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WATER3VOLUTION

Funded by the Marrickville community through the Stormwater Charge

Rain Garden Design Manual

June 2016

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Document information	
Document title:	Rain Garden Design Manual
Version:	Final
Date:	June 2016
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Glossary

Acid sulphate soils: naturally occurring soil that have been formed under waterlogged conditions and which when exposed to air can oxidise and release acid into waterways.

Batter: Sloped or graded areas adjacent to the bioretention filter media

Biodiversity: the abundance and variety of living organisms, species, and ecological communities.

Bioretention Systems (also called rain garden): A vegetated soil filter system to collect, detain, and treat stormwater by filtration through the soil.

DBH (Diameter at Breast Height): The trunk diameter at 1.4m above the ground

Erosion: The process of washing away of soil by water movement or air movement (wind).

Establishment: The period immediately after a bioretention system has been constructed when vegetation is growing to a point that the vegetation is ready to accept stormwater into the treatment system.

Extended detention: The area ('air space') above the bioretention system filter surface which is used for temporarily storing water during and shortly after a rainfall event. Extended detention helps to capture more water for treatment by temporarily storing water, instead of directly flowing out of the bioretention system.

Filter media: A prescribed soil media using in the bioretention system to filter the stormwater and also support plant growth

Forebay: A small basin installed at the inlet to the bioretention system, to remove coarse sediment from stormwater prior to entering the filter area of the bioretention system.

High flow bypass: A method to ensure that in large flows, excess water is diverted around the bioretention system to prevent erosion in the bioretention system

Infiltration: A small basin installed at the inlet to the bioretention system

Inlet: The part of the bioretention system which receives water from the stormwater system

Litter (anthropogenic): Waste created by human activity

Nutrients: Substances such as phosphorous, nitrogen that promote the growth of plants and other living organisms such as algae. Excessive nutrients in waterways contribute to algal blooms and degrade waterways.

Outlet The part of the bioretention system where water leaves the bioretention system back into the stormwater system or waterway

Overflow: The movement of water out of the bioretention system. Can also refer to the structures that allow water to exit the system (e.g. overflow pit).

Pollutants: Substances that may either naturally occur but are present at elevated and potentially harmful levels (e.g. sediment) or unnatural in the environment that cause harm (e.g. pesticides, plastics).

Rain garden: refer to bioretention system

Structural root zone: The area around the base of a tree required for the tree's stability in the ground and to hold the tree upright. It considers the zone required for stability only and not for tree's long term vigour and health.

Swale: A vegetated shallow channel that conveys stormwater and assists in improving water quality

Tree protection zone: A specified area above and below the ground set aside for the protection of a trees roots and crown to provide for viability and stability of the tree during adjacent works

Water quality: Physical, chemical and biological characteristics of water

Weed: A plant that is growing out of place, typically an introduced species which not native to the local area.

For a full glossary of terms used in reference to stormwater, refer to the Stormwater Australia comprehensive document "Glossary of Terms used in the Stormwater Industry" publication, available at Stormwater Australia's website.

1 INTRODUCTION

Marrickville Council is committed to sustainable water management, including:

- Reduce the use of potable mains water in homes, businesses, Council facilities and public spaces
- Manage the stormwater system and its impacts on the urban environment
- Support regional projects to improve the health of the Cooks River, Botany Bay, Lower Parramatta River, Sydney Harbour and their catchments
- Implementing sustainable urban water management

As part of Marrickville's Strategy for a Water Sensitive Community, the following targets have been set for 2021:

- 30 hectares of the LGA is treated by vegetated stormwater treatment systems constructed by Council
- The effective impervious areas have decreased from 2010 levels

Rain gardens have been identified as an important part of the Strategy to meet these targets.

The relationship of this design manual to other key Council strategic planning documents is shown in Figure 1

Figure 1 Relationship of this design manual to key strategic Council documents

1.1 Intent of the manual

The intent of this design manual is to integrate rain gardens and WSUD facilities as the standard design approach to stormwater management and treatment.

Rain gardens are currently the most common form of vegetated stormwater treatment systems in Marrickville and are likely to continue to be in the near future. Council currently has constructed rain gardens at approximately 15 sites across the LGA and a number of additional rain gardens are being planned.

As rain gardens are the most common vegetated stormwater treatment system, this document has been developed to assist in developing designs for rain gardens, and ensuring that important Council-specific design factors are considered during the detailed design process. These local design factors include specific guidance about Council's maintenance requirements, plant selection and provenance the procurement process and internal consultation engagement required. An example of a detailed design of a Marrickville Council rain garden is included in Appendix B.

The scope of this manual does not include initial site selection, feasibility assessment and concept design. These components will be undertaken in planning and options analysis stages, and are beyond the scope of the manual. Some general guidance has been provided in this document, with the major focus of the design guideline on the detailed design step of the design process.

1.2 Users of the manual

The primary target audience for this manual is design staff, including consultants, directly involved in the detailed design process for rain gardens. It is assumed that those using this manual have experience in design and are familiar with the design process. Familiarity with design of vegetated stormwater systems would also be beneficial. The target audience is likely to include:

- Stormwater and drainage engineers
- Civil engineers
- Landscape architects

The secondary target audience for this manual is broader and includes staff who may refer to this manual for guidance from time to time or in understanding specific details about how rain gardens may impact on their work. This includes those involved in:

- Strategic planning and asset planning
- Operation and maintenance
- Biodiversity, vegetation and tree management
- Parks and open space
- Town centres and streetscapes
- Community facilities including libraries, sports facilities, etc.

1.3 References to other design guidelines

This design manual is intended to *supplement* other design manuals and should be used in conjunction with the *Bioretention Technical Design Guidelines,* developed by Water by Design (2014).

This manual provides recommendations on the overall design process and a step by step process for rain gardens, for those who are less familiar with designing rain gardens. This manual should also be read in conjunction with other documents, including but not limited to:

Marrickville specific documents	Street Tree Masterplan Public Domain Code (Draft) Marrickville WSUD DCP (DCP Section 7.1) Marrickville Urban Forest Strategy [TRIM 115460.14] Our Nature – Marrickville Biodiversity Strategy [TRIM 8672.15] Marrickville Council *WSUD Reference Guideline* [TRIM 16035.13]
Planning and Concept Design	WSUD In Sydney Interim Reference Guidelines *Concept Design Guidelines for WSUD* Water by Design *Concept Design Guidelines for Water Sensitive Urban Design*
MUSIC Modelling	Greater Sydney Local Land Services NSW Music Modelling Guidelines (Draft)
Detailed Design for other vegetated assets	Water By Design WSUD Technical Design Guidelines for South East Queensland [TRIM 66506.16] Sydney Metropolitan CMA *WSUD Typical Drawings* *Bioretention Technical Design Guidelines*
Construction and Establishment	WSUD In Sydney Interim Reference Guidelines *Construction and Establishment Guidelines: Bioretention Systems and Wetlands* Water By Design *Construction and Establishment Guidelines: Swales, Bioretention Systems and Wetlands* [TRIM 66517.16]
Sediment and Erosion Control	NSW EPA *Managing urban stormwater: Soils and construction – Volume 1* ("Blue Book")
Operation and Maintenance	Water by Design *Maintaining Vegetated Stormwater Assets* Landcom *Water Sensitive Urban Design Book 4 Maintenance*

2 RAIN GARDEN CONCEPT DESIGN

During the concept design phase the design process needs to consider the following main elements:

- Stormwater drainage and its diversion into and out of the rain garden
- The sizing of the rain garden
- The siting of the rain garden

These elements are discussed in the following sections below.

2.1 Stormwater drainage

Marrickville Council has a detailed GIS layer with relatively accurate information consisting of:

- Stormwater drainage pit and pipe locations
- Stormwater drainage pit depths
- Stormwater pipe sizes
- Information on converters

This GIS database is reasonably comprehensive but is not complete in all instances. Where the information is not complete it is recommended to field verify any critical drainage information, using CCTV, potholing, or similar investigations during the concept design phase.

Important factors which need to be resolved at the concept stage include:

- What catchment is being diverted into the rain garden
- What area should the rain garden be, in relation to the catchment size and the space available and its site constraints
- Where diverting from an existing stormwater asset (e.g. pipe, open channel):
    - the key levels of the drainage infrastructure (e.g. the diversion pipe invert level at the proposed diversion location)
    - the diversion pipeline to the rain garden location and the level at which the diversion will daylight at the rain garden
- Where diverting from the gutter the preferred location of the diversion in the gutter
- Presence of underground stormwater drainage for discharge:
    - this is a key consideration for streetscape systems in Marrickville. In the upper parts of small sub-catchments, there may not be stormwater drainage in the street. This is partly due to the presence of 'converters' which re-direct stormwater back into the kerb and gutter at traffic intersections.
    - In some instances rain gardens may not be feasible due to the lack of stormwater and/or flat grades which do not allow the treated water to discharge into an underground stormwater system
- Where underground stormwater drainage is present and the rain garden will direct treated flows and overflows into this system it is important to determine the invert levels of the rain garden outlet pipe

- What underground and other services are presents which limit the treatment area or require approvals
- What other constraints may exist (e.g. trees, traffic, parking, access, etc.)

The concept design should clearly highlight the following:

- The catchment area draining to the diversion
- The diversion location
- The invert of the diversion
- Any diversion pipes, their alignment and invert levels
- The proposed surface level of the rain garden as determined by the diversion
- the discharge location for the rain garden and its invert level
- any pits and pipes required to direct treated and overflow water into the discharge location

2.1.1 Sydney Water owned drainage assets

In a number of catchments in Marrickville LGA, Sydney Water owns the trunk drainage. Approval from Sydney Water is required for any diversion from their infrastructure or discharge into their infrastructure. To facilitate this approval, Sydney Water have a formal approval process for connections to their drainage assets.

The approval includes lodging detailed designs of the connection to the drainage asset through a Water Services Coordinator, at the detailed design stage. 3 months should be allowed for approval from Sydney Water. To enable a smooth process, it is suggested that there is early consultation with Sydney Water to help understand Sydney Water's key requirements which are likely to impact on the design.

2.1.2 Pumped Diversions

Pumped diversions need to be considered case by case, but are generally not supported by Marrickville Council. Council currently does not own pumped stormwater diversions and hence does not have existing capability (e.g. SCADA systems, specialist pump maintenance staff) to maintain pumped stormwater diversions.

Pumped diversions require power which increase the ongoing operational cost of these systems as well as contribute to emitting greenhouse gas emissions. In many instances Council does not have a readily available supply of power at the diversion location and either requires a new power connection (e.g. most streetscape locations) or an upgrade of an existing distribution board (e.g. parks).

If a pumped diversion is being considered early discussions should be held with Council's design engineers, environmental services and operations and maintenance staff at an early stage in the process to seek in principle approval.

2.1.3 Infiltration systems

Rain gardens which incorporate Infiltration need to be considered on a case by case basis. Systems which are reliant solely on infiltration (e.g. rain gardens without an underdrain) are typically not feasible in Marrickville LGA. Soil maps for Sydney should be consulted in the first instance to gain an appreciation of the in-situ soils.

Significant portions of Marrickville LGA are underlain by heavy clay soils, derived from Wianamatta shales. These soils are common higher up in the catchment away from drainage lines and the Cooks River. Infiltration on these heavy clay soils in Marrickville is generally not feasible due to the low infiltration rates achieved. These soils are typically expansive soils which swell when wet and infiltration on these soils needs to consider potential impacts on buildings and structures. In many instances the required clearance of 4 to 5m for structures and footings won't be able to be achieved due to the relatively dense form of development in Marrickville and limited space, particularly in streetscapes. If a liner is used, then the clearances are not required.

Many of Council's open spaces consist of some form of fill overlying natural ground. Infiltration into fill is also not recommended due to the potential to increase leaching of contaminants into the groundwater from the fill material.

If infiltration is proposed, it is necessary to undertake geotechnical investigations during the concept design to verify the site soil conditions. If medium to heavy clays or fill are present infiltration is not recommended. If soils which appear suitable for infiltration are present it is recommended to undertake field tests to verify the in-situ infiltration rates which should then be adopted in modelling of these systems to determine their performance.

It should be noted that in both these situations, heavy clays and fill soils, rain gardens can still be constructed with the use of an impermeable liner. Liners are discussed further in Section 6.8.

2.2 Sizing of the rain garden

At the concept design stage a key step is sizing the rain garden. Ideally the rain garden should be sized to meet best practice target objectives of 85% removal of total suspended solids, 65% removal of total phosphorous and 45% removal of total nitrogen.

In retrofit situations the size of the rain garden is often limited by the space available and may not be able to achieve the best practice targets.

In retrofit situation it is often required to treat only a portion of the catchment by diverting partial flows into the rain garden. It should be noted that these systems typically require higher cleaning and maintenance schedules when diverting flows from large catchments for treatment.

Rain gardens in Marrickville should be sized using MUSIC. Refer to the Marrickville Council WSUD DCP Guideline [TRIM 16035.13] for specific values for:

- Rainfall
- Potential evapotranspiration

- Impervious fractions
- Soil properties
- Pollutant generation parameters
- Treatment node inputs

An indicative sizing curve to treat a generic one-hectare urban impervious catchment to best practice for Marrickville LGA is shown in Figure 2. This sizing curve can be used to quickly develop an initial sizing for preliminary concept designs or to 'double check' the size of a rain garden. Based on the curves in Figure 2, a bioretention system for a typical development needs to least 2% of the catchment area to meet the TSS target of 85% load removed.

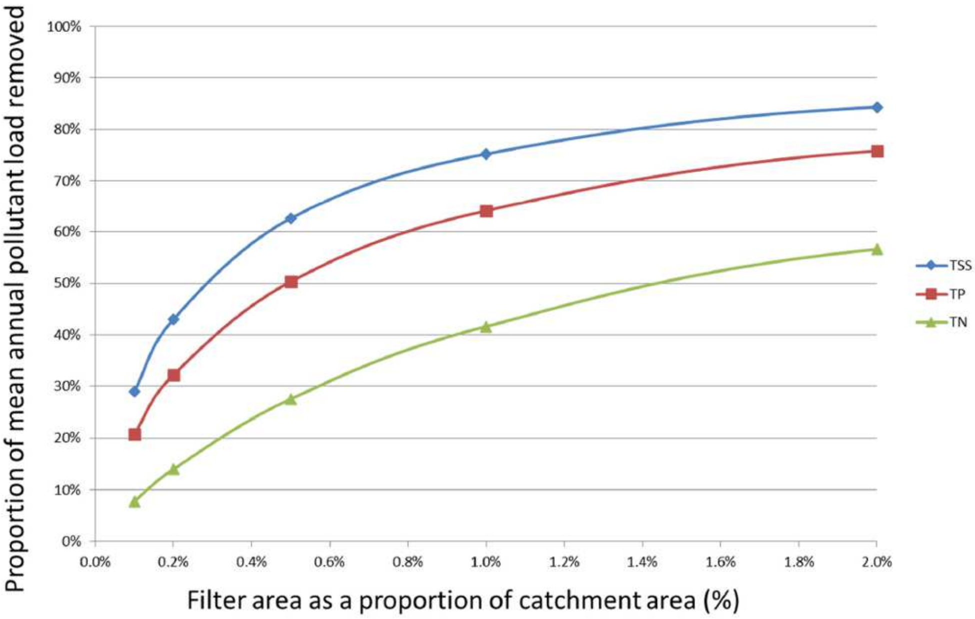

Figure 2 Bioretention sizing curve to treat a generic one-hectare urban impervious catchment to best practice for Marrickville LGA.

Generally, for very small rain gardens (<5 m^2) it is important that the catchment size is not too large. As small rain gardens can be prone to smothering with leaf litter or sediment, and the overflow pit can be a large area of the rain garden, and careful consideration needs to the design of very small rain gardens.

2.2.1 Undersized rain gardens

In many instances in retrofit situations the rain garden is 'undersized' relative to a rain garden that would treat the upstream catchment to meet the best practice targets. This is due to the constraints on available space in existing urban environments. While these systems may not be able to meet best practice treatment, these rain gardens are still feasible, and provide all of the advantages of typical rain gardens, provided that the design flow into the system is "throttled back". Limiting the flows ensures that only a sustainable portion of the catchment is diverted into the rain garden. This is to ensure that the rain garden is able to maintain an appropriate performance by diverting the excess flows beyond its assimilative capacity to meet the treatment targets when the rain garden is undersized relative to the catchment.

For undersized systems:

1. MUSIC is to be used to set the diversion rate into the rain garden.
2. The area of the rain garden is included in the MUSIC model.
3. The diversion flow rate is set such that the system meets the best practice pollutant targets for the set diversion rate (i.e. the high flow bypass effectively reduces the volume of flow into the rain garden).
    a. This can be achieved in MUSIC using a 'high flow bypass' on the rain garden node and adjusting this value until the rain garden meets 85% TSS removal, 65% removal of TP and 45% removal of TN
4. This diversion rate must be noted and included in the concept design.

2.3 Siting of rain gardens

Determining the location of a rain garden is a major part of the concept design process. In Marrickville LGA there is a relative shortage of open space, there are many competing uses for this open space (active recreation, passive recreation, dog walking, event usage, etc.). In the streetscapes there is also limited space as many of the LGA's streets are narrow with relatively small or no nature strips. Also on-street parking in the LGA is also highly valued by the community.

2.3.1 Consultation

Incorporating rain gardens into public open space in the LGA needs to carefully consider all the potential site uses and will require consultation with a wide range of stakeholders in Council to understand all the potential uses and constraints at a particular site. It is important that consultation occurs early in the process to ensure that all key factors are considered in the design.

Engagement is also essential with the local community in helping to identify a suitable site for rain garden. The local community have excellent knowledge about their local area and can provide information that is valuable in the design process (e.g. anecdotal evidence on dumping, sediment loads, litter loads, basement pump outs, etc). The local community will also be invaluable in identifying information about how the community use the space and the local values of the site.

In some cases, engagement may be required with other stakeholders when determining a suitable site for rain gardens. For example, if the land is owned by a utility or state government department, consultation will be required with the land owner and approval/consent must be obtained at an early stage.

In some instances, land may be built adjacent to a utility (e.g. adjacent to Sydney Trains land) and information will be required to understand future plans (e.g. proposed new Sydenham to Bankstown Metro line) and future access and future recreational requirements.

2.3.2 Options

It is recommended at the concept stage to investigate a number of potential options for locating rain gardens and a number of potential configurations of the rain gardens.

2.3.3 Existing Stormwater systems considerations

Siting of a rain garden needs to determine an appropriate location for the system in relation to the existing stormwater system. For example:

- For treatment systems diverting from a stormwater system or which involve a diversion pit and pipeline the rain garden needs to be located at a level which is suitable for the stormwater system to be able to daylight to.
- For treatment systems located in the streetscape the inlet to the rain garden needs to be located upstream of existing stormwater inlet pits.

At the concept design phase it is also important to determine where the treated water and overflow will be directed to. The concept design should clearly show where both treated water and overflows from the rain garden will go and also how high flow bypasses will be managed.

2.3.4 Rain garden Finished Surface Level

At the concept design phase a key step is determining the level of the rain garden. This will be determined by the diversion pit and pipe or gutter invert level. It is important to ensure that the rain garden is set at an appropriate surface level in relation to the adjacent levels of the surrounding landscape. If the rain garden is too deep relative to the adjacent levels this will require significant excavation and increase the need for large retaining walls to minimise the land take required for the rain gardens. As a general rule the rain garden should not be set more than about

- 300mm to 400mm below the existing surface level for a streetscape system
- 1000mm below the ground for a park/bushland system

If there is significant fall across a site due to the grade of the existing ground levels, the rain garden will mostly likely require a number of cells to 'step' the surface of the rain garden down to ensure a good relationship exists between the existing surface levels and the rain garden.

2.3.5 Site constraints

After determining a location (or a number of locations) where a rain garden may be suitable the existing site constraints should be considered. There are a wide range of site constraints which need to be considered including (but not limited to the following)

- Existing trees and vegetation
- Aboveground and underground services
- Existing topography
- Pedestrian and cycling access
- Parking
- Traffic
- Provision of access for maintenance
- Heritage items (e.g. heritage footpaths)
- Street and park furniture (lights, seats, etc)
- Soils/bedrock
- Proximity to structures

A site assessment checklist has been provided below to assist in identifying common constraints in Marrickville LGA. There are also likely to be other site specific constraints which also need to be considered.

2.3.6 Site assessment checklist

Site Assessment Checklist		
Treatment system		
In attendance:		Date:
Site details	**Instructions/notes**	**Field Notes**
Land ownership	Who is the land owner? Council/Leased/Crown/Utility/State Government/Private	
Existing land use	e.g. park, road reserve, laneway	
Park land uses	Active or passive recreation? Playground? Compliant with relevant planning documents (e.g. Plan Of Management/ Masterplan /etc.)	
Neighbouring land uses	e.g. residential, commercial, industrial	
Event use	Is the space used for special events (e.g. Magic Yellow Bus, festivals, concert events, etc)	
Litter	High/medium/low	
Organic matter	High/medium/low (Related to trees and impervious surfaces)	
Sediment loads	High/medium/low	
Topography	Is the site very steep/very flat?	
Stormwater system	Identify the stormwater drainage system. Check stormwater pit locations, depths and pipe alignments For streetscape systems are there roof downpipes that traverse the site that can be diverted?	
Existing trees	Note any trees, observe ground surface for presence of root systems Note if deciduous trees Investigate TPZ and leaves from deciduous trees (and native trees) require additional cleaning / maintenance. Consult Council's tree management team to determine the cleaning and maintenance requirements from leaves.	
Other vegetation	Native bushland, well-maintained garden beds	
Services	Are there any service constraints on site? Verify DBYD on site.	

Site Assessment Checklist		
Treatment system		
In attendance:		Date:
Site details	**Instructions/notes**	**Field Notes**
Structures	Make note of existing structures, including paths, buildings, power poles, electricity kiosks, etc	
Street/park furniture	Make note of features such as seats, bins, paths, signs, fences, bubblers, etc	
Pedestrian and cycle use	Low/Medium/High Make note of how people use the site, including (if possible) different uses at different times of day	
Vehicle Traffic	Low/Medium/High Do vehicles need to traverse the site? Is access required for service vehicles?	
Parking	Is parking impacted (temporary or permanent basis)?	
Vehicle Access	Identify vehicle access location for construction and maintenance	
Amenity	Note any issues which detract from the existing site, e.g. graffiti, illegal dumping, weeds, erosion, redundant structures	
Existing material palette	Note use of materials on site (concrete, brick, sandstone, etc.)	
In –situ soils	Take note of any evidence of in-situ soils Review Acid Sulphate Soils maps. Any evidence of filling on site? Any evidence of clay/sandy soils?	
Water – runoff	Evidence of how water flows through the site, including flow paths, areas of ponding, sediment deposition, scour and erosion	
Water – demands	Are there irrigation, toilet flushing or other demands on site?	
Road grades (longitudinal and cross falls)	One-way cross fall? Steep/flat longitudinal grades?	
Heritage	Are there any heritage items?	
Sightlines	Consider sightlines for visual surveillance including pedestrian and cyclists	

3 DESIGN PROCESS

It is recommended that the design team include a range of design skills. It is recommended that the following be included in the design team:

- A design engineer with experience in the design of vegetated stormwater systems
- A landscape architect familiar with working in an inner city environment
- Council's senior construction project manager to provide advice on constructability

The design engineer and landscape architect should collaborate on the design as each designer brings important design skills which are required to resolve the design. The landscape architect should take a more active role in the design in more urban environments or where there is high pedestrian and public use of the space and the quality of the design needs to reflect this high use.

The following chart provides an outline of the proposed design process from project inception to completion of detailed design.

The process chart provides a

- List of the key tasks that should be completed at each stage, such as when modelling should be undertaken, when underground services detection should be undertaken etc.
- A summary of the external consultation that may be required. It should be noted that in many instances some of these external stakeholders will not need to be consulted. For example if the stormwater is not owned by Sydney Water and there are no Sydney Water assets affected by the works then Sydney Water will not need to be consulted with regards to their existing assets
- A summary of Council (internal) stakeholders which are required to be consulted and the stage(s) at which these consultations are required to take place.
- A summary of the design tools which should be used or referred to at each stage in developing the designs. There are a wide range of tools that are of use and many of Council staff will be able to provide guidance on these tools (e.g. Council's tree officer can provide guidance on the Street Tree Masterplan)

Stage	**Key tasks**	**External consultation**	**Internal consultation**	**Tools available**
Project inception	• Set design objectives • Identify key stakeholders • Joint project team site visit	• Landholders (if land not owned by Council) • Utilities (if relevant) • Sydney Water (if stormwater owned by Sydney Water)	• Planning (Strategic & Development) • Heritage (if relevant) • Infrastructure Planning • Culture and Recreation	• Subcatchment Management Plan • Site Assessment checklist
Option development	• Options development and assessment • MUSIC modelling • Stormwater drainage and catchment assessment • Opportunities and constraints mapping • Preliminary service investigation • Initial cost estimates	• **Local community** • **Landholders (if land not owned by Council)** • Utilities providers (if relevant) • **Sydney Water (if stormwater owned by Sydney Water)**	• Tree Management • Design and Investigation • Traffic Engineering Services • Parks and Streetscape • Landscape Maintenance • Biodiversity	• WSUD Priority Assessment tool • MUSIC + MUSIC Modelling Guidelines • Council GIS Stormwater Maps • Council ALS data • Other Council GIS data • DBYD – services search • Flood studies and models • Site Assessment checklist
Concept Design	• Concept design development • MUSIC modelling • Soil investigations • Service detection and potholing • Tree root mapping and estimate tree protection zone (TPZ) • Initial cost estimates	• **Local community** • Landholders (if relevant) • Utilities (if relevant) • Sydney Water (if relevant)	• Tree Management • Design and Investigation • Traffic Engineering Services • Biodiversity • Parks and Streetscape • Landscape Maintenance	• Community consultation outcomes • Soil investigation report • Service detection report • Tree root map (Tree Management) • Site assessment checklist • MUSIC + MUSIC Modelling Guidelines • Council GIS data • Council's unit rates
Detailed Design	• Detailed site survey • Prepare detailed design 50% drawings (plans and typical section) • Prepare 90% design drawings (Complete set of drawings) • Prepare final set of drawings • Technical specifications • BOQ and cost estimate • Contract documentation	• Landholders (if relevant) • Utilities (if relevant) • Sydney Water (if relevant)	• Design and Investigation • Traffic Engineering Services • Parks and Streetscape • Maintenance staff • Biodiversity • Tree Management	• Rain Garden Design Manual • Water by Design Bioretention Technical Design Guideline • Detailed site survey • SMCMA *WSUD Typical Drawings* • Vehicle Access Checklist • Safety Checklist • Detailed design checklist • Drains or other hydraulic models • Council's unit rates • Public Domain Strategy and Codes • Street Tree Master Plan

4 VEGETATION AND PLANTING

Marrickville Council's general preference is to, wherever possible,

- supply plants from local provenance species, within 20km from the site
- for these plants to be sourced from Council's native nursery located at Addison Rd Community Centre
- undertake community planting days where the local community, construction contractor and Council staff undertake the planting of the systems.

The detailed design process needs to consider these preferences when developing the planting plan for the rain garden design. During the design process the design team will need to liaise with Marrickville Council's nursery to verify suitable plants are available or can be sourced for the project.

It should be noted that Council's nursery is not a commercial nursery and is staffed by both Council staff and volunteers. The nursery only provides local provenance plant material and it has a relatively small nursery yard, with limited holding space for plants. Hence the lead times for the nursery may be longer than a commercial nursery and the ability to provide large order of plants is not guaranteed. A rain garden being prepared for planting is shown in Figure 3.

Figure 3 Laying out plants according to planting plan prior to planting

4.1 Preferred species list

For all rain gardens it is recommended that at least 5 species be used on the filter media with no one species dominating. It is recommended to plant at least 2 of the robust rain garden plants (plants that have been known to do well). Mass planting of single species is typically not recommended due to the risk of failure of any one species resulting in significant loss of vegetation. Where mass planting is desired due to the preferred aesthetic species selection needs to be carefully considered.

An indicative list of species that are known to work well in Marrickville is outlined in Table 1. It I recommended that approximately 80% of the plant species are selected off this list and approximately 20% of plants are chosen which are not on this list to ensure that experimentation with species continues. This list has been developed based on what is known to do well in Marrickville and is generally available at Marrickville's nursery. This list is not exhaustive and other plant species can also be considered with consultation with Council's nursery and biodiversity officers.

Table 1 Preferred species list

Species	Notes
Filter Zone Grasses and Sedges – 8 plants per m²	
Carex appresa	Only in systems with a saturated zone and no more than 15% of total plant numbers
Crinum pedunculatum	Good feature plant and no more than 5% of total plant numbers
Dianella caerulea	No more than 15% of total plant numbers
Dianella revolute	No more than 15% of total plant numbers
Danthonia tenuoir	No more than 10% of total plant numbers, not recommended in saturated zone systems
Ficina nodosa	Robust rain garden plant
Gahnia siberiana	Large clumping plant, Good feature plant. Not suitable adjacent to paths. No more than 5% of total plant numbers
Imperata cylindrica	Robust rain garden plant. Can become dominant.
Juncus usitatus	Robust rain garden plant
Poa affinis	No more than 10% of total plant numbers, not recommended in saturated zone systems
Lomandra longifolia	Robust rain garden plant. Tends to dominate. No more than 10% of total plant species at time of planting
Groundcovers (e.g. Viola hederacea, Hardebergia violacea, Hibbertia scandens, Hibbertia spp, Kennedia rubicunda, Einadia hastata, Pratia pupurescens, Wahlenbergia gracilis, etc	No more than 10% groundcovers in filter media

Species	Notes
Filter Zone Shrubs and small trees – 0.1 plants per m²	
Acmena smithii	
Bauera rubioides	
Callicoma serrata	
Callistemon spp,	
Kunzea ambigua	
Leptospermum spp	
Melaleuca spp	
Batter slopes – Grasses and Sedges 6 plants per m²	
Dianella spp	
Dichelachne crinita	
Echinopogon caespitosus	
Entolasia stricta	
Ficina nodosa	
Imperata cylindrica	Good plant to prevent access to rain garden if required
Lomandra spp	Good plant to prevent access to rain garden if required
Microlaena stipoides	No more than 10% of total plant numbers
Poa affinis	
Themeda australis	
Groundcovers (e.g. *Viola hedaracea, Hardebergia kennedia rubicunda, Einadia hastata, Pratia pupurescens, Hibbertia spp, Wahlenbergia gracilis, etc*)	No more than 25% of total plant numbers
Batter slops shrubs and small trees – 0.1 plants per m²	
Acacia spp	
Banksia spp	
Callistemon spp	
Dodanaea triquetra	
Hakea spp	
Indigofera australis	
Melaleuca spp	
Leptospermum spp	
Westringia fruticosa	

Note all plants should be supplied as tubestock.

Species which are low and 'delicate' e.g. *Microlaena stipoides* are difficult to weed amongst and increase maintenance requirements. Species of this form should be restricted to no more than 10 to 15% of the total species in the rain garden.

4.2 Plant Suppliers

The supplier of plants in the first instance for rain gardens is Marrickville Council's native nursery. The nursery has capacity to supply orders up to 5,000 plants. This may vary depending on other concurrent projects and the number of months lead time provided. Orders larger than this will need to be supplemented with plants from other suppliers.

The following are known plant suppliers of local provenance plants:

- Randwick Council native nursery
- Strathfield Council Community nursery
- Rozelle Bay Community nursery
- Cornucopia
- Toolijooa
- Greening Australia nursery
- Dragonfly Environmental (particularly for wetland plants, salt marsh, etc.)

4.3 Trees in rain gardens

Marrickville Council recommends the planting of trees in rain gardens including in the filter media. Marrickville LGA has a relatively low tree canopy and rain gardens offer an excellent opportunity to increase tree plantings and canopy cover in the LGA. Trees provide a wide range of benefits including shade, habitat, aesthetics, a reduction in air pollution, an uptake of carbon, microclimate benefits, rainfall interception, uptake and evapotranspiration of stormwater runoff, uptake of nutrients from stormwater and facilitation of infiltration into the filter media. In Marrickville LGA these benefits are considered to outweigh the disadvantages of tree in rain gardens. The disadvantages of trees in rain gardens include tree roots, which over time, enter subsoil drains and can clog the sub soil drains, they make it more complex to replace the filter media without removing the tree and some trees (especially if planted densely) can shade out other species over time.

To address these issues it is recommended to

- Plant trees at suitable densities (e.g. identify the full future extent of the canopy of the tree and plant at suitable densities e.g. 1 tree per 10 square metres).
- Jet the subsoil drains at a frequency of once every two to three year to clean roots out of subsoil drains
- CCTV a small selection of subsoil drains every 5 years
- Determine the depth of the soil media which has reached saturation of pollutant uptake using a soil core and then use air spading as a method to replace the top layer of filter (where pollutants have accumulated) without damaging the roots or destabilising the tree

Where rain gardens incorporate trees the following issues need to be considered:

- Provide 800mm of free draining media wherever possible
- Do not place a liner to the rain garden where possible

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- Specify the exact location of every large tree in the planting plan at suitable densities
- Consider overhead height constraints (e.g. overhead power lines) when locating trees in rain gardens
- Trees which are strongly allelopathic or drop significant amounts of leaf litter (e.g. Casuarinas, deciduous trees) are not recommended
- Locate trees away from the inlet or outlet structure (as overtime trees can damage these structures and prevent flows from entering or exiting the rain garden
- Traffic constraints, particularly sight lines in streetscape rain gardens
- Sightlines for visual surveillance for pedestrians, cyclists, etc.,
- Crime Prevention Through Environmental Design (CPTED), especially for open space
- Shading constraints for sports fields

4.3.1 Tree Species

Council's Street Tree Masterplan should be consulted for potential tree species, noting that not all trees are recommended for rain gardens. Trees for rain gardens need to be able to tolerate periods of extended moist soil conditions and temporary ponding. Tree species which typically grow on riparian zones of the Cooks River and its tributaries are likely to be suitable. A small selection of recommended tree species includes:

- *Angophora floribunda*
- *Banksia robur*
- *Eucalyptus robusta*
- *Eucalyptus botryoides*
- *Eucalyptus saligna*
- *Melaleuca styphelioides*
- *Melaleuca linariifolia*

Note that the above list of species is not exhaustive and a number of other tree species are likely to be suitable.

Marrickville Council's tree officer should be consulted about suitability for tree planting at particular sites and preferred tree species. Refer also to Councils Urban Forest Strategy and Council's Street Tree Masterplan.

4.3.2 Existing trees adjacent to rain gardens

In the first instance, without advice from an arborist or Council's street tree officer, it is to be assumed that existing trees cannot be removed to create rain gardens and are to be considered a constraint to the design. In some instances, a tree may be replaced if it is diseased or it is structurally unsound. Council's tree officer should be consulted about the condition of existing trees and if they can be removed.

Where an existing tree is located adjacent to the rain garden it should be incorporated into the rain garden wherever possible. This should include planting out between the rain garden and the tree and allowing the tree roots to enter into the rain garden filter media (i.e. no walls or liners should be placed between the rain garden and the tree) wherever possible.

To determine the extent of the constraints for excavation due to trees, in the first instance a standard tree protection zone should be adopted based on trunk diameter and if more detailed assessment is required through tree root mapping using air spading or similar.

An estimate of the Tree Protection Zone (TPZ) radius and Structural Root Zone (SRZ) radius can be made from the following:
TPZ = trunk diameter (measured at 1.4m above ground) x 12
SRZ = (trunk dimeter above the root buttress x50)$^{0.42}$ x 0.64

4.4 Plant procurement process and timeline

The general preferred arrangement for planting is as follows:

1. Marrickville Council orders the plants from Marrickville Council Nursery
2. Marrickville Council Nursery to procure and supply plants
3. Construction contractor is to liaise with the nursery for supply of plants to site
4. The contractor is to reject any plants they consider unsuitable for planting
5. Council is to provide alternatives as required to replace unsuitable plants
6. The contractor is to prepare the site for planting which is to be undertaken with the community and Council. The contractor is to give five weeks' notice to Council of when the site will be ready for planting
7. The site is to be prepared for the planting day including all required plants, mulch, water, hand tools and ensuring that the site is safe for the public to participate in the planting day
8. The contractor in consultation with Council is to layout the plants in the locations they are to be planted
9. Contractor, Council and the community are to plant out the rain garden
10. Council to provide tools, gloves, refreshments, first aid, PPE etc. and induction for all participants.

The plant procurement process and timeline is summarised in Table 2.

Table 2 Plant procurement process

Task	Notes	Timing
Prepare plant list	Contact Marrickville's nursery for the latest plant list. Consult with biodiversity, nursery and tree officers.	Allow for 2 weeks review by Council
Procure plants	Provide finalised plant schedule to Council's nursery.	At least 6 months prior to proposed planting day
Nursery Holding	Council's nursery has a limited holding area and can only hold plants for limited time if a project is delayed.	4 months of holding time
Confirm plant supply	Discuss with Council's nursery progress on plant propagation and requirement for any substitutes or delays to proposed planting date.	2 months prior to proposed planting day
Rain garden civil works complete	Contractor notifies Council that the rain garden will be ready for the community planting day	Two weeks prior to planting day
Planting day	Contractor organises plants and mulch and makes site safe for public. Contractor is to layout plants for planting for planting day	Planting Day

4.5 Preferred planting and establishment timeframes

The preferred planting timeframe includes:

- Propagation – Summer prior to planting
- Planting – Winter prior to spring growing season, to avoid summer

The rain garden wherever possible is to be established offline. This requires:

- a temporary plate to be placed over the diversion for systems which have a pipe diversion into the rain garden
- sand-bagging the inlet or similar for streetscape systems

Using a temporary flow diversion (using plates or sand bags) must ensure that there is no localised flooding. Also the temporary blocked diversion can accumulate sediment which requires cleaning and maintenance prior to bringing the rain garden on-line.

In some instances, (e.g. where there is a drainage gully pit is included in the rain garden) it may not be possible to establish the system offline. These systems will require longer establishment times and high maintenance during the establishment period.

The establishment period should last for a minimum of typically one growing season which (spring-summer period) which is typically a period of 6 to 9 months depending on when the rain garden was constructed.

Stormwater should not be let into the system until the plants are fully established (when the soil is no longer visible). This may take up to 2 years (or two growing seasons).

4.6 Opportunities

When considering planting for rain gardens the following opportunities, outlined in Table 3, could be explored when selecting plants.

Table 3 Planting opportunities to be considered during design

Design Consideration	Description
Habitat	Consider what local fauna may use the site or could be encouraged to use the site and provide appropriate food (e.g. seeds for small birds, nectar for avifauna and large birds, dense shrubs for small bird habitat, etc.). Consult with Council's biodiversity officers.
Seed collection	For larger rain gardens consider opportunities where the rain garden could become a seed collection site for propagation of future native plants. Ensure sufficient numbers of targeted seed collection plants are planted to have sufficient genetic diversity. Consult with Council's biodiversity and nursery officers.
Feature plants	In more formal areas or areas of high pedestrian traffic consider the option to select a feature plant(s) (e.g. colourful flowering plants such as Grevilleas). Consult with Council's landscape architect.
Biodiversity corridor	Consult with the biodiversity officers to understand if the rain garden is part of an existing or future biodiversity corridor (e.g. greenway) and what plant species should be considered as part of the biodiversity corridor [TRIM 8672.15]. Consult with Council's biodiversity officers
Urban Forest	Consider opportunities to contribute to Council's urban forest. Refer to the urban forest strategy and consult with Council's tree officers and biodiversity officers [TRIM 115460.14].
Microclimate	Consider opportunities which respond and also help to create the microclimate and to provide shading and cooling to the urban environment.
Aesthetics	Consider surrounding urban fabric and contribute to the aesthetic improvement of the area. Consult with Council's landscape architect and planners where appropriate.

5 RAIN GARDEN FILTER MEDIA

Rain gardens typically consist of a filter media, a transition layer and a drainage layer (Figure 4). These layers form the essential components of a rain garden. They need to be specified carefully to ensure:

- Effective stormwater treatment
- Healthy plant growth
- No migration of fines from the system
- Consistency with assumptions used in MUSIC modelling (e.g. the hydraulic conductivity of the filter media needs to match that used in the MUSIC model to ensure the modelled outcomes are able to be achieved). All modelling should use Marrickville Council's *WSUD Reference Guideline* [TRIM 16035.13].

Figure 4 Rain garden media (filter media (sandy loam), transition media (coarse glass) and drainage media (gravel) from left to right)

5.1 Potential suppliers of rain garden media

Listed below are potential suppliers of rain garden media. Due to the variability of quarried products the following parameters should be tested as a minimum:

- Particle size distribution
- Hydraulic conductivity
- pH
- TP and TN content
- Dispersibility (and any requirement for gypsum to be added)

Known suppliers of the filter media include the following:

- Benedicts Sand and Gravel – Menangle Sandy Loam with no organic matter
- Collins Construction material – A5 Sand
- Rocla Calga Double Washed Sand

It is important that all of the bioretention filter material does not include too much organic matter. For this reason, for example, it is recommended to use the Benedict's Menangle sandy loam with no organic matter added. It is also known that some bioretention media can leach out fines for about 3 to 6 months after construction. This can be reduced by adding gypsum to the soil. Where possible treated water should also be directed to a filter or a temporary geotextile filter over the outlet pipe in the overflow pit. This temporary filter would be removed after 6 months.

Potential suppliers of transition media include the following
- Benedicts Sand and Gravel – Washed Glass sand
- Benedicts - coarse washed sand

Potential suppliers of the drainage media include the following
- Benedicts Sand and Gravel – CRG A 2-5mm gravel

An installation of filter media is shown in Figure 5. Note the transition layer underneath the fitler media, vertical risers for the subsoil drain flush points and the geosynthetic clay liner (white) wrapping under the bioretention sides and base.

Figure 5 Rain garden media overlying glass sand and a geosynthetic clay liner

5.2 Erodibility and Dispersibility

The filter media being a loosely compacted top soil with high proportions of fine sand, is susceptible to erosion. Therefore, the filter media is not installed on a grade (less than 1% grade and velocity of less than 0.5 m/s is recommended). Generally installation of filter media on the batter slopes is not recommended rather top soil is used. This is particularly important where there is potential for runoff from adjacent areas to flow down the batter slope. It is recommended that a top soil which is more resistant to erosion is used on the batter slopes. The batter slopes should also include mulch and jute mesh.

The filter media can be dispersive (in contact with water the soil particles will become suspended and can easily wash out with the water) and in saturated zone systems due to uplift pressure. This is true, for example, of the Benedicts Menangle Sandy Loam (M1 and M165 products). The filter media must be tested for dispersion and its Emerson Class Number determined. If the media is classed as dispersive it should not be used unless the dispersion can be corrected with gypsum. If added gypsum is required, it is critical that this material is added to the soil during construction at the specified rate determined by the soil laboratory.

5.3 Saturated zone soil media

Saturated zones in rain gardens are becoming increasingly common. The bottom portion of the rain garden does not freely drain out in a saturated zone rain garden. The saturated zone is a semi-permanent pool of water at the base of the rain garden. This water can be depleted under prolong dry periods due to evapotranspiration.

Partially treated water is retained in the base of the rain garden. This creates anaerobic zones, which assist in denitrification, and also provides a source of water for passive irrigation of the rain garden vegetation. Saturated zones enhance nitrogen removal through denitrification of nitrates. However phosphorous removal typically decreases due to leaching of phosphorous in the anaerobic zone.

A significant benefit of a saturated zone is healthy and rigorous plant growth. Due to the supply of a water source for irrigation during dry times this ensures plants retain vigorous plant health even during long dry periods. This provides for better aesthetics as well as improved pollutant removal. Anecdotally it has been observed that establishment is also faster with saturated zones.

Saturated zones typically require an impermeable liner to the base of the rain garden to retain water. Where the system is installed in natural in-situ medium to heavy clay soils, the clay acts as a de facto liner and an artificial liner is generally not required. Types of liners are discussed in section 6.

Installation of saturated zones adjacent to roads and other structures needs to be carefully considered to ensure that there is no impact on the sub-base of the road or the foundations of adjacent structures. Adjacent to structures and roads, it is recommended to install a liner, even in natural clay soils. The natural clay soils of

Marrickville typically are expansive clays which have the potential to damage structures and foundations when subject to wetting and drying.

Saturated zones should have a carbon source added to the saturated media component. The carbon source improves denitrification processes. The carbon source should be a

- hardwood chip, such as ANL forest blend 15-40mm mulch.
- be added at the rate of 5% by volume to the saturated components of the media (including the saturated transition and drainage layers)
- should not be a fast decomposing carbon source (as this can create odours and does not provide a long term carbon source)

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6 PREFERRED DESIGN DETAILS

The following section outlines the requirements and considerations for the key components of design details of the rain garden. An example of a detailed design of a Marrickville Council rain garden is also included in Appendix B. A conceptual rain garden plan and section is shown in Figure 6 and Figure 7. These figures show the typical components of a rain garden.

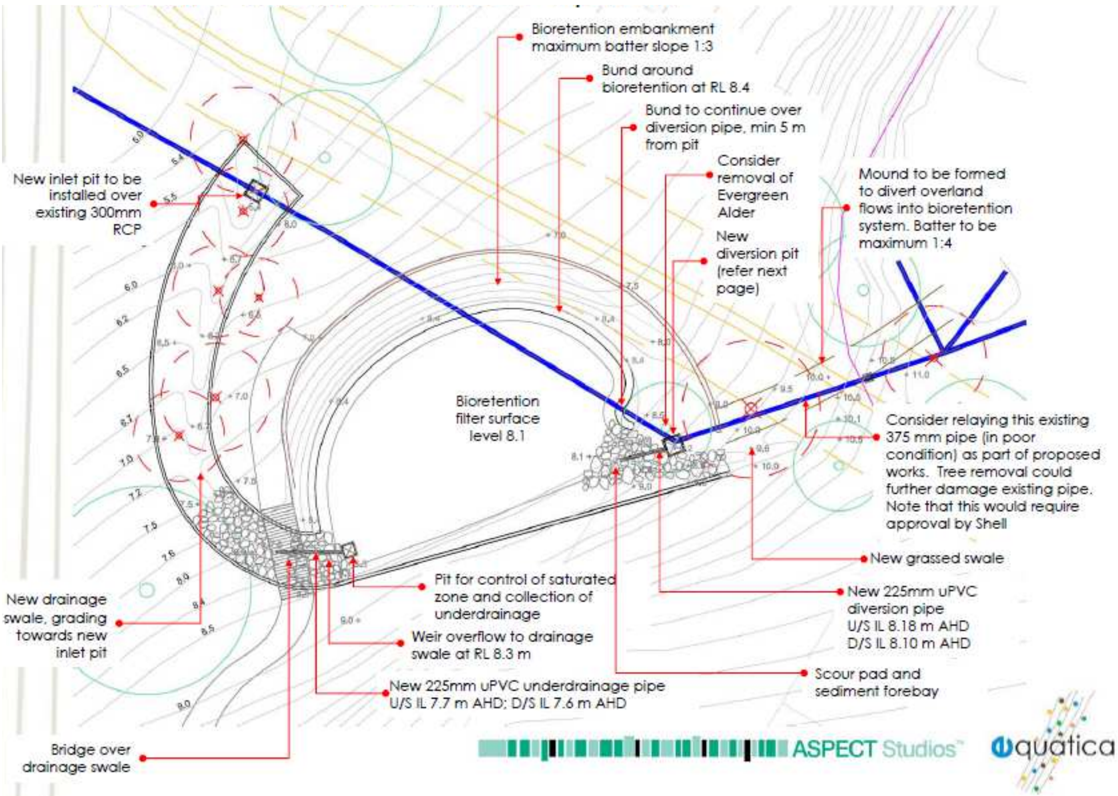

Figure 6 Example Concept Plan of a rain garden showing key element (Bruce St rain garden)

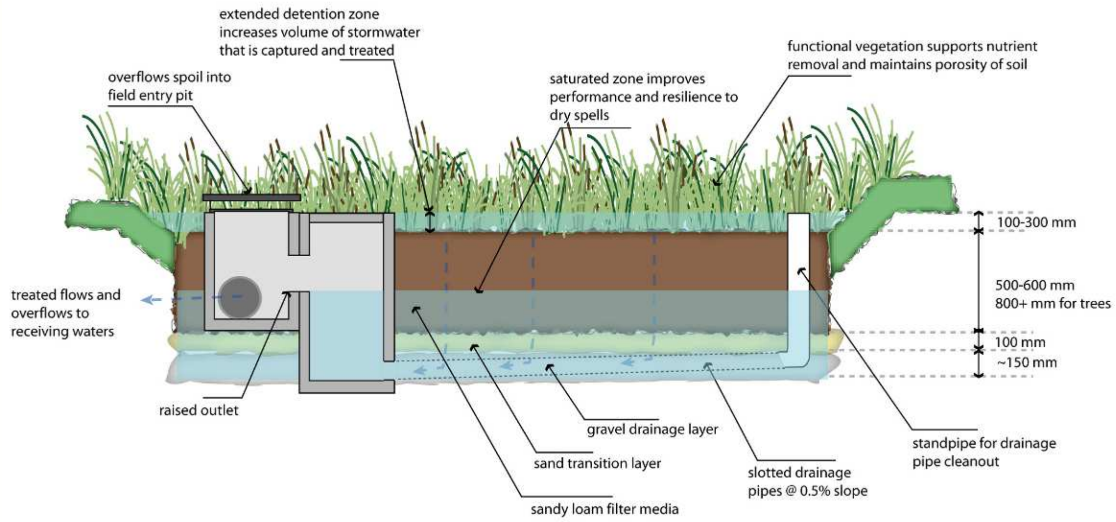

Figure 7 Typical Rain garden Section including a saturated zone

6.1 Inlet and outlet pits (including positioning)

Rain gardens require an inlet and outlet for stormwater. The inlet design is a critical design feature of a rain garden. The inlet serves the following functions:

- Directs stormwater into the rain garden
- Ensures that sufficient water enters the rain garden (if the inlet is undersized the rain garden will receive too little water)
- Ensures that water entering the rain garden does not cause scour or erosion of the filter media
- Spreads the flows as they enter the rain garden
- Diverts high flow around the rain garden to protect it from damage.

Particularly in streetscape rain gardens the inlet is one of the main reasons for failure of rain gardens. If the inlet is not well designed sufficient water will bypass the rain garden. The inlet design needs to ensure that:

- It is not undersized
- It does not become easily blocked (this is particularly important for kerb inlets which can be blocked by coffee cups or aluminium cans or organic debris)
- It is easily accessible for maintenance so that if it does become blocked it can be easily cleaned
- For streetscapes it is recommended that the inlet is sized assuming a relatively high blockage factor (e.g. 75% blocked)
- It is installed in a suitable location
- Where high sediment loads are expected that the inlet does not become blocked
- The design treatable flow rate enters the system but flows higher than this bypass the system

Further details on the inlet design in relation to scour and erosion control and sediment and litter management are included in sections 6.2, 6.3 and 6.4. A detailed step by step guide on how to design an inlet is provided in the Water by Design Bioretention Technical Design Guideline [TRIM 66506.16] and for those not familiar with the design process for rain garden inlets it is highly recommended to follow this step by step guide.

The outlet performs the key role in the rain garden of conveying filtered water and partially treated overflows during high flow events from the rain garden.

The outlet in a rain garden typically consists of a pit which collects the subsoil drainage. Typically, this pit is also used to collect the overflows in a large event. In some instances the overflow can also be a weir – for example in a streetscape this could be a simple weir (kerb opening) back to the kerb and gutter or in a large system this could be a weir to a swale. The exact form of the outlet for the overflow will be site specific.

All overflow pits must use a surcharge grate (and not a flush grate) to ensure the overflow grate does not become blocked.

It is important that the overflow is designed for the maximum peak flow into the rain garden. For example, a rain garden may have a design treatable flow rate of '100 L/s' before a diversion occurs. However, in peak flows as there may have been a blockage factor included and with maximum water levels at the diversion, the inlet to the rain garden may be capable of passing '300 L/s' into the rain garden. It is critical that the overflow caters for the maximum potential peak flow into the rain garden (300 L/s) to ensure water does not spill out of the rain garden in an uncontrolled manner, causing local flooding.

A detailed step by step guide on how to design an outlet is provided in the Water by Design Bioretention Technical Design Guideline [TRIM 66506.16] and for those not familiar with the design process for outlets it is highly recommended to follow this step by step guide.

It is generally recommended, but is not essential, to place the inlet and outlet at opposite ends of the treatment system. This ensures that stormwater has to travel the length of the treatment system ensuring additional treatment during peak flows through the rain garden. In larger systems care should be taken to ensure that flows can pass to the downstream end without surcharging back at the inlet.

6.1.1 Access requirements

Inlets and outlet pits require relatively frequent maintenance. For this reason, the inlet and outlet require good access. Council cleans out rain garden inlets using an eductor truck with vacuum and jetting facilities. Vehicle access to the inlet is therefore critical and vehicle access to every rain garden inlet is required in the design unless otherwise agreed with Council's operation and maintenance staff. The vacuum of the eductor truck has a reach of approximately 4m. Hence the vehicle access needs to be provided to within 4m of the inlet and preferably the outlet pit.

Direct vehicle access to the overflow pit is less critical as the overflow pit typically does not require vacuuming. The jetting facility of the eductor truck has a reach of approximately 25m. Hence it is required to provide person access via a wheelbarrow and vehicle access within 25m of the overflow pit.

The inlet and outlet must not be placed in the centre of the rain garden, but must be placed at the edge where they are accessible.

The access path to the inlet requires a suitable material such as concrete or bitumen which is designed to take the weight of a 20-ton vehicle. The outlet path is required to be at least a stabilised crushed gravel or geogrid reinforced path. Where possible the inlet and outlet of the rain garden should be located close to existing roads and paths to reduce the need for specific access paths which increase the cost and reduce the overall aesthetics of the design.

Streetscape rain gardens generally do not require any additional access paths. However, it is important to ensure that adequate consideration is given to how vehicles will access rain gardens from the street. For example, if an inlet pit is placed in the kerb and gutter in the street, an important consideration is if there is on-street parking which would affect access. Consideration needs to be given to where maintenance vehicles can park without requiring a temporary road closure or traffic management. Careful consideration needs to be given to locating inlets and outlets to rain gardens on any RMS, district or regional roads.

An example of an arrangement of a rain garden inlet and outlet configuration is shown in Figure 8. This system shows a relatively large rain garden (approximately 2,500 m^2) in Cranebrook in Western Sydney. The system has been designed with a sediment forebay to manage coarse sediment. For guidance on the siting and sizing of the forebay refer to the Water by Design Bioretention Technical Design Guideline [TRIM 66506.16].

There is a bitumen access track from the adjacent local road to the base of the forebay allowing access for a bobcat or similar into the forebay. There is a cement stabilised crushed sandstone maintenance path which runs around the entire system to provide access to the system. The overflow pit is located at the opposite end to the inlet to ensure all water is treated by flowing through the length of the system. There is wheelbarrow access to this pit and if required a ute or similar could also access the overflow pit (but is generally not expected to be required). Due to the size of the system it also has a GPT which is located in the local road where there is good access to clean the GPT.

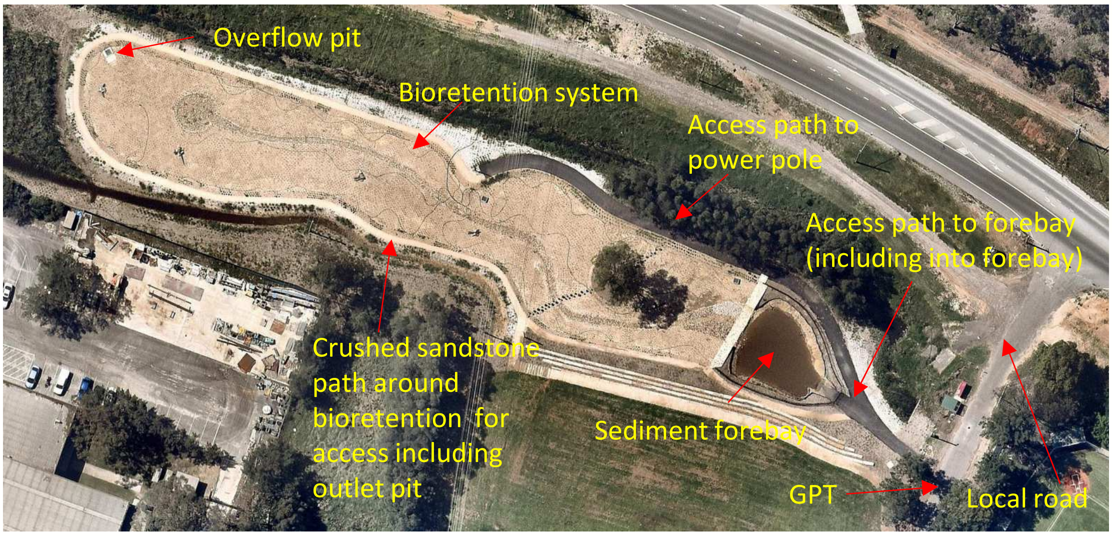

Figure 8 Rain garden inlet and access arrangement example

6.2 Scour pads

A scour pad is required at the inlet of rain gardens to protect the system from erosion. The scour pad does this by slowing down the velocity of the incoming stormwater reducing the energy and dissipating the flows into the rain garden. For guidance on the siting and sizing of the scour pad refer to the Water by Design Bioretention Technical Design Guideline [TRIM 66506.16].

It is recommended to use a scour pad with a flat base as shown in Figure 9. A hard flat base allows the scour pad to be easily cleaned during operation and maintenance using an eductor truck.

Where additional scour protection is required, particularly for larger systems this base can be combined with similar hard edged blocks as shown in Figure 10.

Inlets such as those shown in Figure 11, using irregular rough rock, are generally not recommended for use in Marrickville. Where these inlets are proposed consultation and approval with operation and maintenance staff is required.

Figure 9 Hard flat base scour pad – recommended in Marrickville

Figure 10 Hard flat base rock scour pad with energy dissipation blocks – recommended

Figure 11 Irregular rock scour pad – not recommended due to difficulty of cleaning out sediment

6.3 Litter management arrangements

Due to the relatively higher urban density of Marrickville, litter is an issue throughout the LGA. High litter loads can be expected around all retail outlets, transport nodes (e.g. train stations, light rail stations), public open space, commercial areas and industrial areas. 'Dumping' of waste is also an issue in the LGA, particularly in laneways and industrial areas and this also generates high litter loads. Organic leaf litter loads can be an issue in some areas and this also needs to be managed.

The recommended approach for litter management is outlined in Table 4.

It should be noted that litter baskets (e.g. Enviropods) are not a suitable litter management device and are not accepted by Council.

Table 4 Litter management recommendations

Scenario	Catchment area	Typical catchment and rain garden type	Litter management
1	Typically, less than 5,000m²	Road catchment and streetscape rain garden	Double pit arrangement with sediment sump
2	Typically, less than 20,000m²	Car park or small end of pipe catchment system treated in a small rain garden	If low litter/organic loads, coarse sediment forebay
3	Any areas greater than 20,000 m² other than scenario 2 above	End of pipe rain garden	GPT required

6.4 Sediment management arrangements

Marrickville Council is considered, anecdotally, to have relatively high sediment loads. This is thought to be due to the relatively steep catchments in many parts of Marrickville and the soil types.

High sediment loads can smother rain garden vegetation and cause plant death and clogging of the surface. Hence it is recommended to provide coarse sediment management in Marrickville LGA to protect the rain garden from damage and to allow for operation and maintenance suitable to Marrickville LGA.

The recommended coarse sediment management arrangement for Marrickville is outlined in Table 5.

Table 5 Sediment management recommendations

Scenario	Catchment area	Typical catchment and rain garden type	Litter management
1	Typically, less than 5,000m²	Road catchment and streetscape rain garden	Double pit arrangement with sediment sump
2	Typically, less than 20,000m²	Car park or small end of pipe catchment system treated in a small rain garden	If low litter/organic loads, coarse sediment forebay
3	Any areas greater than 20,000 m² other than scenario 2 above	End of pipe rain garden	GPT required capable of removing fine sediment (e.g. CDS unit)

An example of a double pit arrangement is shown in Figure 12. This figure shows a pit in the gutter on the right hand side of the image. Stormwater enters this pit. There is a sump in the base of the pit allowing coarse sediment to settle. There is a letter box opening from the right hand side pit into the second pit on the left in the rain garden. Water surcharges from the right side pit into the left side pit and exits through the grate of this pit into the rain garden. The pit is able to capture floating litter.

Figure 12 Double pit arrangements in streetscape rain garden

An example of a coarse sediment forebay arrangement is shown in Figure 13. This figure shows water ponded in the sediment forebay. The concrete wall in the foreground of the photo is the sediment forebay overflow weir. In high flows water flows out over the weir and into a bypass channel. Behind the sewer access chamber there are two inlets cut into the wall directing stormwater into the rain garden.

Figure 13 Coarse sediment forebay

An example of a gross pollutant trap is shown in Figure 14. This figure shows a CDS 'Nipper' prior to installation. This is the smallest CDS unit and is suitable to be installed on small catchments up to pipe sizes of typically 375mm in diameter.

Figure 14 Gross pollutant trap

6.5 Mulch

Mulch is important to help suppress weeds, retain moisture in the soil and allow the vegetation to establish. Rock mulch is required to be used in rain gardens as bark mulch will float with the ponded water and be washed out of the system and it can also cover pit lids and create blockages.

When the plants are young, rock mulch can heat up and provide heat stress to the plants, therefore a light coloured rock mulch is to be used in the rain garden.

Mulch is essential for systems which cannot be established offline and will have stormwater entering the system from the end of construction. Mulch is generally recommended for systems which are established offline, but is not essential.

The mulch within the rain garden is to be:

- A light coloured rock mulch such as a sandstone rock mulch
- Particle size of10 to 20mm. Larger diameter rock mulch is difficult to plant into.
- It is important that the rock mulch is free of fines to ensure that the mulch does not become compacted and then reduce infiltration
- Must be screened and have no fines to ensure that the fines in the mulch do not clog the rain garden and prevent infiltration
- Mulch is to be at least 50mm in thickness and no more than 100mm in thickness

An example of a suitable rock mulch for the rain garden is shown in Figure 15.

Figure 15 Clean no fines rock mulch to base of rain garden and jute mesh to batter slopes

It is recommended to place bark mulch to the areas surrounding the rain garden including the batter slopes above the maximum water level and any adjacent areas to the rain garden which are planted with native plants. For batter slopes which are relatively steep (steeper than approximately 1 in 10) it is recommended to use mulch which is then covered with an open weaved jute mesh to prevent the mulch washing off the batters.

The mulch surrounding the rain garden is to be:

- A suitable bark mulch
- Mulch is to be at least 50mm in thickness and no more than 100mm in thickness
- When placed on steep batter slopes covered in jute mesh to prevent wash off of the bark mulch

An example of this is shown in Figure 15 and Figure 16.

Figure 16 Bark mulch surrounding rain garden with jute covering bark mulch on batters outside of ponding area and sandstone rock mulch on base

6.6 Edge details

Edges can be broken up into two general types:

- Vegetated edges, typically used in parklands, natural bushland, riparian areas and similar
- Hard, formal edges, typically used in streetscapes, public plazas and building forecourts or similar areas

6.6.1 Vegetated edges

Vegetated edges are simple, cost effective and widely used for rain gardens. These are typically used in larger systems located in parklands and natural bushland setting. Vegetated batters require:

- A batter slope of 1 in 5 or flatter, but no steeper than 1 in 3
- more land area (compared to a vertical edge)
- extensive native planting to the batters to stabilise the batter slope and adjacent planting.

Planting on the vegetated batter is typically slower to establish as it receives less moisture and typically has less top soil. It is important therefore that

- a reasonable proportion of the species are quick establishing and robust species (e.g. *Imperata cylindrica*)
- includes a reasonable portion of clumping plants
- includes higher densities to ensure good plant establishment
- Where there is potential for erosion (e.g. steep batter slopes with the potential for water flowing over the batter) it is recommended to install a sterile Japanese millet grass (hydro-mulch application) to quickly establish the batter slope. This is then 'overplanted' with native species.

It is important that top soil be provided to the edge of the rain garden. The existing excavated and exposed soils are unlikely to be suitable for good plant growth and at least 200mm of top soil is to be provided to the vegetated batter slopes.

Also with steeper planted batters it is recommended to include larger rocks along the batters which can take up grade and also help to stabilise the batter slopes. These also provide useful flat benches for maintenance access. Large rock can also be function as habitat as well.

An example of a vegetated edge is shown in Figure 17. The 'Bruce St' rain garden on Marrickville golf course is another example of a vegetated edge in Marrickville.

Figure 17 Vegetated edges adjacent to parkland (foreground) and bushland (background)

An important consideration for vegetated edges is the interface between native vegetation and turf. To separate the two zones, preventing turf species invading the rain garden (a common problem) and providing a defined edge for mowing, an edge strip is required. It is recommended to use either:

- Concrete edges (Figure 18, right hand side) or
- Steel edges (Figure 18, left hand side)

The finish of concrete edge mowing strips, particularly when using curves or similar more complex shapes, is very dependent on the ability of the contractor to provide good quality formwork to form the edges. If complex edging is required, it is likely to be cheaper and easier to use steel edging.

Timber edges are generally not recommended due to the failure of the timber over time (e.g. timber lifts out of the ground over time or breaks) and the ability of turf to 'jump' or 'go under' the timber edge and then grow within the rain garden.

Figure 18 Steel edge (left) and concrete edge (right)

6.6.2 Formal edges

In formal parklands, parklands with higher usage, streetscapes and public open space in town centres a range of different edge types should be considered. The edge will depend on the site, its constraints, the uses of the area directly adjacent to the rain garden, and the overall context.

It is recommended that for these sites a landscape architect is involved in the design process, particularly for advice on resolving the design of the interface of the rain garden with the surrounding landscape.

An important part of the resolution of the edge design of a rain garden is the difference in height between the rain garden and the adjacent surface. A rain garden is typically lower than the adjacent surface to allow water to flow into the rain garden and to allow for ponding. In streetscape systems the difference in height between the base of the rain garden and the adjacent surface is typically 200mm to 300mm and can be as much as 500mm. In urban areas, particularly where space is limited, the interface of the levels of the rain garden and the adjacent levels (often a footpath or road) needs to ensure that there is not a sudden large change in surface levels which could create a slip/trip/fall hazard.

Safety is an important edge design consideration for all systems but especially streetscape systems. In most cases through careful design of the edge, fencing will not be required. If the design is still considered unsafe, then key parameters of the design should be re-considered (e.g. extended detention depth, rain garden surface level, etc.). If this still does not resolve the safety risk then either consider fencing or consider an alternate location.

For typical streetscape rain gardens it is recommended that the extended detention should be no more than 100 to 150mm. This should be reflected in the modelling for the site and the size adjusted, if required, to meet the treatment performance requirements.

A range of edge types which address the resolution of the difference in height and the risk to public safety are appropriate and have been used in rain gardens. The following provides a list of potential edges for formal rain garden systems:

- A planted buffer strip (typically 500mm in width) (refer Figure 19)
- Footpaths with kerb and wheel stop edges (e.g. refer Figure 20, Figure 21)
- Paved/rock edges which may be raised (refer Figure 21)
- Walls which can also double as seating (refer Figure 20, Figure 21, Figure 22)
- Seats and other street and park furniture (refer Figure 23)
- Vegetated batter slopes can also be used where there is sufficient space available.

Figure 19 Planted buffer strip around rain garden with low kerb walling

Figure 20 Low kerb wheel stop barrier edge (left) and seating wall edge (right)

Figure 21 Kerb edge (foreground), raised paver edge (right hand side) and seating wall edge (background) to a rain garden.

Figure 22 Sandstone wall which also functions as seating

Figure 23 Street furniture (seating on right) used as an edge to the rain garden

When considering materials for bridges or boardwalks over rain gardens timber, FRP and 'Modwood' or equivalent recycled material are all considered suitable and selection should be based on the site specific context.

6.6.3 Fencing

In general fencing is to be avoided in the design of rain gardens. Some simple design rules should be applied including:

- To ensure pool fencing is not required the ponded water depth in the rain garden should be less than 300mm.
- Balustrades and fencing is not required where the vertical fall height is less than 900mm to 'soft fall' such as the vegetation within a rain garden. Hence the use of any retaining walls to the edge of a rain garden should ensure that height from the top of the wall to the rain garden is no greater than 900mm in height.
- Occasionally in larger systems fencing may need to be considered where there are high headwalls, or deep water in an inlet zone. In these instances, dense prickly vegetation may be an alternative.

In some instances, fencing may be required for rain gardens, including:

- High pedestrian use areas where a wall is not appropriate and there is the potential for pedestrians to take a 'short cut' through the rain garden as it is on a desire line (e.g. Figure 24)
- Adjacent to sports fields where there is potential for balls to enter the rain garden and hence the rain garden is at risk of tramping (e.g. Figure 25)

Large dense spiky shrubs (e.g. *Acacia ulicifolia)* could be used to discourage access.

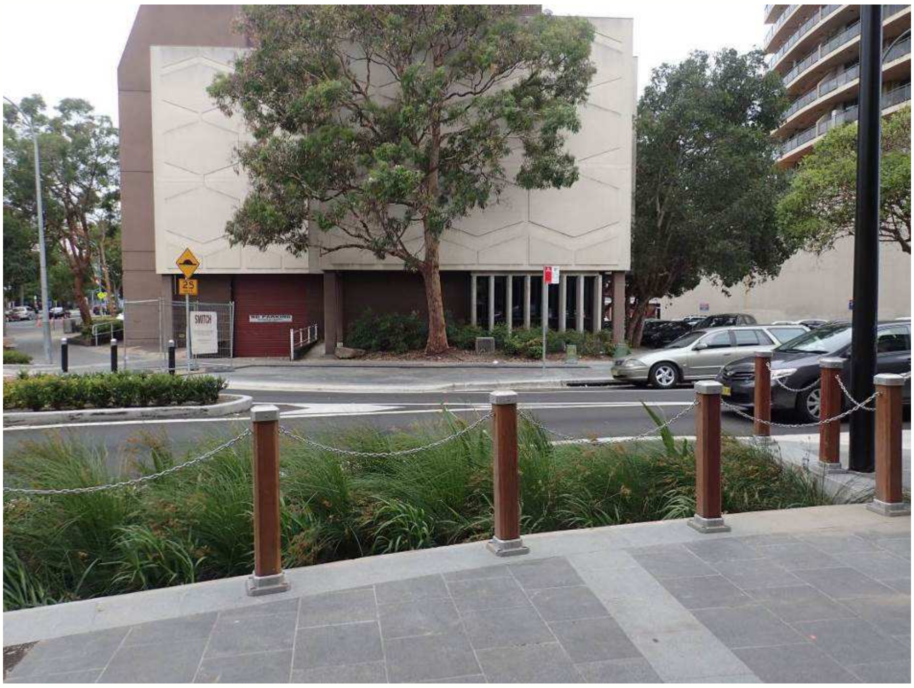

Figure 24 Chain and bollard fencing

Figure 25 Low timber log wall immediately adjacent to a hockey field

6.6.4 Public Domain Code

Marrickville Council has a Public Domain Code (at the time of writing this was in draft form) which applies to all public areas with Marrickville excluding parks. The edge design of rain gardens must be consistent with the preferred selection of style, materials, furniture, etc outlined in the public domain code. The edge design should be consistent with the surrounding landscape as outlined in the public domain code.

6.7 Subsoil drainage and flushing points

Subsoil drainage lines are required to collect the treated water from the base of rain gardens. The subsurface drainage should be sized and spaced as outlined in the Water By Design, Design Guidelines. It is also noted that for saturated zone systems, larger subsoil drains may be required due to reduced effective height of ponding over the subsoil drains.

Subsoil drains should be made of slotted PVC, preferably sewer grade PVC, and 100mm in diameter. Where trees are planted in the rain garden it is required to space subsoil drains at 1m intervals to ensure there is a high redundancy of subsoil drains in case of blockage by tree roots. Where trees are not required, subsoil drains are required at 2m intervals.

Flexible subsoil drains ('ag-pipe') are not recommended. An example of the installation of slotted PVC pipes is shown in Figure 26.

Figure 26 Brickies plastic liner and sub soil drains

At the end of each subsoil drain a flushing point is required to enable drainage to be jetted if the subsoil drainage becomes blocked. Flushing points are required every 30m for longer subsoil drainage lines to allow jetting of the lines.

The flushing point is to be installed:

- with an airtight PVC screw cap (or bolt down metal cap where there is a risk of vandalism)
- where there is a high risk of vandalism to the lid installed with a concrete surround
- to be installed with solid PVC risers to the vertical components
- to be installed with two 45-degree bends (and not just one 90-degree bend) to enable jetting and rodding
- if the lid is bolted down no more than 2 bolts are to be used (to enable easy access)

- is to be installed in the batter of the rain garden wherever possible to enable easy access, particularly if the rain garden has ponded and is not draining
- to be installed flush with the surface when installed in the batter slope
- to be installed 50mm above the ground when installed in the filter media (to enable easy access to the lid and to make it easier to identify in the field

An example of a flushing point connected to a subsoil drain prior to backfill is shown in Figure 27.

Figure 27 Flushing point connected to a subsoil drain prior to back fill

An issue with flushing points over time is that the subsoil drains become hard to find. For this reason, it is recommended to capture an image of the system shortly after construction as well as photos to enable identification in the future. Also it may be possible where there is edging to make a mark in the edging to enable identification.

6.8 Liners

An impermeable liner is used to prevent stormwater from infiltrating into the ground. The liner acts as a 'waterproof' barrier which prevents the water from exiting the rain garden and ensures that water drains through subsoil drains into the stormwater drainage system. Liners are typically used in the following situations:

- poor quality fill (e.g. landfill) exists underneath the rain garden
- infiltration would cause an issue downstream (e.g. shallow bedrock)

- where the rain garden is immediately adjacent to structures and foundations
- shallow groundwater where there is a requirement to ensure that the groundwater is not lowered by the rain garden
- where the rain garden is part of a stormwater harvesting systems where water is to be captured and directed to a storage

The following types of liners are typically used:

Liner type	**Advantages**	**Disadvantages**
High Density Polyethylene (HDPE) liner Refer Figure 28	Low permeability Resistant to chemical attack Can be installed in wet environments Different grades available	Requires welding Requires specialist installation Sealing around structures requires expert installation If punctured integrity of liner is lost
Geosynthetic clay liner (GCL) Refer Figure 29	Very low permeability Does not requires welding or specialist installation	Sealing around structures is important to retain seal If punctured integrity of liner is lost Requires installation in dry environments
Compacted clay liner Refer Figure 30	Very low permeability Is unlikely to be damaged by punctures Easy installation by civil contractors	Requires deeper excavation Generates more spoil Clay needs to be carefully sourced and installed Requires installation in relatively dry environments
Flexible Polypropylene (recommended 1mm)	Low permeability Can be factory cut to size to suit application and then installed by draping without any seaming Easy installation	Suited to small systems Less resistant to punctures than HDPE or GCL
'Brickies plastic' typically installed as a double layer Refer Figure 26	Inexpensive Easy to install Readily available Seams can be easily taped on site	Only suitable where some leakage is acceptable Very easily punctured Seaming is generally not possible

Figure 28 Subsoil drains being installed on top of a HDPE liner

Figure 29 Geosynthetic clay liner being installed (note preparation of subgrade below liner which is free of any irregular rocks or sharp material)

Figure 30 Compacted clay liner – note 1m depth of clay liner on trench face on left hand side of photo

7 CHECKLISTS

Checklists are a useful design tool that allows designers to quickly undertake a simple review of all the important components of a design that need to be considered. There are a number of useful general design checklists that are available for designing rain gardens. The

- Water by Design Bioretention Technical Design Manual 'Design Check' is recommended in particular section 3.7, as well as the worked example in section 5 [TRIM 66506.16]
- Water by Design Construction and Establishment Guidelines: Swales, Bioretention Systems and Wetlands 'Sign off Forms: Bioretention Systems' are a useful resource for designers as well as during construction [TRIM 66517.16]

The checklists provided here are specific checklists for Marrickville Council which highlight what are required. These checklists include:

- A site assessment checklist (refer section 2.3.6)
- A Marrickville Design Constraints checklist (refer 7.1)
- An operation and maintenance access checklist (refer 7.2)
- A construction access checklist (refer 0)
- A public and occupational health and safety checklist (refer 7.4)

7.1 Marrickville design constraints checklist

Marrickville Design Constraints checklist		
Treatment system		
Date		
Item	**Complete**	**Comments**
Has a DBYD services investigation been undertaken (mandatory). If Yes, state date.	Yes/No	
Has a Ground Penetrating Radar (FPR) services investigation been undertaken (mandatory). If Yes, state date.	Yes/No	
Has potholing investigation of services been undertaken (if required). If Yes, state date.	Yes/No/NA	
Are there service adjustments requiring approval?	Yes/No	
Are all works located outside of required service buffer zones? If not have approvals been obtained?	Yes/No	
Is the land owned by Council? If not has consent been obtained?	Yes/No	
Is the land managed by Council? If not has consent been obtained?	Yes/No	
If the land is owned/managed by others is there an agreement for ongoing operation and maintenance arrangements?	Yes/No/NA	
Have soil investigations been undertaken? If Yes, state date.	Yes/No	
Is the soil classified as Virgin Excavated Natural Material (VENM) / General Solid Waste/Restricted waste/asbestos contaminated waste?	VENM/GSW /RW/ACM	
Is the land classed as Potential Acid Sulphate Soils? If yes, have PASS been tested for?	Yes/No	
Is there bedrock present at the site at shallow depths? If yes, is excavation into rock required?	Yes/No	
Is shallow groundwater present at the site? Is dewatering required? How will groundwater be managed? Has an EPA approval been obtained?	Yes/No	
Is a liner required due to latent soil conditions or harvesting?	Yes/No	
Are street trees in the vicinity of the works?	Yes/No	
Are all works outside the Tree Protection Zone?	Yes/No/NA	
Has root mapping been undertaken?	Yes/No/NA	
Internal consultation undertaken with all relevant Council staff?	Yes/No/NA	

7.2 Operation and maintenance access checklist

Operation and maintenance access checklist		
Treatment system		
Date		
Item	**Complete**	**Comments**
Heavy vehicle access to inlet provided (within 4m of entire inlet and scour pad zone).	Yes/No	
Heavy vehicle is constructed form concrete/asphalt	Yes/No	
Wheelbarrow access to inlet provided (directly to inlet)	Yes/No	
Wheelbarrow access to outlet provided (directly to outlet)	Yes/No	
Does the access path require a locked gate?	Yes/No/NA	
Outlet pit contains saturated zone? use a *Terra Firma* lid (or equivalent) with pit raised to the top of extended detention	Yes/No	
Is the diversion inlet pit located in an area which is subject to parking? If so reconsider location to allow 24 hour maintenance access	Yes/No/NA	
Is the diversion inlet pit located in the street where traffic management will be required? If so consider relocating location	Yes/No/NA	
Gross pollutant trap accessible to heavy vehicle (within 1m)	Yes/No/NA	
Overhead power lines present in vicinity of GPT?	Yes/No	
Is the diversion inlet pit located in the street where traffic management will be required? If so consider relocating.	Yes/No/NA	
Flushing points located in bank and accessible when dry?	Yes/No/NA	
Overhead power lines present in vicinity of rain garden?	Yes/No	
Services present in or adjacent to rain garden which impact on operation access	Yes/No	
Is there potable water access available at the site?	Yes/No	
Are there restrictions on access due to use of the adjacent land (e.g. use by sporting groups, etc.)	Yes/No/NA	

7.3 Construction access checklist

Construction access checklist		
Treatment system		
Date		
Item	**Completed**	**Comments**
Heavy vehicle access to rain garden site available	Yes/No	
Temporary haul road required and included in design?	Yes/No/NA	
Is pedestrian and cycle management required?	Yes/No	
Has a site compound area between identified and is it shown on the drawings?	Yes/No	
Has a temporary stockpile area between identified and is it shown on the drawings?		
Does construction require temporary road closure or traffic management? Permit obtained?	Yes/No/NA	
Does construction garden require temporary road closure or traffic management? Permit obtained?	Yes/No/NA	
Does construction require temporary loss of parking? Permit obtained?	Yes/No/NA	
Is the diversion inlet pit/GPT located in the street where traffic management will be required? If so consider relocating location	Yes/No/NA	
Overhead power lines present in vicinity of works which require a crane?	Yes/No	
Is the diversion inlet pit located in the street where traffic management will be required? If so consider relocating location	Yes/No/NA	
Services present in or adjacent to rain garden which impact on construction access?	Yes/No	
Is there potable water access available at the site including for plant establishment?	Yes/No	
Are there restrictions on construction access due to use of the adjacent land (e.g. use by sporting groups, etc.)	Yes/No/NA	

7.4 Public and occupational safety checklist

Marrickville Design Safety checklist		
Treatment system		
Date		
Item	**Complete**	**Comments**
Has a safety in design risk assessment been undertaken?	Yes/No	
Is the site a high use pedestrian/cyclist site (and therefore higher risk)?	Yes/No	
Are there trip hazards present around the edges?	Yes/No	
Are there trip hazards at the inlet?		
Are there trip hazards at the outlet?		
Is there a vertical drop into the rain garden (and therefore high risk)?	Yes/No	
Is there any pooled water of a depth greater than 300mm? If yes, redesign or 'pool fencing' required	Yes/No	
Is there a vertical height greater than 900mm in the design to 'soft fall'? If yes redesign or a balustrade is required.	Yes/No	
Are vegetated batter slopes 1 in 4 or gentler?	Yes/No	
Does the design include large heavy lids? Can a *Terra Firma* lid be used instead?	Yes/No	
Is there potential for sharps to be present at the inlet on the surface?	Yes/No	
Does the site have any other occupational hazards (e.g. golf balls, adjacent to river, in floodplain etc.)	Yes/No	
If the outlet pit blocks can it be cleaned from the edge without entering the rain garden?	Yes/No	
Have operations and maintenance staff been consulted on the proposed design?	Yes/No	
Is it possible to isolate the inlet to the rain garden?	Yes/No	
Are there any pumps involved with potential for electrocution?	Yes/No	
Have non-slip surfaces been applied to all maintenance paths?	Yes/No	
Are there any deep pits or confined spaces? Is access in accordance with the Australian Standards?	Yes/No	
Does maintenance or construction require traffic management? Has a traffic management plan been provided?	Yes/No	
Is there any manual handling required of heavy pit lids, litter bags, etc.?	Yes/No	
Is emergency egress available from the rain garden if water levels were to suddenly rise?	Yes/No	

8 REFERENCES

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APPENDIX A SAMPLE TECHNICAL SPECIFICATIONS

The following provides a sample technical specification fro rain gardens in Marrickville. All sections should be reviewed for the design circumstances of each rain garden, however the text in red is meant to be updated for each rain garden.

A.1. Sample Planting Technical Specification

The following is a sample planting technical specification. This technical specification is based on the preferred standard arrangement where the plants are supplied by Council's nursery. The text in red must be reviewed and updated as appropriate for the specific project.

A.1.1. General

Marrickville Council will supply all plants as shown in the landscape plans. The contractor is responsible for undertaking planting of all plants to planting areas with the community or as otherwise specified in the contract and as shown on the landscape plans as well as replacing vegetation to all other surfaces that have been damaged due to construction works with 'like for like'.

The contractor should verify the quality of all plants received from Council to ensure that they can achieve successful plant establishment. Any unsuitable plants may be rejected and will be replaced by Council.

A.1.2. Materials

Council will supply plants. The contractor is to confirm the species and available number of the supplied plants with sufficient time **prior** to undertaking planting.

Council may vary the numbers and species from the planting plan based on availability of supply.

The contractor shall liaise with Council's representative to replace any plants that fail or are damaged at any stage of the work under the contract.

A.1.3. Plant Schedule

Refer to drawings

A.1.4. Execution

The Contractor shall allow for planting of all landscaped areas to be undertaken in partnership with the local community unless otherwise stated in the contract.

The Contractor shall agree with the Superintendent on suitable dates for planting giving at least four weeks' notice for the Superintendent to liaise with the community.

Immediately prior to community planting, the Contractor shall ensure that all plants and mulch is available on-site and that the site is safe for public access. To facilitate planting by the community, the Contractor shall coordinate with Council's officers in laying out all plants in accordance with the contract drawings.

Planting conditions
Planting shall be carried out when weather and soil conditions are favourable to plant establishment. Do not plant in unsuitable weather conditions. Planting shall not occur in extreme weather conditions, such as extreme heat, cold, wind or rain or when clear skies and cold weather threaten frosty conditions in winter. In other than bioretention system soils, suspend excavation when the soil is wet, or during frost periods. The plants shall be planted using appropriate horticultural techniques and in accordance with the landscape drawings.

Storage
Deliver plant material to the site on a day to day basis, and plant immediately after delivery. Protect plants at all times from sun or drying winds. Plants that cannot be planted immediately on delivery shall be kept in the shade, well protected and adequately watered. Plants shall be handled in such a manner to avoid any damage to the plant. After removing plant from container, scarify side of root ball to prevent root bound condition.

Watering
Soil moisture levels shall be at or above field capacity prior to planting. Thoroughly water the plants before planting begins and immediately after planting, and as required to maintain growth rates free of stress. Less frequent heavy watering is preferable to light watering. The soil moisture content needs to be assessed daily and watering regime adjusted accordingly. Typically 20mm week is required during summer and spring and 10mm week during autumn and winter. This can be provided by rainfall or an irrigation event.

Placing
When planting into either rip lines or holes the size of the hole shall be at least twice the size of the plant root ball. The hole shall be heavily watered immediately prior to planting and shall have ample loose soil to ensure that root soil contact is complete and that no air gaps exist.

In areas outside the bioretention sand shall be used if excessive heavy clay or stones are found. A slight depression or raised lip shall be made around the plant to assist in the trapping and infiltration of water.

Install plant stock to the areas indicated at the spacings shown, in random pattern, insuring complete coverage.

Fertilising and additives
No fertiliser is to be added to any of the plantings.

Replacement
Replace damaged or failed plants with plants of the same type and size.

A.1.5. Establishment and Maintenance Period

Maintenance of the vegetated areas is required until practical completion of the works. Ongoing maintenance of the vegetation must be undertaken by the contractor for a period of 6 months. Ongoing maintenance requires the following:

- Remove all weeds and re-plant any dead plants on an ongoing basis. Handover of the system will require the system to be weed free with sufficient plant cover (equivalent to 6 to 8 plants per square metre)
- Hand weeding only – no herbicides, fungicides or pesticides to be used without the prior written consent of Council.
- Watering in of all new vegetated areas including the bioretention system vegetation areas for the 6 month establishment period at a sufficient rate to ensure successful plant establishment.
- Handover at the end of 6 months will require all planting to be healthy, weed and disease free with good even coverage of plants over the entire area
- Litter and sediment removal from the system on a regular basis (at least once a month and after all rainfall events greater than 10mm)
- Cleaning out of inlets, outlets and forebays including removal of all litter, sediment and any other pollutants.
- *For saturated systems, the saturation zone must be filled at least once a month to aid in plant establishment,*

At the end of the establishment period a report is to be provided. The report is to include

- Photos every month, with the date and labels on the photos
- Records of activities undertaken and when (incl. weeding, litter removal, sediment and organics removal, irrigation, re-planting, any scour or erosion, etc.)
- A summary of the establishment status and handover process

A.2. Sample Rain garden media technical specification

The following is a sample rain garden media technical specification. The text in red must be reviewed and updated as appropriate for the specific project.

A.2.1. General

The filter media, transition layer and drainage layer form essential components of the bioretention system. They are specified carefully to ensure:

- Effective stormwater treatment
- Healthy plant growth
- No migration of fines from the system

Prevention of contamination of the soil media with any other materials (other soils, particularly clay soils, cement, chemicals, fertiliser, building materials, etc) is **critical** to ensure its proper functioning.

At **no time** are any building materials to be stored on the bioretention system surface.

A.2.2. Timing of installation of media

The bioretention media is to be installed towards the end of the project and project timetables should clearly outline when media is to be installed. Installation should occur:

- after completion of all bulk earthworks,
- immediately prior to planting out of the bioretention surface.

If the surface of the bioretention system is to be installed and planting is not able to be undertaken within two days, the surface of the bioretention media must be covered with an impermeable plastic liner (e.g. brickies plastic or similar) to prevent contamination of the soil.

The liner and any material collected on the surface is to be removed immediately prior to planting.

Council's Superintendent and/or representative is to be notified on installation and removal of any plastic liner covering the surface.

A.2.3. Materials

Filter Media:

The filter media is to meet the following specification:

- In general the soil should be loamy sand with an appropriately high permeability under compaction and shall be free of rubbish, deleterious material, toxicants, declared plants and local weeds, and shall not be hydrophobic. The filter media shall contain some organic matter for increased water holding capacity but be low in nutrient content.
- Hydraulic conductivity = 100-300 mm/hr, as measured using the ASTM F1815-06 method

- The filter media shall be well-graded i.e., it shall have all particle size ranges present from the 0.075 mm to the 4.75 mm sieve (as defined by AS1289.3.6.1 - 1995). There shall be no gap in the particle size grading, and the composition shall not be dominated by a small particle size range. An ideal particle size distribution is as follows:
    - Clay & Silt (<0.05 mm) <3%
    - Very Fine Sand (0.05-0.15 mm) 5-30%
    - Fine Sand (0.15-0.25 mm) 10-30%
    - Medium Sand (0.25-1.0 mm) 40-60%
    - Coarse Sand (1.0-2.0 mm) 7-10%
    - Fine Gravel <3% (2.0-3.4 mm)
- Organic Matter Content – less than 5% (w/w).
- pH – as specified for "natural soils and soil blends" 5.5 – 7.5 (pH 1:5 in water).
- Electrical Conductivity (EC) – as specified for "natural soils and soil blends" <1.2 dS/m.
- Phosphorus - <50 mg/kg.

The specified product is **Benedict's Bioretention Filter Media (M01)**.

Alternate material may be used however approval MUST be gained before use.

Transition layer:
The transition layer is to meet the following specification:

- Transition layer material shall be a clean, well-graded sand/ coarse sand material containing little or no fines.
- Coarse sand (1.0-2.0 mm) 100%
- Mixed with 5% by volume hard wood

A suitable product is **Benedict's *Washed Glass Sand* (GSMEDIUM)**.
Alternate material may be used however approval MUST be gained before use.

Drainage layer:
The drainage layer is to meet the following specifications:

- The drainage layer is to be clean, fine gravel, such as a 2-5 mm washed screenings
- Gravel (2.0 – 5.0 mm): 100%

A suitable product is **Benedicts No Fines Drainage Gravel (5mm grade)**.

Alternate material may be used however approval MUST be gained before use.

For rain gardens with saturated zone systems, hard wood chips must be added to the drainage layer at a rate of 5% by volume. Note that this is approximately equivalent to 14.5 kg of woodchips per tonne of drainage gravel. Hard wood chips are to be evenly mixed into the drainage layer.

An approved product for the hard wood chips is the 15-40mm Forest Blend product available from Australian Native Landscapes.

Alternate material may be used however approval MUST be gained before use.

Bioretention Media properties schedule

Property	Drainage Layer	Transition Layer	Filter Media
pH (water) - can be amended on site	5.5-7.5	5.5-7.5	5.5-7.5
Salt Content (EC1:5)	< 1.2 dS/m	< 1.2 dS/m	< 1.2 dS/m
Saturated Hydraulic Conductivity	Min 500 mm/hr (as measured by saturated hydraulic conductivity)	Min. 400mm/hr (as measured by saturated hydraulic conductivity using ASTMF1815-06)	150 to 300mm/hr (as measured by saturated hydraulic conductivity using ASTMF1815-06)
Organic matter	Nil	Nil	<5% composted materials
Bulk Density	Not applicable	Not applicable	1.0-1.6 g/cm3
Moisture (%)	Not applicable	Not applicable	20-35
Dispersivity (using Emerson Dispersion Test)	Not applicable	Not applicable	Not dispersive (gypsum maybe used as additive if required)

Bioretention Media nutrient schedule

Nutrient	Drainage Layer	Transition layer	Filter Media
Phosphate	< 50 mg/kg	< 50 mg/kg	< 50 mg/kg
Potassium	Not applicable	Not applicable	> 0.4 meq%
Nitrogen	< 500 mg/kg	< 500 mg/kg	< 500 mg/kg
Calcium	Not applicable	Not applicable	> 2.0 meq%
Magnesium	Not applicable	Not applicable	> 0.7 meq%
Cation Exchange Capacity	Not applicable	Not applicable	< 7%

A.2.4. Execution

No fertiliser shall be added to any of the soil media in the bioretention systems.

Testing: Contractor shall arrange and meet all costs for conducting laboratory testing of samples.

Samples: Prior to delivery of media, a minimum of 1kg of material per sample is required and a minimum of fourteen days should be allowed for testing prior to submitting conforming sample.

Additives: If using additives ensure compliance with the relevant test criteria.

Placing media within the bioretention system

The drainage layer and transition layer can each be placed in a single layer. The unsaturated zone filter media shall be placed in at least two layers, maximum 300 mm each.

General: Spread each layer and grade evenly, making the necessary allowances to permit the following:

- Required finished levels may be achieved after light compaction.

Contamination: Where diesel oil, cement or other phytotoxic material has been spilt on the soil media, the Contractor will need to remediate the system at their own cost. Excavate the contaminated soil, dispose of it off the site, and replace it with the specified media to restore design levels.

Consolidation

The filter media can be lightly compacted to achieve a uniform finish. It shall not be over-compacted, as it is important to maintain porosity for infiltration. The finished surface shall be:

- Finished to design levels.
- Ready for planting

Aeration

Any compacted areas **must** be de-compacted prior to planting or seeding. This must be done by hand and caution must be taken to ensure that there is no damage to lower layers.

APPENDIX B: EXAMPLE DESIGN DRAWING – SCOULLER ST RAIN GARDENS

MARRICKVILLE council

WATER3VOLUTION

Funded by the Marrickville community through the Stormwater Charge

MARRICKVILLE COUNCIL
SCOULLER ST RAINGARDENS
DETAILED DESIGN DRAWINGS

PLAN P01 – SITE AERIAL
SCALE 1:200 @ A1

SCHEDULE OF DRAWINGS	
P01	OVERVIEW PLAN AND DRAWINGS LIST
P02	DEMOLITION PLAN
P03	STORMWATER OVERVIEW PLAN
P04	NORTHERN BASIN PLAN
P05	SOUTHERN BASIN PLAN
P06	PLANTING PLAN
P07	SET OUT PLAN
D01	NORTHERN BASIN SECTIONS
D02	SOUTHERN BASIN SECTIONS
D03	BIORETENTION DETAILS
D04	GENERAL DETAILS
D05	GENERAL DETAILS CONTINUED

GENERAL NOTES

- THESE DRAWINGS SHALL BE READ IN CONJUNCTION WITH THE ACCOMPANYING TECHNICAL SPECIFICATIONS DOCUMENT
- ALL LEVELS ARE TO AHD UNLESS OTHERWISE SPECIFIED IN THE DWGS
- ANY DISCREPANCIES BETWEEN THESE DRAWINGS AND THE TECHNICAL SPECIFICATIONS SHALL BE REFERRED TO THE SUPERINTENDENT FOR DECISION BEFORE PROCEEDING WITH THE WORK
- ALL STRUCTURES ARE TO BE CONSTRUCTED IN ACCORDANCE WITH THE DETAILS PROVIDED, UNLESS SPECIFIED OTHERWISE
- MAKE SMOOTH TRANSITION BETWEEN NEW WORK AND EXISTING SURFACES
- SURVEY MARKS SHALL BE RETAINED AND PROTECTED AT ALL TIMES. WHERE RETENTION IS NOT POSSIBLE THE SUPERINTENDENT SHALL BE NOTIFIED AND CONSENT OBTAINED PRIOR TO REMOVAL. A REGISTERED SURVEYER MUST BE USED TO RELOCATE THE SURVEY MARK.
- THE CONTRACTOR SHALL CONTROL SEDIMENTATION, EROSION AND POLLUTION DURING CONSTRUCTION IN ACCORDANCE WITH THESE PLANS AND COUNCIL'S REQUIREMENTS
- DO NOT SCALE FROM DRAWING. USE FIGURED DIMENSIONS ONLY. CHECK ALL DIMENSIONS ON SITE BEFORE ANY MANUFACTURE OR CONSTRUCTION
- IF BEDROCK IS ENCOUNTERED AT ANY STAGE OF EXCAVATION. HOLD CONSTRUCTION AND CONTACT THE SUPERINTENDANT AND AWAIT FURTHER INSTRUCTION.
- ALL WORK SHALL COMPLY WITH THE BUILDING CODE OF AUSTRALIA, CONDITIONS OF THE DEVELOPMENT CONSENT AND RELEVANT AUSTRALIAN STANDARD CODES.
- DRAWINGS MUST BE PRINTED IN COLOUR

ABBREVIATIONS

US – UP STREAM
DS – DOWN STREAM
IL – INVERT LEVEL
CL– COVER LEVEL
RC – REINFORCED CONCRETE
GL – GRATE LEVEL
M – METERS
MM – MILLIMETERS

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SCALE (at A1)
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MARRICKVILLE COUNCIL
SCOULLER ST RAINGARDENS
OVERVIEW AND DRAWING SCHEDULE

Drawing No. P01
Sheet No. ? OF ?
Revision No. -
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A1

SERVICES LEGEND

TELSTRA SERVICE
GAS MAIN
WATER MAIN
EXISTING STORMWATER
ELECTRICITY MAINS
SEWER MAIN
OPTIC FIBRE MAIN (WITH 1M BUFFER)

LEGEND

NEW BIORETENTION FOOTPRINT
FOR DEMOLITION
DEMOLISH STORMWATER PIPE

PLAN P02
DEMOLITION PLAN
SCALE 1:100 @ A1

NOTES:
1. SANDSTONE BLOCKS FROM EXISTING CONVERTERS AND KERB AND GUTTER ARE TO BE REMOVED CAREFULLY WITHOUT DAMAGING THE STONE BLOCKS.
2. SANDSTONE BLOCKS ARE TO BE STOCKPILED AND RE-USED TO TAKE UP GRADE AROUND SCOUR PADS.
3. BRICKS FROM PAVEMENT ARE TO BE REMOVED CAREFULLY AND STOCKPILED FOR RE-USE TO CREATE THE NEW FOOTPATH OVER THE BIORETENTION SYSTEMS.

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SCOULLER ST RAINGARDENS
DEMOLITION PLAN

Drawing No. P02
Revision No. -
Sheet No. ? OF ?
File Name:

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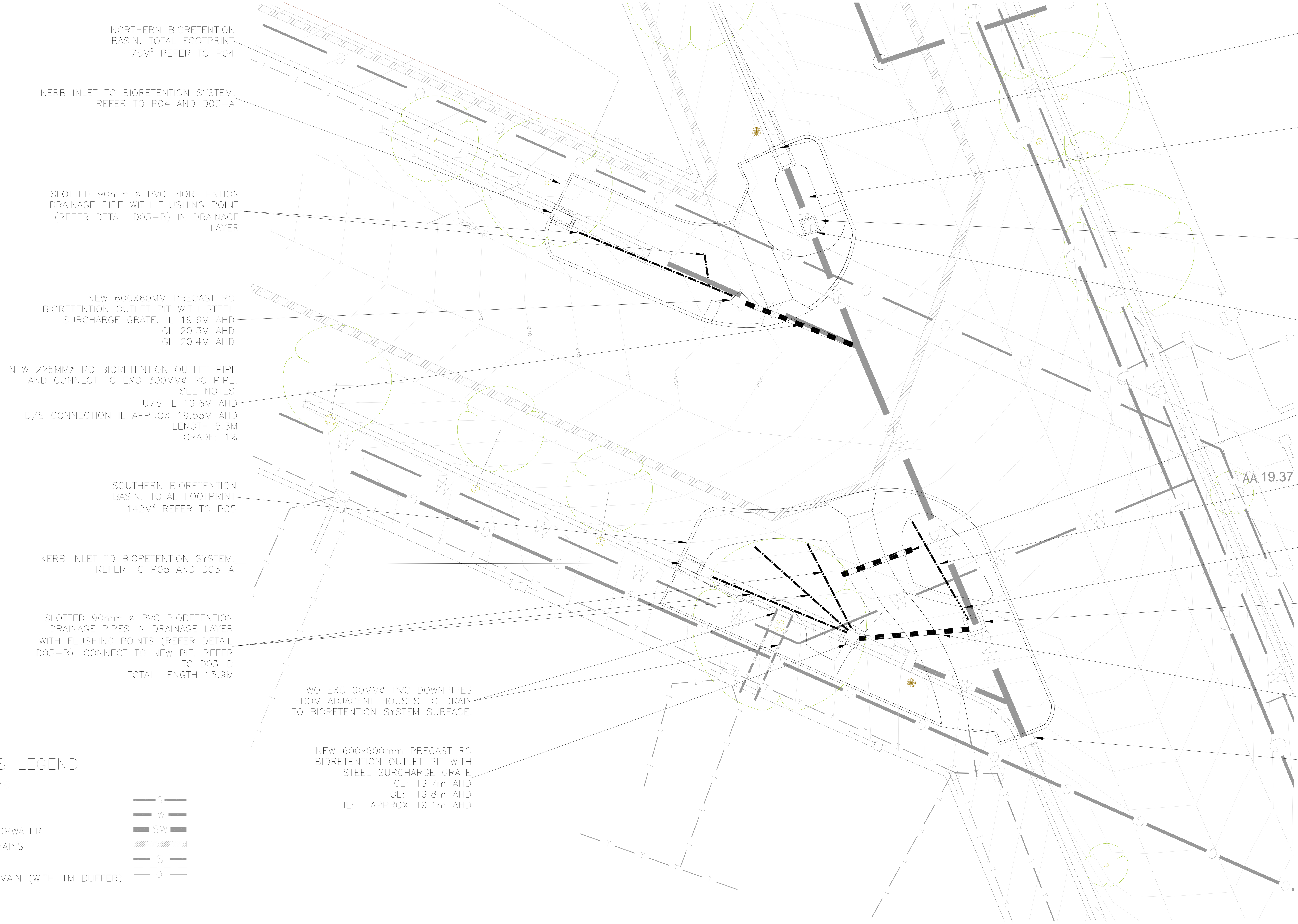

PLAN P03
STORMWATER INFRASTRUCTURE PLAN
SCALE 1:100 @ A1

NOTES
1. EXACT INVERT OF NORTHERN BASIN BIORETENTION OVERFLOW PIT IS TO BE DETERMINED BY EXISTING 300MMø PIPE LEVEL. PIT INVERT IS TO BE FLUSH WITH EXISTING 300MMø PIPE INVERT LEVEL AT THE DOWNSTREAM END OF THE NEW PIT.
2. EXISTING 225MMø PIPE CANNOT BE USED AS THE PIPE LEVEL IS TOO HIGH. THE EXISTING PIPE MUST BE DEMOLISHED AND REMOVED AND A NEW PIPE INSTALLED TO THE SPECIFIED LEVELS.

SERVICES LEGEND

TELSTRA SERVICE	T
GAS MAIN	G
WATER MAIN	W
EXISTING STORMWATER	SW
ELECTRICITY MAINS	
SEWER MAIN	S
OPTIC FIBRE MAIN (WITH 1M BUFFER)	O

LEGEND

- DESIGN LINES
- NEW STORMWATER PIPES (SOLID)
- NEW STORMWATER PIPES (SLOTTED)
- FLUSHING POINT
- 0.1M DESIGN CONTOURS
- 0.5M DESIGN CONTOURS

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STORMWATER INFRASTRUCTURE PLAN

Drawing No. P03 — Revision No. -
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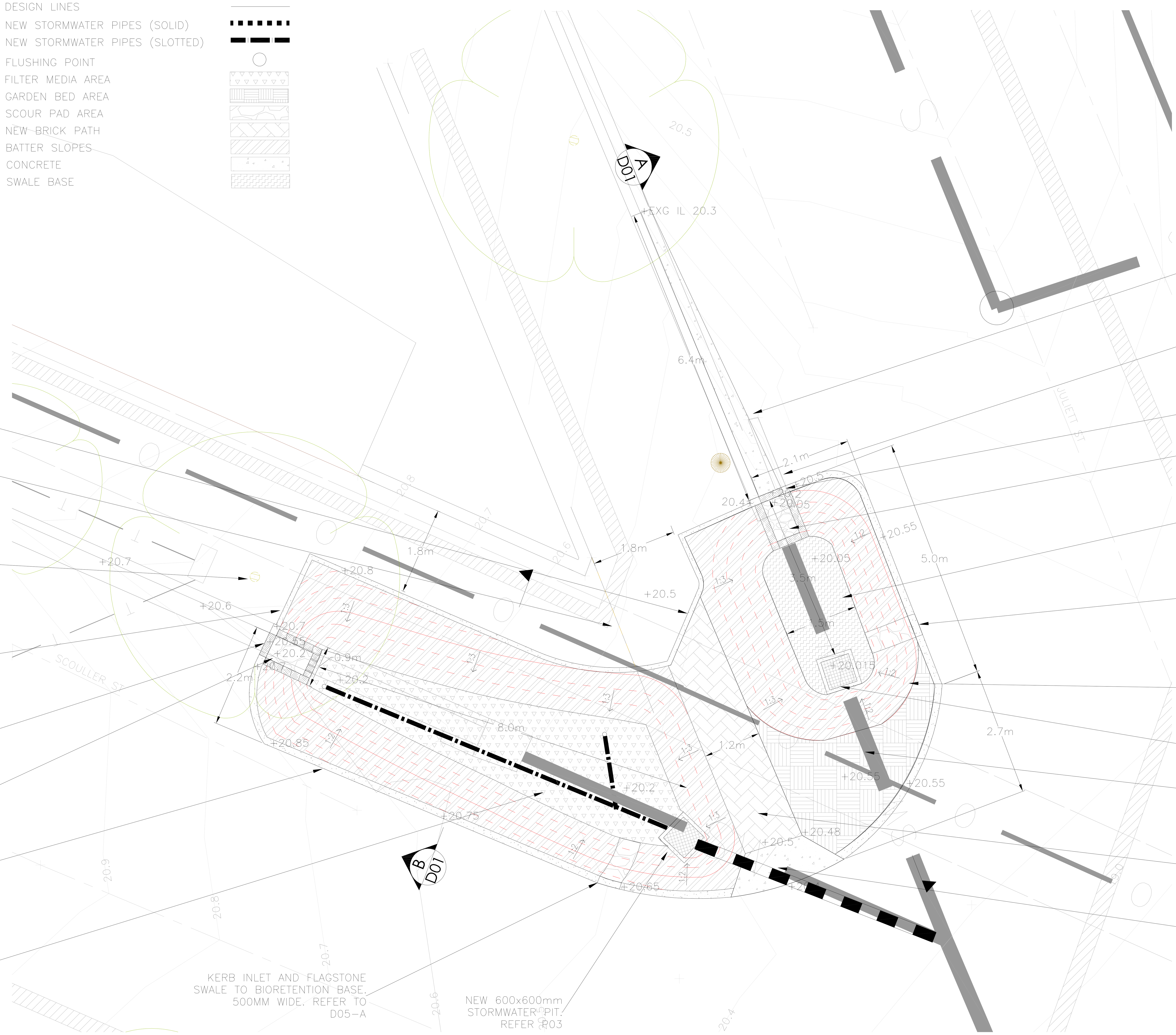
SERVICES LEGEND

- TELSTRA SERVICE
- GAS MAIN
- WATER MAIN
- EXISTING STORMWATER
- ELECTRICITY MAINS
- SEWER MAIN
- OPTIC FIBRE MAIN (WITH 1M BUFFER)

AREAS	NORTH
FILTER MEDIA	12.5M²
BATTER SLOPES	36.0M²
SCOUR PAD	1.4M²
SWALE BASE	4.0M²
GARDEN BED	6.4M²
FOOTPATH	7.5M²
TOTAL FOOTPRINT	75M²

LEGEND

- DESIGN LINES
- NEW STORMWATER PIPES (SOLID)
- NEW STORMWATER PIPES (SLOTTED)
- FLUSHING POINT
- FILTER MEDIA AREA
- GARDEN BED AREA
- SCOUR PAD AREA
- NEW BRICK PATH
- BATTER SLOPES
- CONCRETE
- SWALE BASE



PLAN P04
NORTHERN BASIN PLAN
SCALE 1:50 @ A1

NOTE: REFER TO P03 FOR STORMWATER INFRASTRUCTURE DETAILS.

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NORTHERN BASIN PLAN

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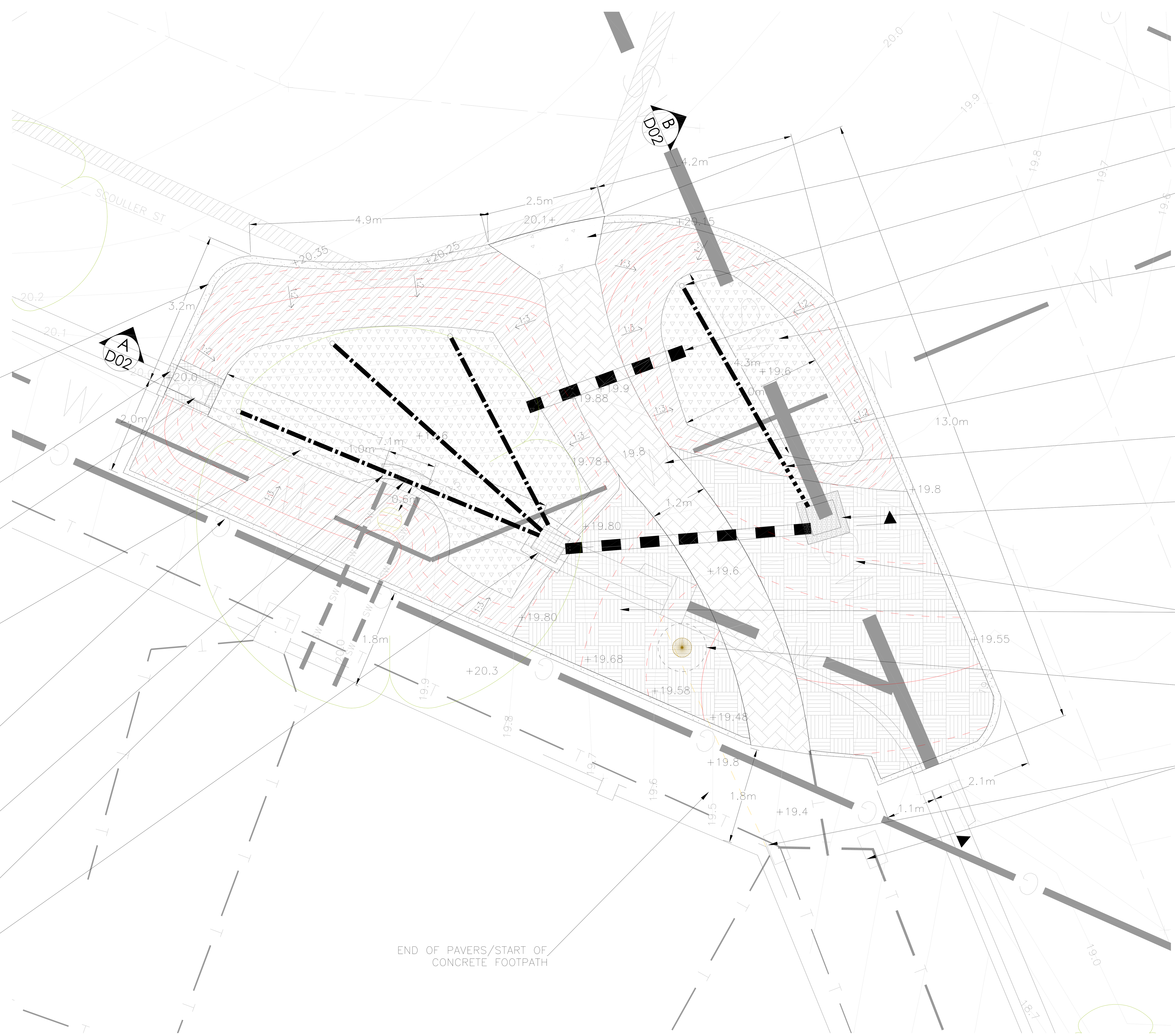
SERVICES LEGEND

- TELSTRA SERVICE
- GAS MAIN
- WATER MAIN
- EXISTING STORMWATER
- ELECTRICITY MAINS
- SEWER MAIN
- OPTIC FIBRE MAIN (WITH 1M BUFFER)

LEGEND

- DESIGN LINES
- NEW STORMWATER PIPES (SOLID)
- NEW STORMWATER PIPES (SLOTTED)
- FLUSHING POINT
- FILTER MEDIA AREA
- GARDEN BED AREA
- SCOUR PAD AREA
- NEW BRICK PATH
- BATTER SLOPES
- CONCRETE



PLAN P05
SOUTHERN BASIN PLAN
SCALE 1:50 @ A1

NOTE: REFER TO P03 FOR STORMWATER INFRASTRUCTURE DETAILS.

AREAS	SOUTH
FILTER MEDIA	33.5M²
BATTER SLOPES	49.5M²
SCOUR PAD	0.8M²
GARDEN BED	34M²
FOOTPATH	13.5M²
TOTAL FOOTPRINT	144M²

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SOUTHERN BASIN PLAN

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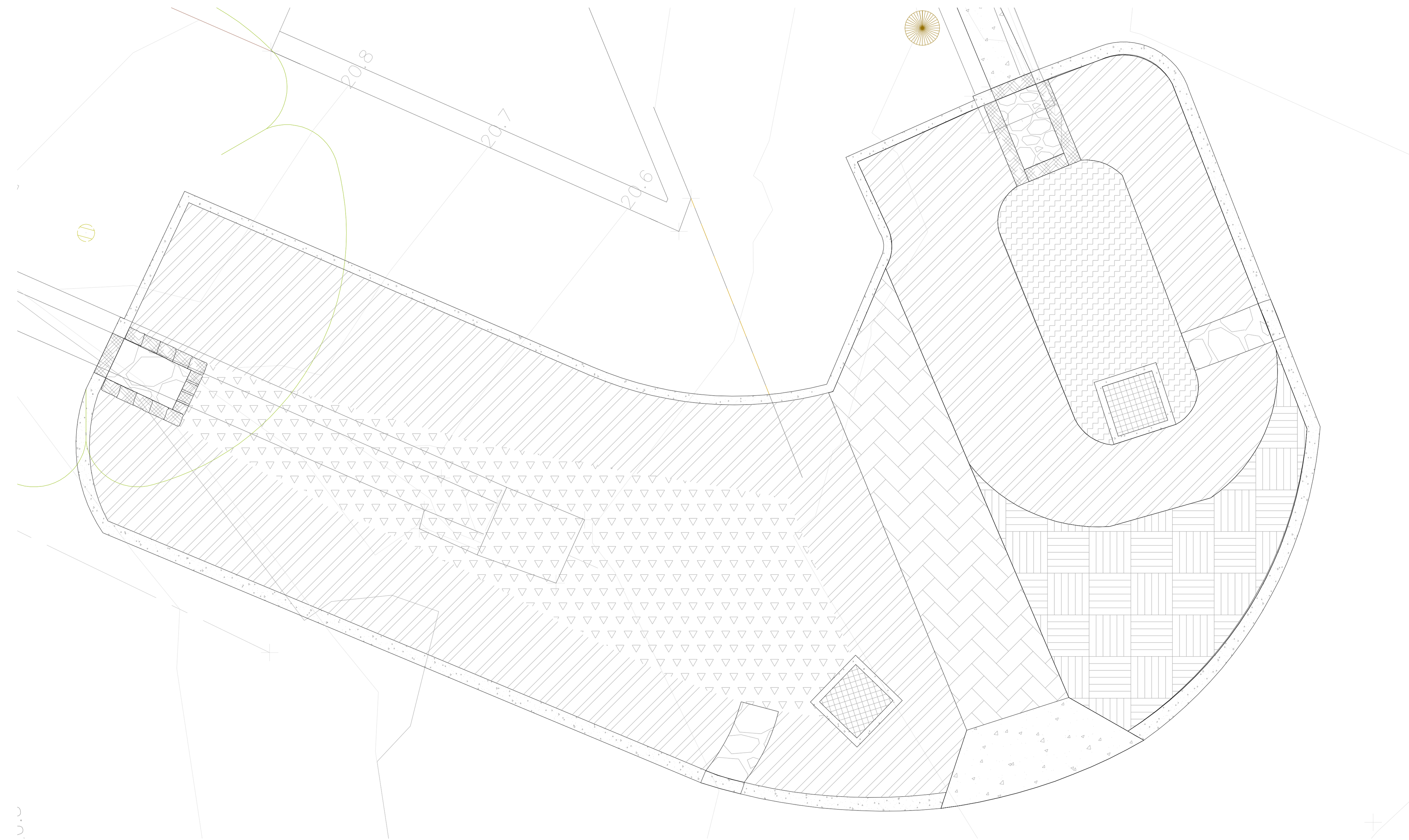

PLAN P06–A
PLANTING PLAN – NORTHERN BASIN
SCALE 1:50 @ A1

PLAN P06–B
PLANTING PLAN – SOUTHERN BASIN
SCALE 1:50 @ A1

Planting Schedule

Area	Species		Density	Number	Pot size
Bioretention filter	*Ficinia nodosa*	3		140	tubestock
	Dianella caerulea	2		93	tubestock
	Danthonia spp.	1		47	tubestock
	Dichelachne crinita	1		47	tubestock
	Poa affinis	1	8	47	tubestock
Batter slopes	*Commelina cyanea*	1		86	tubestock
	Cymbopogon refractus	1		86	tubestock
	Microlaena stipiodes	1		86	tubestock
	Danthonia spp.	1		86	tubestock
	Dichelachne crinita	1		86	tubestock
	Wahlenbergia gracilis	1	6	86	tubestock
Swale	*Lomandra longifolia*	2		8	tubestock
	Ficinia nodosa	2		8	tubestock
	Dianella caerulea	2	6	8	tubestock
Garden bed	*Carpobrotus glaucescens*	1		40	tubestock
	Dianella caerulea	1		40	tubestock
	Danthonia spp.	1		40	tubestock
	Hibbertia serpyllifolia	1		40	tubestock
	Pratia purpurescens	1		40	tubestock
	Wahlenbergia gracilis	1	6	40	tubestock

PLANTING AREAS	NORTH	SOUTH
BIORETENTION FILTER	13M²	33.5M²
BATTER SLOPES	36M²	50M²
GARDEN BED	6.4M²	34M²
SWALE	4M²	

LEGEND

- DESIGN LINES
- SWALE BASE
- NEW BRICK PATH
- GARDEN BED
- BATTER SLOPES
- BIORETENTION AREA
- SANDSTONE
- SCOURPAD
- CONCRETE

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SCOULLER ST RAINGARDENS
PLANTING PLAN

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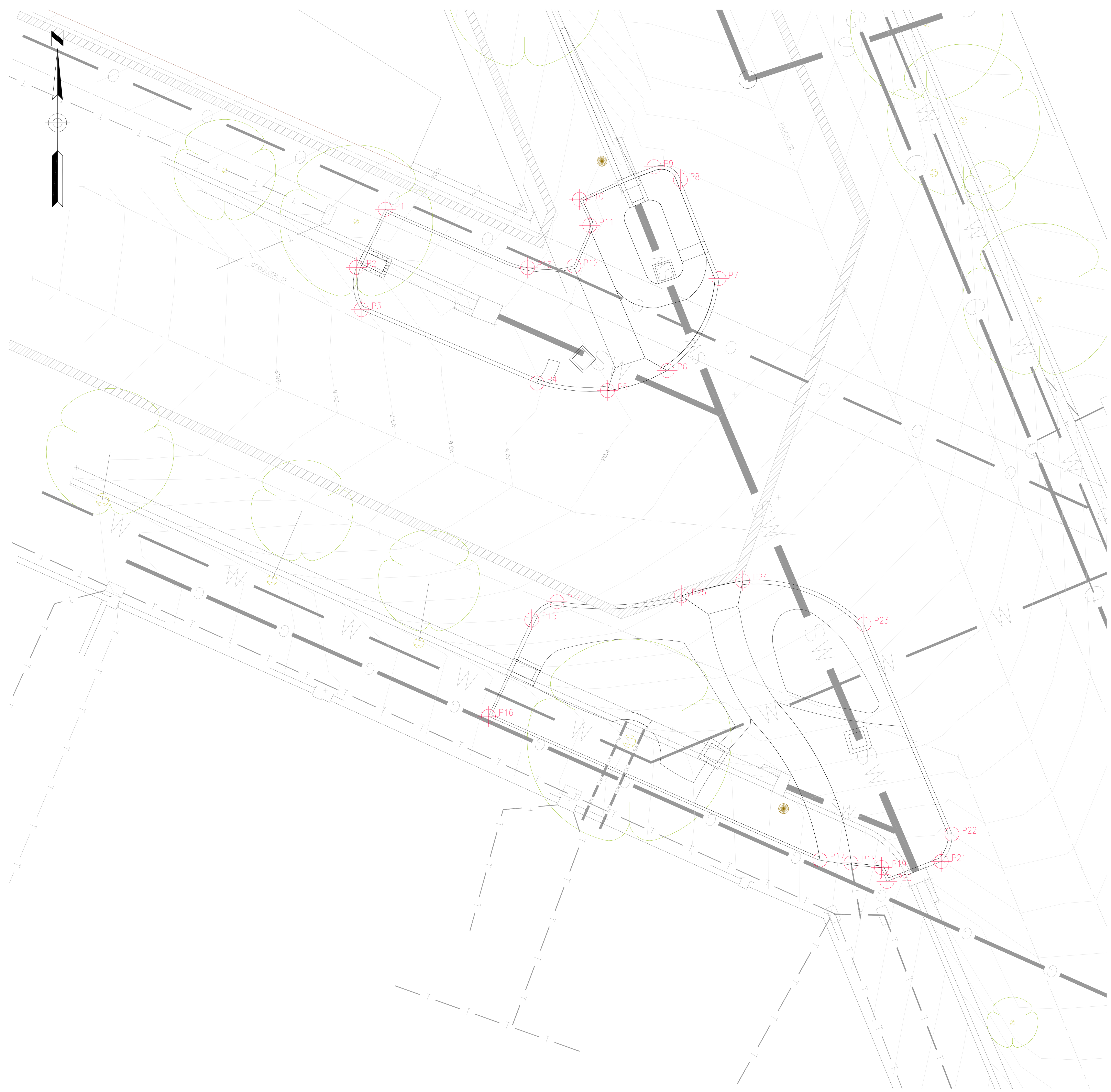

SET OUT POINTS TO GDA 94 MGA 56

	Set Out Point	X Co-ordinate	Y Co-ordinate
Northern Basin	P1	330897.027	6247087.504
	P2	330895.892	6247085.225
	P3	330896.085	6247083.570
	P4	330902.976	6247080.691
	P5	330905.742	6247080.396
	P6	330908.081	6247081.181
	P7	330910.113	6247084.791
	P8	330908.604	6247088.659
	P9	330907.571	6247089.173
	P10	330904.647	6247087.895
	P11	330905.049	6247086.874
	P12	330904.426	6247085.282
	P13	330902.611	6247085.214
Southern Basin	P14	330903.761	6247072.122
	P15	330902.771	6247071.411
	P16	330901.074	6247067.628
	P17	330914.076	6247061.996
	P18	330915.293	6247061.884
	P19	330916.491	6247061.698
	P20	330916.703	6247061.156
	P21	330918.836	6247061.936
	P22	330919.253	6247063.010
	P23	330915.798	6247071.240
	P24	330911.044	6247072.937
	P25	330908.640	6247072.352

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STORMWATER INFRASTRUCTURE PLAN

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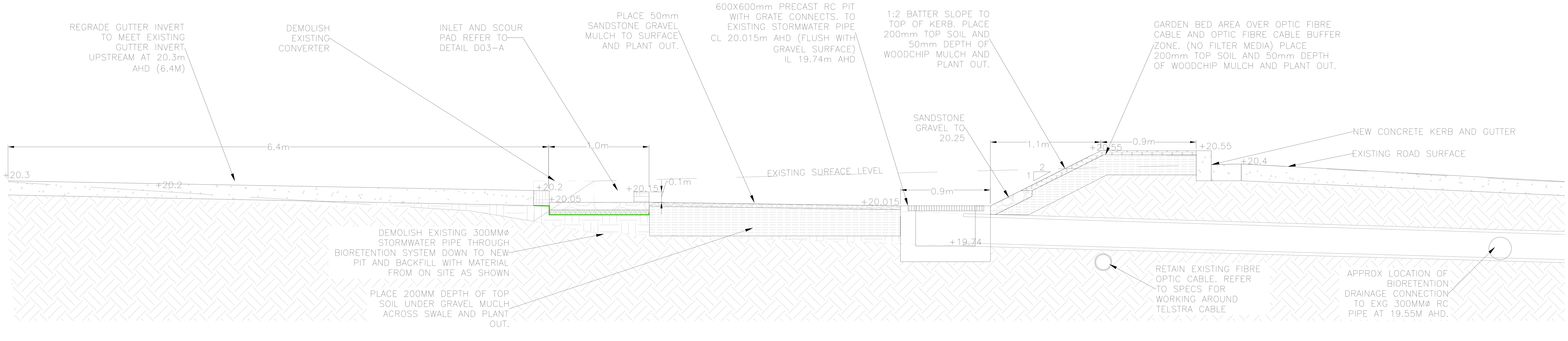
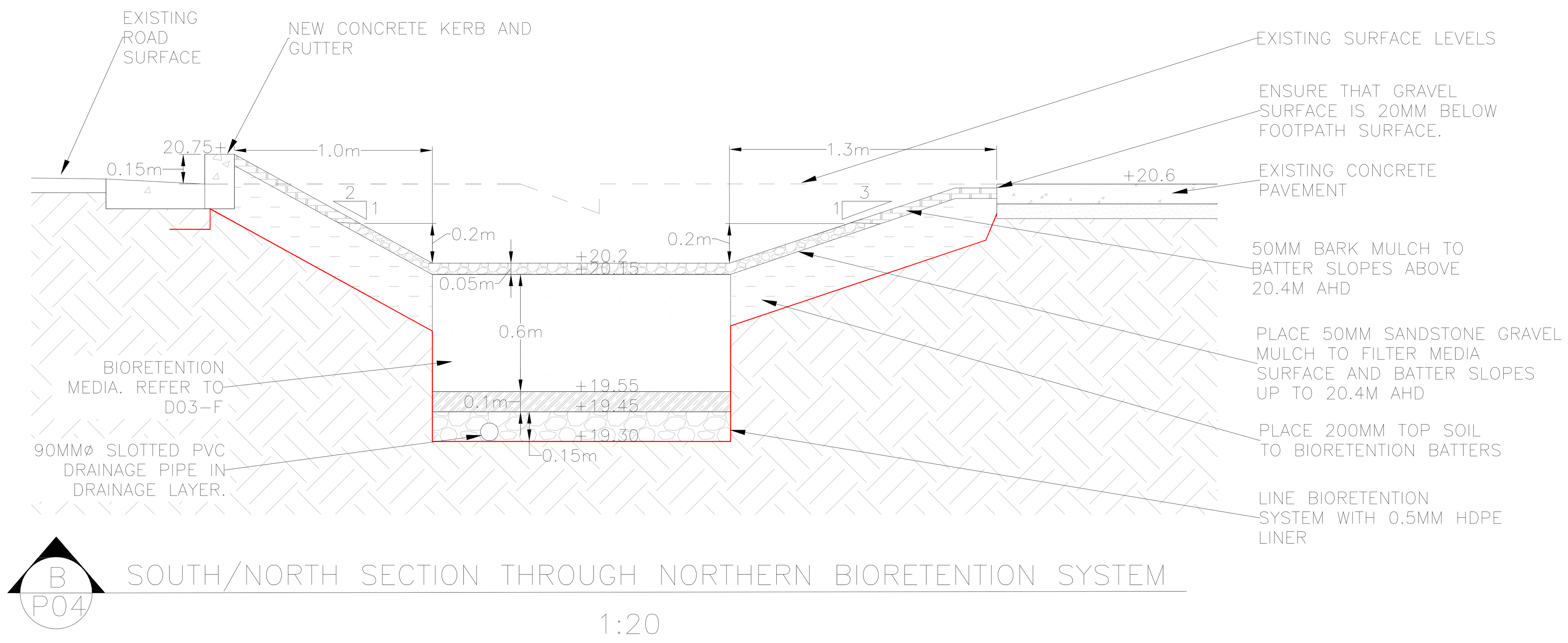


NORTH/SOUTH SECTION THROUGH NORTHERN SWALE

1:20



SOUTH/NORTH SECTION THROUGH NORTHERN BIORETENTION SYSTEM

1:20

LEGEND

- DESIGN LINES
- HDPE LINER
- GEOTEXTILE LINER
- FILTER MEDIA AREA
- TRANSITION MEDIA
- DRAINAGE GRAVEL
- SANDSTONE GRAVEL MULCH
- SCOUR PAD AREA
- BRICK PATH
- WOODCHIP MULCH
- SANDSTONE
- EXISTING EARTH
- FILL

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NORTHERN BASIN SECTIONS

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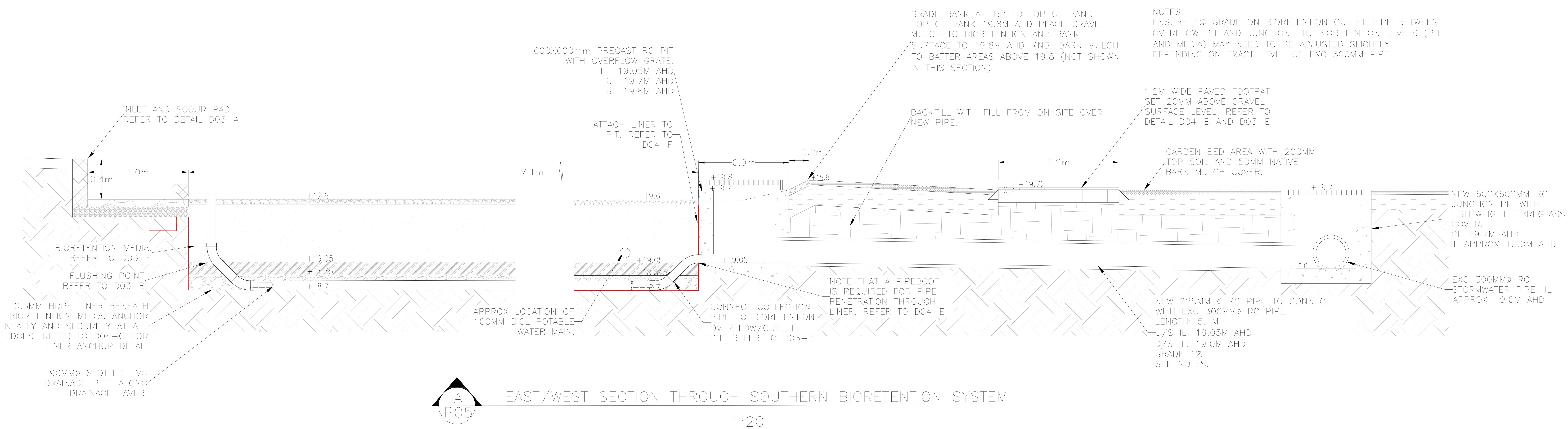
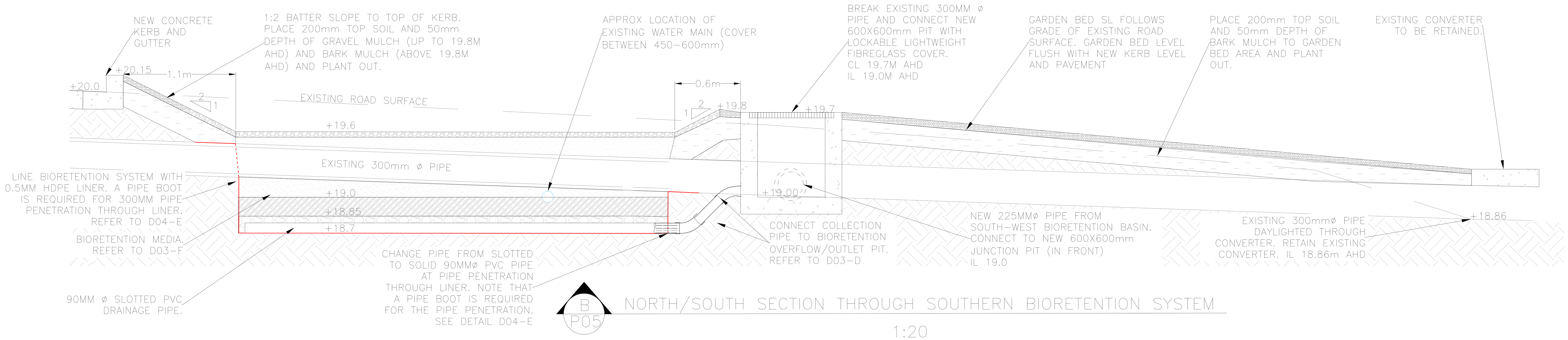


EAST/WEST SECTION THROUGH SOUTHERN BIORETENTION SYSTEM

1:20



NORTH/SOUTH SECTION THROUGH SOUTHERN BIORETENTION SYSTEM

1:20

LEGEND

- DESIGN LINES
- BRICKIES PLASTIC LINER
- FILTER MEDIA AREA
- TRANSITION MEDIA
- SANDSTONE GRAVEL MULCH
- DRAINAGE GRAVEL
- SCOUR PAD AREA
- BRICK PATH
- BARK MULCH
- SANDSTONE
- EXISTING EARTH
- FILL

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SOUTHERN BASIN SECTIONS

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SCOULLER ST RAINGARDENS
BIORETENTION DETAILS

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DRAWN:	AT	
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APPROVED:	AM	

SCALE (at A1)
A 1:100 0 10 20 30 40 50 60 70 80 90 100 m
B m
C m
D m

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Drawing No. D04
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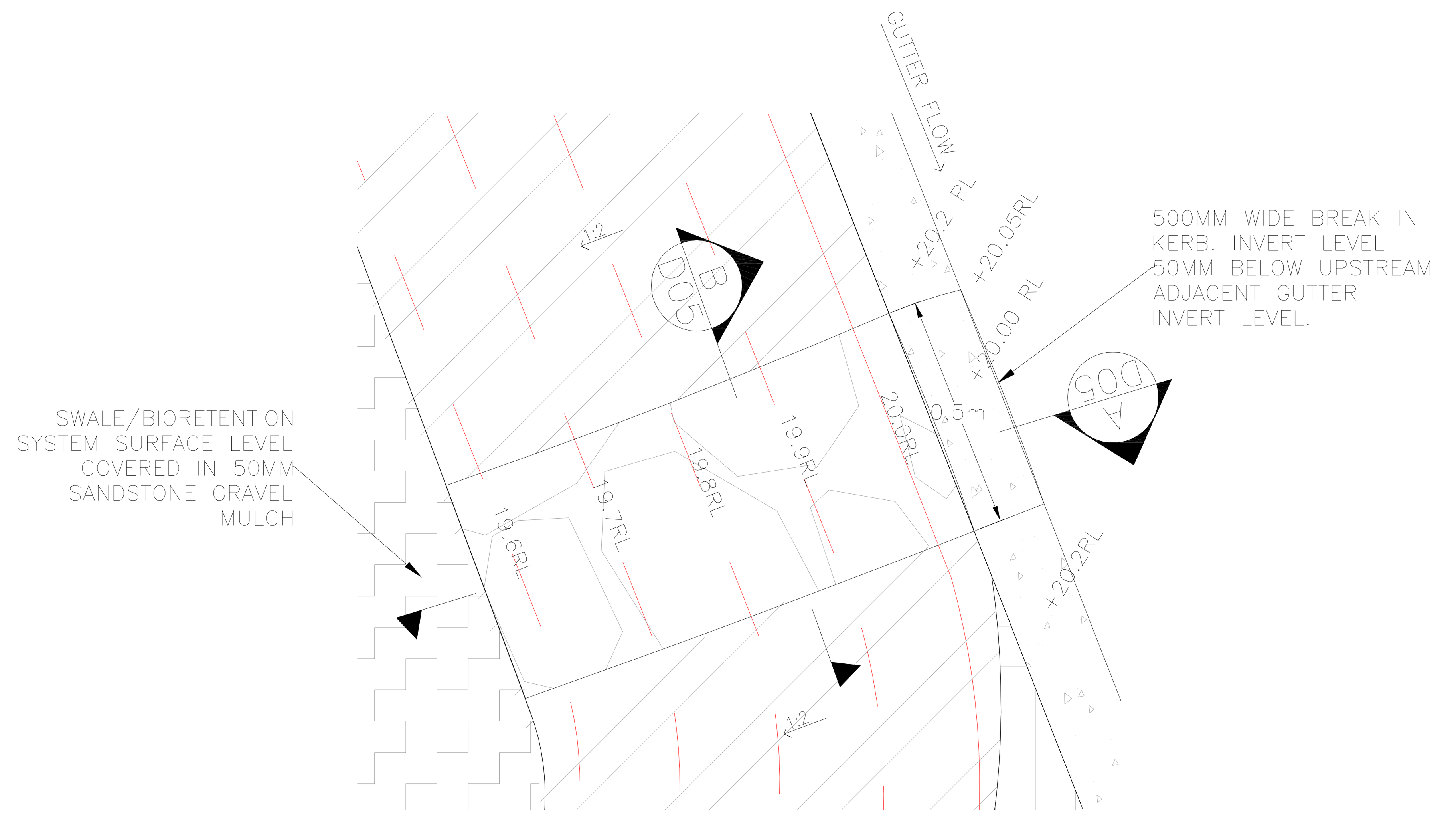
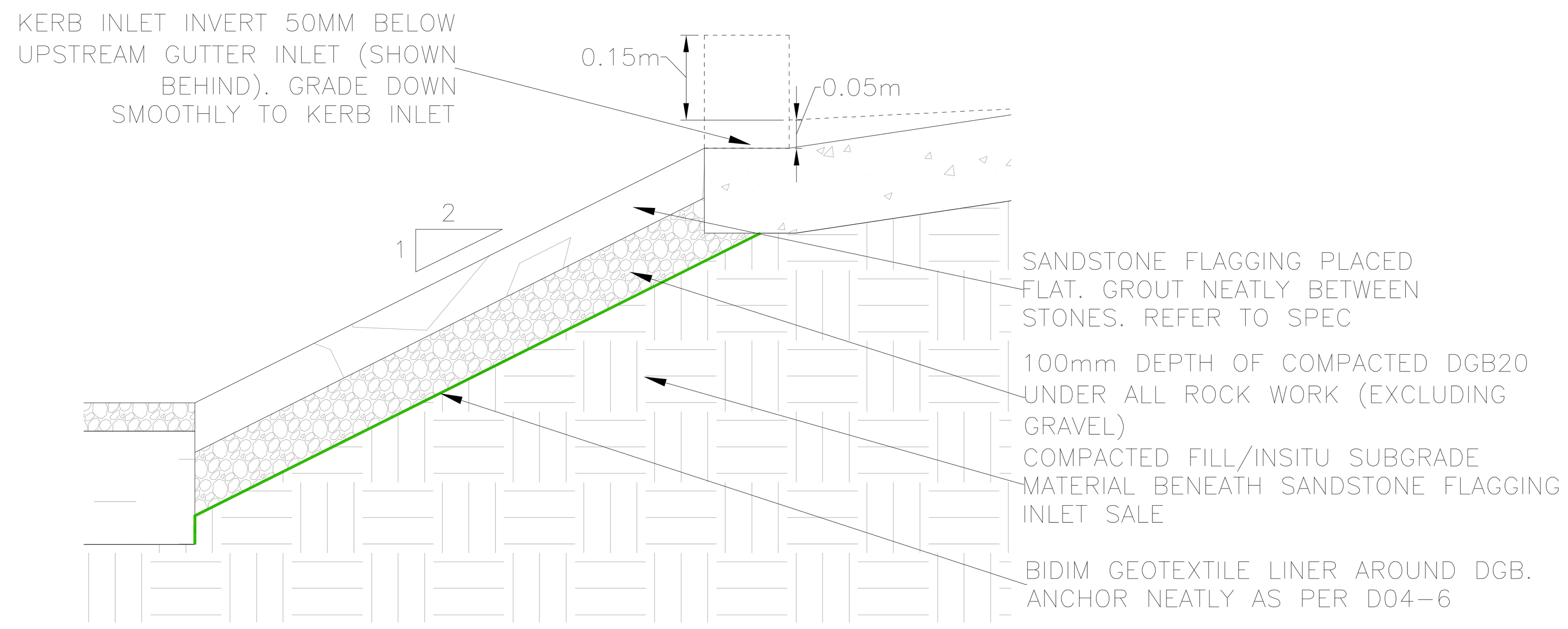
ABN 45 653 522 596

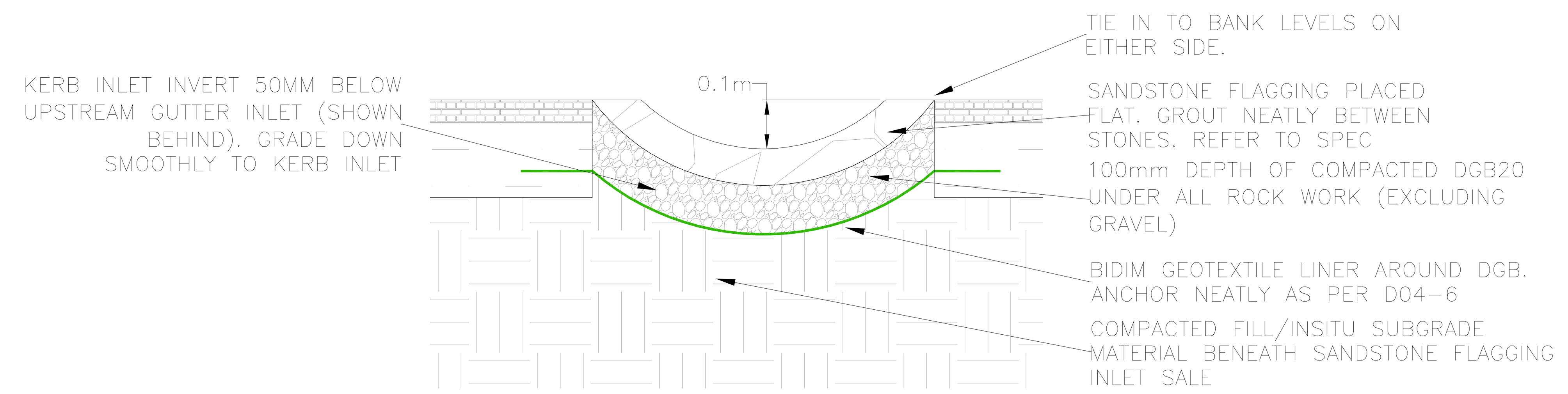
A1



DETAIL D05-A
SMALL KERB INLETS
1:10



A D05 TYPICAL CROSS SECTION KERB INLET
1:10



B D05 TYPICAL CROSS SECTION OF KERB INLET
1:10

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E	100% DRAWINGS	25/02/15	AT
D	80% DRAWINGS	16/02/15	AT
C	50% DRAWINGS	29/01/15	AT
B	CONCEPT DESIGN V2	11/12/14	AT
A	CONCEPT FOR REVIEW	12/11/14	AT

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SCALE (at A1)
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D

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A1