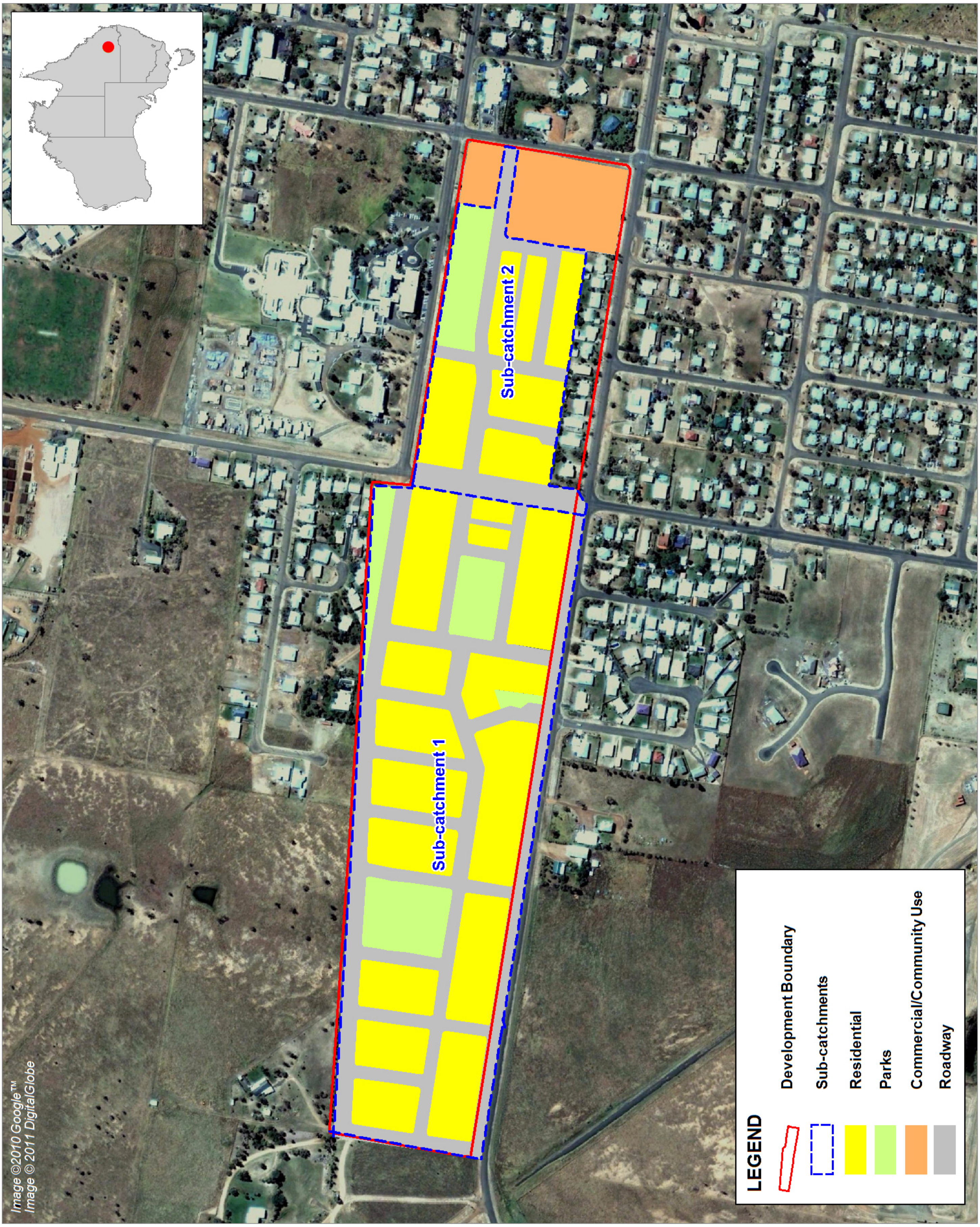

Title:

Sub-catchment Layout for Proposed Development

Figure: 3-1

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Approx. Scale

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3.3.3 Rainwater Tanks

Every allotment within the development will be required to install a rainwater tank (to collect roof runoff to supplement non-potable water demands) in accordance with the Queensland Government (2010) "*Queensland Development Code (QDC) MP4.2: Water Savings Targets*".

For the purposes of the MUSIC modelling, the rainwater tanks have been represented in the MUSIC model as a single 'rainwater tank' in each of the sub-catchments. The provision and size of rainwater tanks have been modelled in accordance with the QDC requirements as summarised in Appendix B, which also provides the assumed reuse rates.

3.3.4 Bioretention Treatment Systems

There were 2 bioretention treatment nodes in the "developed case" MUSIC model i.e. one for each sub-catchment shown in Figure 3-1.

The configuration, size and number of the individual bioretention systems does not make any difference to the overall stormwater quality performance as long as:

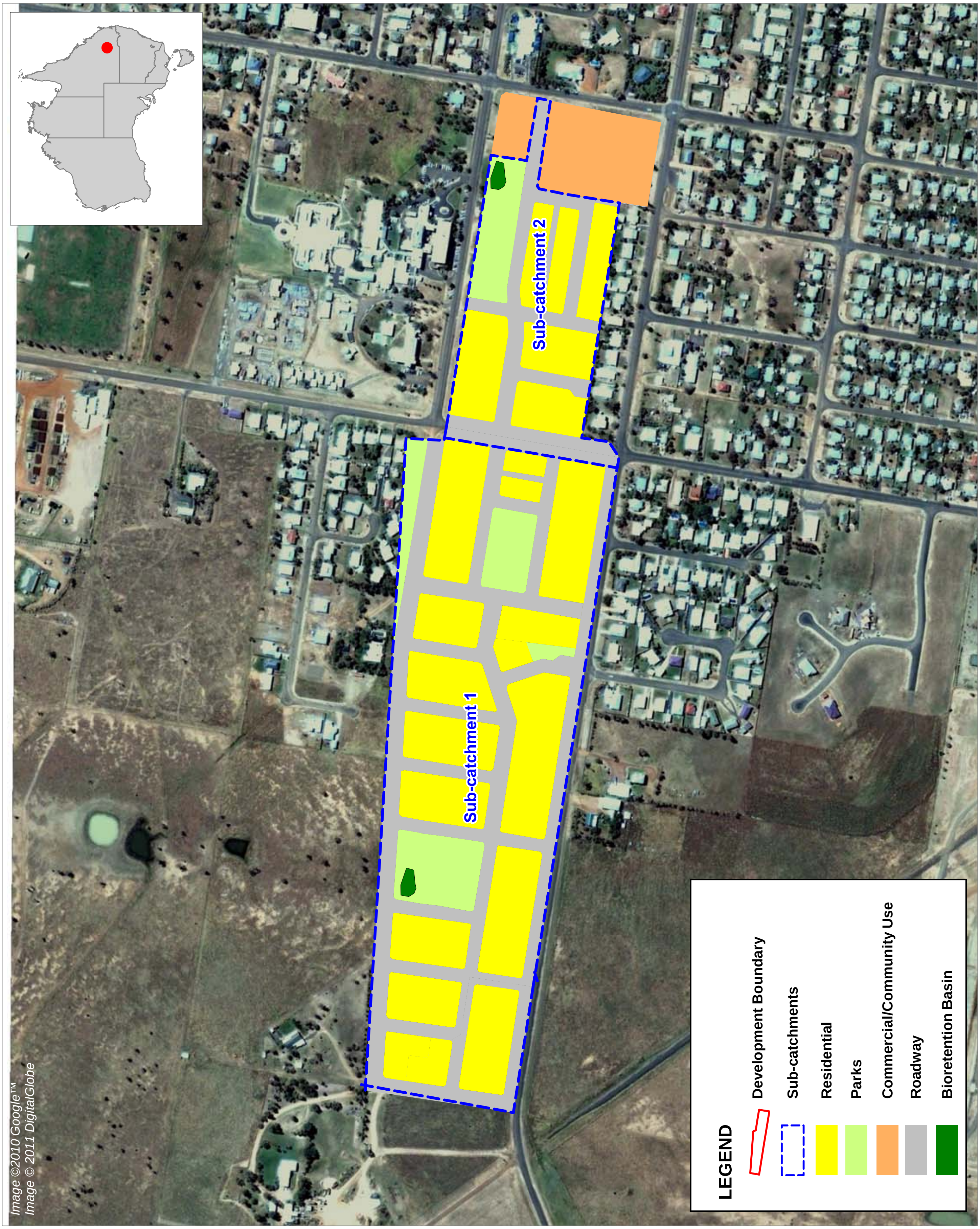
- the overall percentage of filter media compared to the contributing catchment area remains the same
- the equivalent area which drains to the bioretention systems remains consistent with the model
- all other parameters remain the same.

This means that there is flexibility in how the systems will be configured at the operational works stage (the number of systems and their location) and there is flexibility in their ultimate design (their shape and size). This is important to ensure that both the bioretention systems and detention can be passively integrated into the parklands.

Figure 3-2 provides the preliminary location of the bioretention/detention systems while Figure 3-3 and Figure 3-4 provide preliminary detailed designs of the bioretention systems. The ultimate location and design will be further refined during operational works in collaboration with the ULDA, landscape architects and civil engineers.

It is noted the bioretention system modelled include "submerged zones" which provide an important store of water for extended plant survival during dry periods. This water store will help support both the establishment and long-term survival of plants in the systems. The media in the submerged zones comprises of medium-to-coarse sand or gravel and a carbon source (e.g. woodchips) and typically remains saturated. The carbon source is essential to promote the denitrification process by feeding denitrifying bacteria thereby enhancing nitrogen removal (due to additional denitrification) and providing a slightly greater reduction in nitrogen compared to conventional bioretention systems.

The depth of these systems is important as deeper systems provide a greater store of water (supporting plants for longer) and increased denitrification but are also more expensive. An assessment of the most appropriate depth for these systems is presented in Appendix C. Given that the primary aim of saturated zones is to support plants, the depth of the modelled systems is based primarily on the assessment presented in Appendix C and to a lesser extent the need to meet the water quality objectives.



Title:

Proposed Bioretention Basin Locations

Figure: **3-3**

Rev: **A**

BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

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Approx. Scale

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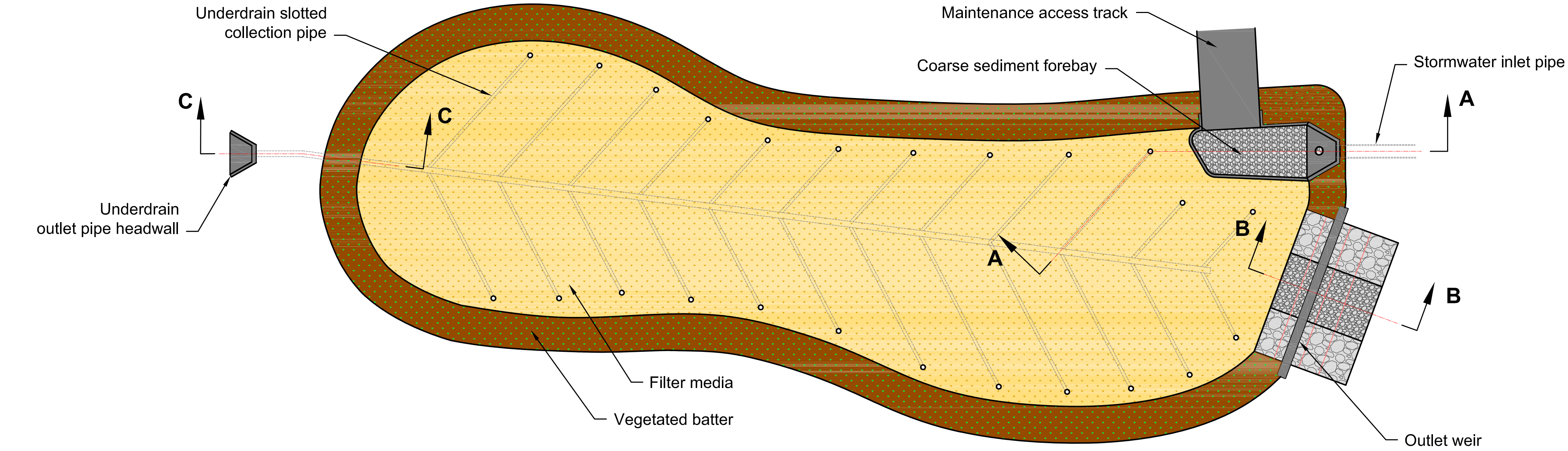
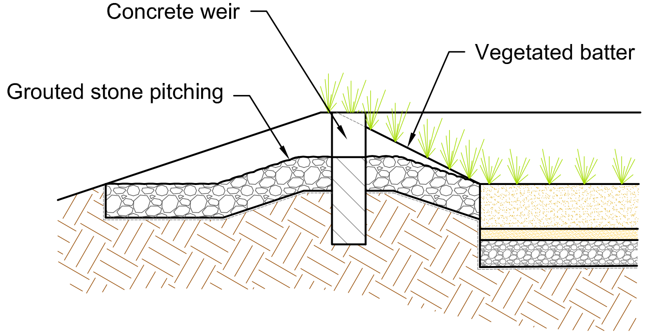
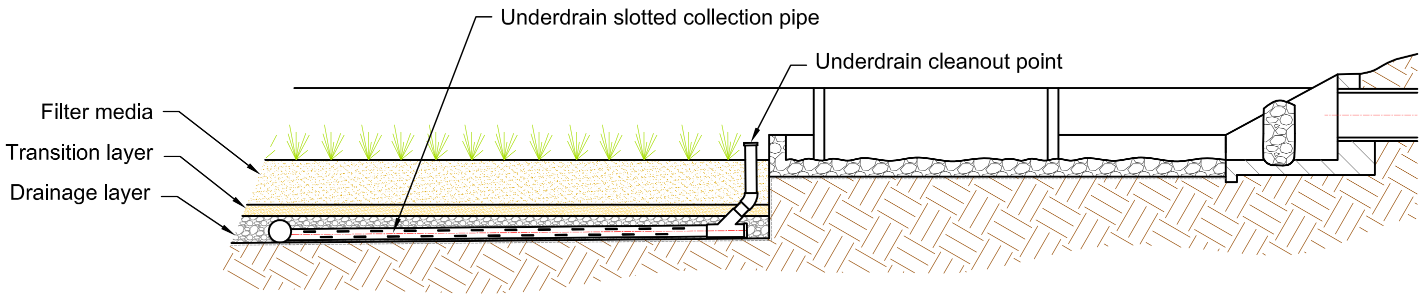
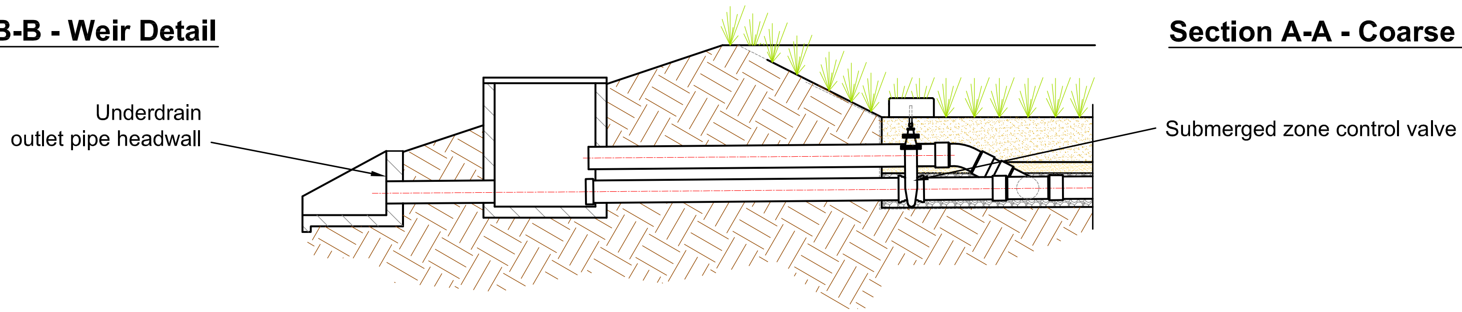




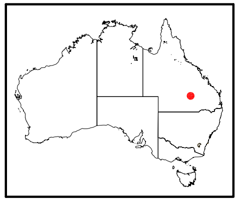
Section B-B - Weir Detail



Section A-A - Coarse Sediment Forebay Detail



Section C-C - Outlet Detail



Title:
ULDA Roma
Preliminary Bioretention Basin Design - Stage 8

Figure: 3-4

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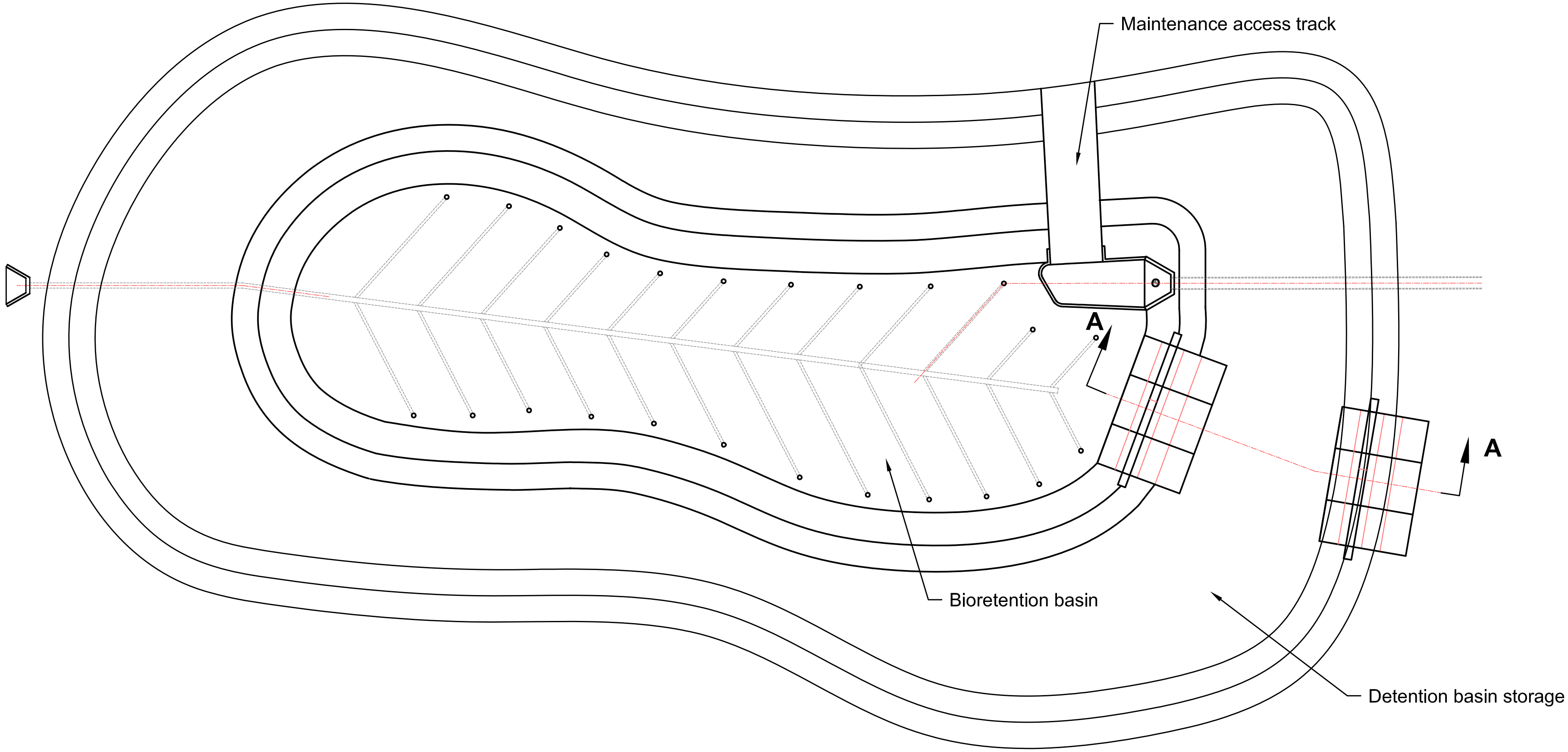
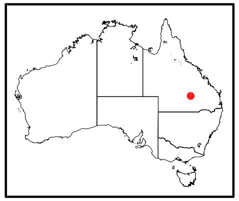


Section A-A - Weir Detail



Title:

ULDA Roma
Preliminary Bioretention Basin Design - Stage 6

Figure: 3-5

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3.3.5 Stormwater Quality Modelling Results

Stormwater Quality

Total annual flow and pollutant loads from the site for each of the three modelled scenarios are presented in Table 3-2. These values represent the flow and loads that are predicted to discharge from the site.

Table 3-2 Predicted Change in Flow and Annual Pollutants

	Flows & Pollutant Loads				
	Flow (ML/yr)	TSS (kg/yr)	TP (kg/yr	TN (kg/yr)	GP (kg/yr)
The Base Case - Undeveloped Site	24	7 370	7.66	63.1	650
Developed Case - Unmitigated	67	14 200	26.8	144	2 190
Developed Case - Mitigated	61	1 200	11.4	64	0
	% Reductions (Compared to 'Developed Case – Unmitigated')				
	Flow	TSS	TP	TN	GP
Developed Case – Mitigated with rainwater tanks and 0.8% bioretention	25	86	79	58	100
Developed Case – Mitigated with rainwater tanks and 1% bioretention	26	90	82	61	100
Stormwater Quality Objectives	N/A	85	70	45	100

From these results it can be seen that by developing the site for urban purposes, the change in land use would result in significantly greater pollutant loads being discharged from the site to the local waterways. The table also demonstrates that adopting the bioretention systems (sized at 0.8% of the catchment), the pollutant loads will be sufficiently reduced to meet the revised load-based stormwater quality pollutant reduction targets. This includes predicted pollutant reductions of 86% for TSS, 79% for TP, 58% for TN and 100% for GP.

Bioretention systems sized at less than 1% of a catchment area can experience a range of operational risks which may reduce performance, lifespan and increase maintenance costs. These risks include:

- plant mortality due to extended waterlogging
- formation of a biofilm on the filter surface as a result of water logging
- excessive sediment accumulation and subsequent cogging of the filter media
- plant mortality due to excessive smothering with sediment.

As a result **it is recommended that the bioretention systems be sized at 1% of the contributing catchment.** This will result in slightly higher pollutant reductions including 90% for TSS, 82% for TP, 61% for TN. The equivalent bioretention filter surface area required for treatment would include be:

- **1,844m^2 for the western catchment. This will be accommodated in the Stage 6 parkland**
- **922m^2 for the eastern catchment. This will be accommodated in the Stage 8 parkland.**

As noted above the, configuration, size and number of the individual bioretention systems does not make any difference to the overall stormwater quality performance as long as the systems meet the criteria outlined in the dot points provided in Section 3.3.3.

Hydrologic Management

The local planning scheme does not detail any relevant compliance methodologies for hydrologic objectives and Council does not enforce the objectives listed in the State Planning for Healthy Waters (DERM, 2010). The proposed treatment train includes bioretention which exceeds the stormwater quality objectives and a number of local Council accept that meeting stormwater quality objectives will also provide hydrologic management objectives to the extent that hydrologic objectives are also achieved. Given that the recommended filter area exceeds the objectives, the proposed bioretention systems will be more likely to achieve the hydrological management objectives compared to a "typical" bioretention system.

3.4 Construction Phase Stormwater Management

3.4.1 Erosion and Sediment Control

The pollutants of concern during the construction phase are not readily modelled due to the site-specific nature of typical construction pollutant sources. Pollutant export would be largely dependent on site management practices and would vary throughout the construction phase depending on the particular activities being undertaken. A Best Management Practice (BMP) approach should be adopted in selecting management options for the construction phase.

A detailed Erosion and Sediment Control Program (E&SCP) will be prepared during the operational works stage. The concept report provides information to identify the controls and procedures that would be incorporated into the detailed E&SCP. During the construction phase of the development, the E&SCP will be implemented to minimise water quality impacts.

3.5 Staged Construction of Bioretention Systems

The proposed bioretention systems should be constructed and established in accordance with the the staged construction and establishment methodology "Option 1: Surface protection with temporary vegetation" outlined in Water by Design's (2010a) "*Construction & Establishment Guidelines: Swales, Bioretention Systems and Swales*".

According to this methodology, the functional elements (e.g. underdrain pipes, gravel drainage media, transition layer and filter media) of the bioretention systems can be constructed/ installed during road and lot-scale construction activities. However, they will need to be protected (e.g. from excessive sediment loads) by over-laying a temporary geo-fabric over all the media, followed by a 25mm layer of topsoil and turf.

This protection can be applied to all of the filter media or a section (with stormwater flows prevented from entering the remainder of the bioretention system by a plywood barrier or similar barrier). Figure 3-5 provides an example of a bioretention basin with temporary protection (during lot-scale works) as described above.

Figure 3-5 Example of a Bioretention Basin with Temporary Protection (During Lot-Scale Works)

As part of the operational works phase a stormwater quality operational works package will be prepared including:

1. Detailed design operational works drawings for the bioretention systems
2. Civil and landscape construction and establishment sign-off forms for bioretention systems
3. Bioretention construction tolerance limits and filter media specifications (to be noted on plans). Filter media specification will be in accordance with *Guidelines for Soil Filter Media in Bioretention Systems* (Facility for Advancing Water Biofiltration 2008).
4. Civil and landscape contract clauses as they relate to the construction and establishment of bioretention systems.

Coordination between landscape design, stormwater quality and flooding design will be undertaken to ensure designs are compatible and complementary.

Following 90% completion of construction and building works the temporary protection layers will be removed and the bioretention basins landscaped in accordance with the detailed landscape plans.

3.6 Asset Hand-over

It is expected that the proposed stormwater management systems (including responsibility for all ongoing maintenance requirements) will be transferred to Maranoa Regional Council after the "on-maintenance" period. The on-maintenance period should be 18 months unless it can be demonstrated that the systems have established earlier.

Asset transfer checklists will need to be completed and approved by Council prior to asset handover to Council for maintenance after the conclusion of the off-maintenance period. The checklist for bioretention systems is contained in Appendix D.

3.7 Maintenance Plans

Indicative maintenance requirements for bioretention systems have been provided in Appendix E. It should be noted that the Water by Design program of the SEQ Healthy Waterways Partnership is developing more advanced maintenance guidelines. When these become available they should be used in place of the maintenance advice provided herein. Alternatively where locally available bioretention maintenance guidelines become available these should be used.

3.8 Stormwater Quality Conclusion

The stormwater quality monitoring undertaken as part of the concept SMP showed that without mitigation, stormwater quality would be worse than existing conditions post development and fail to meet stormwater quality objectives.

Bioretention systems and rainwater tanks were therefore adopted as the preferred stormwater quality treatment train for minimising impact in the receiving environment and meeting the stormwater quality objectives identified by the SPP Healthy Waters.

Modelling results demonstrated that bioretention systems sized at 0.8% of the catchment would be adequate to meet the load-based stormwater quality pollutant reduction targets. A range of operational risks were identified for bioretention systems sized at less than 1% of a contributing catchment which may reduce performance, lifespan and increase maintenance costs.

Given these operational risks **it is recommended that the bioretention systems be sized at 1% of the contributing catchment.** This will result in slightly higher pollutant reductions including 90% for TSS, 82% for TP, 61% for TN. The equivalent bioretention filter surface area required for treatment would include be:

- **1,844m^2 for the western catchment. This will be accommodated in the Stage 6 parkland**
- **922m^2 for the eastern catchment. This will be accommodated in the Stage 8 parkland.**

A staged construction and establishment process will be undertaken to protect the filter media from construction and building phase sediment.

4 REFERENCES

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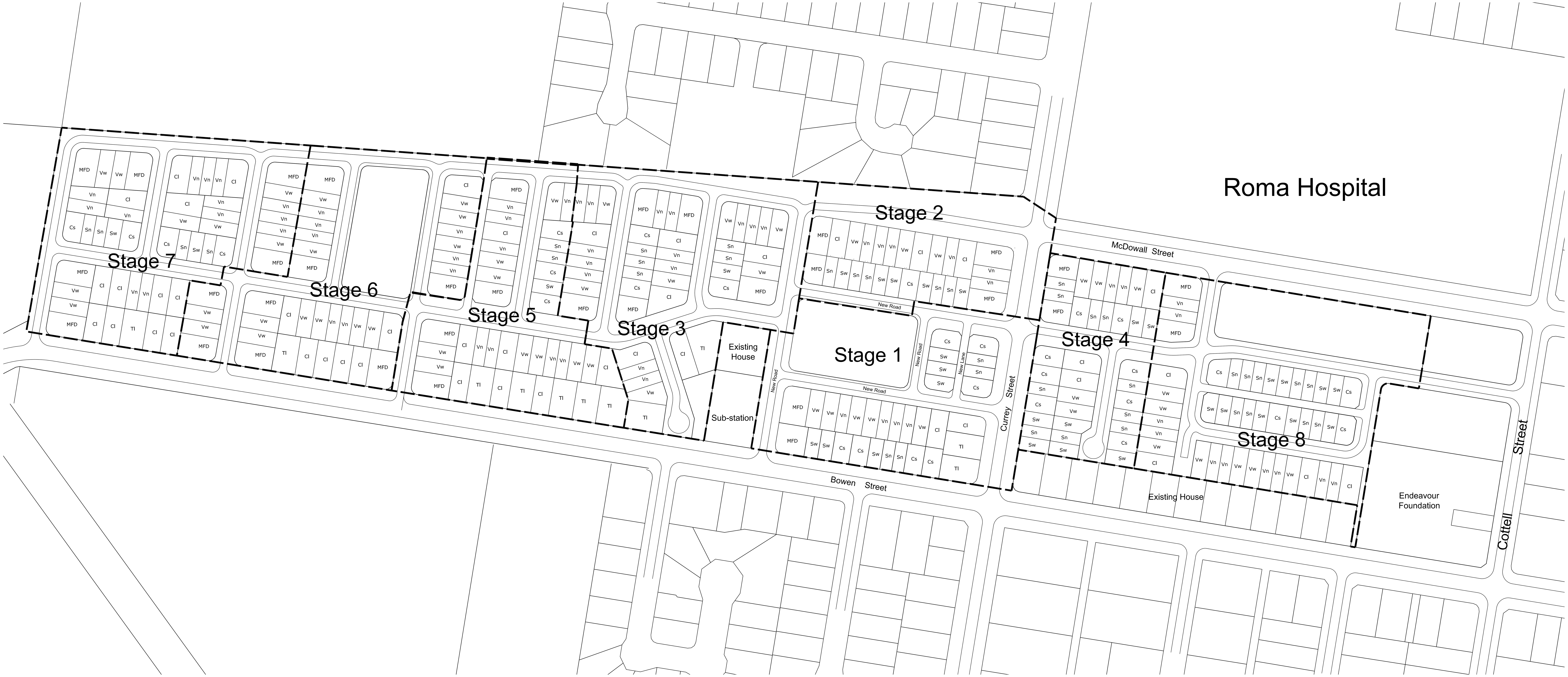
Zinger Y., A. Deletic A. and Fletcher T.D. (2007a) *The Effect of Various Intermittent Dry-Wet Cycles on Nitrogen Removal Capacity in Bioretention Basin Systems*. Rainwater and Urban Design 2007 Conference, Sydney 2007.

Zinger Y., Fletcher T.D., A. Deletic A., blacken G.T., and Viklander (2007b) *Optimisation of the Nitrogen Retention Capacity of stormwater Biofiltration Systems*. Novatech Conference 2007, Lyon France.

APPENDIX A: LOT CONFIGURATION PLAN



Lot Type		Nominal Dimensions			Stage 1		Stage 2		Stage 3		Stage 4		Stage 5		Stage 6		Stage 7		Stage 8		Total Site	
		Width	Depth	Area	Lots	%	Lots	%	Lots	%	Lots	%	Lots	%	Lots	%	Lots	%	Lots	%	Lots	%
Traditional (long)	Tl	20	32	640	2	6.25%	0	0%	2	4.7%	0	0%	5	12.8%	1	2.7%	1	2%	0	0%	11	3.5%
Courtyard (long)	Cl	15	32	480	2	6.25%	3	11.1%	6	14%	3	8.1%	7	17.9%	7	18.9%	12	24%	4	8.9%	44	14.2%
Villa (wide)	Vw	12.5	32	400	5	15.6%	3	11.1%	7	16.3%	5	13.5%	9	23.1%	13	35.2%	8	16%	7	15.6%	57	18.4%
Villa (narrow)	Vn	10	32	320	4	12.5%	6	22.2%	14	32.5%	2	5.4%	8	20.5%	8	21.6%	13	26%	10	22.2%	65	21%
Courtyard (short)	Cs	15	25	375	7	21.9%	1	3.7%	3	7%	8	21.6%	3	7.7%	0	0%	4	8%	4	8.9%	30	9.7%
Studio (wide)	Sw	11.5	25	287.5	6	15.6%	5	18.5%	1	2.3%	7	18.9%	1	2.6%	0	0%	2	4%	9	20%	31	10%
Studio (narrow)	Sn	10	25	250	4	15.6%	5	18.5%	5	11.6%	10	27.1%	2	5.1%	0	0%	4	8%	9	20%	39	12.6%
Multi-family Dwelling*	MFD	varies	varies	450	2	6.25%	4	14.9%	5	11.6%	2	5.4%	4	10.3%	8	21.6%	6	12%	2	4.4%	33	10.6%
Total					32	100.0%	27	100.0%	43	100.0%	37	100.0%	39	100.0%	37	100.0%	50	100.0%	45	100.0%	310	100.0%

*Average number of dwellings per MFD lot = 3

urban land development authority

lat27°

Bowen Street UDA, Roma **Lot Yield and Mix**

02.08.2011

APPENDIX B: WATER QUALITY MODELLING PARAMETERS

Meteorological Data

MUSIC modelling was undertaken using meteorological data from 'Roma' station (BOM 43091) for a period of ten years (from 1 January 1996 to 31 December 2005) at six-minute time steps. This modelling period was selected for the following reasons:

- There is minimal 'missing data' or 'accumulated data'
- The mean annual rainfall for this period (537mm) is relatively close to that for Roma (556mm).

Average potential evapo-transpiration data for the site has been obtained from the Bureau of Meteorology for Roma.

Source Nodes

To allow for accurate pollutant generation and hydrologic assessment of the site, each sub-catchment was assigned source nodes representing the catchment area and appropriate pollutant generating characteristics. The base and stormflow pollutant concentration parameters and rainfall and runoff parameters were adopted in accordance with Water by Design's (2010b) "*MUSIC Modelling Guidelines for South East Queensland*". Justification for use of these objectives is provided in the Concept SMP.

The 'rural residential' land use parameters were used for the existing scenario while, "urban residential" "split-catchment" parameters were used for the developed scenarios. The "split-catchment" modelling approach involves further discretising source nodes according to roof, road reserve and other impervious (ground level) areas.

The existing site was assumed to have an effective imperviousness of 5% while split catchment effective impervious percentages of 100%, 60% and 30% were assumed for roof, road reserve, and ground level respectively. The eastern parkland will feature a skate bowl and shelters so 5% imperviousness was adopted for this open space area while all other open spaces were assumed to have 0% impervious area.

The land use proportions applied in the MUSIC model are summarised in the following table.

Applied Land Usage Proportions for Proposed Developed Areas

	Sub-catchment 1	Sub-catchment 2
Allotment area (ha)	9.36	2.84
Roof area (ha)	4.68	1.42
Ground level area (ha)	4.68	1.42
Road reserve area (ha)	7.23	1.91
Park space area (ha)	1.85	0.81
Total Sub-catchment area (ha)	**18.44**	**5.56**

Rainwater Tank Nodes

For the purposes of the MUSIC modelling, the rainwater tanks have been represented in the MUSIC model as a single 'rainwater tank' in each of the sub-catchments.

The dwelling categories below table are in accordance with the concept layout plan provided in Appendix A. It has been assumed that each tank will be approximately 1.8m in diameter and have a permanent detention depth of 0.2m.

The outdoor irrigation is based on 75% of the impervious area (30% of non-roof ground level).

Assumed Rainwater Tank Properties for MUSIC Modelling

Dwelling Type	Adopted Size of Rainwater Tanks (kL)	Adopted Reuse Rates (kL/dwelling/day)
Traditional Long	5	0.4625
Courtyard Long	5	0.4625
Courtyard Short	5	0.4625
Villa Wide	3	0.4255
Villa Narrow	3	0.4255
Studio Wide	3	0.4255
Studio Narrow	3	0.4255
Multi Family Dwelling	N/A	N/A

Bioretention Nodes

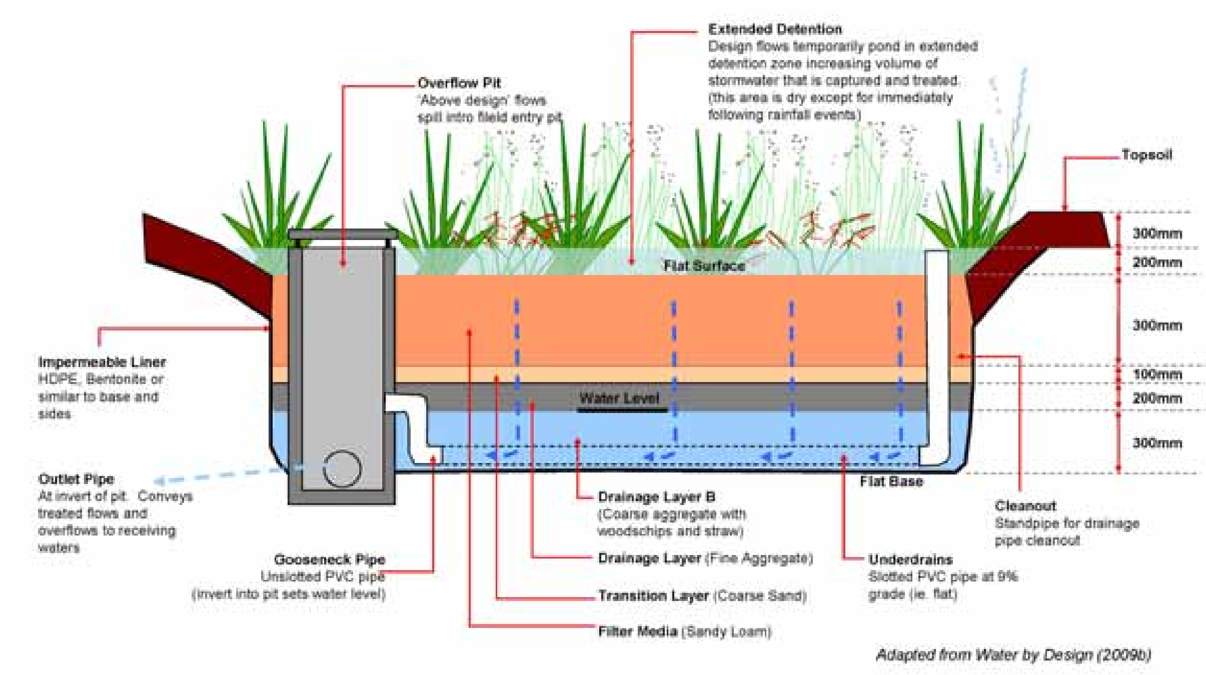
The table below provides a summary of the bioretention systems assumed in MUSIC. The ultimate design will be further be refined during operational works in collaboration with the ULDA, landscape architects and civil engineers.

Assumed Properties for Bioretention Systems

	Subcatchment 1	Subcatchment 2
Surface area (m^2)	1,844	922
Filter area (m^2)	1,844	922
Low flow bypass (m^3/sec)	0.00	
High flow bypass (m^3/sec)	100.00	
Extended Detention Depth (m)	0.20	
Filter depth (m)	0.50	
Filter median particle diameter	0.45	
Saturated Hydraulic Conductivity (mm/hr)	180	
Depth below underdrain pipe (m)	0.30	
TN content of filter media (mg/kg)	800	
Orthophosphate content of filter media (mg/kg)	20.0	
Submerged zone depth	0.30	

APPENDIX C: BIORETENTION SATURATED ZONE INVESTIGATION

Saturated zones are typically designed for bioretention systems to support plants particularly in dry climates. The diagram below shows a typical cross section of a saturated zone bioretention system.



Typical Cross Section of Saturated Bioretention System

The saturated zones provide a store of water which plants can draw upon during inter-event periods and have the added bonus of increased nitrogen removal, particularly where designed with a carbon source (e.g. wood chips). This carbon source aids in the denitrification process by feeding denitrifying bacteria.

The high hydraulic conductivity and low nutrient level required for efficient stormwater treatment through bioretention filter media creates a challenging environment for plants to survive. These conditions are further exacerbated in climates such as those encountered in Roma where long dry periods are typically experienced over the winter months.

Nitrogen removal in conventional bioretention systems (without saturated zones), rapidly deteriorates when the media begins to dry out and nitrogen leeching can occur in these type of systems after just 3 weeks without rainfall (Zinger et al, 2007a). Systems with saturated zones, however, not only minimise nutrient leeching during dry weather but can actually continue to remove nitrogen during subsequent dry periods at rates equivalent to the previous rain event (Zinger et al, 2007a).

These results led Zinger et al (2007a and 2007b) to recommend 300mm deep saturated zone as the preferred minimum saturated zone depth. The minimum depth of 300mm is expected to provide protection against drying for up to 5 weeks however this is highly dependent on climate and site conditions.

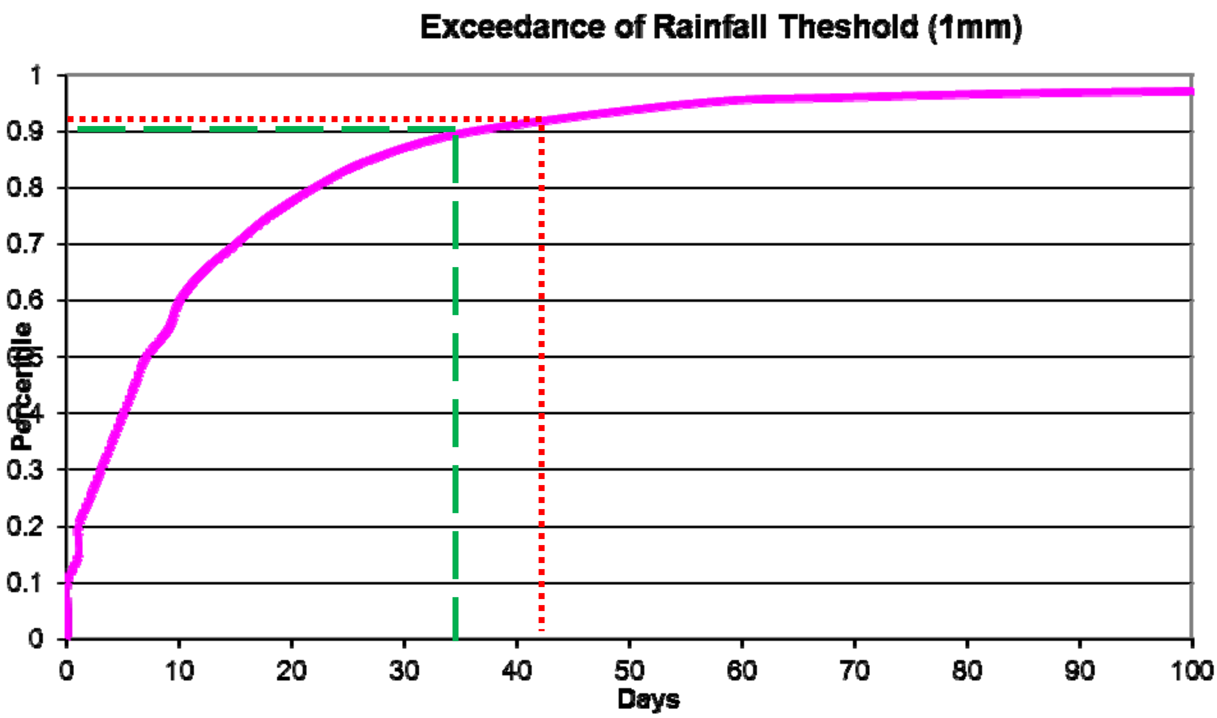
The long dry season experienced in Roma is likely to be characterised by occasional dry periods well beyond five weeks. The minimum saturated zone depth recommended by Zinger et al (2007a and 2007b) may therefore be inappropriate for Roma. An assessment of rainfall patterns was therefore undertaken to determine the most appropriate depth of saturated zone for the proposed development.

Sizing Bioretention Saturated Zones

Historical rainfall data recorded at the Yuleba Daily station was interrogated to determine appropriate saturated zone depths. This station provides a much longer period of reliable rainfall and therefore more appropriate for this type of assessment Rather than using the data described in Appendix B it was necessary to assess a much longer rainfall period to account for less frequent events such as droughts and rare flooding events.

Over 39 years of available data (1967-2006) was assessed for suitability. The historical records were found to have limited missing and accumulated data. The whole rainfall period could subsequently be used and results interpreted with a high degree of reliability. To assess how saturated zones would be expected to perform locally, the rainfall data was exported from MUSIC and plotted in Excel measuring the frequency which rainfall exceeds a rainfall threshold of 1 mm [1] (see the graph below).

The longest drought period[2] experienced in Roma according to the available rainfall was between 08/05/1994 and 01/09/1995 (451 days) however such droughts are rare in the region with there being weekly rainfall greater than 1mm for 50% of the time on average.



Exceedance of rainfall threshold (1mm)

[1] A rainfall threshold of 1mm was selected as the estimated minimum rainfall required to generate runoff from impervious surfaces.
[2] Defined here as the greatest number of consecutive days where the rainfall threshold of 1mm is not met.

Water by Design (2009) recommends that saturated zone depth should be increased by 120mm for every week of dry weather additional to the five weeks of continuous dry weather mitigated by the recommended minimum 300mm deep saturated zone. The dashed, green line on the graph shows that for 90% of the time on average, a 300mm deep saturated zone will protect a bioretention system in Roma from drying out to the point of leeching (35 days).

The shape of this performance curve enables the informed selection of the 'optimal' treatment size beyond which any further increase in saturated zone depth (and thus cost) yields only limited incremental increase in protection from drought. This so called "point of diminishing performance (or return)" can be considered to represent the reasonable limit of performance of the saturated zone which can then be adopted as the most appropriate depth of the saturated zone.

For example, the dotted, red line on the graph has been plotted to show that if the saturated zone depth was increased by an additional 120mm to provide an extra week of protection this would on average result in the protection of the system for only an additional 1-2% of the time. The cost associated with the construction of an additional 120mm would therefore be beyond the point of diminishing return and an unsustainable option for ULDA and Council from both a life cycle cost and performance perspective.

It is therefore recommended that the saturated zones are not increased in depth beyond the minimum depth of 300mm recommended by Zinger et al (2007a and 2007b).

During droughts[2] which exceed 5 weeks it may be necessary to top up bioretention systems to protect the systems from leeching nitrogen. It should be noted however that carefully selected plant species will be used in the bioretention system capable of survival well beyond the point where the saturated zone dries up and therefore significantly less frequent watering would be required maintain plant viability. Watering and planting is further discussed below.

Watering Bioretention Systems

The need to top up saturated zones will be reliant not only on rainfall but also on a range of interrelated factors including evapotranspiration, plant species and surface runoff as result of base flows (e.g. from lawn/garden watering, leaking pipes etc.). The number of variables makes it therefore unrealistic to reliably predict a top up frequency however there two methods for determining an appropriate watering regime:

1. **Topping up the systems to limit nitrogen leeching and improve denitrification** - topping up to limit nitrogen leaching and improve denitrification should be undertaken after every five weeks where there has been no runoff (including domestic source base flows). As discussed above however, a 300mm deep saturated zone will on average protect a bioretention system in Roma from drying out to the point of leeching for 90% of the time on average.

2. **Topping up the systems to maintain plant health** – topping up to maintain plant health should be undertaken when plants display any sign of stress related to a lack of water. However with water in the saturated zones present for 90% of an average year and species selection based in part on drought tolerance, the systems will remain healthy well beyond five

weeks where there has been no runoff. This means that the likelihood of a dry spell which begins to effect plant health would be very rare.

As with any other public asset in the Maranoa Regional Council the bioretention systems will need to be monitored by the asset manager and managed responsively with more or less watering required depending on prevailing conditions. Watering can be undertaken either via surface irrigation or direct filling via the overflow pits/drainage pipes.

APPENDIX D: ASSET TRANSFER CHECKLIST

BIORETENTION BASIN DESIGN ASSESSMENT CHECKLIST			
Asset I.D.		**DA No.**	
Basin Location:			
Hydraulics:	Minor Flood (m^3/s):	Major Flood (m^3/s):	
Area:	Catchment Area (ha):	Bioretention Area (ha):	

TREATMENT	**Y**	**N**
Treatment performance verified from curves?		
BIORETENTION MEDIA AND UNDER-DRAINAGE	**Y**	**N**
Design documents bioretention area and extended detention depth as defined by treatment performance requirements.		
Overall flow conveyance system sufficient for design flood event(s)?		
Where required, bypass sufficient for conveyance of design flood event?		
Where required scour protection provided at inflow point to bioretention?		
Bioretention media specification includes details of filter media, drainage layer and transition layer (if required)?		
Design saturated hydraulic conductivity included in specification?		
Transition layer provided where drainage layer consists of gravel (rather than coarse sand)?		
Perforated pipe capacity > infiltration capacity of filter media?		
Selected filter media hydraulic conductivity > 10 x hydraulic conductivity of surrounding soil?		
Liner provided if selected filter media hydraulic conductivity < 10 x hydraulic conductivity of surrounding soil?		
Maximum spacing of collection pipes <1.5m?		
Collection pipes extended to surface to allow inspection and flushing?		
BASIN	**Y**	**N**
Bioretention area and extended detention depth documented to satisfy treatment requirements?		
Overflow pit crest set at top of extended detention?		
Maximum ponding depth will not impact on public safety?		
Maintenance access provided to surface of bioretention system (for larger systems)?		
Protection from coarse sediments provided (where required) with a sediment forebay?		
Protection from gross pollutants provided (where required)?		
LANDSCAPE	**Y**	**N**
Plant species selected can tolerate extended dry periods, periodic inundation and design velocities?		
Bioretention design and plant species selected integrate with surrounding landscape or built environment design?		
COMMENTS		

Source: Water by Design (2006)

APPENDIX E: INDICATIVE MAINTENANCE REQUIREMENTS FOR BIORETENTION SYSTEMS

SCHEDULE OF SITE VISITS													
Purpose of Visit	**Frequency**	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Routine inspection	6/year	✓		✓		✓		✓		✓		✓	
Annual inspection	1/year					✓							
Routine Maintenance	4/year	✓			✓			✓			✓		

The above schedule is a guideline only. Inspection and maintenance activities during the plant establishment period (first two years) are likely to be more frequent when frequent weed removal and replanting may be required. Inspections should also be performed after large rainfall events to check for damage or significant pollutant accumulation. Maintenance should only occur after a reasonably rain free period when the soil in the bioretention system is dry. Inspections are also recommended following large storm events to check for scour and other damage. Resetting (i.e. complete reconstruction) of the bioretention basin will be required if the system fails to drain adequately after tilling of the surface. The bioretention basin inspection checklist is based on Water by Design (2006).

INSPECTION	
1	**Routine Inspection**
1.1	Routine inspection should be carried out on a regular bi-monthly basis. The purpose of the inspection is to check for weed invasion, litter accumulation and any damage/vandalism.
1.2	The bioretention system (including floor and batters) should be inspected for weed growth.
1.3	The bioretention system (including inflow points, overflow pits, under-drains and vegetation) should be checked for litter accumulation.
1.4	Identify areas of obvious sediment deposition, damage from vehicles and/ or clogging within the bioretention basin (evident by ponding and/ or 'boggy' filter media surface). If there is shallow ponding or evidence of clogging, firstly ensure that cause is not a build up of sediment. Investigate effect of "turning over" or "tilling" filter media soil, and inspect outflow pipes for clogging.
1.5	Identify areas of erosion, including scouring from storm flows and rill erosion of the batters from lateral inflows.
1.6	Any structures such as maintenance accesses, weirs, piping and access restrictions (eg. lock-rails, fencing) should be inspected for damage and or vandalism.
2.	**Annual Inspection**
2.1	Once per year, the condition of the bioretention basin should be closely inspected. Any damage or problems should be noted on the inspection form for action by the relevant maintenance agency.

ROUTINE MAINTENANCE	
3	**Purpose**
3.1	Routine maintenance of the bioretention system involves weed control and the collection of any litter and minor remedial works if required. If turf has been planted across the surface of the bioretention system, this will obviously require mowing (with mowed grass deposited offsite at an appropriate waste management facility).
4	**Weed Management**
4.1	If weeds have been observed within the bioretention system during routine inspection, these weeds should be removed by hand.
4.2	Where physical removal has been specified, the aim is to remove the weed including the roots when the weeds are less than 3 months old.
4.3	Herbicides should not be used.
4.4	The weeds should be disposed of offsite at an appropriate waste management facility.
4.5	Replant plant species as necessary in areas that have been extensively weeded.
4.6	*In general, the planted species should not be harvested. Harvesting plants has little, if any, benefit for treatment performance.*
5	**Litter Management**
5.1	Remove and dispose of any accumulated litter/debris within the bioretention basin.
6	**Surface Tilling**
6.1	If there is evidence of clogging of the bioretention system, tilling the bioretention basin surface or remove of the surface layer.
7	**Sediment Removal**
7.1	Removal of sediment where it is smothering the bioretention basin vegetation. Remove accumulated sediments by surface scraping (if it does not damage the vegetation too much) or reforming of the bio-retention system.
8	**Under-Drainage Cleaning**
8.1	If the bioretention system is not draining, a reason may be due to the under-drainage being blocked by sediment or litter/ debris. This blockage should be removed by ‘rodding’ or ‘jetting’ (using high pressure water) of the under-drainage. As a result, ‘rodding’ points should be provided at the upstream ends of all under-drainage.
9	**Remedial Works**
9.1	Routine inspection may detect minor damage to the bioretention system after storms that should be repaired. This may include erosion on the bioretention system or scouring at the inlet and/or outlet. This damage should be repaired as part of the routine maintenance of the bioretention system. Measures to reduce future damage (eg. erosion) from occurring should also be investigated and, if possible, implemented.
9.2	Resetting (i.e. complete reconstruction) of the bioretention system will be required if the system fails to drain adequately after tilling of the surface and no evidence of sediment accumulation or under-drainage blockage can be identified.

BIORETENTION SYSTEM MAINTENANCE CHECKLIST			
Asset I.D.			
Inspection Frequency:	1 to 6 monthly	**Date of Visit:**	
Location:			
Description:			
Site Visit by:			

INSPECTION ITEMS	**Y**	**N**	**ACTION REQUIRED (DETAILS)**
Sediment accumulation at inflow points?			
Litter within bioretention system?			
Erosion at inlet or other key structures?			
Traffic damage present?			
Evidence of dumping (building waste)?			
Vegetation condition satisfactory (density, weeds etc)?			
Watering of vegetation required?			
Weed removal required?			
Mowing/slashing required?			
Pruning and/ or removal of dead or diseased vegetation required?			
Replanting required?			
Damage/vandalism to structures present?			
Set down from kerb still present (if road-side bioretention swale)?			
Evidence of ponding?			
Surface clogging visible?			
Drainage system inspected?			
Clogging of drainage points (sediment or debris)?			
Resetting of system required?			

COMMENTS

Source: Water by Design (2006)

BMT WBM Brisbane	**Level 11, 490 Upper Edward Street Brisbane 4000** **PO Box 203 Spring Hill QLD 4004** **Tel +61 7 3831 6744 Fax +61 7 3832 3627** **Email wbm@wbmpl.com.au** **Web www.wbmpl.com.au**
BMT WBM Denver	**14 Inverness Drive East, #B132** **Englewood Denver Colorado 80112 USA** **Tel +1 303 792 9814 Fax +1 303 792 9742** **Email wbmdenver@wbmpl.com.au** **Web www.wbmpl.com.au**
BMT WBM Mackay	**Suite 1, 138 Wood Street Mackay 4740** **PO Box 4447 Mackay QLD 4740** **Tel +61 7 4953 5144 Fax +61 7 4953 5132** **Email wbmmackay@wbmpl.com.au** **Web www.wbmpl.com.au**
BMT WBM Melbourne	**Level 5, 99 King Street Melbourne 3000** **PO Box 604 Collins Street West VIC 8007** **Tel +61 3 8620 6100 Fax +61 3 8620 6105** **Email wbmmelbourne@wbmpl.com.au** **Web www.wbmpl.com.au**
BMT WBM Newcastle	**126 Belford Street Broadmeadow 2292** **PO Box 266 Broadmeadow NSW 2292** **Tel +61 2 4940 8882 Fax +61 2 4940 8887** **Email wbmnewcastle@wbmpl.com.au** **Web www.wbmpl.com.au**
BMT WBM Perth	**Suite 3, 1161 Hay Street West Perth 6005** **Tel +61 8 9322 1577 Fax +61 8 9226 0832** **Email wbmperth@wbmpl.com.au** **Web www.wbmpl.com.au**
BMT WBM Sydney	**Level 1, 256-258 Norton Street Leichhardt 2040** **PO Box 194 Leichhardt NSW 2040** **Tel +61 2 9713 4836 Fax +61 2 9713 4890** **Email wbmsydney@wbmpl.com.au** **Web www.wbmpl.com.au**
BMT WBM Vancouver	**1190 Melville Street #700 Vancouver** **British Columbia V6E 3W1 Canada** **Tel +1 604 683 5777 Fax +1 604 608 3232** **Email wbmvancouver@wbmpl.com.au** **Web www.wbmpl.com.au**