5.3 Major WSUD Measures

5.3.1 Biofiltration Basins

Figure 5-1 Biofiltration Basin Examples

Biofiltration basins assist with achieving stormwater quality and quantity management objectives. Biofiltration basins comprise an above ground retention/detention storage and below ground filter. The above ground storage performs sedimentation which is a function of the hydraulic residence time and the below ground filter acts to intercept finer particles including heavy metals. Nutrients are removed through uptake by appropriate vegetation planted within the measure. Biofiltration measures assist with disconnecting impervious areas from urban streams by retaining stormwater for an extended period. A typical biofiltration system configuration is shown in **Figure 5-2**.

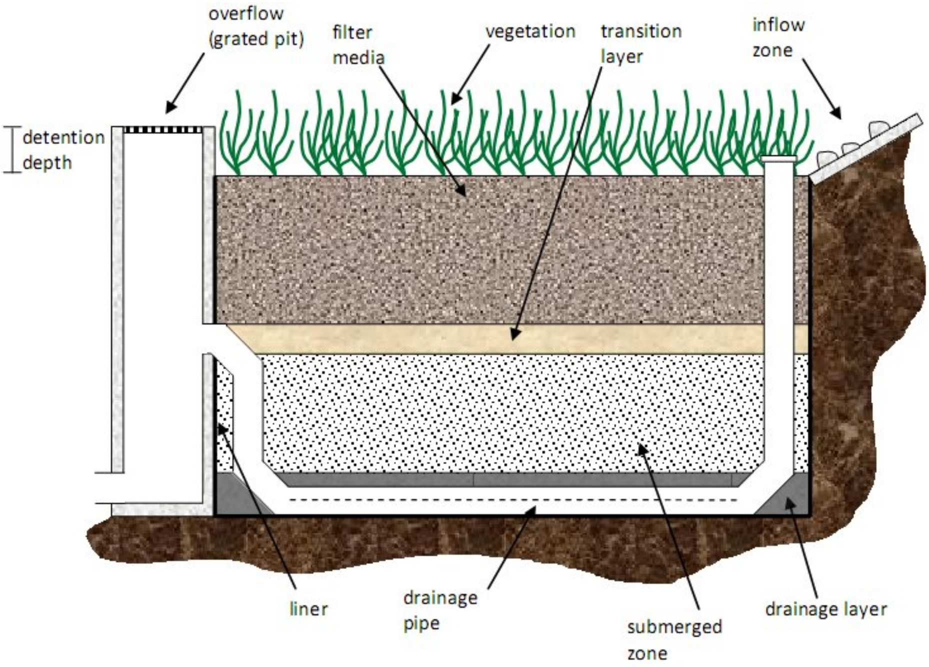


Figure 5-2 Typical Biofiltration Arrangement (FAWB, 2009)

Other biofiltration measures including raingardens and biofiltration swales perform a similar function, although at different scales.

Biofiltration basins are typically provided as large end-of-line measures that can be combined with other community functions (e.g. detention basins, sporting fields). Smaller biofiltration basins may also be distributed throughout a development precinct

The concept plan incorporates biofiltration basins as the major WSUD measure for managing runoff quality and quantity from Tallawarra Lands. Biofiltration basins would be provided within open space areas adjacent to riparian areas.

The biofiltration basins would perform a multi-purpose role incorporating passive recreation in addition to a designated biofilter zone where stormwater discharged from piped drainage systems would be treated prior to discharge into the watercourses or diversion to a stormwater harvesting system. For the concept plan, the basins have conservatively been configured to have an above ground extended detention depth of approximately 0.6m and a biofilter media depth of 0.3m. The biofilter would be planted out with indigenous vegetation species that are appropriate for frequent inundation and are tolerant of extended periods of dry weather. It is envisaged that further refinement of the basins could achieve an increased extended detention depth and biofilter media depth at some locations which would result in a reduction in the footprint shown on the concept plan.

The biofilter area within the floor of each basin would be a minimum of 50% of the average surface area (average of the basin floor and crest surface areas). The footprint shown on the concept plan allows for land area 50% greater than modelled to allow for embankments, community facilities and access. Examples of similar biofiltration basins to that proposed for Tallawarra Lands are shown in Figure 5-1.

5.3.2 Gross Pollutant Trapping

Gross pollutant traps (GPTs) are provided to capture litter, organic debris and coarse sediment conveyed by stormwater in urban areas. GPTs are a pre-treatment measure for other measures designed to remove fine sediment, heavy metals, nutrients and other particulate or dissolved pollutants. GPTs essentially concentrate the larger visible stormwater pollutants at one location and therefore avoid the time consuming task of removing this matter when it is dispersed within a downstream measure or receiving water. Capture of these pollutants can also assist in minimising the potential for blockage of downstream measures.

GPTs can be provided with either an above or below-ground detention storage. Above-ground storage GPTs typically store the captured pollutants in a dry state, whilst below-ground GPTs store pollutants wet (with the exception of pit inserts). Storing gross pollutants dry is preferable for transportation and disposal costs will be lower. In sites where space is limited, a below-ground GPT may be more feasible.

The concept plan incorporates GPTs to pre-treat runoff discharging to large biofiltration basins located downstream of planned business, primary school and industrial land uses where gross pollutant loads can typically be high. The biofiltration basins also incorporate a pre-treatment filtration/settling storage (equivalent to approximately 10-15% of the biofiltration basin) that would be provided at the inlet to the basins. The pre-treatment storage would temporarily detain incoming stormwater to enable gross pollutants to be separated prior to overflow into the main biofiltration basin. These storages would be dry between events enabling litter and other debris to be removed mechanically. In circumstances where the aesthetics are crucial, GPTs would be provided in lieu of pre-treatment basins.

The concept plan also incorporates allowance for GPTs to be provided as source controls within specific highly impervious business or industrial lot scale developments, and downstream of schools where litter and sediment loads are potentially high. The GPTs would ideally be above-ground dry storage structures maintained on an approximate monthly basis.

For smaller biofiltration measures located within primarily residential catchments, separate pre-treatment filter strips, grassed swales or sediment basins would be formed at the biofiltration measure inlet to separate organic debris, litter and coarse sediment from the stormwater.

5.3.3 Rainwater Tanks

Figure 5-3 Rainwater Tank Examples

Rainwater tanks are typically installed within private lots in urban areas to capture roof runoff for internal and external use. Benefits of harvesting roof runoff include potable water conservation, stormwater retention and water quality improvement. Harvesting rainwater reduces reliance on potable water supply systems in urban areas and as such can assist with deferring potable water system upgrades. The retention of roof runoff can also contribute to reducing the volume and duration of elevated stream flows from urban catchments. Rainwater tanks will typically have limited influence on water quality concentrations, although retention and diversion of stormwater to the sewer and garden areas reduces the volume of stormwater pollutants discharging to watercourses in the catchment of the development.

Rainwater tanks are more efficient when the retained water is used to supply multiple water demands within a development. Within residential areas, rainwater can typically contribute to supplying up to 90% of water demands including toilet flushing, garden watering, laundry, hot water and pool filling. The NSW Department of Health does not expressly prohibit rainwater tanks being used as a source of drinking water, however, the guidelines recommend avoiding drinking rainwater where a reticulated potable supply is available. Rainwater tanks can be relatively simple and efficient to maintain provided the tanks are initially configured appropriately and on-going attention is given to maintaining electrical equipment and tank inlets/outlets.

Average annual residential water demand for 2008-2009 was 198kL/property in Sydney Water's supply area (NOW, 2010). Monitoring of rainwater tanks installed under BASIX between 2005 and 2008 identified that approximately 60% of residential potable water is used for outdoor irrigation, washing machine and toilet flushing (refer Figure 5-4).

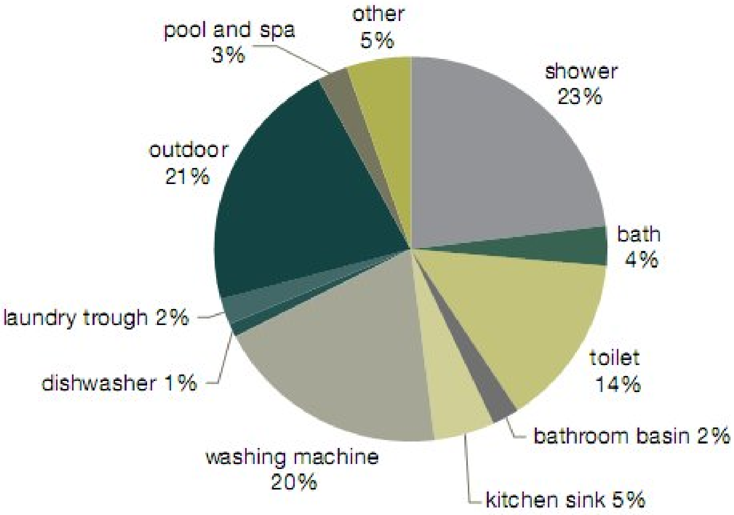


Figure 5-4 Typical Residential Water Demand Distribution (NSW DoP, 2008)

For MUSIC modelling (refer Section 6), it was assumed that outdoor irrigation, washing machine and toilet uses would be supplied from rainwater tanks when storage is available. It was assumed that hot water would not be supplied by rainwater tanks which is a conservative assumption for estimating stormwater volume reductions. Based on these assumptions, the annual water demand from rainwater tanks would currently be approximately 100kL/dwelling in Tallawarra Lands (i.e. approximately 50% of annual residential water demand).

The concept plan incorporates rainwater tanks within individual residential lots to assist in achieving a 50% reduction in potable water demand (i.e. BASIX + 10%). It is estimated that rainwater tanks with a minimum storage volume of 3.5kL per dwelling would be sufficient to achieve BASIX water conservation criteria in lieu of a reticulated recycled water supply system.

Modelling indicates that 3.5kL rainwater tanks could potentially supply 55 to 60% of the non-potable residential water demand within the development (conservatively assuming that rainwater would only be used for non-potable uses). This is equivalent to approximately 30% of the total residential water demand for Tallawarra Lands. To achieve the 50% reduction in potable water demand, other acceptable water efficient measures (e.g. low flow fittings) would be incorporated into residential properties.

5.3.4 Stream Rehabilitation

Existing watercourses that receive runoff from future development areas are proposed to be protected from further bank erosion and impacts on water quality. Bank erosion protection would be achieved through diversion of increased flows, stormwater retention, riparian zone protection and revegetation. Diversion of increased flows would be achieved through stormwater drainage systems constructed parallel to steep watercourses to control the locations and volume of stormwater discharging to the watercourses. Stormwater retention to reduce peak discharges to the streams would be achieved by biofiltration basins intercepting development runoff prior to discharge into the streams. The proposed riparian zone protection and revegetation are outlined in the ecology assessment (ELA, 2010).

5.4 Minor WSUD Measures

5.4.1 Reduce Directly Connected Impervious Areas

Significantly increasing the impervious areas within Tallawarra Lands has the potential to convey high runoff volumes and associated stormwater pollutant loads to receiving watercourses. Roof and road surfaces comprise the majority of directly connected impervious areas in conventionally drained developments. Conventional drainage systems typically collect and convey stormwater along a series of impervious surfaces prior to point discharge into a receiving watercourse. There is limited opportunity for retention, filtration, infiltration or evapotranspiration of stormwater in these systems. A fundamental WSUD objective is to break the series of impervious surfaces to reduce flow rates and the volume of additional stormwater runoff that reaches the watercourses. This disconnection of impervious surfaces has the additional benefit of intercepting pollutant loads.

Figure 5-5 Example Disconnection of Roof Surfaces

The Tallawarra Lands concept plan incorporates rainwater tanks to achieve disconnection of roof areas and biofiltration measures for road surfaces (in addition to overflow from rainwater tanks). Rainwater tanks are included in the concept plan for all residential lots within Tallawarra Lands. Optional stormwater harvesting basins within open space areas would achieve further disconnection of impervious surfaces.

The concept plan also includes consideration of options where rainwater tanks would not be required to achieve BASIX water conservation criteria. In these circumstances, additional storage would be provided within biofiltration measures to achieve an equivalent retention volume.

5.4.2 Permeable Paving

Figure 5-6 Permeable Paving Examples

Permeable paving filters stormwater during frequent runoff events to remove fine sediment and associated particulates. Detention and retention of stormwater is achieved by storage on the surface and within the granular base under the paving. During high runoff events the infiltration capacity of the voids would be exceeded and the excess rainfall converted to runoff. During these events runoff is directed to an appropriate minor or major drainage system and conveyed to the receiving waters.

Permeable paving is typically positioned close to the source of pollutant generation and provides primary (and partial secondary) treatment of stormwater runoff draining to tertiary treatment measures. Permeable paving also forms a key option in urban areas for disconnecting impervious surfaces from receiving waters. Typically permeable paving can be provided in residential driveways, shared accesses, minor residential streets and car parking spaces where traffic loadings are relatively low. Permeable paving can be relatively simple and efficient to maintain provided appropriate pre-treatment of surface runoff draining onto the paving is undertaken.

The concept plan incorporates allowance for provision of permeable paving along driveways in residential lots, parking bays within streets and carparks adjacent to the sporting fields and other lightly loaded traffic areas. Permeable paving will be a minor WSUD measure in the concept plan that will enhance the performance of the main WSUD measures and further reduce the potential risks to receiving water quality and ecology.

5.4.3 Raingardens

Figure 5-7 Raingarden Examples

Raingardens are typically provided close to a runoff source where catchment areas are relatively small. They are typically formed as small shallow retention cells/basins constructed at strategic points within private lots or within the streetscape.

The concept plan includes provision for optionally incorporating small scale biofiltration cells (raingardens) within the road reserve at strategic locations along the road alignments. Raingardens would be considered at appropriate road intersections and along streets incorporating traffic calming devices. Raingardens would primarily be appropriate for locations within the Southern Precinct where the terrain is appropriate. Raingardens potentially can also be used within the Northern and Central Precincts where final road gradients are appropriate.

5.4.4 Biofiltration Swales

Figure 5-8 Biofiltration Swale Examples

Biofiltration swales are typically provided in conjunction with grassed swales to function as a combined flow and water quality management measure. Biofiltration swales are commonly provided within public road reserves (footpath or central median), public open spaces and carparks.

The concept plan includes provision for optionally incorporating biofiltration swales along appropriate streets. The swales would have a relatively shallow above-ground storage (max. 0.25m) and approximately 3m wide to enable them to be blended into the road reserve landscape. Filtered flows would be discharged into a parallel piped drainage system conveying the flow to the receiving streams.

Biofiltration swales would only be appropriate for the Southern Precinct where road gradients will be appropriately low.

5.5 Water Conservation Measures

5.5.1 Stormwater Harvesting Basins

Stormwater harvesting basins are increasingly being considered in urban areas to reduce potable water use. Their primary function is to capture, treat and use stormwater runoff for irrigation of public open space areas. However, they also have many additional benefits including potable water conservation, reducing the impact of urban development upon stream flows and water quality, establishment of new habitat for wildlife and improving the usability of public open space during periods of water restrictions.

During water restriction periods, harvested stormwater can be used to irrigate sporting fields, parks and gardens which would otherwise have been subject to water restrictions. This means that sporting activities can continue which may otherwise have been suspended and landscaping can be preserved from wilting.

Reducing the potable water demand also increases the resilience of the water supply system. During non-restriction periods, harvested stormwater can substitute potable water, thus delaying the introduction of restriction periods during a drought and hastening the removal of restrictions following a drought.

The feasibility of stormwater harvesting for Tallawarra Lands is reliant on three fundamental components, sufficient stormwater supply, available area and demand. The concept plan provides sufficient stormwater supply and provides areas with potential for positioning stormwater harvesting facilities. To ensure the on-going viability of any stormwater harvesting scheme, the demand must be continuing into the foreseeable future and furthermore, it should be of high value, beneficial to the community and supported by Council who are likely to retain ownership. Further investigation is required to confirm the viability of demand for harvested stormwater.

Multiple opportunities exist where harvested stormwater could be used within Tallawarra Lands including irrigation of open space, irrigation of street planting, irrigation of revegetation areas, irrigation of community gardens, irrigation of adjacent baseball fields, cooling water for the power station, irrigation of biofiltration vegetation during dry periods and emergency fire fighting supply. Consideration is also being given to sourcing water from ponds for irrigation of the public domain where water quality is appropriate (particularly salinity).

A key area where stormwater harvesting is being investigated is the central precinct. In this precinct the topography provides a catchment for stormwater harvesting for use irrigating the sports grounds and possibly the landscaping in the neighbourhood centre. This system would collect water from the street network for treatment and storage in tanks beneath the sports fields. The stormwater harvesting system will be considered in consultation with Council and confirmed at the civil works phase and agreements with Council.

Stormwater harvesting is considered to be an option with merit for Tallawarra Lands but will require further investigation at later development stages to confirm its long-term viability. The performance of the WSUD strategy outlined in the concept plan is not reliant on a stormwater harvesting system being in place, but would benefit from inclusion of such a system which would further reduce reliance on the potable water system and improve water conservation within the site.

5.5.2 Rainwater Tanks

Rainwater tanks would have a dual purpose of stormwater quantity management (refer Section 5.3.3) and water conservation. TRUenergy is considering installing in ground water tanks on lots at civil works stage. The scale of economy in construction of multiple tanks could result in larger storages being provided on individual sites, thereby embedding value and water conservation initiatives into the overall development of Tallawarra Lands. It is noted this initiative would require careful planning to offer some flexibility for integrating / connecting future buildings on the lots.

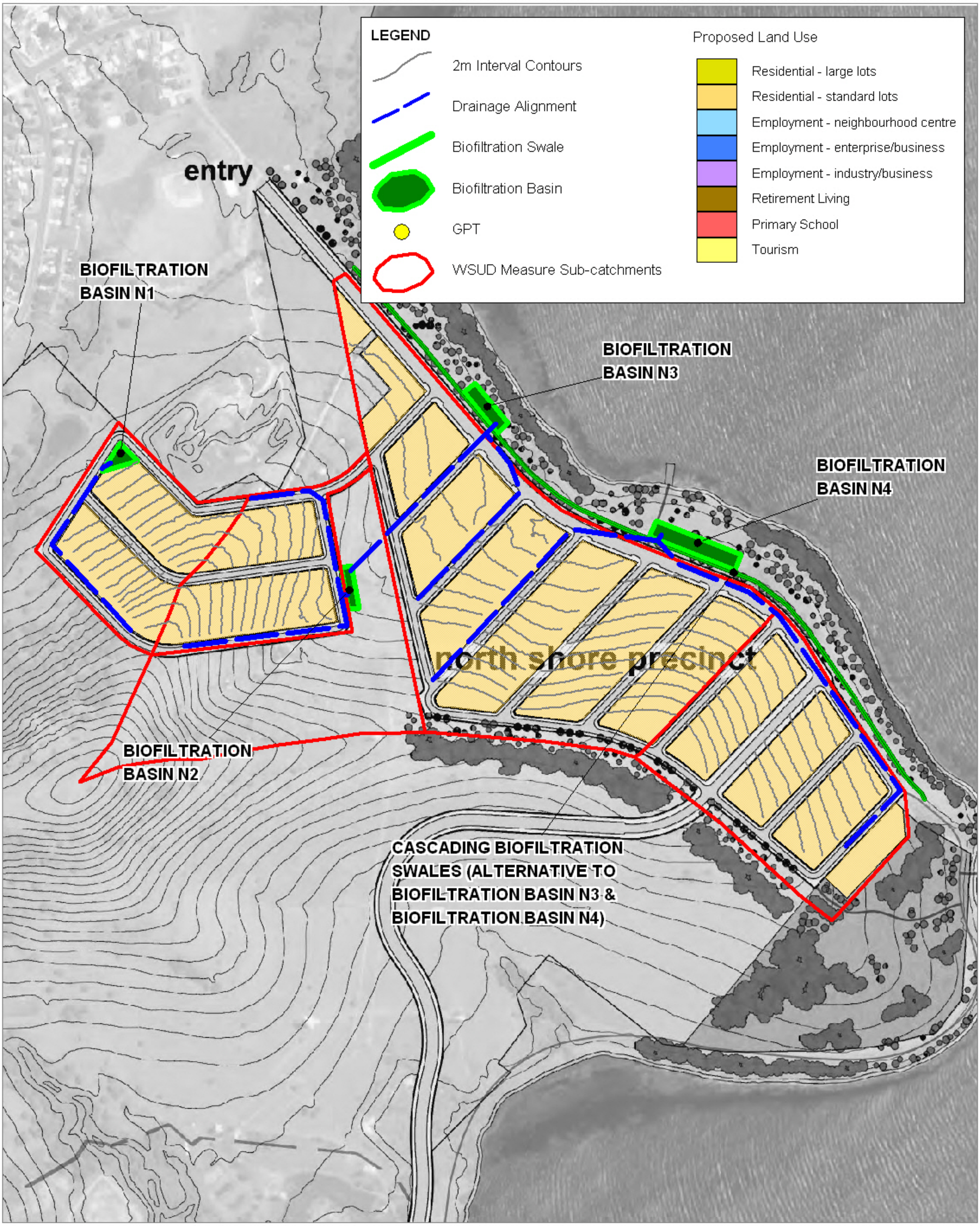
TRUenergy is investigating opportunities to harvest and treat water from portions of the site for potential use in the neighbouring Power Station.

5.5.3 Recycled Water

Sydney Water has confirmed their preferred strategy for water servicing to Tallawarra Lands should incorporate rainwater harvesting for non-potable uses (where appropriate) and they have not confirmed whether a third pipe recycled water system would be supported. TRUenergy are currently in discussions with Sydney Water about opportunities to provide a third pipe recycled water system for the development.

5.6 WSUD Strategy Figures

The WSUD Strategies for the Northern, Central and Southern Precincts are shown in Figure 5-9, Figure 5-10 and Figure 5-11 respectively. These figure show the locations and estimated footprint of the major WSUD measures proposed to manage stormwater quality and quantity within Tallawarra Lands. The modelling approach applied to estimate the size of these measures is described in Section 6.



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Northern Precinct - WSUD Strategy

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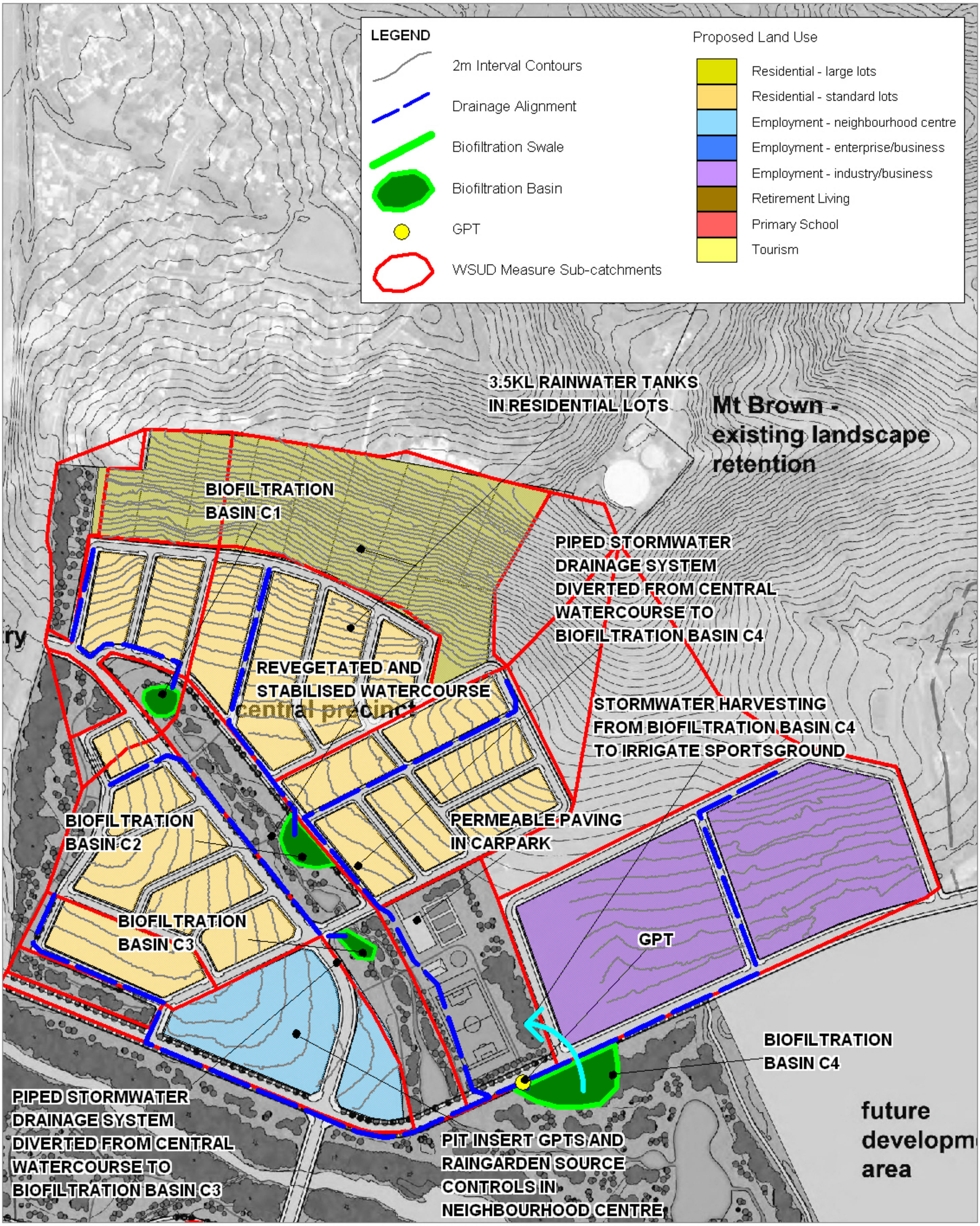

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Central Precinct - WSUD Strategy

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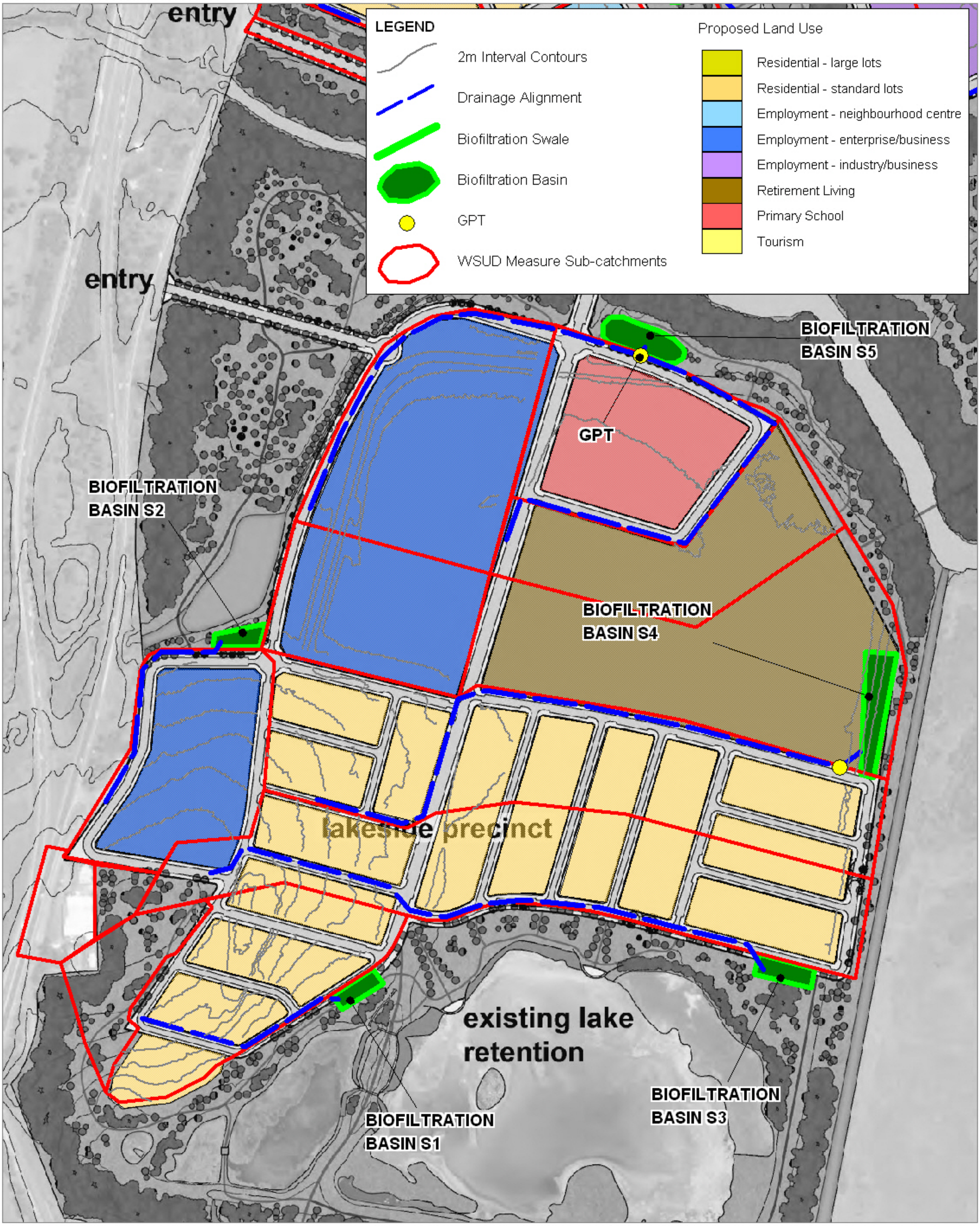

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Southern Precinct - WSUD Strategy

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6 PRELIMINARY MUSIC MODELLING

6.1 Modelling Approach

Preliminary stormwater quantity and quality modelling was undertaken using the Model for Urban Stormwater Improvement and Conceptualisation (MUSIC) to estimate runoff volumes and loads of common stormwater pollutants including Total Suspended Solids (TSS), Total Phosphorus (TP) and Total Nitrogen (TN). The modelling was completed for Tallawarra Lands to inform development of the concept plan and WSUD strategy for the site.

MUSIC includes algorithms to evaluate the hydrology and concentrations / loads of common stormwater pollutants (i.e. TSS, TP and TN) from urban catchments and estimate the performance of WSUD measures at capturing these pollutants.

MUSIC was designed to continuously simulate urban stormwater systems over a range of temporal and spatial scales utilising historically representative rainfall data. MUSIC is considered within the industry to be an appropriate conceptual design tool for the assessment and sizing of stormwater treatment measures.

The hydrologic algorithm in MUSIC is based on the model developed by Chiew & McMahon (1997). The model simplifies the rainfall-runoff processes and requires input of the following variables to perform the hydrological assessment:

- Rainfall data (time steps varying from 6 minutes to 1 days);
- Potential evapotranspiration rates;
- Catchment parameters (area, % impervious and pervious areas);
- Impervious and pervious area parameters (rainfall threshold, soil and groundwater parameters) and
- Storm event and base flow stormwater pollutant concentrations.

MUSIC can be utilised for comparison of alternative scenarios that adopt the same base inputs. Although the magnitude of the estimates may not be equivalent to actual site conditions (due to limitations in available data for a particular site), the relative differences between scenarios is expected to be appropriate for supporting decision making. MUSIC can also be applied to evaluate the performance of stormwater treatment measures against load-based objectives.

The MUSIC modelling approach applied to assist in developing the concept plan for Tallawarra Lands is described in the following sections.

6.2 Meteorological Input Data

The meteorological template includes the rainfall and areal potential evapotranspiration data. It forms the basis for the hydrologic calculations within MUSIC.

Rainfall data were sourced from Bureau of Meteorology (BoM) Station 68131 Port Kembla (BHP Central Lab). Data were available for the 1963 to 1983, and 1993 to 2009 periods. Interpolated data were also sourced from the SILO database for comparison with Stn. 68131.

Review of the rainfall data indicated that the 1995 to 1999 period was relatively free of gaps and periods of accumulated rainfall data. The mean annual rainfall for this period is 1065mm which is within approximately 5% of the long term average of 1133mm calculated from the SILO data. The long term mean annual rainfall for the site is similar to the long-term average of 1256mm for BoM Station 68038 Kiama Bowling Club located approximately 25km south-east of Tallawarra Lands. The 1995 to 1999 period was adopted for modelling stormwater quality.

An additional rainfall data period 1995 to 2004 from Stn 68131 was utilised for the stream erosion potential assessment. This period has a lower average annual rainfall of 974mm although the longer period is more appropriate for flow modelling.

The areal PET rates adopted for the MUSIC modelling are summarised in Table 6-1.

Table 6-1 Adopted Average Monthly Areal PET Rates

Month	Mean monthly areal PET (mm)
January	166
February	130
March	115
April	74
May	49
June	39
July	40
August	58
September	80
October	120
November	142
December	159

A 6-minute model time step was adopted for the MUSIC modelling.

6.3 Catchment Parameters

Sub-catchments for the biofiltration basins were estimated considering the existing terrain, preliminary site regrading levels, preliminary road gradings and future land uses. The sub-catchments are shown on Figure 5-9, Figure 5-10 and Figure 5-11. Sub-catchment areas are summarised in Table 6-2.

Standard lot residential sub-catchments were assumed to comprise 80% residential lots and 20% road reserve area. Residential lots were assumed to have an average roof area of 300m^2. It was assumed that 75% of the roof area would be directed to a rainwater tank, with the remaining 25% bypassing to a drainage system. The remaining lot area was assumed to comprise a mix of hard and soft landscaping surfaces. Road reserves were assumed to be 50% road pavement and 50% footway.

Table 6-2 MUSIC Modelling Sub-catchment Areas

Precinct	WSUD Measure Sub-catchment ID	Land uses	DCIA[1]	Area (ha)
Northern	BBN1	Standard lot residential	57%	3.30
	BBN2	Standard lot residential	57%	3.05
		Cleared land	0%	5.33
	BBN3	Standard lot residential	57%	12.63
	BBN4	Standard lot residential	57%	5.93
Total Northern Precinct Sub-catchment Area =				**30.24**
Central	BBC1	Standard lot residential	57%	3.80
		Large lot residential	10%	2.30
		Open space	10%	2.20
		Watercourse	0%	0.60
	BBC2	Standard lot residential	57%	7.20
		Large lot residential	10%	8.30
		Cleared land	0%	2.20
	BBC3	Standard lot residential	57%	6.70
	BBC4	Standard lot residential	57%	9.60
		Neighbourhood centre	80%	5.70
		Industrial	90%	14.20
		Open space	10%	5.10
		Cleared land	0%	9.00
	Other	Watercourse	0%	5.20
Total Central Precinct Sub-catchment Area =				**82.10**
Southern	BBS1	Standard lot residential	57%	4.68
		Open space	10%	1.56
	BBS2	Business	80%	5.11
		Open space	10%	0.40
	BBS3	Standard lot residential	57%	9.19
	BBS4	Standard lot residential	57%	9.98
		Business	80%	3.67
		Retirement	70%	8.22
	BBS5	Primary school	50%	4.95
		Business	80%	6.06
		Retirement	70%	4.34
Total Southern Precinct Sub-catchment Area =				**58.16**

1. Estimated directly connected impervious area (refer Section 5.4.1)

6.4 Rainfall-Runoff Parameters

Modelling of the rainfall-runoff process in MUSIC requires the definition of two impervious surface parameters and eight pervious surface parameters. These parameters can be determined through a calibration and validation exercise where concurrent stream flow, rainfall and evapotranspiration data are available for the catchment being considered.

BMT WBM has completed previous calibration/validation modelling to ascertain reasonable MUSIC impervious and pervious parameters for developments in similar catchments as Tallawarra Lands. Appropriate MUSIC rainfall-runoff parameters for catchments with ephemeral streams found in similar topographic, soil and climatic conditions as Tallawarra Lands are summarised in Table 6-3. These parameters were adopted for developing the MUSIC models.

Table 6-3 MUSIC Rainfall-Runoff Parameters

Impervious Area Parameters	
Rainfall Threshold (roofs, mm)	1.0
Rainfall Threshold (road pavement, mm)	2.0
Rainfall Threshold (mixed urban surfaces, mm)	1.4
Pervious Area Parameters	
Soil Storage Capacity (mm)	155
Initial Storage (% of capacity)	30
Field Capacity (mm)	95
Infiltration Capacity Coefficient – a	150
Infiltration Capacity Exponent - b	3.5
Groundwater Properties	
Initial Depth (mm)	10
Daily Recharge Rate (%)	25
Daily Baseflow Rate (%)	10
Daily Deep Seepage Rate (%)	0

6.5 Runoff Quality Parameters

The MUSIC input stormwater constituent concentrations were adopted from those recommended for NSW in Fletcher et. al. (2005). The normalised values presented within that report were converted to logarithmic values for input to MUSIC.

Mean values for each parameter were calculated from the ‘typical’ values presented in Fletcher et. al. (2005). The existing default standard deviation values in MUSIC were adopted. This approach was consistent with that adopted for scenario modelling in Fletcher et. al. (2005). The calculated $\log_{10}$ values are summarised in Table 6-4 and Table 6-5.

Table 6-4 Storm flow concentrations for MUSIC modelling in NSW (log_{10})

	TSS		TP		TN	
	mean	std. dev	mean	std. dev	mean	std. dev
Residential	2.15	0.32	-0.60	0.25	0.30	0.19
Industrial	2.15	0.32	-0.60	0.25	0.30	0.19
Commercial	2.15	0.32	-0.60	0.25	0.30	0.19
Rural	1.95	0.32	-0.66	0.25	0.30	0.19
Forest	1.60	0.20	-1.10	0.22	-0.05	0.24

Table 6-5 Base flow concentrations for NSW MUSIC modelling in NSW (log_{10})

	TSS		TP		TN	
	mean	std. dev	mean	std. dev	mean	std. dev
Residential	1.20	0.17	-0.85	0.19	0.11	0.12
Industrial	1.20	0.17	-0.85	0.19	0.11	0.12
Commercial	1.20	0.17	-0.85	0.19	0.11	0.12
Rural	1.15	0.17	-1.22	0.19	-0.05	0.12
Forest	0.78	0.13	-1.52	0.13	-0.52	0.13

6.6 Results

6.6.1 Stormwater Quality

MUSIC modelling results for the WSUD strategy are summarised in Table 6-6. The results demonstrate that the modelled % reductions in stormwater pollutant loads achieve the default targets and approach or achieve the ambitious targets outlined in Section 3.2.3.

Table 6-6 MUSIC results – Development with BASIX+10% Rainwater Tanks

	Northern Precinct			Central Precinct			Southern Precinct		
	Source	Outlet	% red.	Source	Outlet	% red.	Source	Outlet	% red.
Flow (ML/yr)	162	142	**12%**	417	384	**8%**	416	388	**7%**
TSS (kg/yr)	28200	4070	**86%**	70614	9514	**87%**	73800	11400	**85%**
TP (kg/yr)	46	16	**66%**	118	41	**65%**	121	43	**64%**
TN (kg/yr)	348	177	**49%**	890	458	**49%**	896	475	**47%**
GP (kg/yr)	3610	0	**100%**	8610	0	**100%**	9850	0	**100%**

Additional scenarios were modelled to determine the performance of the WSUD strategy in the event that alternative water conservation measures to rainwater tanks were incorporated into future developments to satisfy BASIX equivalent criteria. The modelling results for these scenarios indicate that the objectives would not be achieved without rainwater tanks if the biofiltration basin sizes were not increased. The biofiltration basins were increased in size by 10% to account for the loss of retention storage provided by the rainwater tanks. Results of these model runs are shown in Table 6-7. The results indicate that similar treatment can be achieved (with the exception of flow volumes) if rainwater tanks are replaced with biofiltration basins increased in size by 10%.

Table 6-7 MUSIC results – Development without BASIX+10% Rainwater Tanks

	Northern Precinct			**Central Precinct**			**Southern Precinct**		
	Source	Outlet	% red.	Source	Outlet	% red.	Source	Outlet	% red.
Flow (ML/yr)	162	157	**3%**	417	403	**3%**	416	404	**3%**
TSS (kg/yr)	28100	3760	**87%**	71114	8714	**88%**	74000	11200	**85%**
TP (kg/yr)	47	16	**65%**	118	40	**66%**	121	44	**64%**
TN (kg/yr)	349	179	**49%**	887	448	**49%**	896	476	**47%**
GP (kg/yr)	3610	0	**100%**	8610	0	**100%**	9850	0	**100%**

The biofiltration basin sizes incorporated into the concept plan are summarised in Table 6-8. The sizes indicated are for the scenario where BASIX+10% rainwater tanks would be provided in residential lots. The biofiltration basins would all have a similar configuration to that described in Section 5.3.1.

Table 6-8 Biofiltration Basin Surface Areas

Basin ID	**Biofiltration Basin Areas**	
	Modelled (m^2)	Estimated footprint (m^2)
Northern Precinct		
BB-N1	350	525
BB-N2	450	675
BB-N3	1400	2100
BB-N4	650	975
Central Precinct		
BB-C1	1050	1575
BB-C2	1780	2670
BB-C3	750	1125
BB-C4	4500	6750
Southern Precinct		
BB-S1	750	1125
BB-S2	800	1200
BB-S3	1035	1553
BB-S4	2530	3795
BB-S5	1950	2925

The biofiltration basin locations are shown in Figure 5-9, Figure 5-10 and Figure 5-11.

6.6.2 Stream Erosion Potential

The upper section of the watercourse that drains centrally through the Central Precinct is likely to be the section of watercourse within Tallawarra Lands that is most susceptible to erosion following development. The Concept Plan would mitigate the impacts of increased surface runoff from the sub-catchments draining to the central watercourse by reducing the catchment area draining to the upper watercourse and providing stormwater retention.

The catchment area draining to the watercourse upstream of proposed Biofiltration Basin C3 will be reduced from 46ha to 34ha following development. This will be achieved by diverting stormwater from part of the catchment on the northern side of the watercourse through a piped drainage system to proposed Biofiltration Basin C4.

A total retention storage of approximately 2850m^3 will be provided within the biofiltration basins and rainwater tanks to achieve disconnection of impervious areas from the watercourse. The proposed retention storage is equivalent to a runoff depth of 25mm from the directly connected impervious surfaces within the catchment (19mm provided in biofiltration basins and 6mm in rainwater tanks). These retention storages would effectively assist in preventing elevated discharges to the watercourse in all but the largest storm events.

The impact of providing the retention storage on stream erosion potential was evaluated for the upper section of the watercourse. The impact was evaluated considering the stream erosion potential for natural and developed (with WSUD) conditions. A natural 2yr ARI discharge of 4.6m^3/s was estimated applying the Probabilistic Rational Method. A natural condition MUSIC model was prepared and partial flood frequency analysis completed for the modelled flows (refer to Figure 6-1). The estimated natural 2yr ARI discharge based on this analysis was 4.9m^3/s which is within 10% of the Probabilistic Rational Method estimate.

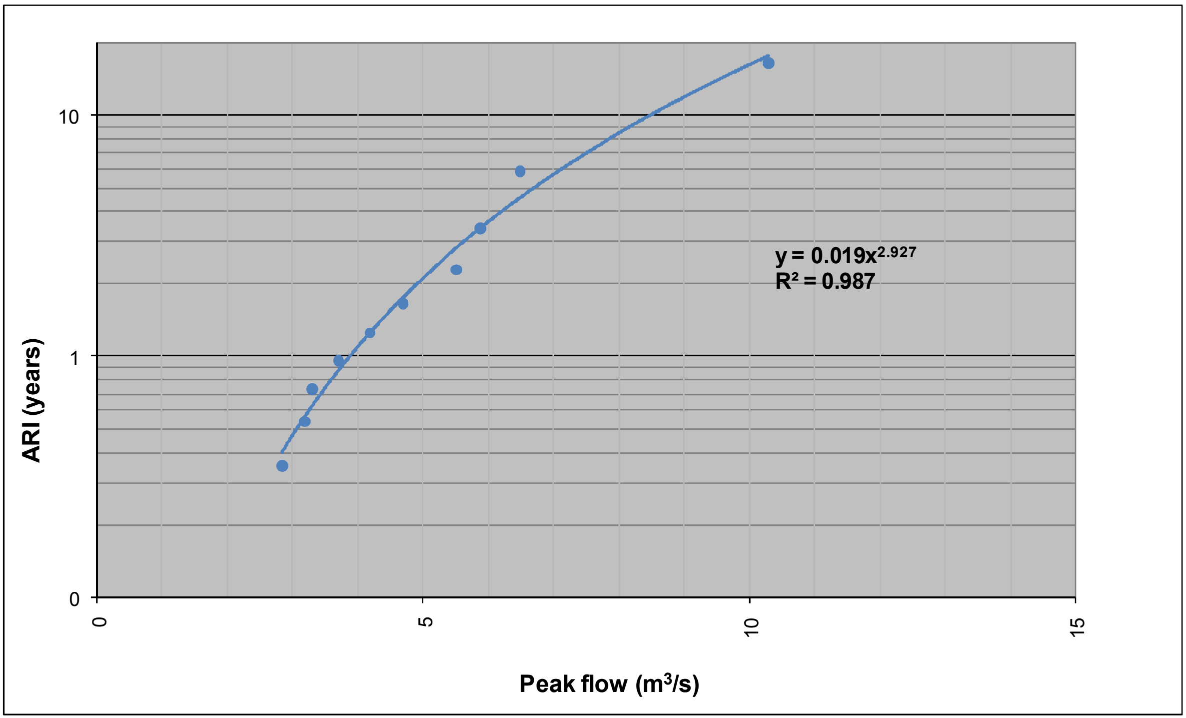

Figure 6-1 Partial Flood Frequency Analysis Plot

The total flow volume above the 50% of 2yr ARI flows for the natural and developed (with WSUD) conditions were calculated using MUSIC. The total volume above these discharges was adopted as a measure of the volume of flow that has the most potential to erode the stream banks. Within MUSIC it was estimated that the average annual flow volumes above the natural 50% of 2yr ARI flow would be 5.5ML/yr and 2.8ML/yr for the natural and developed (with WSUD) conditions respectively. The modelling results indicate that reducing the catchment area draining to the upper section of the watercourse and providing significant retention storage within the development will reduce the potential for erosion of the stream.

The 50% of 2yr ARI flow as a measure of stream erosion potential is more relevant to watercourses with a clay substrate. Sections of the watercourse also have a gravel/sand alluvium substrate that would be more susceptible to erosion at lower flows and these flows potentially are more critical. Additional assessment was completed to evaluate changes to the flow volumes above the natural 25% of 2yr ARI flow. Within MUSIC it was estimated that the average annual flow volume above the natural 25% of 2yr ARI flow would be 17.8ML/yr and 9.5ML/yr for the natural and developed (with WSUD) conditions respectively. Similarly to the 50% of 2yr ARI condition, the potential for stream erosion is estimated to reduce with the proposed diversion and retention strategy.

6.6.3 Climate Change

The Tallawarra Lands climate change assessment (BMT WBM, 2010) has identified the following key potential risks to drainage and WSUD:

- Increased rainfall intensities leading to increased runoff volumes and stormwater pollutant loads;
- Sea level rise; and
- Increased discharges of stormwater from the site to the adjacent wetlands.

Additional scenarios were modelled to estimate the performance of the WSUD strategy in the event of projected regional climatic changes. NSW government agencies and the University of NSW developed interim climate change forecasts for the Illawarra Region in 2008 (DECC, 2008). The forecasts indicate that the Illawarra region will become warmer and slightly wetter. Daily temperatures are projected to be hotter over all seasons (1.5 to 3°C) with the increase projected to be greatest in the winter, spring and autumn months. The Illawarra region is projected to experience a substantial increase in summer rainfall and a slight to moderate increase in spring/autumn rainfall. Rainfall in winter is likely to be similar to current levels. Evaporation is projected to increase with temperature, more significantly in the summer and spring. When considered in conjunction with projected changes in rainfall, increased evaporation could result in slightly drier conditions in winter and spring. The projected changes in seasonal rainfall are shown in Figure 6-2.

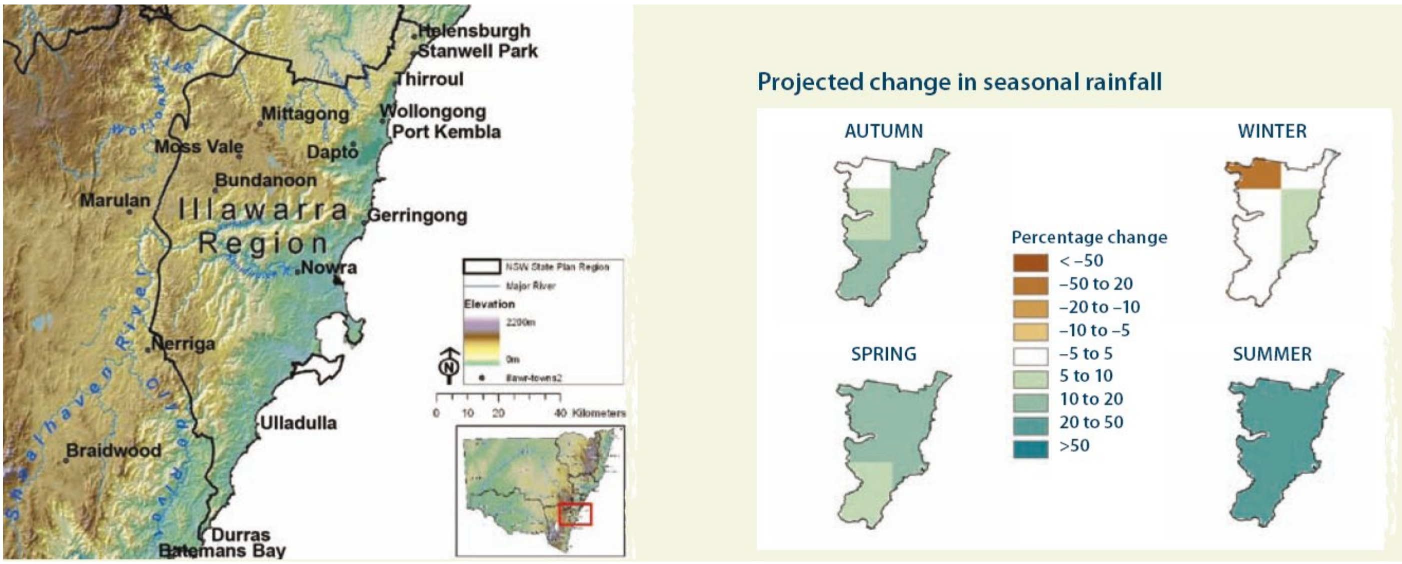

Figure 6-2 Projected Rainfall Changes Associated With Climate Change (DECC, 2008)

The projected changes to seasonal rainfall suggest that autumn and spring rainfall at Tallawarra Lands would increase by 10 to 20%, winter rainfall by 5 to 10% and summer rainfall by 20 to 50%. To evaluate the impact of increased seasonal rainfall associated with climate change, additional MUSIC models were developed. Rainfall data input to the models were increased by scaling. Autumn, winter and spring rainfall data values were each increased by 15% and summer rainfall data values were increased by 35%. Monthly potential evapotranspiration data values were conservatively retained at the original values. No further changes were made to the WSUD strategy. The MUSIC modelling results for the increased rainfall scenario is shown in Table 6-9.

Table 6-9 MUSIC results – Increased Seasonal Rainfall Associated with Climate Change

	Northern Precinct			Central Precinct			Southern Precinct		
	Source	Outlet	% red.	Source	Outlet	% red.	Source	Outlet	% red.
Flow (ML/yr)	206	185	**10%**	532	498	**6%**	522	493	**6%**
TSS (kg/yr)	35790	6390	**82%**	90478	15278	**83%**	92600	17400	**81%**
TP (kg/yr)	60	22	**62%**	151	57	**62%**	152	60	**61%**
TN (kg/yr)	441	242	**45%**	1130	622	**45%**	1130	638	**43%**
GP (kg/yr)	4080	0	**100%**	9720	0	**100%**	11100	0	**100%**

As expected, the results in Table 6-9 show that increased rainfall would increase stormwater runoff volumes. The modelling indicates that the performance of the WSUD strategy under increased rainfall conditions would be close to the targets. Although, it was assumed that runoff concentrations would remain the same under climate change conditions, it is expected that with an increase in rainfall of 35% during summer that more regular flushing of the catchment potentially would reduce the runoff pollutant concentrations. Therefore, during summer when the measures may be bypassed more often under climate change conditions, the pollutant concentrations in the bypass flow potentially would be lower than for smaller events. The modelled load reductions outlined in Table 6-9 may therefore be slightly under predicting the performance of the WSUD strategy under climate change conditions.

Street drainage systems within Tallawarra Lands would be designed allowing for a 30% increase in design rainfall intensities under climate change conditions.

The WSUD measures would be positioned at elevated sites outside the predicted floodplain extents associated with climate change. The performance of the measures would therefore not be directly impacted by sea level rise.

Increased stormwater discharges to existing wetlands under climate change conditions would be limited as the concept plan incorporates diversion of drainage systems away from the wetlands to existing drains that flow to Duck Creek.

7 CONCLUSIONS

Future urban development within Tallawarra Lands has the potential to significantly increase the quantities of pollutants and runoff volumes draining to Duck Creek and Lake Illawarra. If unmitigated, these increased loads have the potential to adversely impact on stream stability and receiving water ecology.

The Tallawarra Lands Concept Plan addresses the potential environmental impacts through provision for a number of major biofiltration basins that will be positioned between the development and receiving waters. These measures will intercept stormwater for retention, filtering and treatment prior to discharge into the watercourses. The biofiltration basins will also achieve disconnection of impervious areas from the watercourses which will assist to protect the watercourses from further erosion following development. Diversion of significant proportions of stormwater runoff from upper reaches of the watercourses will also assist with reducing stream erosion potential.

A range of other minor source control WSUD measures are proposed to support the major biofiltration basins. WSUD measures including disconnected impervious areas, permeable paving, raingardens and biofiltration swales are recommended for consideration at appropriate locations within lots and streetscapes. Provision of these additional WSUD measures would provide additional treatment and would function as buffering measures for the major biofiltration basins.

Areas of salt marsh are proposed to be protected by filtering runoff and minimising additional stormwater discharges to the wetlands supporting this vegetation community. Re-vegetation along degraded watercourses within the development will also assist to protect stream banks and filter stormwater runoff.

Potable water conservation would be achieved through the provision of rainwater tanks within residential areas. Rainwater harvesting from industrial areas is included as an opportunity for further consideration as development planning progresses.

The proposed drainage and WSUD measures conceptually will provide treatment that exceeds Council’s targets. In addition, the Concept Plan incorporates sufficient space and flexibility to optimise the treatment measures as development planning progresses.

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