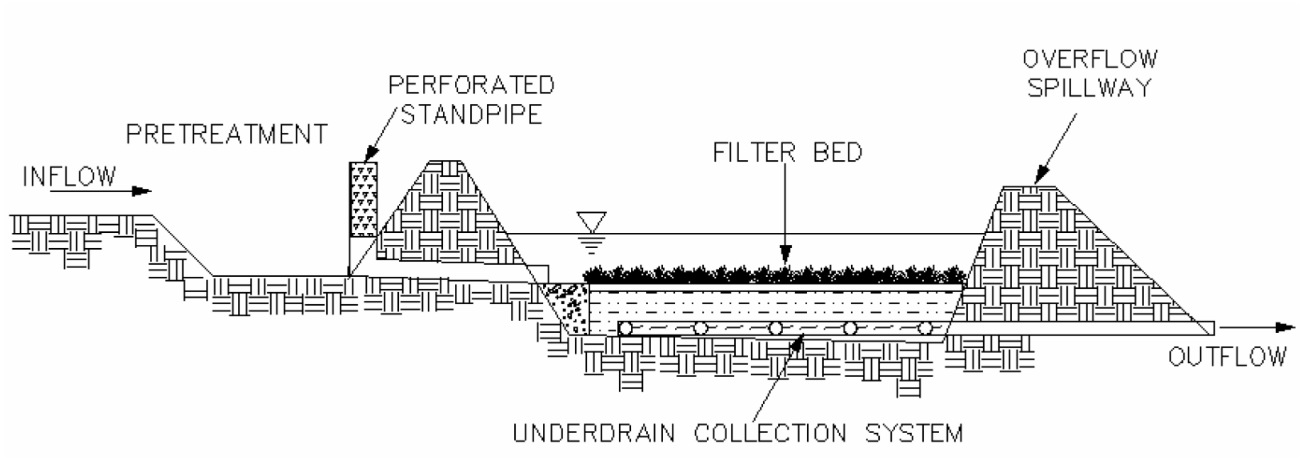
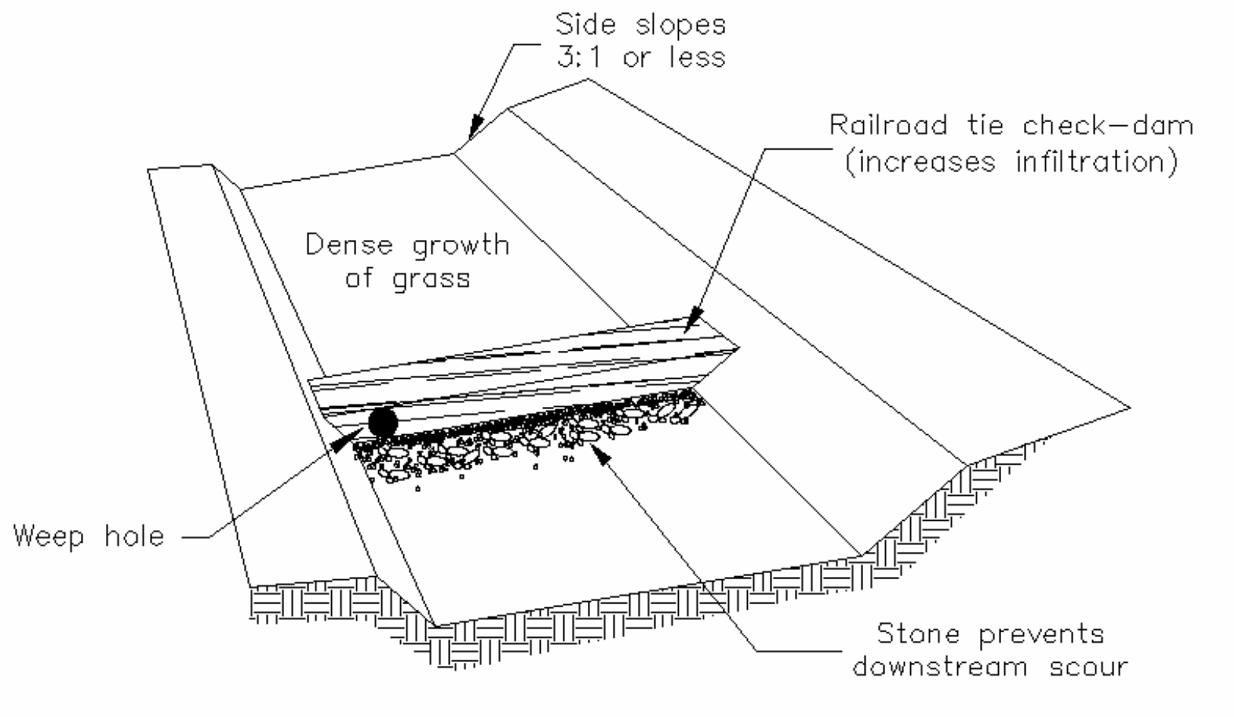


FIGURE C2 – TYPICAL SECTION THROUGH BIORETENTION SYSTEM



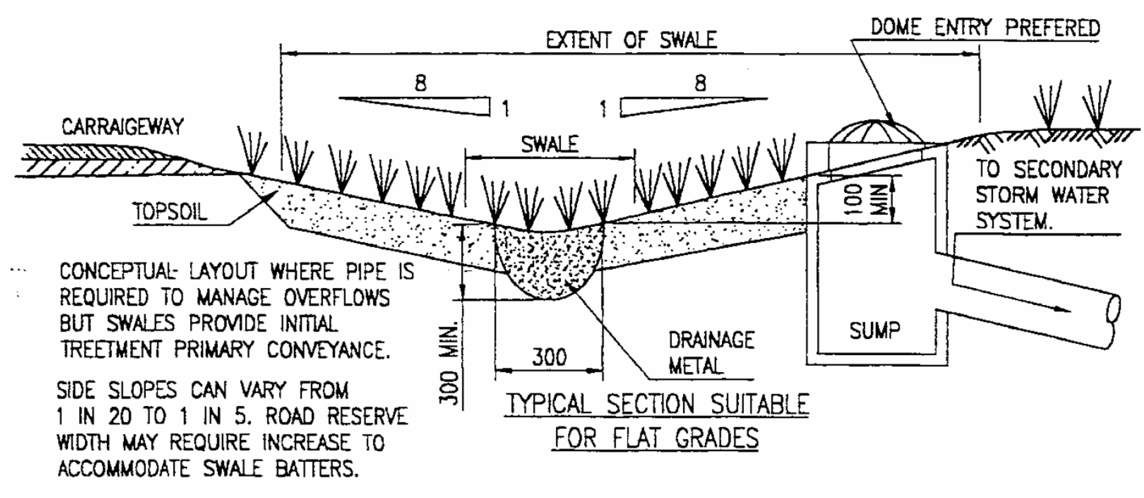
APPENDIX D – GRASS LINED SWALES

FIGURE D1 – TYPICAL GRASS LINED SWALE



Schematic of an enhanced grassed swale (source: Schueler, 1987)

FIGURE D2 – GRASSED LINE SWALE TYPICAL SECTION



APPENDIX E – ON-SITE STORMWATER DETENTION SYSTEM DESIGN

<u>WORKED EXAMPLE</u>
This is a worked example for the design of a below-ground On-site Stormwater Detention (OSD) system.

Following from previous example given in **APPENDIX B**

Development Type: New single residential dwelling home
Site area: 650 sqm
Proposed footprint of roof area: 300 sqm
Associate works: paths, driveway and associated landscaping
Site is located in Zone 1, RED hatched area

For the site located in **ZONE 1 (**from Catchment **FIGURE 5.1 ZONE MAP),** the proposed development requires **Extended Detention** and **Flood Control Detention**.

From the previous example, the impermeability factor is 65%.

STEP 1 – Calculate the minimum Site Storage Volumes (SSV) and the maximum Permissible Site Discharge (PSD) values from **TABLE 8.1** and **TABLE 8.2**.

For Extended Flood Detention (Erosion Control):
V_{EC} = 1.2 x (0.65 x 650) / 100 = 5.07 cum
PSD_{EC} = 0.41 x (0.65 x 650) / 100 = 1.73 L/s

For Flood Control Detention:
V_{FC} = 3.04 x (0.65 x 650) / 100 = 12.85 cum
PSD_{FC} = 1.80 x (0.65 x 650) / 100 = 7.61 L/s

Total SSD and PSD:
$V_{total} = V_{EC} + V_{FC}$ = 5.07 + 12.85 = 17.92 cum
$PSD_{total} = PSD_{EC} + PSD_{FC}$ = 1.73 + 7.61 = 9.34 L/s

STEP 2 – Design the required OSD tank and configuration.

Only two types of orifice configurations can be used. Refer **TABLE E1** below for coefficient values. The nominated outlet control is a circular ORIFICE PLATE dyna-bolted over an oversized outlet pipe.

TABLE E1

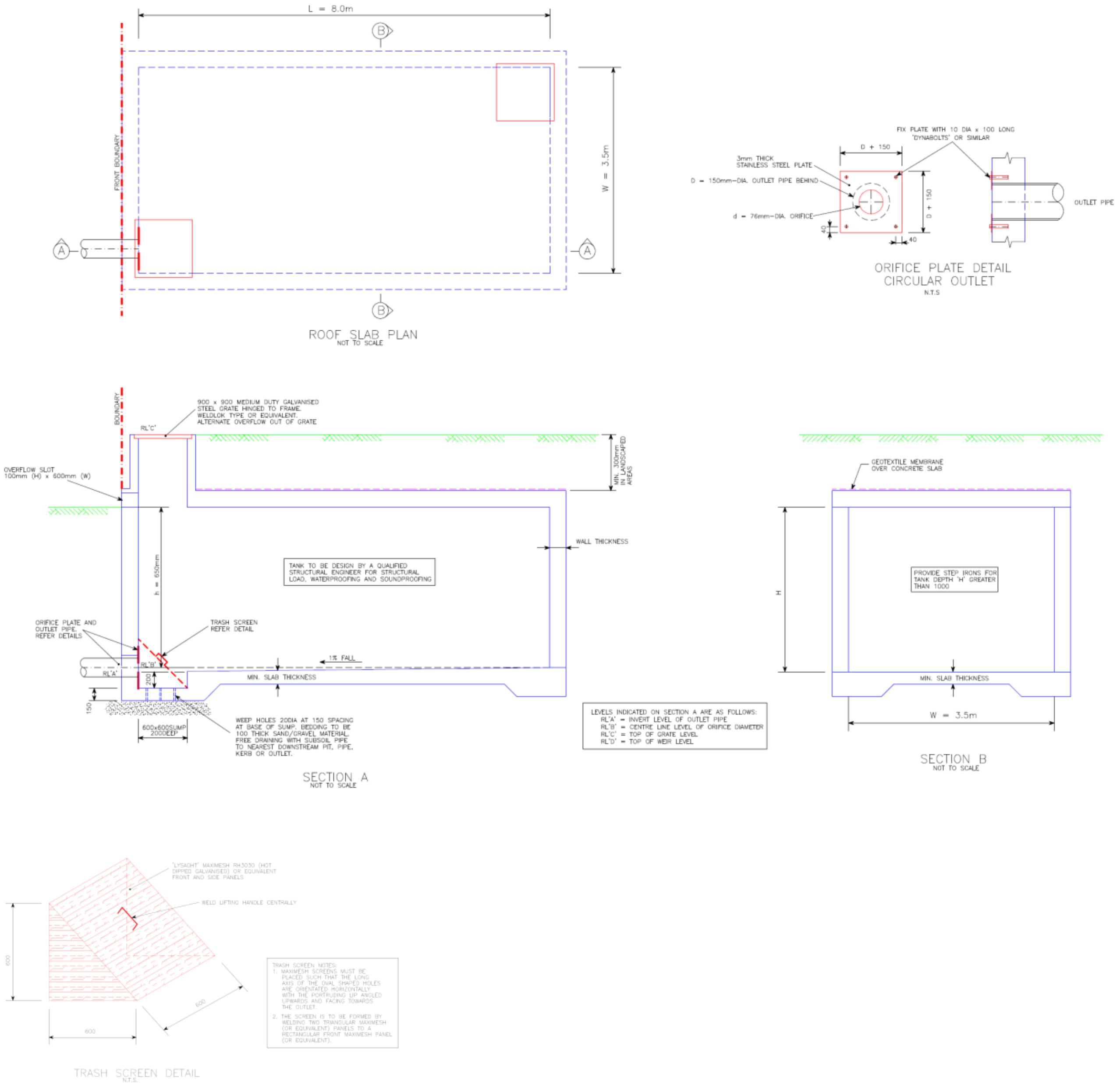
ORIFICE TYPE	Discharge Coefficient (dimensionless)
Stainless Steel Flat Plate with circular cut hole	0.60
Pipe Stub 150mm long	0.80

Adopting a stainless steel flat plate with orifice coefficient, C = 0.6.
Using the Orifice Equation **Q = C x A x √ (2.g.h)**

Where:
D = diameter of orifice = √(4.A/π) in meters
A = area of orifice hole in square meters
π = pi = 3.1416 (dimensionless)
g = acceleration due to gravity = 9.81 m/s^2
C = orifice coefficient (dimensionless) = 0.6
h = depth of water to centre of orifice in meters

OSD Tank
If only one tank is to be used
PSD_{tot} = 9.34 L/s
Adopt h = 650mm
Therefore Orifice = 76mm-dia
Adopt tank dimensions = 0.65m (H) x 3.5m (W) x 8m (L) = 18.2cum > 17.92cum OK.
The basic under-ground OSD tank design details are given in **FIGURE E1**.

FIGURE E1 – OSD UNDERGROUND TANK DESIGN DETAILS

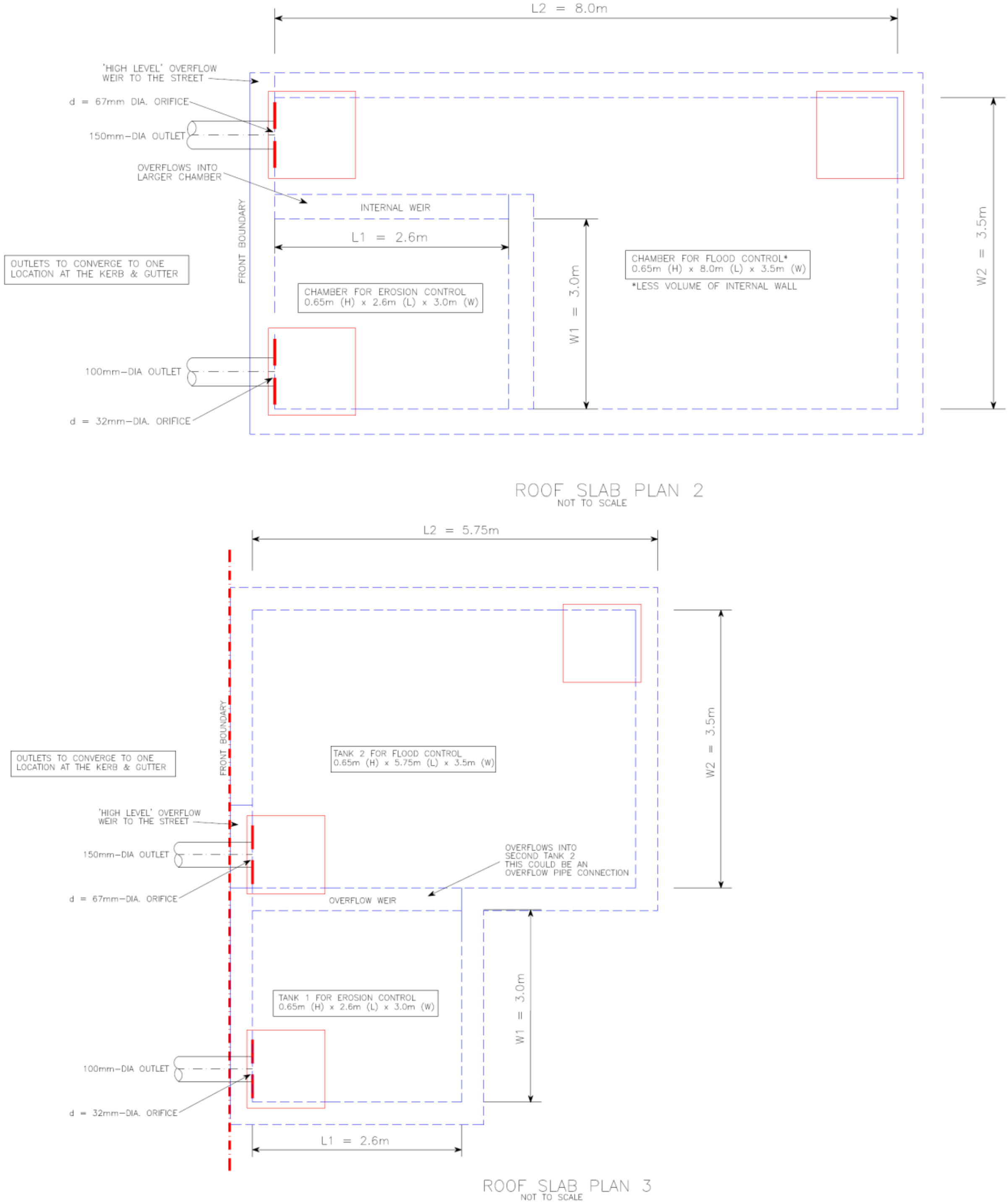


More accurately, the tank should be separated into two chambers or two separate tanks to cater for Erosion Control and Flood Control respectively. The plan that best illustrates the typical separation is shown in **FIGURE E2**.

The separated chambers require duplicate sediment traps, trash screens and outlet conduits and would be more difficult to maintain than a single tank with no internal chambers.

The application of two separate tanks would be most suitable where space is limited in one location and which an upstream smaller OSD tank can be constructed with the larger secondary tank installed downstream of it. The second tank can be smaller and may be ideal where space is limited in that location.

FIGURE E2 – EXAMPLES OF RECONFIGURED OSD TANKS WITH SEPARATE CHAMBERS



APPENDIX F – LEGAL INSTRUMENTS

F1 – FOR EXISTING ALLOTMENTS

Use where there is no land sub-division, that is, no Section 88B instrument required. The following standard wording for POSITIVE COVENANT is to be used and is to be lodged with the Lands Department along with Form 13RPC.

TERMS OF POSITIVE COVENANT
(Show full details of Positive Covenant)

The registered proprietors covenant with Hunters Hill Council (Council) that they will maintain and repair the structure and works on the land in accordance with the following terms and conditions:

I. The registered proprietor will:

i. keep the structure and works clean and free from silt, rubbish and debris

ii. maintain and repair at the sole expense of the registered proprietors the whole of the structure and works so that it functions in a safe and efficient manner.

II. For the purpose of ensuring observance of the covenant the Council may by its servants or agents at any reasonable time of the day and upon giving to the person against whom the covenant is enforceable not less than two days notice (but at any time without notice in the case of an emergency) enter the land and view the condition of the land and the state of construction maintenance or repair of the structure and works on the land.

Ill. The registered proprietors shall indemnify the Council and any adjoining land owners against any claims for damages arising from the failure of any component of the OSD system, or failure to clean, maintain and repair the OSD system.

IV. By written notice the Council may require the registered proprietors to attend to any matter and to carry out such work within such time as the Council may require to ensure the proper and efficient performance of the structure and works and to that extent section 88F(2) (a) of the Act is hereby agreed to be amended accordingly.

V. Pursuant to section 88F(3) of the Act the authority shall have the following additional powers pursuant to this covenant:

i. In the event that the registered proprietor fails to comply with the terms of any written notice issued by the Council as set out above the Council or its authorised agents may enter the land with all necessary equipment and carry out any work which the Council in its discretion considers reasonable to comply with the said notice referred to in l hereof.

ii. The Council may recover from the registered proprietor in a Court of competent jurisdiction:

(a) Any expense reasonably incurred by it in exercising its powers under sub-paragraph i hereof. Such expense shall include reasonable wages for the Council's own employees engaged in effecting the said work, supervising the said work and administering the said work together with costs, reasonably estimated by the Council, for the use of machinery, tools and equipment in conjunction with the said work.

(b) Legal costs on an indemnity basis for issue of the said notices and recovery of the said costs and expenses together with the costs and expenses of registration of a covenant charge pursuant to section 88F of the Act or providing any certificate required pursuant to section 88G of the Act or obtaining any injunction pursuant to section 88H of the Act.

VI. This covenant shall bind all persons who claim under the registered proprietors as stipulated in section 88E(5) of the Act.

For the purposes of this covenant:

Structure and Works shall mean the on-site stormwater detention (OSD) system constructed on the land as set out in the plan annexed hereto and marked with the letter "A" or alternatively as detailed on the plans approved by the Principal Certifying Authority: {INSERT DA NUMBER, DRAWING NUMBER, DATE, REVISION NUMBER AND DESIGNER DETAILS} including all gutters, pipes, drains, walls, kerbs, pits, grates, tanks, chambers, basins and surfaces designed to temporarily detain stormwater on the land. The Act means the Conveyancing Act 1919.

Use where there is no land sub-division, that is no Section 88B instrument required. The following standard wording for RESTRICTION ON THE USE OF LAND is to be used and is to be lodged with the Lands Department along with Form 13RPA.

Terms of Restriction on the Use of Land
(Show full details of the Restriction)

The registered proprietors covenant with Hunters Hill Council (Council) that they will not:

I. Do any act, matter or thing which would prevent the structure and works from operating in an efficient manner.

II. Make any alterations or additions to the structure and works or allow any development within the meaning of the Environmental Planning and Assessment Act 1979 to encroach upon the structure and works without the express written consent of the authority.

Ill. This covenant shall bind all persons who claim under the registered proprietors as stipulated in section 88E(5) of the Act.

For the purposes of this covenant:

Structure and Works shall mean the on-site stormwater detention (OSD) system constructed on the land as set out in the plan annexed hereto and marked with the letter "A" or alternatively as detailed on the plans approved by the Principal Certifying Authority: {INSERT DA NUMBER, DRAWING NUMBER, DATE, REVISION NUMBER AND DESIGNER DETAILS} including all gutters, pipes, drains, walls, kerbs, pits, grates, tanks, chambers, basins and surfaces designed to temporarily detain stormwater on the land. The Act means the Conveyancing Act 1919.

F2 – FOR SUB-DIVISIONS AND NEWLY CREATED ALLOTMENTS

Where a sub-division has been lodged and a Section 88B instrument created, then the following standard wording for "The Terms of Positive Covenant" shall be used.

Terms of Positive Covenant referred to in the above-mentioned Plan

The registered proprietors covenant with Hunters Hill Council (Council) that they will maintain and repair the structure and works on the land in accordance with the following terms and conditions:

I. The registered proprietor will:

i. keep the structure and works clean and free from silt, rubbish and debris

ii. maintain and repair at the sole expense of the registered proprietors the whole of the structure and works so that it functions in a safe and efficient manner.

II. For the purpose of ensuring observance of the covenant the Council may by its servants or agents at any reasonable time of the day and upon giving to the person against whom the covenant is enforceable not less than two days notice (but at any time without notice in the case of an emergency) enter the land and view the condition of the land and the state of construction maintenance or repair of the structure and works on the land.

Ill. The registered proprietors shall indemnify the Council and any adjoining land owners against any claims for damages arising from the failure of any component of the OSD, or failure to clean, maintain and repair the OSD.

IV. By written notice the Council may require the registered proprietors to attend to any matter and to carry out such work within such time as the Council may require to ensure the proper and efficient performance of the structure and works and to that extent section 88F(2) (a) of the Act is hereby agreed to be amended accordingly.

V. Pursuant to section 88F(3) of the Act the authority shall have the following additional powers pursuant to this covenant:

i. In the event that the registered proprietor fails to comply with the terms of any written notice issued by the Council as set out above the Council or its authorised agents may enter the land with all necessary equipment and carry out any work which the Council in its discretion considers reasonable to comply with the said notice referred to in I hereof.

ii. The Council may recover from the registered proprietor in a Court of competent jurisdiction:

(a) Any expense reasonably incurred by it in exercising its powers under sub-paragraph i hereof. Such expense shall include reasonable wages for the Council's own employees engaged in effecting the said work, supervising the said work and administering the said work together with costs, reasonably estimated by the Council, for the use of machinery, tools and equipment in conjunction with the said work.

(b) Legal costs on an indemnity basis for issue of the said notices and recovery of the said costs and expenses together with the costs and expenses of registration of a covenant charge pursuant to section 88F of the Act or providing any certificate required pursuant to section 88G of the Act or obtaining any injunction pursuant to section 88H of the Act.

VI. This covenant shall bind all persons who claim under the registered proprietors as stipulated in section 88E(5) of the Act.

For the purposes of this covenant:

Structure and Works shall mean the on-site stormwater detention system constructed on the land as set out in the plan annexed hereto and marked with the letter "A" or alternatively as detailed on the plans approved by the Principal Certifying Authority: {INSERT DA NUMBER, DRAWING NUMBER, DATE, REVISION NUMBER AND DESIGNER DETAILS} including all gutters, pipes, drains, walls, kerbs, pits, grates, tanks, chambers, basins and surfaces designed to temporarily detain stormwater on the land.

The Act means the Conveyancing Act 1919.

Where a sub-division has been lodged and a Section 88B instrument created, then the following standard wording for the "The Terms of Restriction on the Use of Land" shall be used.

Terms of Restriction on the Use of Land referred to in the above-mentioned Plan

The registered proprietor covenant with Hunters Hill Council (Council) in respect to the structure erected on the land described as "on-site stormwater detention system" (which expression includes all ancillary gutters, pipes, drains, walls, kerbs, pits, grates, tanks, chambers, basins and surfaces designed to temporarily detain stormwater) shown on plans approved by the Principal Certifying Authority: {INSERT DA NUMBER, DRAWING NUMBER, DATE, REVISION NUMBER AND DESIGNER DETAILS} (hereinafter called "the system").

The registered proprietors covenant with Hunters Hill (Council) that they will not:

I. Do any act, matter or thing which would prevent the structure and works from operating in an efficient manner.

II. Make any alterations or additions to the structure and works or allow any development within the meaning of the Environmental Planning and Assessment Act 1979 to encroach upon the structure and works without the express written consent of the authority.

Ill. This covenant shall bind all persons who claim under the registered proprietors as stipulated in section 88E(5) of the Act.

For the purposes of this covenant:

Structure and Works shall mean the on-site stormwater detention system constructed on the land as set out in the plan annexed hereto and marked with the letter "A" or alternatively as detailed on the plans approved by the Principal Certifying Authority: {INSERT DA NUMBER, DRAWING NUMBER, DATE, REVISION NUMBER AND DESIGNER DETAILS} including all gutters, pipes, drains, walls, kerbs, pits, grates, tanks, chambers, basins and surfaces designed to temporarily detain stormwater on the land.

The Act shall mean the Conveyancing Act 1919.

APPENDIX G – GENERIC LETTER FOR SEEKING STORMWATER DRAINAGE EASEMENT/S ON ADJOINING LAND

The following generic letter may be used to seek easement/s from adjoining property/s.

Dear . . . .

I/we are proposing to redevelop our property at . . . .

Before we can proceed with this proposal, Hunters Hill Council has advised us that we need to seek a formal drainage easement (Council's preferred option) to convey the stormwater runoff from our property to the nearest downstream public stormwater drainage infrastructure or to a Council approved discharge point, being (street). . . . .

This will require you to grant me/us a drainage easement through your property with all legal and survey costs for the creation of the easement being borne by us, together with any consideration for the use of your property as determined by an independent valuation or agreement.

(Attach independent valuation/agreement to this form)

The other alternative is to have the development of our site limited to a discharge rate nominated by Council to allow sufficient area between the house and our rear/side boundary next to your property to install an underground absorption system (if appropriate for this site) to spread and disperse the stormwater flows into the ground. Discharging our stormwater to the street frontage is not a preferred option for Council as this could severely impact on the capacity of the existing drainage system in the street.

As the runoff and seepage from this system may flow towards your property because of the slope of the land, the best solution would be to have a drainage system that will convey our stormwater to (downstream street) . . . .

You are advised that if Council determines that the only way for the drainage of stormwater is via an easement through your property, I/we may have to use Section 88K of the Conveyancing Act 1919 to request the Supreme Court to grant me/us the drainage easement.

This will probably result in legal expenses and time spent for both you and I/us.

Could you please indicate your position regarding this matter so that we can advise Council to enable our application to progress?

YES I/we are/are not willing to grant you a drainage easement.

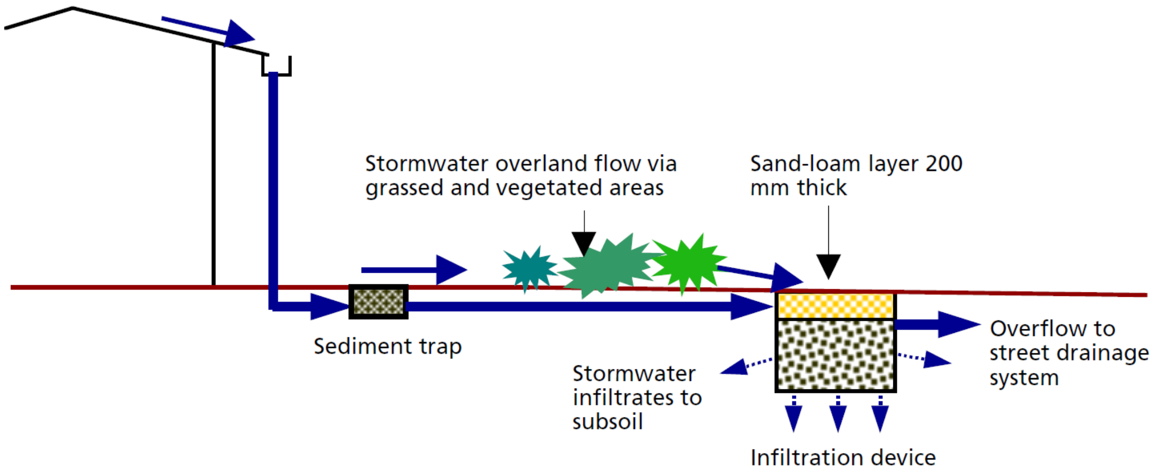
NO I/we are not willing to grant you a drainage easement.

Signed . . . .

Dated . . . .

APPENDIX H – ABSORPTION SYSTEMS

FIGURE H1 – TYPICAL ABSORPTION SYSTEM CONFIGURATION



WORKED EXAMPLE

This is a worked example for the design of an On-site Stormwater Absorption (OSA) system.

Using the same development from previous example as given in **APPENDIX B**

Development Type: New single residential dwelling home
Site area: 650 sqm
Proposed footprint of roof area: 300 sqm
Associate works: paths, driveway and assoicated landscaping
Site is located in Zone 1, RED hatched area

Assuming the site falls away from the street frontage.
Although the site is designated in Zone 1, which requires OSD, if the soil conditions are suitable for infiltration, then OSD may not be necessary. In this situation, the OSD system may be required to reduce the inflow of the stormwater into the OSA system such that the soil's capacity for infiltration can be achieved. For this example, it is not necessary.

A Geotechnical Report prepared by ABCD Geotechnical Engineers Pty Ltd gives the following field results:

Parameter	Result	Description
Water Table	No water table encountered	Testing extended to 2.0m
Bore Logs	0.0m to 0.3m	Topsoil brown grey fine loose soil
	0.3 to 1.5m	Sandy soils of uniform consistency
Stand Pipe Test at 0.6m	0.65 L/s per sqm	Measure infiltration rate
	0.60 L/s per sqm	Design infiltration rate (long term)

STEP 1 – Calculate impervious area which is to be routed into the absorption system and set the minimum design parameters.

It is required that all the site's impervious areas are to be routed into the OSA system.

A_{imp} = 420 sqm
C = 1 impervious coefficient
ARI = 100-year design storm event
Clogging Factor = 15%
Absorption Rate = 0.0006 m/s from Geotech Report
Adjust Rate = 0.00051 m/s
Trial Length, L = 5.0m
Trial Width, W = 3.0m
Trial Depth, h = 1.0m

Trench Area = 5 x 3 = 15sqm
Available Storage = 15cum = 15,000L

STEP 2 – Using the Mass Curve Method (reference **Australia Rainfall and Runoff Volume 1**) and tabulating this in **TABLE H1**.

TABLE H1

Duration (min)	Intensity (mm/hr)	Inflow Rate (L/s)	Vi (L)	Vo (L)	Vi – Vo (L)
5	240	28	8400	2295	6105
6	225	26	9450	2754	6696
7	211	25	10339	3213	7126
8	202	24	11312	3672	7640
9	194	23	12222	4131	8091
10	188	22	13160	4590	8570
11	180	21	13860	5049	8811
12	174	20	14616	5508	9108
13	169	20	15379	5967	9412
14	164	19	16072	6426	9646
15	168	20	17640	6885	10755
20	143	17	20020	9180	10840
25	132	15	23100	11475	11625
30	122	14	2562011,850)	13770	**11850**
40	102	12	28560	18360	10200
45	100	12	31500	20655	10845
50	90.6	11	31710	22950	8760
55	85.8	10	33033	25245	7788
60	86	10	36120	27540	8580
65	77.9	9	35445	29835	5610
70	74.6	9	36554	32130	4424
75	71.5	8	37538	34425	3113
80	68.7	8	38472	36720	1752
85	66.2	8	39389	39015	374
90	69	8	43470	41310	2160
100	59.8	7	41860	45900	-4040
120	58	7	48720	55080	-6360

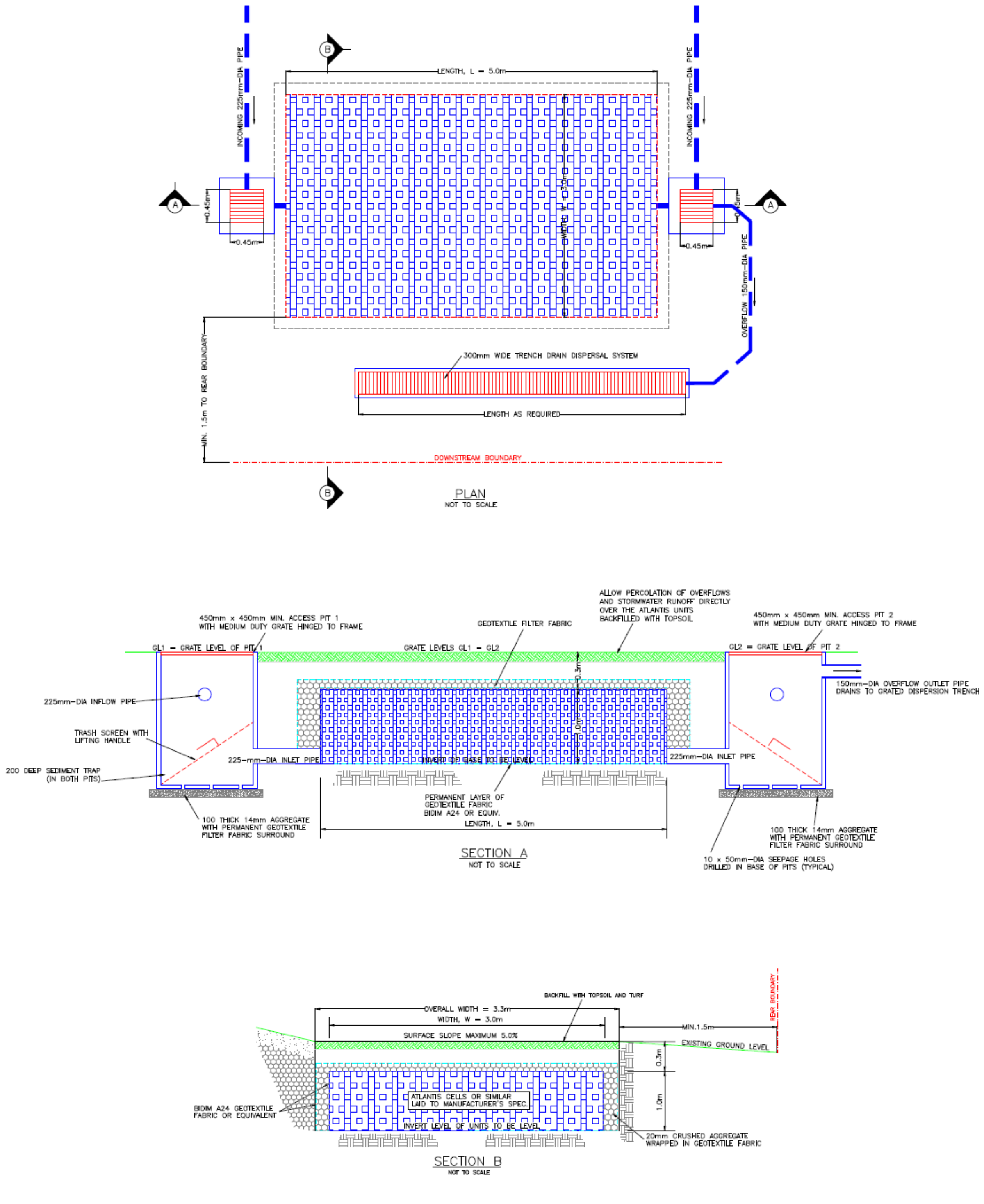
Note:
1. This method does not allow for emptying time. It is assumed that the trench fills and quickly empties instantaneously and is a conservative estimate.
2. The rainfall data and IFD values are to be obtained from the Bureau of Meteorology (BoM) website for the specific site.

Since Available Storage [15,000L] > the maximum (Vi – Vo) [11,850L], the storage provided is adequate.

The basic OSA tank design details using Atlantis™ cells are given in **FIGURE H2**.

It is noted that alternative types of absorption systems such as half round pipes (e.g. Everhard™ jumbo system) may be used. As the soil can fully absorb all the site's runoff from the impervious areas into the ground, an OSD system was not required in this situation. It is noted that runoff from pervious areas of the site were not routed into the OSA system, because it was assumed that these surfaces were not concentrated and some of these areas were able to be graded to the street.

FIGURE H2 – OSA DESIGN DETAILS



ON–SITE ABSORPTION SYSTEM USING ATLANTIS CELLS

APPENDIX I – HOLDING SUMP AND MECHANICAL PUMP-OUT SYSTEM

WORKED EXAMPLE
This is a worked example for the design of a holding sump with mechanical pump-out system.

Following from previous example given in **APPENDIX B**

Development Type: New single residential dwelling home
Site area: 650 sqm
Proposed footprint of roof area: 300 sqm
Associate works: paths, driveway and assoicated landscaping

The proposed development includes a basement garage.
All the driveway of 100sqm slopes back into the basement.

STEP 1 – Calculate the minimum design parameters

$Area_{driveway}$ = 100sqm
$Area_{subsoil\ water}$ = 25sqm (without known seepage rate, 25sqm is to be used as per Design Criteria)
Therefore Contributing $Area_{total}$ = $Area_{driveway}$ + $Area_{subsoil\ water}$ = 125sqm = 0.0125 ha

Design Storm = 100-years ARI
Duration = 2-hour storm
Rainfall Intensity = 58 mm/hr
Coefficient of Runoff, C = 1.0

STEP 2 – Calculate Peak Discharge and volume

Peak Discharge using the Rational Method (for areas < 1200sqm):

Therefore, Q_{peak} = (C x A x I) / 0.360 = (1 x 0.0125 x 58) / 0.360 = 2.02 L/s

Volume for the 2 hour storm:

Therefore, V_{2hr} = 2 x 60 x 60 x 2.02 = 14,500L = 14.50cum

The minimum required holding tank volume is 14.50cum.
We now wish to reduce the size of the tank by increasing the pump-out capacity.
This is achieved in the following tabulation.

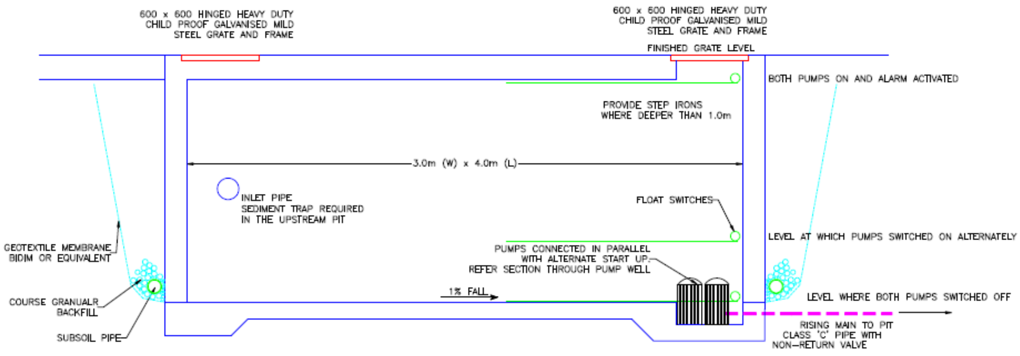
Pump Capacity (L/s)	Volume pumped in 30 min. (cum)	Required Wet well Volume (cum)
5	9	5.50
6	10.8	3.7
7	12.6	1.9
8	14.4	0.1

In accordance with Clause 9.3.6. of AS 3500, the storage volume cannot be less than 3cum.
Therefore adopt tank volume 5.50cum with pump-out rate 5L/s.

Min. tank dimensions: Adopt 0.50m (H) x 3.0m (W) x 4.0m (L)

Design details are given in **FIGURE I1**.

FIGURE I1 – HOLDING SUMP AND MECHANICAL PUMP-OUT SYSTEM DETAILS

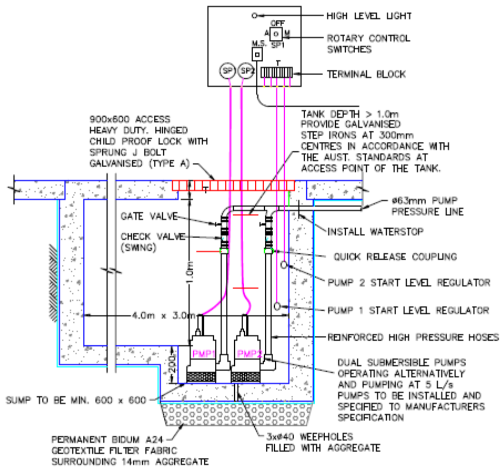


STORAGE SUMP TYPICAL SECTION DETAIL

N.T.S.

PUMP OPERATION NOTES

1. THE PUMPS SHALL BE PROGRAMMED TO WORK ALTERNATELY SO AS TO ALLOW BOTH PUMPS EQUAL OPERATION TIME AND PUMP LIFE.
2. PUMPS SHALL BE CONTROLLED BY FLOAT SWITCHES. A LOW LEVEL FLOAT SHALL BE INSTALLED TO ENSURE THAT THE MINIMUM DESIGN WATER LEVEL IS MAINTAINED WHEREBY THE PUMPS ARE SWITCHED OFF.
3. A HIGH LEVEL FLOAT SHALL BE INSTALLED WHEREBY THE PUMPS WILL OPERATE ALTERNATELY AND DRAIN THE SUMP TO THE LOW LEVEL FLOAT BEFORE SWITCHING OFF.
4. A MAXIMUM LEVEL FLOAT SHALL BE INSTALLED APPROXIMATELY 200 BELOW THE GRATE LEVEL. THIS FLOAT WILL ACTIVATE THE SECOND DORMANT PUMP AND TRIGGER THE ALARM.
5. AN ALARM SYSTEM SHALL BE INSTALLED WITH A FLASHING STROBE LIGHT AND A PUMP FAILURE WARNING SIGN WHICH ARE TO BE LOCATED AT THE DRIVEWAY ENTRANCE TO THE BASEMENT. THE ALARM SHALL BE PROVIDED WITH A BACK-UP BATTERY IN THE EVENT OF POWER FAILURE.



SECTION THROUGH PUMP WELL

N.T.S.

END OF DOCUMENT