





Wilton South East Precinct

Water Cycle Management Strategy Report Stage 1

Walker Corporation

December 2018

SUSTAINABLE CERTIFICATION
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CONSULTING CIVIL INFRASTRUCTURE ENGINEERS
& PROJECT MANAGERS

Wilton South East Precinct – Water Cycle Management Strategy Report (Stage 1)

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1 EXECUTIVE SUMMARY

J. Wyndham Prince Pty Ltd (JWP) have been engaged by *Walker Corporation* to prepare a *Water Cycle Management Strategy (WCM) Report* to support the proposed Stage 1 Development Application (DA) subdivision within the Wilton South East Precinct (WSEP).

The Wilton South East Precinct is located in the South - East corner of the Greater Wilton Junction Release Area and will be delivered across a number of stages. Stage 1 comprises of around 696 lots across a range of residential densities (small to large lot, terrace, villa and courtyard) with associated roads and open space (active, local and passive).

In 2014, J. Wyndham Prince prepared an overall *WCM Strategy Report* (JWP, 2014) for the Greater Wilton Junction Release Area. The investigation identified all stormwater, recycled water and flood management issues which need to be considered as part of any future developments within the release area. The overall report (JWP, 2014) formed part of the 2011 gazettal which has now been endorsed by Wollondilly Shire Council and the Department of Planning and Environment and therefore forms an important document in setting the objectives for the area.

This report presents details of the WCM Strategy which is proposed to support Stage 1 in the Wilton South East Precinct. A more defined assessment has therefore been undertaken to ensure both water quantity and water quality objectives are achieved in accordance with the overall WCM Strategy Report (JWP, 2014) along with the Department of Planning and Environment and Wollondilly Shire Council objectives.

An initial DA submission for WSEP Stage 1 was made to Wollondilly Shire Council in May 2018. This resulted in a revised layout being prepared for the subdivision and series of issues and requests for information (RFI) being issued, some of which pertaining to stormwater management. These have been addressed in Section 6 of this report and water quantity (XP-RAFTS) and water quality (MUSIC) modelling for the revised layout have been undertaken in Section 7 and 8 respectively.

The *Water Cycle Management Strategy* for WSEP Stage 1 consists of the following:

- 3kL rainwater tank on each lot.
- Gross pollutant traps at each discharge point to basin or raingarden.
- Four (4) detention basins with a total active storage of approximately 17,420 m^3 (in the 1% AEP flood event).
- Eight (8) bio-retention raingardens with a total filter area of approximately 5,240 m^2 – generally co-located within detention basins plus an additional standalone device at the entry road.
- On-lot treatment (GPT with raingarden or proprietary devices) for the future commercial area.
- Swale / channel from the outlet of Basin 4A and 4B through to the existing culverts under Picton Road. Configuration to include flow splits as discussed in Section 7.2 to match pre-post at each culvert location.

The proposed works are detailed on the supporting engineering design drawings prepared by BG&E Consulting Engineers and should be read in conjunction with this report.

2 BACKGROUND

The overall Greater Wilton Junction Release Area will deliver between 11,000 to 13,000 dwellings, employment lands, a Town Centre, two (2) local shopping villages, five (5) schools and 64 Ha of open space for some 36,000 residents. Refer to Plate 2.1.

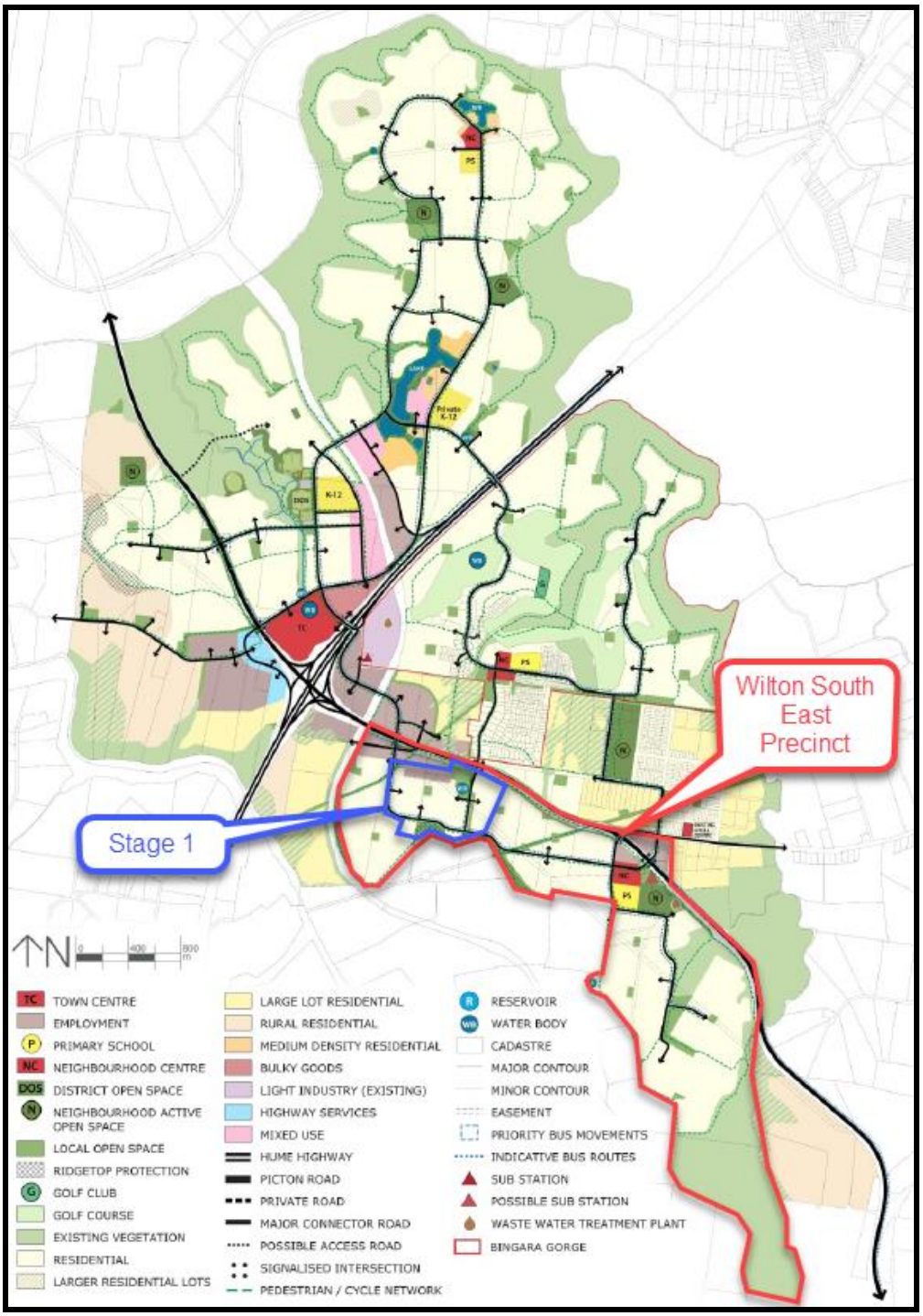


Plate 2.1 – Wilton Junction Overall Masterplan (Extract: JWP, 2014 Report)

The Wilton South East Precinct is located in the South - East corner of the Greater Wilton Junction Release Area and will include around 3431 lots across a total of six (6) stages. Stage 1 (which is the subject of this report) includes approximately 696 lots across a range of residential densities (small to large lot, terrace, villa and courtyard) with associated roads and open space (active, local and passive).

2.1 Previous Studies and Reports

2.1.1 Wilton Junction Water Cycle Management Strategy (JWP, 2014)

In July 2014, J. Wyndham Prince prepared the overall *Wilton Junction Water Cycle Management Strategy* (JWP, 2014). The objective of the investigation was to identify the stormwater, recycled water and flood management issues to be considered in the future development of the Wilton Junction Project, to identify flood risks, evaluate and propose appropriate solutions and locations for the control of the quantity and quality of stormwater leaving the site, assess all watercourses which are proposed as part of the urban development; and to identify the land areas required to implement the recommended stormwater management options. The costs associated with the Water Cycle Management infrastructure were then estimated to inform a Section 94 Contributions Plan for the Release Area.

The WCM Report (JWP, 2014) identified a combination of treatment train consisting of on lot treatment, street level treatment and subdivision / development treatment measures. These devices (for the overall release area) included the following:

- Proprietary GPT units at each stormwater discharge point.
- Seventy-Six (76) proposed bio-retention raingardens of total area 149,260 m^2.
- Gravel soakaway / level spreaders to distribute flows to the bushland perimeter.
- One (1) proposed regional detention basin on-line within Allens Creek (approximate total volume 35,000 m^3).
- A Recycled Water Management System [To be confirmed] consisting of;
    - Sewage Treatment Plant (STP)
    - A cascading raingarden system
    - Two (2) treatment / evaporation lakes (10.9 Ha total).
    - Irrigation of 49 ha of Active open space and road verges
    - Recycled water returned to employment lands for toilet flushing, irrigation, washdown and other suitable uses.
    - Distribution pipe and control infrastructure and polishing raingardens.

Following a detailed water quality modelling investigation, proposed water quality treatment devices were recommended to incorporate an Orthophosphate Content of 36.5 mg/kg to ensure that the post development stormwater discharges will meet Wollondilly Shire Council's and the Hawkesbury - Nepean water quality objectives.

Results of the assessment demonstrated that the provision of WSUD elements within Wilton Junction will assist in minimising the impact of urbanisation on the waterway stability of the Nepean River and Allens Creek.

The hydrological assessment demonstrated that discharges along the Nepean River have had little impact due to the proposed development within Wilton Junction and that from a regional perspective, detention storages are not required for catchments draining directly into the Nepean River. The hydrological assessment also demonstrated that a detention storage detaining discharges within the upper reaches of Allens Creek is sufficient to effectively restrict post development peak discharges to pre-development levels within Allens Creek.

It is noted however that detention basins may be required for those areas of Wilton Junction which drain into surrounding private properties as part of the staged delivery.

Preliminary hydraulic assessments determined that 1% AEP Post Climate change discharges through the major watercourses result in flooding levels well below the lowest proposed development levels. In addition, proposed urban catchments within the site have a size that is generally less than 40 ha and flows will be managed by conventional street drainage systems. Consequently, a more detailed flood assessment is not required for the development.

Plate 2.2 shows the Stormwater Concept Plan for the Greater Wilton Junction Release Area in the vicinity of the Wilton South East Precinct (Walker Corporation land). A full copy is provided in Appendix A.

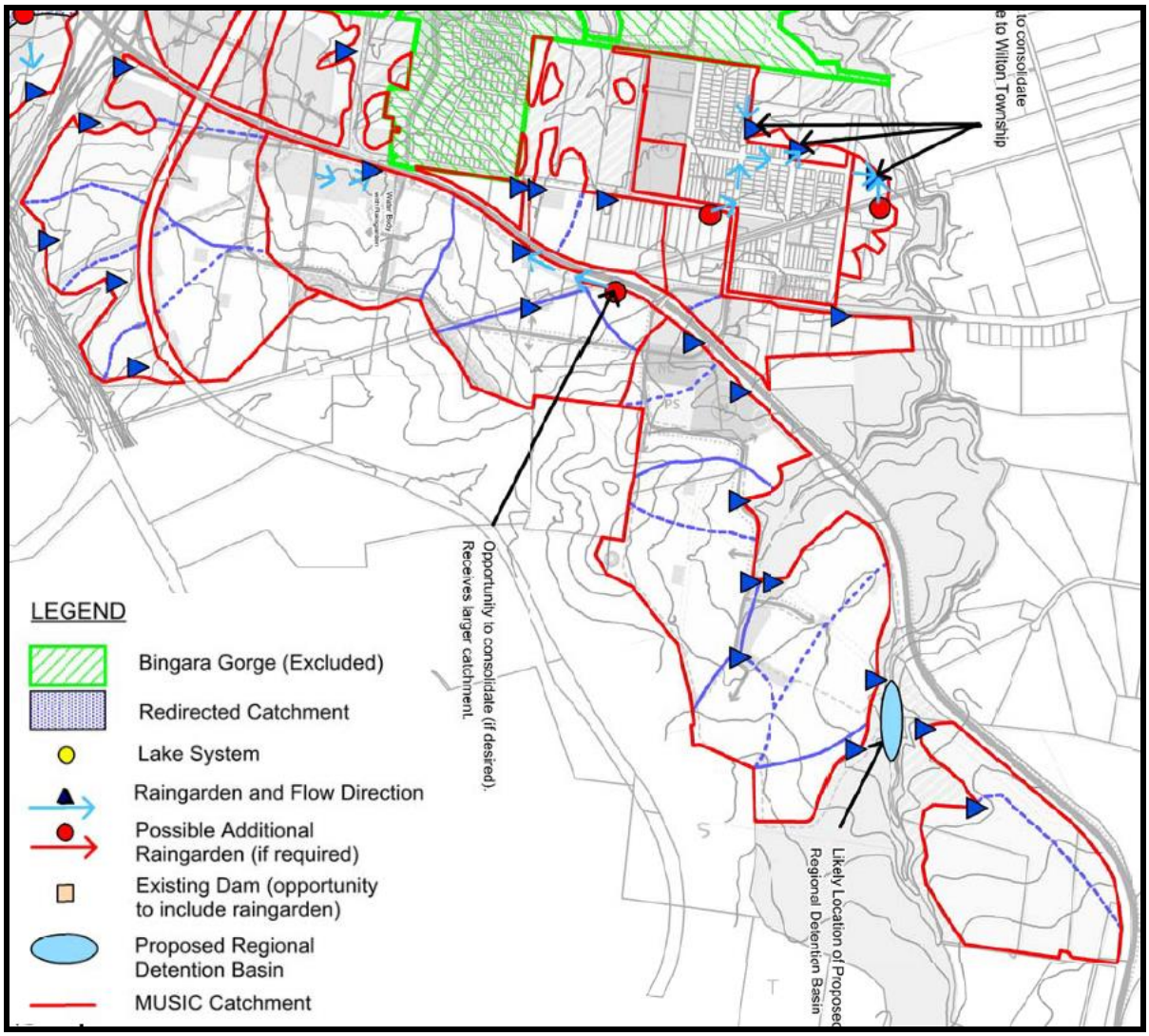


Plate 2.2 – Wilton Junction – Stormwater Concept Plan (Extract: JWP, 2014 Report)

A riparian corridor assessment was undertaken as part of the WCM Strategy (JWP, 2014). The assessment included an investigation upon each of the watercourses and riparian lands across the Precinct. Each of the watercourses were mapped and categorised based on the NSW Office of Water guidelines (NOW, 2012) and Strahler classification.

A visual stream assessment confirmed that all of the minor watercourses across the Precinct are not “rivers” as defined under the Water Management Act 2000 and could be removed or replaced by urban drainage infrastructure. Refer to Appendix E for the letter that was subsequently received from DPI Water which contains “in principle” support of the riparian assessment.

Across Stage 1 of Wilton South East Precinct, several watercourses were identified as 1st or 2nd order watercourses. Each of these were identified to not be "rivers" under the Water Management Act 2000 and were proposed for removal. Refer to Plate 2.3.

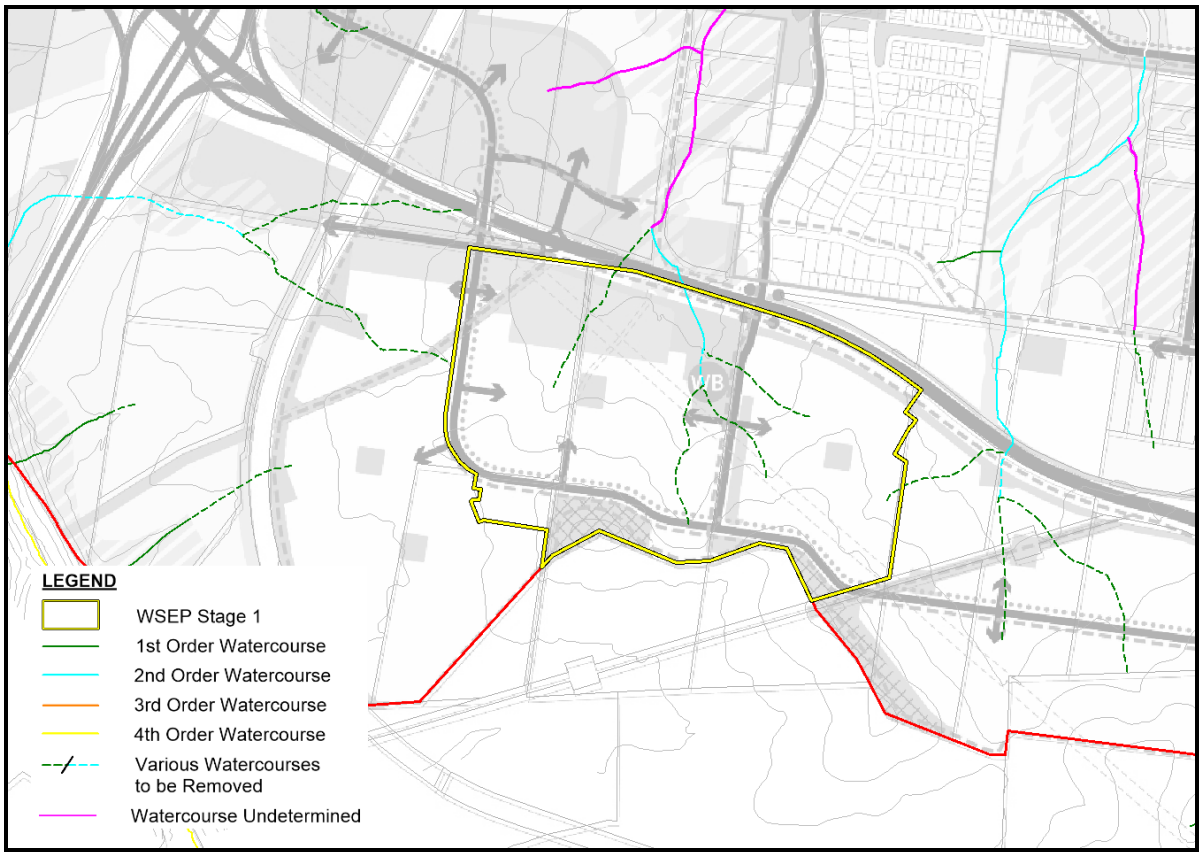


Plate 2.3 – Wilton South East Precinct – Riparian Corridor (Extract: JWP, 2014 Report)

3 THE EXISTING SITE

The Wilton South East Precinct is located within Wollondilly Shire Council, near the township of Wilton, and forms the South – East portion of the Greater Wilton Junction Release Area. The overall site (Stages 1 to 6) will cover approximately 377 ha. Refer to Plate 2.1.

Stage 1 covers 59 ha of undulating terrain across rural grazing pastures. The study area is bisected by a series of crestlines which naturally drains flows to the west, east and north. Refer to Plate 3.1.

The majority of Stage 1 (approximately 48.2 Ha) naturally drains overland towards two (2) existing culvert crossings under Picton Road (1200mm and 1350mm dia). Flows are then conveyed through the existing rural – residential properties to the north, into a riparian corridor within the Bingara Gorge development before ultimately connecting to Allens Creek. It is noted that this watercourse bisects through existing properties immediately downstream of Picton Road with flooding expected close to existing dwellings and under driveways.

A portion of the Stage 1 study area drains to the west and discharges upon land owned by Walker Corporation (future stage 2). These catchments ultimately drain across the future rail corridor and through existing rural – residential properties to the west (via existing riparian corridors) before ultimately connecting to the Nepean River.

Similarly, a portion of Stage 1 also drains to the east and discharges to land owned by Walker Corporation (future Stage 3). These catchments ultimately drain to a series of culverts under Picton Road (2 x 1350 mm dia) and into a riparian corridor to the North which connects to Allens Creek.

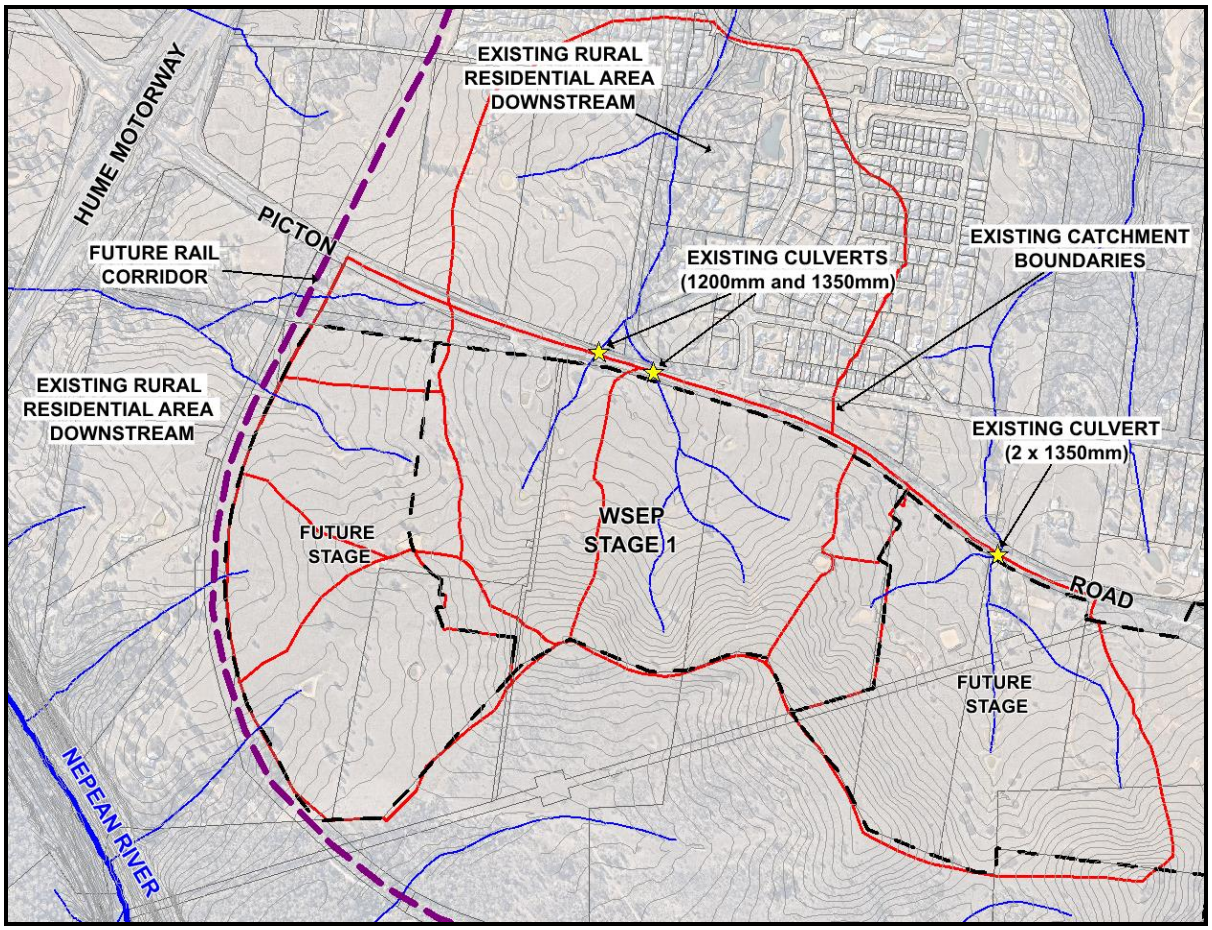


Plate 3.1 - Existing Site

4 PROPOSED DEVELOPMENT

Stage 1 includes 696 lots across a range of residential densities (small to large lot, terrace, villa and courtyard) with associated roads and open space (active, local and passive). Refer to Plate 4.1.

An entry road is located along the northern edge of Stage 1 which provides vehicular access off Picton Road. A future commercial enterprise area is positioned between Stage 1 and Picton Road and will form part of a future DA.

The proposed development will include a series of co-located raingarden / detention basins to manage stormwater quality and quantity. These include:

- **"Interim Basin West"** – located to the west of Stage 1, the interim basin will attenuate and treat runoff prior to discharging overland into land owned by Walker Corporation. The basin is targeted towards ensuring that peak flows are not increased into adjacent properties to the west. The location of the basin has also been positioned to align within the future park / basin which will be constructed in Stage 2.

- **"Interim Basin East"** – located to the east of Stage 1, the interim basin will attenuate and treat runoff prior to discharging overland into land owned by Walker Corporation. The basin is targeted towards ensuring that peak flows are not increased at the existing culvert under Picton Road. The location of the basin has also been positioned to align within the future park / basin which will be constructed in Stage 3.

- **"Basin 4A"** - located in the northern portion of Stage 1, the basin will attenuate and treat runoff for the western portion of Stage 1. The basin will include provision for open space, whilst also providing a detention function.

- **"Basin 4B"** – also located in the northern portion of Stage 1, the basin will attenuate and treat runoff for the central portion of Stage 1. The basin will include provision for open space, whilst also providing a detention function.

See further discussion in Section 6 about how the Stage 1 strategy will dovetail into the overall WSEP water cycle management strategy.

Consistent with the overall WCM Strategy (JWP, 2014), bio-retention raingardens are strategically positioned across Stage 1 to ensure that water quality objectives are achieved. These raingardens are generally co-located in each of the detention basins, whilst a small additional device is also located alongside the entry road.

Refer to Figure 4.1 for the Stormwater Concept Plan.

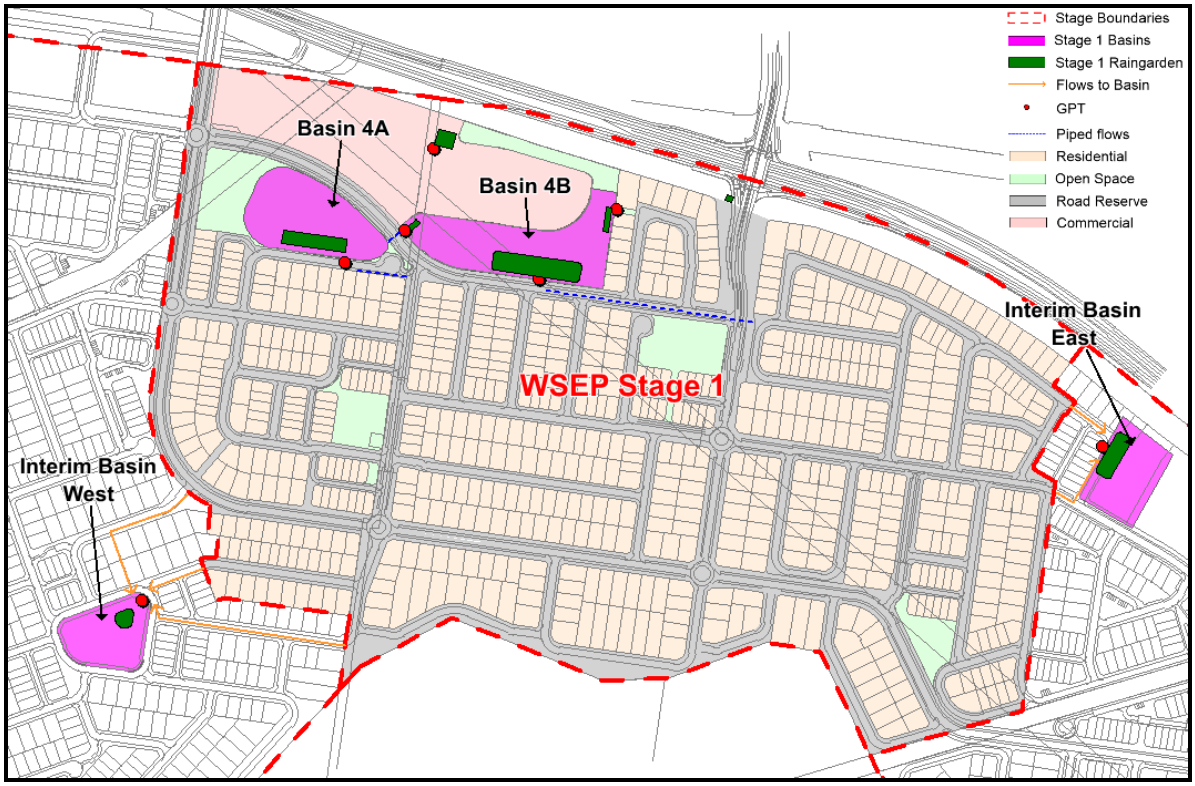


Plate 4.1 – Proposed Site

5 DEVELOPMENT GUIDELINES, OPPORTUNITIES & CONSTRAINTS

Several guidelines were considered in the development of the WCM Strategy for Stage 1. These are summarised in Sections 5.1 to 5.3 below.

5.1 Draft Wollondilly Shire Council Growth Area Precincts Development Control Plan (DCP) 2018

The NSW Department of Planning & Environment are currently in the process of writing the DCP for Growth Centre Precincts within the Wollondilly Shire Council LGA.

It is expected that the Growth Centre Precincts DCP identifies the following objectives with regard to flooding and water cycle management:

- To manage the flow of stormwater from urban parts of the Precinct to replicate, as closely as possible, pre-development flows.
- To define the flood constraints and standards applicable to urban development in the Precinct.
- To minimise the potential of flooding impacts on development.

The DCP will also provide guidelines for stormwater quality from urban developments within the Growth Centre Precinct. The DCP will nominate quantitative post construction phase stormwater management objectives for the reduction of various pollutants for a range of new developments. The expected criteria for the site are nominated as follows:

Table 2-1: Water quality and environmental flow targets

	WATER QUALITY % reduction in pollutant loads				ENVIRONMENTAL FLOWS Stream erosion control ratio[1]
	Gross Pollutants (>5mm)	Total suspended solids	Total phosphorous	Total nitrogen	
Stormwater management Objective	90	85	65	45	3.5-5.0: 1
'Ideal' stormwater outcome	100	95	95	85	1:1

[1] This ratio should be minimised to limit stream erosion to the minimum practicable. Development proposals should be designed to achieve a value as close to one as practicable, and values within the nominated range should not be exceeded. A specific target cannot be defined at this time.

The DCP will also nominate a 'stream erosion index' target most likely 3.5 – 5.0, where the stream erosion index is defined as the post-development duration of flows greater than the 'stream-forming flow' divided by natural duration of flows greater than the 'stream-forming flow'. For the purposes of these objectives, the 'stream forming flow' is defined as 50% of the 2-year flow rate estimated for the catchment under natural conditions.

5.2 Wollondilly Design Specifications – Subdivision and Engineering Standards

Section D5 of Wollondilly Shire Council's *Subdivision and Engineering Standards (2016)* is applicable to the management of stormwater and water quality for the proposed site. The modelling parameters considered in this assessment are discussed below.

5.2.1 XP-RAFTS Hydrologic Modelling

Where hydrologic modelling is carried out using *XP-RAFTS*, Section D5.07 of Council guideline provides the following parameters that shall be used in this type of modelling:

Table 5.1– Initial and Continuing Loss

Initial Loss:		Continuing Loss :	
Impervious	1 mm	Impervious	0 mm/hr
Pervious	10 mm	Pervious	2.5 mm/hr

It is noted that these values have slightly changed from Council's previous DCP (WSC,2008) which was relevant at the time of the overall WCM Report (JWP, 2014). At that time, the initial losses were listed as 10 mm Impervious and 0 mm pervious, whilst the continuing losses were listed as 0 mm/hr impervious and 2.5 mm/hr pervious.

Details of percentage impervious for various land uses are given in Table D5.1 of the Wollondilly Shire Council's *Subdivision and Engineering Standards (2008)* and should be used where actual information is not available. This table was reproduced in Table 7.1 below.

Table 5.2– Landuse

Land Use	% Impervious
Residential (450 to 699m²)	60%
Residential (700 to 1499m²)	50%
Residential (1500 to 4000m²)	40%
Rural Residential	30%
Industrial/Commercial	90%
Road Reserve	70%
Public Recreation Area	10%

5.2.2 Water Quality

Specification D5 of Wollondilly Shire Council's *Subdivision and Engineering Standards (2016)* includes a number of items related to 'Water Sensitive Urban Design' as follows:

- The main treatment measures to achieve the target stormwater quality are listed as:
  - (a) Buffer Zones and Filter Strips, being grassed, or similarly treated areas to facilitate the natural assimilation of water pollutants and reduce run-off.
  - (b) Gross Pollutant Traps (GPT) designed to intercept litter and debris to maintain visual quality in downstream waterways, and to reduce the coarse sediment load on downstream water management structures.
  - (c) Wet Retention Ponds are permanent sediment ponds designed to allow particulate matter to settle out. They operate under both sedimentation and macrophyte regimes. Note that a large proportion of nutrients adhere to the sediments, and therefore settle out. Other nutrients are removed by macrophyte vegetation as part of the food chain.
  - (d) Wetland (Nutrient) Filter to enhance the removal of fine sediment and nutrients from stormwater run-off and are largely dependent on biochemical removal mechanisms (i.e nutrients taken up as part of the plant food chain).
  - (e) Vegetated Swales provide stormwater filtration during its passage to the drainage system.

It is noted that while raingardens are not listed above in Councils main treatment measures, it is important to understand that the WSUD Policy outlined in the document does not preclude the use of raingardens as a treatment solution. In fact, the same document, in section D5.36, provides guidance on the implementation of "Bio-retention systems and raingardens" as a WSUD treatment measure in new developments.

- Council's DCP indicates that in the absence of site-specific data, the designer shall refer to Australian Standard 'Australian Runoff Quality – a Guide to Water Sensitive Urban Design' (EA, 2007) for pollutant loads and design of the treatment system.

  It is noted however that we have adopted the more recent guidelines for the pollutant loading rates in this Study as defined by the NSW MUSIC Guidelines (CMA, 2015).

- Gross pollutants and course sediment shall be treated to a flow rate of 60L/s/ha.

- For a development site greater than 2 ha, permanent treatment systems are to be implemented and designed for the 3 month ARI with the exception of constructed wetlands which are to be designed so that post development stormwater loads (Ryde Council 2001) meet the objectives of the Healthy Rivers Commission Inquiries.

- The volume of runoff and hydrograph shape for existing stormwater runoff from the site up to the 2 year ARI storm event shall be maintained when the site discharges into a creek or natural water course. The flow rate and the frequency of the 2 year ARI event shall not differ from the existing runoff from the site. Details as to how this is to be achieved shall be submitted with the Engineering Plans.

- Stormwater detention and treatment systems shall be constructed off-line of any watercourse, regardless of the order of the stream

- Larger developments shall develop a water quality monitoring program for the site. Details of the monitoring shall be submitted as part of the site planning requirements.

- Unless otherwise required in the development consent, the treatment objectives in the table below, shall be met by provision of stormwater treatment measures:

Table 5.2 – Healthy Rivers Commission Targets

Pollutant	Description	Treatment Objective
Gross Pollutants	Trash, litter and vegetation larger than 5 mm	70% of the load
Coarse Sediment	Contaminant particles between 0.1 mm and 5 mm	80% of the load
Fine Sediment	Contaminant particles 0.1 mm or less	50% of the load
Nutrients	Total phosphorus Total nitrogen	45% of the load. 45% of the load
Hydrocarbons, motor oils, oil & grease		Whichever is greater: 1. 90% of the load; or 2. Total discharge from site of Total Petroleum Hydrocarbons (TPH) <10 mg/L at all times.

It is important to note that Council's policy currently specifies a different treatment objective percentage for coarse and fine sediments. There is currently no modelling software available on the market that can differentiate treatment between coarse and fine sediments. "MUSIC" is the industry-accepted program used for such analysis and performs assessments upon "Total Suspended Solids" (TSS). Most coarse sediment will be captured in the GPT's that will from part of the development. The modelling demonstrates that the finer TSS particles will be managed to the required levels and, by default, the coarse sediment will be also managed to a much higher standard than the Council target of 80% of the load. Refer to the MUSIC assessment in Section 7.

It is also noted that the treatment objective for total phosphorus is listed at 45% removal. It is noted that the "Draft" DCP lists this removal target at 65% of the load.

5.3 Healthy Rivers Commission Targets

The required (mean) concentration pollution reduction targets are those targets set out in Table 2 of the Healthy Rivers Commission (HRC, 2000). Details of the required targets are provided below in Table 5.4. Wilton South East Precinct is located within the "Mixed use rural areas and sandstone plateau" classification.

Table 5.4 – HRC Targets

Water Quality Indicator (all values µg/l)	Forested areas and drinking water catchment	Mixed use rural areas and sandstone plateau	Urban areas - main streams	Urban areas - tributarry stream	Estuaries areas
Total Phosphorus					
NWQMS range	10-100	10-100	10-100	10-100	n/a
HRC recommendation	**50** [(b)]	**35**	**30**	**~50**	**30**
Measured range (a)	7.-50	10-740	10-100	50-360	15-30
Total Nitrogen					
NWQMS range	100-750	100-750	100-750	100-750	n/a
HRC recommendation	**700** [(b)]	**700**	**500**	**~1000**	**400**
Measured range (a)	100-800	200-3200	400-2200	500-15000	200-500

6 REQUEST FOR INFORMATION (RFI)

6.1 The Planning Hub RFI Letter (dated 24th September 2018)

As part of the initial review of the Stage 1 DA advice was received from The Planning Hub on behalf of Wollondilly Shire Council regarding a series of issues and requests for information relating to stormwater management, lot grading and layout, environmental issues and traffic/transport. The RFI's that relate to the *Water Cycle Management Strategy* for the Stage 1 DA have been listed below along with the necessary details to address the concerns.

Integration of the Stage 1 WCMS with the overall Wilton South East Precinct strategy

The Stage 1 WCMS includes the delivery of two (2) interim detention basins with co-located raingardens (Interim Basin West and Interim Basin East). These devices have been positioned to facilitate the future delivery of the adjacent Stage 2 (to the west) and Stage 3 (to the east). It should be noted that these interim basins are located in land to be dedicated to future permanent water management devices. Refer to Figure 6.1 for details of the Preliminary Stormwater Concept Plan in Stage 2 and 3.

For further clarity, a second Preliminary Stormwater Concept Plan has been prepared to show the proposed future development of Stages 4-6. Refer to Figure 6.2. These plans (Figure 6.1 and 6.2) together provide an understanding of the intended strategy across the entire WSEP.

At this early phase, Stage 2-6 devices are shown as indicative only and are based on preliminary water quality and water quantity modelling/calculations. Please note that the Stage 2-6 strategies are subject to further, more detailed modelling as part of future individual DA submissions.

Further hydrological modelling (XP-RAFTS) and water quality modelling (MUSIC) will be undertaken to support the future DA submissions for WSEP Stages 2-6. The results of these assessments will be consolidated into suitable Water Cycle Management Strategy Reports to provide Council with the details of the strategy outcomes.

The Stage 2 and 3 developments will involve the augmentation of the interim Stage 1 devices to deliver the ultimate, permanent water management devices. These permanent devices will ensure that flow management is achieved at the boundary of the site while the various water quality targets relating to the site will be satisfied, consistent with the Stage 1 WCMS.

It should be noted that any interim management approach will involve the stabilisation and/or construction of sediment control basins as necessary.

Impact on downstream infrastructure to be considered

The impact of WSEP Stage 1 on downstream infrastructure is managed through attenuation of flows upstream (at the property boundary). Wilton SE Stage 1 includes the delivery of two (2) permanent basins (Basins 4A and 4B) and two (2) interim basins (Interim Basin West and East). These basins will ensure that flows discharging to downstream infrastructures are attenuated to pre-development levels, ensuring that no detrimental impacts will arise as a result of development.

Further to this, the operation of the basin outlets will not be affected by any insufficiencies in the existing culverts under Picton Road. Based on survey information, the existing sag along Picton Road (downstream of Stage 1) is approximately 208 m AHD while the base RL of Basin 4A is 210 m AHD. This 2 m difference in levels will ensure that flows will overtop Picton Road before creating a tailwater impact on the Stage 1 basins.

Please note, there is no online infrastructure proposed downstream of the WSEP Stage 1 development within Bingara Gorge. The Bingara Gorge development instead relies on the reuse of stormwater within the development to achieve the necessary flow targets in Allen's Creek downstream. As such, there will be no detrimental impacts of increasing runoff volumes from WSEP Stage 1 on any downstream infrastructure.

Less focus on end of line treatment measures and consideration to be given to treatment measures throughout the catchment in accordance with WSUD principles

Distributed subdivision level treatment measures are problematic given the grading constraints of the site and, as a result, end of line devices such as raingardens and GPTs are considered to be most efficient. The end of line solution will also consolidate the maintenance regime needed by WSC in the long term.

Treatment measures throughout the catchment tend to increase the cost of maintenance when compared to centralised systems.

It is the suggestion of JWP to issue a condition of consent for the assessment of waterway health through a detailed stream erosion index (SEI) assessment at construction certificate (CC) stage of development.

WCMS to extend to Stage 2 with strategy for both interim and ultimate management of runoff

The WCMS Report that was submitted to Council pertains to the development of Wilton South East Precinct – Stage 1. A separate WCMS will be prepared for WSEP Stage 2 (and all subsequent stages) and will be submitted to Council as the development progresses. Notwithstanding, a preliminary strategy has been investigated to set the framework for the future delivery of WSEP Stages 2-6. Refer to Figure 6.1 and 6.2 for the Preliminary Stormwater Concept Plan for Stages 1-6. Please note, these plans are subject to further investigations as part of future development applications.

Erosion and sediment control for WSEP Stage 2 is detailed in the engineering drawings by BG&E Consulting.

Proposed ownership and management of all permanent and interim basins

It is the intention of Walker Corporation to dedicate ultimate stormwater management devices to Council. Ownership of interim devices will remain with Walker Corporation.

GPT type, maintenance schedule and maintenance access to be detailed

The GPT's that have been modelled for Wilton SE Stage 1 are ROCLA CDS Units. This vortex style GPT type uses an internal weir to divert "contaminated" runoff into a screening chamber where gross pollutants are collected and stored at the base of the device. See Plate 6.1 for details.

The GPTs that have been modelled in MUSIC have assumed that "first flush" 4 EY flows are treated by the CDS Units while higher flows are bypassed downstream for further treatment as required.

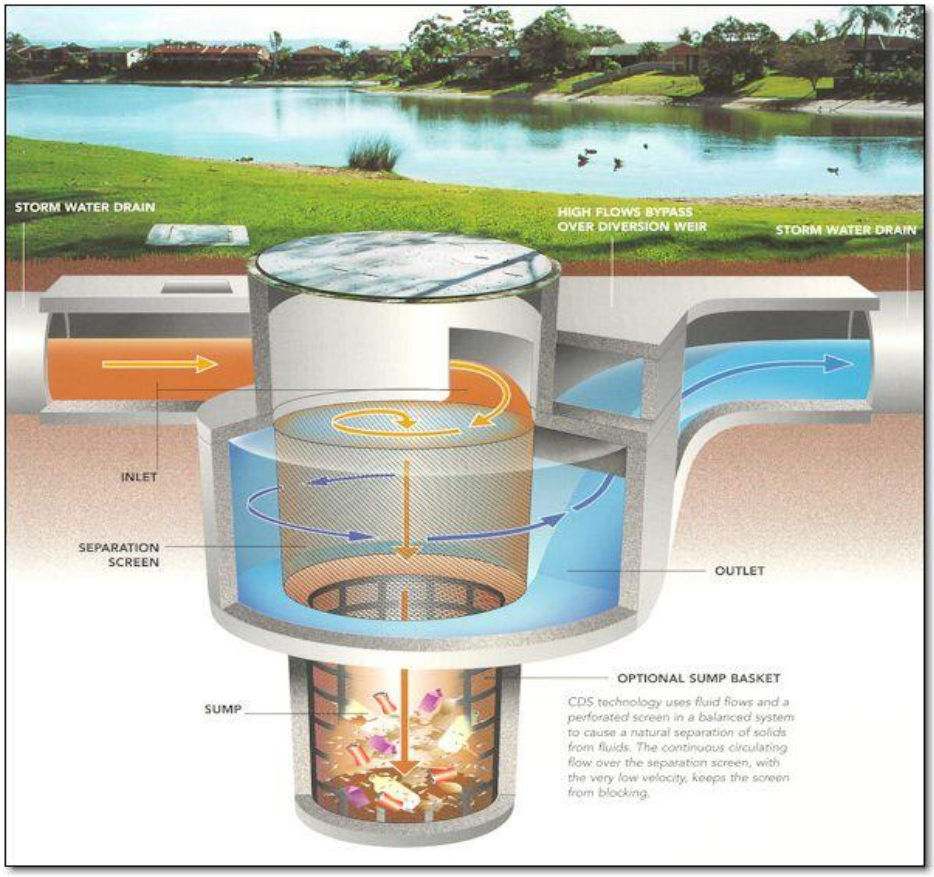


Plate 6.1 – Vortex Style GPT

A maintenance schedule has been included in Appendix D which provides details of the maintenance requirements for ROCLA CDS GPT Units. Further details will be provided in an Operation and Maintenance Manual for all stormwater management devices for Stage 1. It is suggested that this form part of the conditions of consent for WSEP Stage 1 prior to subdivision certificate approval.

Removal of watercourse will require concurrence of WaterNSW

Concurrence from WaterNSW (DPI Water) regarding the removal of watercourses has already been received for the wider Wilton Junction Precinct, encompassing WSEP. Refer to Section 9.7 of the Wilton Junction Water Cycle Management Strategy (WJWCMS) (JWP, 2014) for details of the riparian assessment that was undertaken.

The response letter from the Department of Primary Industries has been included in full in Appendix E. An excerpt from the letter pertaining to the removal of watercourses is provided below.

> *"The WJWCMS notes Wilton Junction includes a large number of 1st and 2nd order watercourses not considered to be rivers and proposed for removal and/or to be replaced by urban drainage infrastructure (section 9.7, page 32). In relation to watercourses mapped within the WSEP, DPI Water has reviewed:*
>
> - *Figure 4 – Riparian Plan (Appendix A of the WJWCMS)*
> - *Figure 13 – Photo Locations (Appendix G of the WJWCMS)*
> - *the photos of watercourses proposed for removal in the WSEP (Appendix G of the WJWCMS).*
>
> *DPI Water supports in principle the watercourse mapping that has been undertaken for the WSEP and the determination of 'rivers' under the Water Management Act 2000.*

Riparian offsetting will be required for any watercourses that are identified as 'rivers' and that are proposed for removal."

It is noted that other issues are raised in the response from DPI Water, however, these are largely related to future stages of development and will be addressed in due course. The watercourses proposed for removal within Stage 1 have received the concurrence of DPI Water that they are not 'rivers' under the Water Management Act (2000) and will therefore not require any riparian offsetting or retention.

Use of tree pits as part of stormwater treatment approach to be further discussed

As explained above, the use of subdivision level treatment devices (such as tree pits) is not considered suitable for this development. The steep nature of the site is not conducive of treatment measures throughout the catchment. Further to this, tree pits are considered to be a costly treatment option that will increase maintenance burden on Council.

Riparian buffers need to be incorporated in layout consistent with Council Natural Resource Water Layer

The Wollondilly Shire Council Natural Resource – Water Map (Local Environmental Plan (LEP), 2011) shows sensitive land offsets pertaining to riparian watercourses across the LGA. An excerpt from the Wollondilly LEP is provided below which outlines the objectives of the 'Water Protection' clause (Cl 7.3) and applies to land identified as "sensitive" on the Natural Resources – Water Map (see Plate 6.2).

"(1) The objective of this clause is to maintain the hydrological functions of riparian land, waterways and aquifers, including protecting the following:

(a) water quality,

(b) natural water flows,

(c) the stability of the bed and banks of waterways,

(d) groundwater systems…

(4) Development consent must not be granted to development on land to which this clause applies unless the consent authority is satisfied that:

(a) the development is designed, sited and will be managed to avoid any adverse environmental impact"

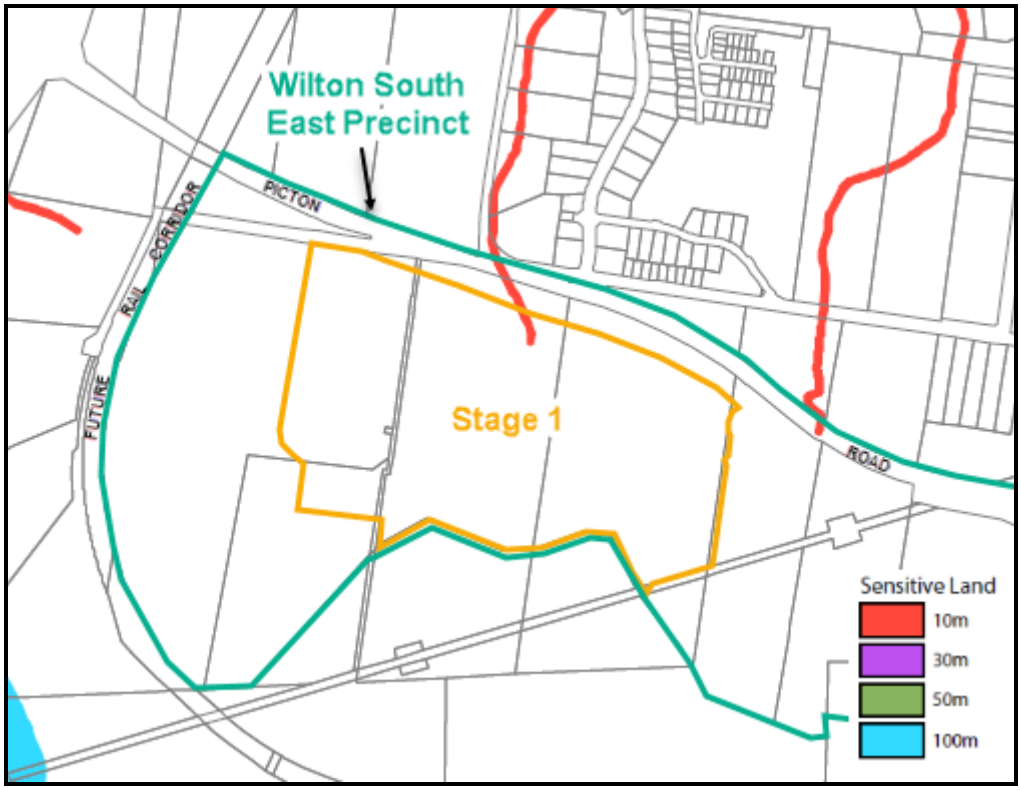


Plate 6.2 – Natural Resources – Water Map (Extract: Wollondilly LEP, 2011, Sheet NRW_011)

As can be seen in Plate 6.2, there is an existing watercourse within the WSEP Stage 1 site that is subject to the 'Water Protection' clause (Cl 7.3). However, this riparian corridor has been removed following the support of DPI Water of the riparian assessment that was completed as part of the WJWCMS (JWP, 2014). Therefore, it is our view that this clause should not apply to the land identified as "sensitive" within WSEP Stage 1.

Nevertheless, water quality and flow management are proposed as part of the Stage 1 DA and will see the "hydrological functions" of the riparian land maintained upstream of Picton Road. Further to this, Stage 1 will involve the construction of a channel to maintain the existing connectivity to Picton Road and to convey flows to the downstream waterways (via the Picton Road culverts). Further details of this channel will be provided at construction certificate (CC) stage.

BEW Pre-Post Catchment Comparison

The proposed bulk earthworks that form part of the WSEP Stage 1 DA submission will result in minor catchment alterations. Figure 6.3 presents the pre-development (existing) and post-development catchments resulting from bulk earthworks (BEW) for WSEP Stage 1 and future Stages 2 & 3. As can be seen, there are minimal increases (2%-7%) in catchment area draining to the existing Picton Road culverts (C1, C2 & C3) as a result of bulk earthworks. These increases have been modelled and will be managed in the proposed devices Basin 4A, 4B and Interim Basin East which form part of the Stage 1 Strategy (refer to Figure 4.1). These pre-post catchment increases are not expected to create any adverse impacts on the various culverts/crossings surrounding WSEP Stage 1.

7 HYDROLOGIC ANALYSIS

XP-RAFTS is a non-linear runoff routing model that generates runoff hydrographs from rainfall data. A catchment is divided into a network of sub-catchments joined by links. The links represent natural watercourses, artificial channels, or pipes. The model divides each sub-catchment into two sub-areas. A sub-area is treated as a cascading non-linear storage governed by the relationship S = b * Qn. The coefficient 'b' is calculated from catchment parameters but can be calibrated to fit observed rainfall and streamflow data.

Rainfall is applied to each sub-area. Losses (representing infiltration, interception, etc.) are subtracted from the rainfall and the excess is then converted into an instantaneous flow. This instantaneous flow is then routed through the sub-area storages to develop local subcatchment hydrographs. Total flow hydrographs at various nodes in the drainage network are calculated by combining local hydrographs. Hydrographs are transported through the drainage network by time lagging or channel routing. Hydrographs may also be routed through storage basins such as dams or detention basins.

As discussed in Section 2.1.1, the overall WCM Strategy for the Greater Wilton Junction Release Area (JWP, 2014) demonstrated that regional detention basins are not required for those areas draining direct to Nepean River, whilst a single basin is required to avoid regional impacts along Allens Creek.

Importantly though, it was also recognised that detention basins are required in locations where "developed" flows discharge into surrounding private properties and could cause adverse localised flooding impacts.

XP-RAFTS models have subsequently been created to represent both "Existing" and "Developed" conditions for Stage 1 Wilton South East Precinct. The objective was to assess the localised flooding issues and to determine the requirement and size of detention basins needed to restrict peak post development to pre development flows at key locations.

7.1 Existing Site Conditions

Sub-catchments for "Existing" site conditions have been derived from a combination of site survey information and LPMA contours. The sub-catchment division also considered the rail corridor easement and culvert positions under Picton Road.

Key locations were identified in order to enable a comparison of peak developed flows to be made against existing flows. Refer to Plate 7.1 and Figure 7.1.

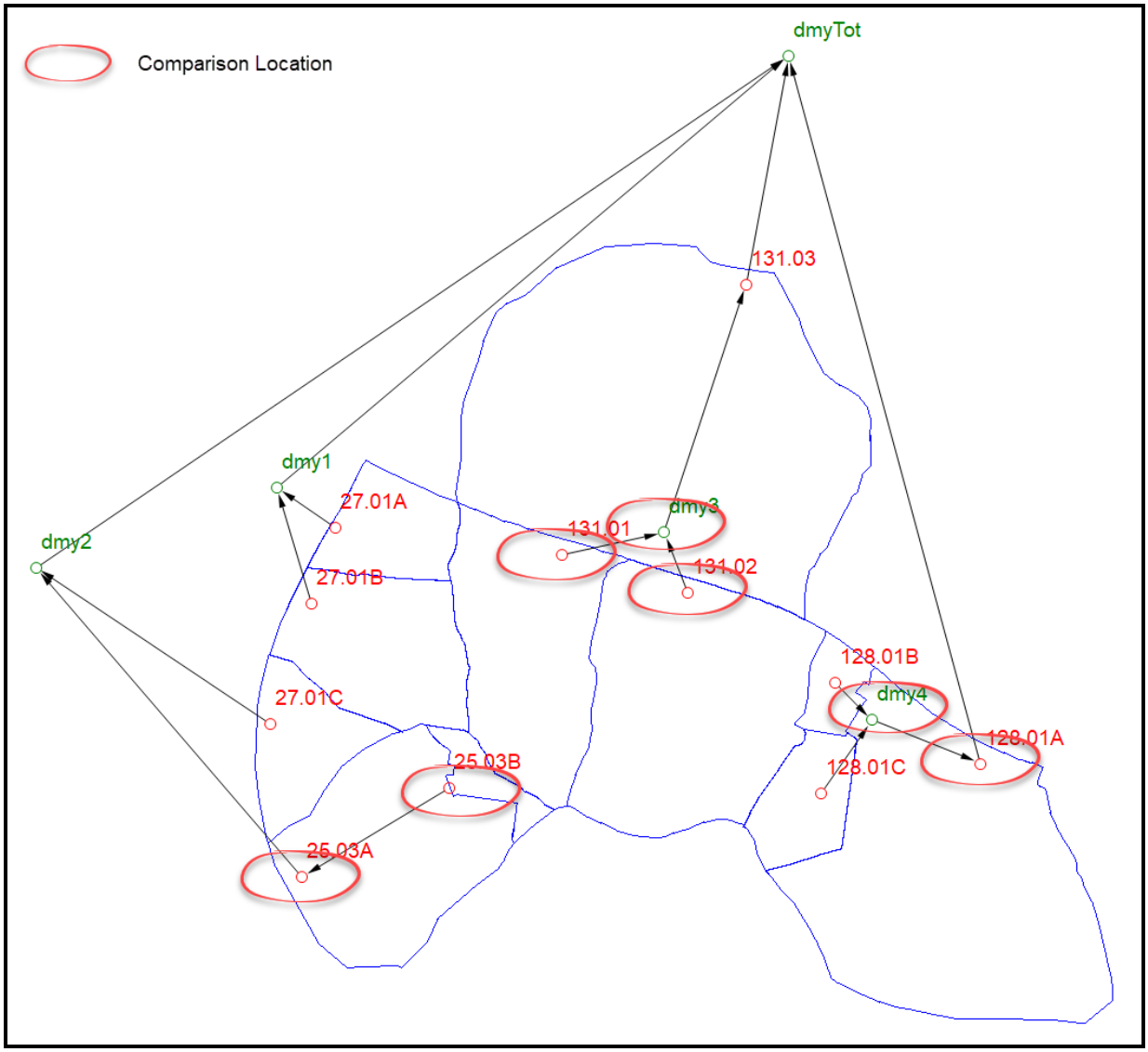


Plate 7.1 – XP-RAFTS Existing Layout (Model: 110384RA_Stage1_Existing.xp)

"Existing" XP-RAFTS model development included the following:

- Parameters have been adopted consistent with the 'base case' modelling which underlied the overall WCM Strategy (JWP, 2014). All modelling parameters including Initial and Continuing Loss, Rainfall and PERN values are summarised in Appendix B.
- All areas, slopes and fraction impervious have been measured digitally based on site survey and aerial contour information. Refer to summary table in Appendix B.
- All time lagging links are assumed to be an average of 1.5 m/s.
- A series of dummy nodes (marked in green) have been added for model connectivity and to ensure flows at the stage boundary can be understood.

7.2 Developed Site Conditions

A "Developed" site conditions model has been created to represent the current Stage 1 DA layout (as of December 2018). Refer to Plate 7.2 for model layout.

Model development of the "Developed" site conditions included the following:

- Sub-catchments have been determined based on the Stage 1 layout, road network and site grading. The proposed catchment plan is shown on Plate 7.2.
- In accordance with Council guidelines, fraction impervious values were applied based on the proposed landuse within the Stage 1 layout (i.e. 60% residential, 85% medium density, 10% open space , 70% road reserve and 90% commercial).
- All links applied at an assumed 1.5 m/s

Full details of the model parameters adopted as part of this analysis: including PERN values, initial and continuing losses and rainfall data are provided in Appendix B.

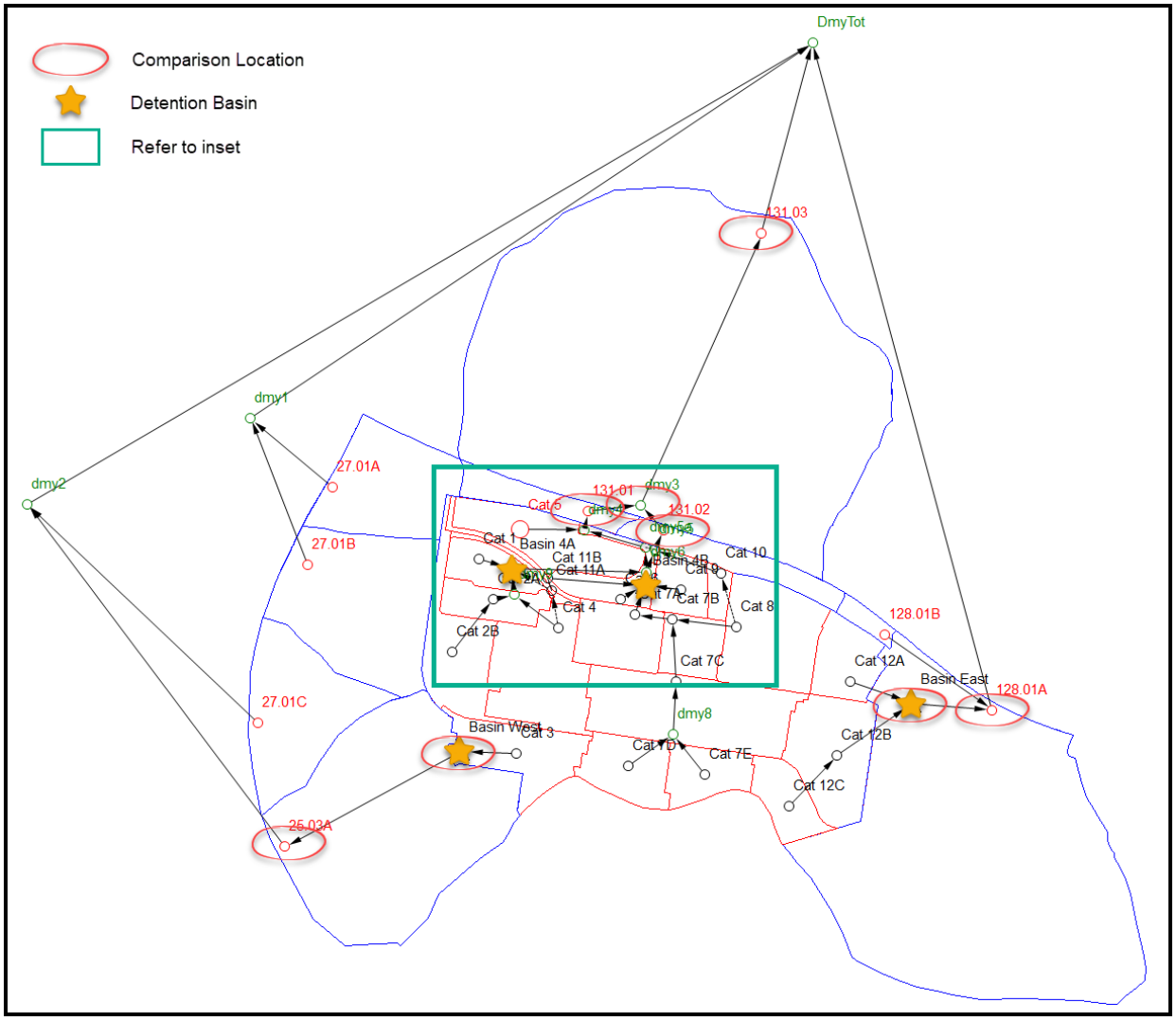


Plate 7.2 – XP-RAFTS Developed Layout (Overall) (Model: 110384RA_Stage1_Developed.xp)

The proposed configuration for the central portion of Stage 1 is shown on Plate 7.3 which includes the following:

- The developed catchment “Cat 8” (located to the East of the entry road), will have piped flows conveyed to Basin 4B with a design capacity up to the 20% AEP. Flows in excess of the pipe capacity (> 1.54 m^3/s) will then bypass the Basin 4B and drain to Picton Road. Importantly, the proposed basin(s) will attenuate developed condition flows to accommodate this bypass area.

- Two (2) dry bed detention basins are located at “Basin 4A” and “Basin 4B”.

- An outlet pipe from Basin 4A will convey flows (up to and including the 1% AEP) alongside Basin 4B with connection to the channel / swale.

- Basin 4B will discharge via a low flow pipe outlet and a high flow weir before draining via the cannel/swale to the existing two (2) culvert crossings under Picton Road. To ensure that pre – post conditions are achieved at both culvert locations, the following configuration is adopted:

  - A pipe will direct 0.95 m^3/s towards the western culvert (from "dmy6" to "dmy5a")

  - The remaining flows will be conveyed via the outlet / swale (from "dmy6" to "dmy5").

  - A weir will be included in the channel design to ensure that approximately 30 % of flows in excess of 1.77 m^3/s are directed to the western culvert.

  - The remainder of the flows will be directed to the eastern culvert.

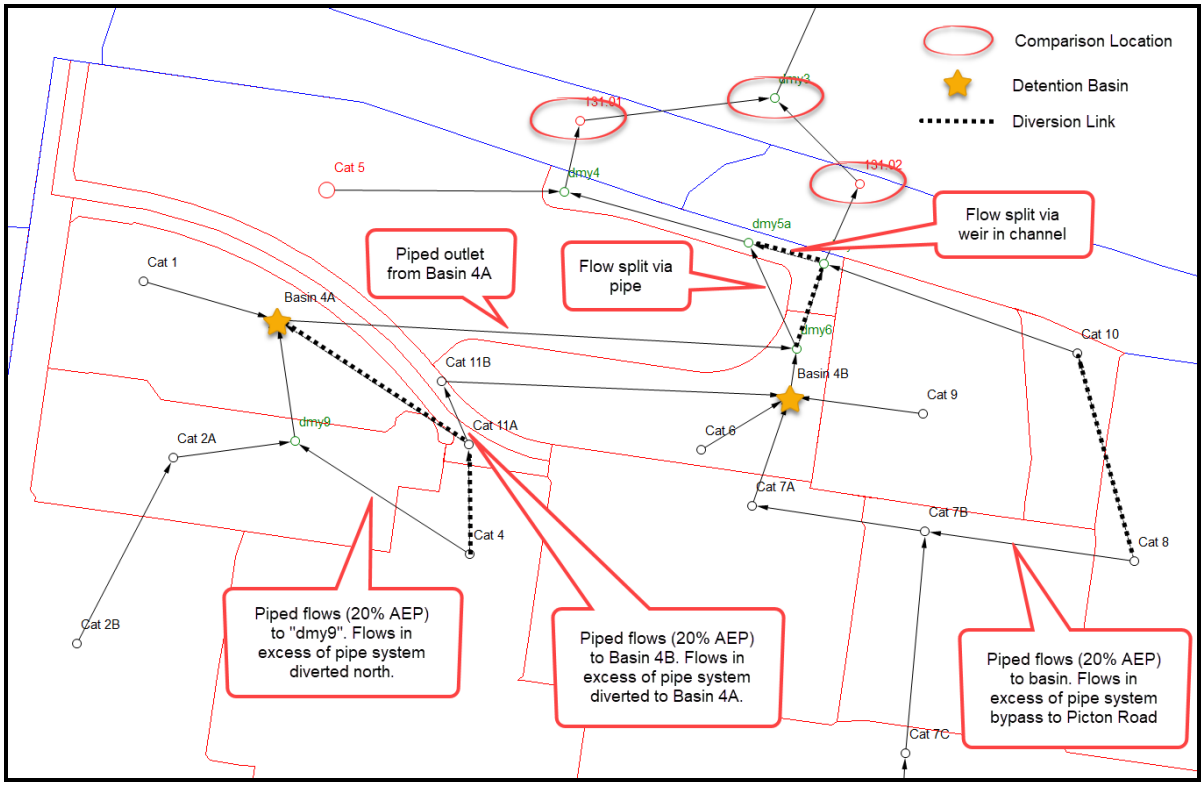


Plate 7.3 – XP-RAFTS Developed Layout (Inset) (Model: 110384RA_Stage1_Developed.xp)

7.2.1 Detention Basins

The proposed WCM Strategy for Stage 1 Wilton South East Precinct encompasses a total of four (4) detention basins to manage stormwater runoff at all key locations. These key locations are shown on Plates 7.2 and 7.3 and generally represent locations where the existing terrain naturally grades into surrounding rural – residential properties or under major culvert crossings.

The location of the four (4) detention basins are shown on Plate 7.4 below. Each of the basins are proposed to be "dry bed" and provide open space functionality whilst also including bio-retention raingarden(s) for water quality treatment. In each instance, the concept designs have made provision for the raingardens to be elevated in the upper portion of the storage to ensure plant health.

For the purposes of modelling, each basin has been represented as an above ground detention basin with a maximum detention depth of 1.2 – 1.3 m for the 1% AEP event. Preliminary stage-discharge relationships for each basin have been derived within HY-8 software.

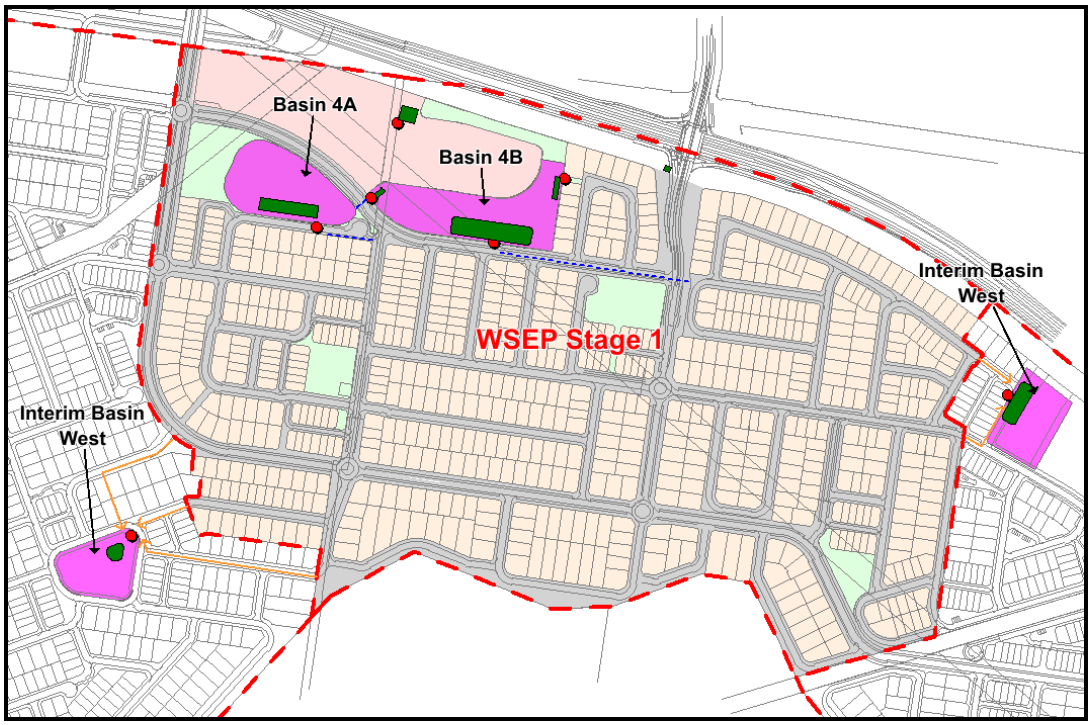


Plate 7.4 – Basin Locations

7.3 Results

Discharge estimates were derived for both the "existing" and "developed" catchments for the 0.5 EY, 20% AEP and 1% AEP events. A range of storm durations from 10 minutes to 24 hours were analysed to determine the critical storm duration. Table 7.1 to 7.3 below shows a comparison between "existing" and "developed" peak flows at each of the key comparison locations shown on Plates 7.1 and 7.2.

Table 7.1 – Comparison of Existing and Developed Peak Flows (0.5 EY)

		0.5 EY		
Location	Node	Existing	Developed	Post / Pre Ratio
West				
Stage 1 bdy	25.03B / Basin West	0.32	0.14	44%
D/S	25.03A	1.63	1.54	95%
East				
Stage 1 bdy	dmy4 / Basin East	0.99	0.53	53%
d/s picton road	128.01A	3.68	3.65	99%
North				
Culvert 1	131.01	1.49	1.38	92%
Culvert 2	131.02	2.17	2.00	92%
d/s picton road	dmy3	3.64	3.32	91%
further d/s	131.03	7.40	6.98	94%

Table 7.2 – Comparison of Existing and Developed Peak Flows (20% AEP)

		20% AEP		
Location	Node	Existing	Developed	Post / Pre Ratio
West				
Stage 1 bdy	25.03B / Basin West	0.55	0.14	25%
D/S	25.03A	2.33	2.33	100%
East				
Stage 1 bdy	dmy4 / Basin East	1.72	0.76	44%
d/s picton road	128.01A	5.79	5.70	98%
North				
Culvert 1	131.01	2.53	1.94	77%
Culvert 2	131.02	3.54	2.83	80%
d/s picton road	dmy3	6.05	4.73	78%
further d/s	131.03	11.13	10.40	93%

Table 7.3 – Comparison of Existing and Developed Peak Flows (1% AEP)

		1% AEP		
Location	Node	Existing	Developed	Post / Pre Ratio
West				
Stage 1 bdy	25.03B / Basin West	1.06	0.66	62%
D/S	25.03A	5.76	4.87	85%
East				
Stage 1 bdy	dmy4 / Basin East	3.50	2.71	77%
d/s picton road	128.01A	13.82	13.62	99%
North				
Culvert 1	131.01	5.92	5.21	88%
Culvert 2	131.02	8.40	7.65	91%
d/s picton road	dmy3	14.28	12.82	90%
further d/s	131.03	26.90	25.44	95%

Table 7.4 below also includes a summary of the detention volumes required at each basin.

Table 7.4 – Summary of Detention Volumes

Basin ID	1% AEP Volume (m^3)	Max Depth (m)
Basin 4A	5120	1.11
Basin 4B	6550	1.26
Basin West	2310	0.71
Basin East	3440	0.99

7.4 Discussion of Modelling Results

Results of the hydrological modelling show that the proposed four (4) detention basins across Stage 1 will ensure that post-development flows do not exceed pre-development flows at all key comparison locations for events up to and including the 1% AEP storm event.

The modelling therefore demonstrates that the proposed *WCM Strategy* supports the Proposed Stage 1 DA for Wilton South East Precinct and will ensure that there are no adverse impacts upon surrounding properties. The modelling of the basin outlets will be optimised at construction certificate (CC) stage to provide more efficient water quantity management outcomes while still achieving pre-post flow targets.

Basins 4A and 4B are permanent devices and will form a critical component of the long term WCM Strategy. It is noted that “Interim Basin West” and “Interim Basin East” are both temporary devices which are provided to support the delivery of Stage 1.

Similar assessments will be undertaken as part of future DA submissions by Walker Corporation. It is noted that these interim basins will be re-assessed as the development unfolds to ensure similar outcomes are achieved.

8 WATER QUALITY ANALYSIS

A water quality analysis has been undertaken using the Model for Urban Stormwater Improvement Conceptualisation (*MUSIC*). This water quality modelling software was originally developed by the Cooperative Research Centre (CRC) for Catchment Hydrology, which is based at Monash University and was first released in July 2002. Water quality modelling for the Stage 1 Wilton South East Precinct site has been undertaken using Version 6.3.

MUSIC modelling provides the following features which are relevant to Stage 1 Wilton South East Precinct:

- Determines the source pollutant loads which are generated from a variety of land uses (i.e. commercial, roads, residential, rural residential, etc)
- Ability to model the potential nutrient reduction benefits associated with Water Quality devices such as gross pollutant traps, constructed wetlands, grass swales, bio-retention systems, sedimentation basins, infiltration systems and ponds. *MUSIC* includes mechanisms which enable stormwater re-use to be used as a treatment technique
- Provides a mechanism to evaluate the attainment of both (a) Wollondilly Shire Council's Water Quality objectives; and (b) Healthy Rivers Commission targets.

The proposed WCM Strategy assessed in MUSIC includes a "treatment train" of Water Quality Control devices to treat runoff from both residential, commercial, and public domain areas prior to discharge to the downstream system. This "treatment train" includes rainwater tanks, gross pollutant traps and bio-retention raingardens.

8.1 Water Quality Objectives

Water quality objectives (WQOs) are set by both Wollondilly Shire Council and the Healthy Rivers Commission (HRC). These are listed below.

Wollondilly Shire Council Targets

It is understood that the NSW Department of Planning & Environment are currently in the process of developing a DCP for the Wilton Growth Area. Table 8.1 below presents the water quality and environmental flow targets that we have assumed will be adopted.

For the purposes of this study, the target % removal targets have been considered.

Table 8.1 – Water Quality and Environmental Flow Targets

	WATER QUALITY % reduction in pollutant loads				ENVIRONMENTAL FLOWS Stream erosion control ratio[1]
	Gross Pollutants (>5mm)	Total suspended solids	Total phosphorous	Total nitrogen	
Stormwater management Objective	90	85	65	45	3.5-5.0: 1
'Ideal' stormwater outcome	100	95	95	85	1:1

[1] This ratio should be minimised to limit stream erosion to the minimum practicable. Development proposals should be designed to achieve a value as close to one as practicable, and values within the nominated range should not be exceeded. A specific target cannot be defined at this time.

Healthy River Commission Targets

Wilton South East Precinct is located within the Hawkesbury - Nepean drinking catchment and is therefore subject to WQOs which were set by the Healthy River Commission (HRC) as part of the *Independent Inquiry into the Hawkesbury Nepean River System* (HRC, 1998).

Consistent with the overall WCM Strategy (JWP, 2014), the WQO targets which are relevant to the study areas are the *'Mixed use rural areas and sandstone plateau'*. These targets were previously agreed with the NSW EPA (email correspondence dated 25 July 2013). Refer to Table 8.2 below.

Table 8.2 – Healthy Rivers Commission Targets

Water Quality Indicator (all values µg/l)	Forested areas and drinking water catchment	Mixed use rural areas and sandstone plateau	Urban areas - main streams	Urban areas - tributarry stream	Estuaries areas
Total Phosphorus					
NWQMS range	10-100	10-100	10-100	10-100	n/a
HRC recommendation	**50** [(b)]	**35**	**30**	**~50**	**30**
Measured range (a)	7.-50	10-740	10-100	50-360	15-30
Total Nitrogen					
NWQMS range	100-750	100-750	100-750	100-750	n/a
HRC recommendation	**700** [(b)]	**700**	**500**	**~1000**	**400**
Measured range (a)	100-800	200-3200	400-2200	500-15000	200-500

Consequently the nutrient concentration targets of **0.035 mg/L Total Phosphorus** and **0.7 mg/L Total Nitrogen** apply for Wilton South East Precinct. These values are the range of average (mean) values that the Wilton Junction development will need to comply with.

8.2 Modelling Scenarios

Three (3) scenarios have been modelled in MUSIC to assess the performance of the Proposed WCM Strategy in satisfying the WQOs which have been set by both HRC and Wollondilly Shire Council. Details of the scenarios modelled are provided below:

- **Scenario 1** – Represents the proposed Stage 1 development layout with source nodes adopted based on NSW MUSIC modelling guidelines. Treatment devices are sized to ensure compliance with WQOs set by Wollondilly Shire Council.
- **Scenario 2** – Also represents the proposed Stage 1 development. Source nodes are modelled as either "urban", "park" or "road" based on pollutant generation / loading rates provided by the NSW EPA. Model is run under "wet" conditions with treatment devices sized to ensure compliance with WQOs set by the HRC.
- **Scenario 3** - Is identical to Scenario 2, but considers the "driest" year only within the rainfall data set (1967-1973) used in the assessment. This scenario will assess the influence of drought conditions on discharge concentrations.

Details of the three (3) MUSIC modelling scenarios are discussed in the following sections.

8.3 Modelling Inputs and Assumptions

8.3.1 Catchment Breakup

The Stage 1 study area has been split into twelve (12) sub-catchments based on the proposed terrain and measured digitally within GIS software. This sub-catchment breakup also considered the proposed road / pipe network, masterplan layout and natural discharge positions. Refer to Plate 8.1 and to Figure 8.1 in Appendix A for the MUSIC catchment breakup.

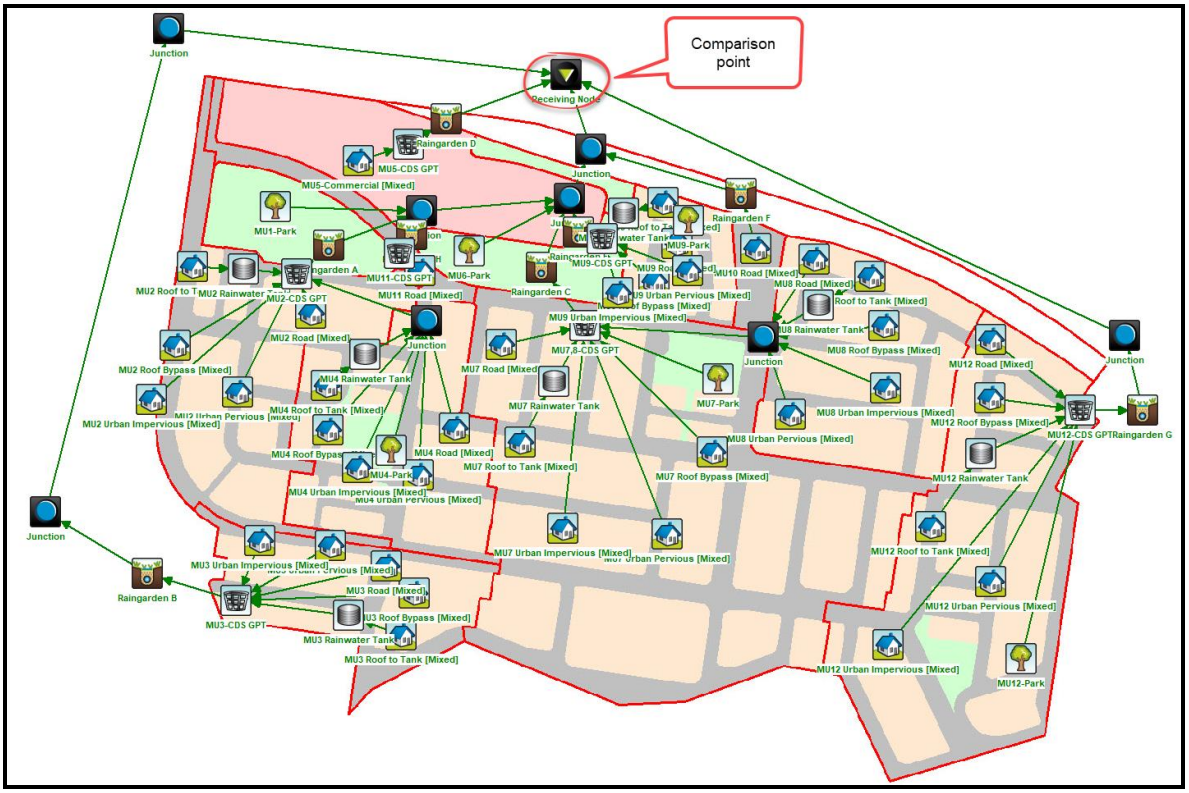


Plate 8.1: MUSIC Layout– Overall Model (110384_MU05_MUSIC guidelines.sqz)

8.3.2 Scenario 1 – Modelling to suit Wollondilly Shire Council requirements

In accordance with the *NSW MUSIC Modelling Guidelines* (CMA, 2015), each sub-catchment has been defined based on landuses including "Commercial", "Roofs" and "Roads" with each assigned to a suitable source node. Base and Storm Flow Concentration Parameters for each type of source node are summarised in Appendix C. Refer to Plate 7.2 for a sample catchment layout.

"General Urban Impervious" and "General Urban Pervious" components were also derived for the remaining areas upon residential lots in order to suit the overall fraction impervious specified in Table 8.3, whilst "Parks" are assigned for all new residential urban parks. These areas were then also assigned to a suitable source node.

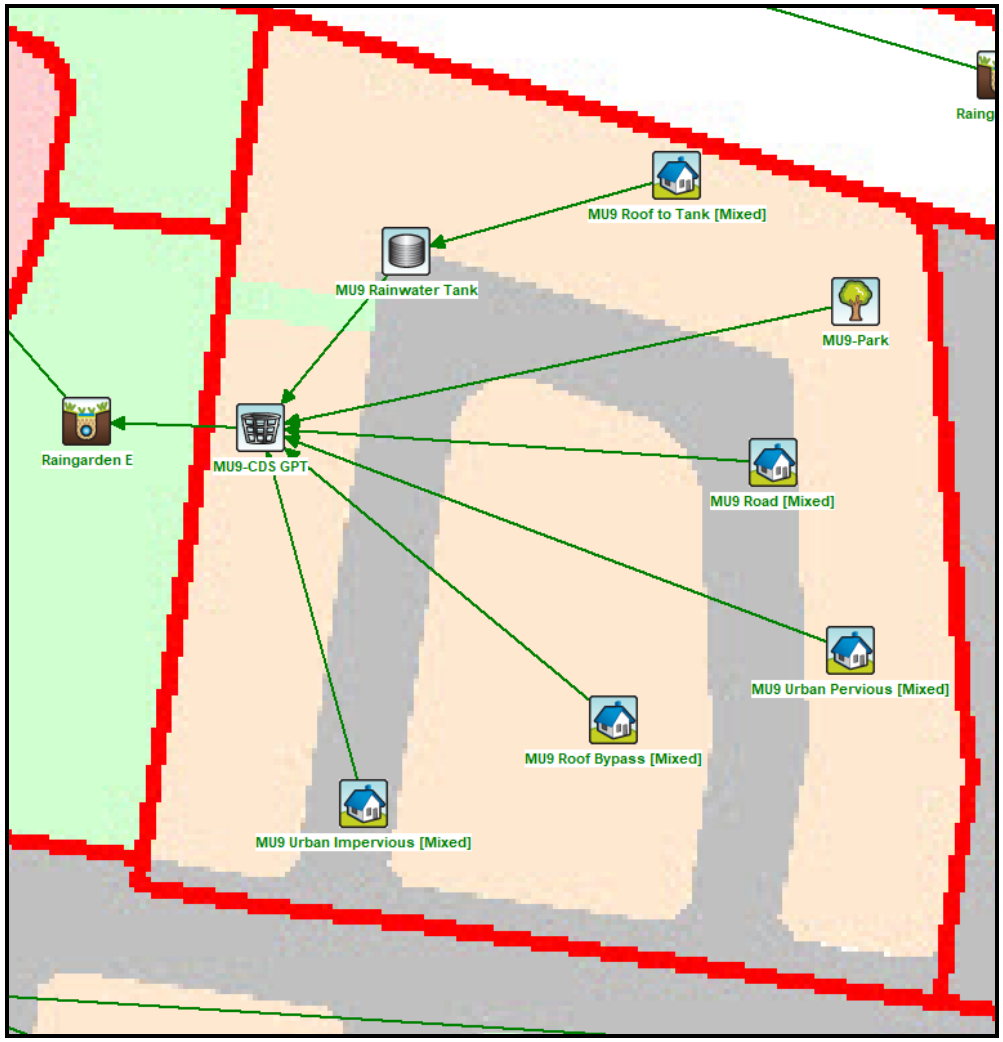


Plate 8.2: MUSIC Layout – Sample Catchment (Council) (110384_MU05_MUSIC guidelines.sqz)

Each of the following has been considered in the model development:

- Stage 1 typically includes residential areas which are classified as either "residential" or "medium residential". Each lot includes a 3 kL rainwater tank as part of the "treatment train". (n.b multi-units could also consider a combined system to specifically cater the site)
- For "residential" and "medium residential" areas, it is assumed that 50% of the residential area as "roofed" with the remaining impervious areas being assigned as "General Urban Impervious". Prior to connection to the formal drainage network, 50% of this dedicated roof area on each lot is then assumed to be connected to individual rainwater tanks for reuse on site whilst the other 50% bypasses the system.
- A commercial (enterprise) area is located between Stage 1 and Picton Road (alongside Basins 4A and 4B). This area is not included as part of the Stage 1 DA, however has been included in the MUSIC modelling given its close proximity to Stage 1 (catchment MU5).

  At this stage, it is expected that the commercial area will provide its own on-site water quality treatment measures (raingardens, cartridge systems, etc) to ensure similar WQOs are achieved. For the purposes of this report, a GPT and a raingarden have been included to provide a provisional water quality solution for this part of the catchment.

- Landuse areas in each sub-catchment have been measured digitally and are presented in the summary table in Appendix C.

  The details of percentage impervious for various land uses which are listed in Table D5.1 of the Wollondilly Shire Council's *Subdivision and Engineering Standards* (2008) have been adopted across each source node. Refer to Table 8.3 below.

Table 8.3 – MUSIC Source Nodes

Landuse	% Impervious
Residential (10 lots / hectare)	40%
Medium density (15 lots / hectare)	60%
Rural Residential	30%
Industrial / Commercial	90%
Road Reserve	70%
Public Recreation Area	10%

- Runoff from all development areas will be connected to the formal drainage network before being treated by a Gross Pollutant Trap (GPT) prior to discharge to a downstream raingarden.

  Consistent with the overall WCM Strategy (JWP, 2014) a Vortex style GPT node has been adopted in MUSIC with a 3 month ARI high flow bypass. Refer to Appendix C for parameters adopted.

  Raingardens are co-located within detention basins to provide water quality treatment. Consistent with the overall WCM Strategy (JWP, 2014) an orthophosphate content of 36.9 mg/kg has been typically adopted at each raingarden. Refer to Appendix C for details of parameters adopted.

- The proposed entry road to Stage 1 grades from Picton Road up into the site and adjoins the internal east – west road. This area will bypass raingarden(s) at the nearby detention basins and therefore requires a standalone raingarden along the site frontage (i.e MU10).

8.3.3 Scenario 2 – Modelling to suit HRC requirements (Wet Condition)

HRC guidelines specify that the water quality objectives are *"indicative targets for management action in dry weather".* It is important to note that MUSIC modelling assesses "All Weather" continuous data sets at typically 6 min time steps (including both storm and dry weather conditions).

Consistent with the overall WCM Report (JWP, 2014), Scenario 2 has been undertaken for Stage 1 Wilton South East Precinct based on the pollutant generation rates specified by EPA (See table in Appendix C).

Each of the following has been considered in model development:

- Sub-catchments have been split into "Road", "Urban" or "Park" with the fraction impervious adopted as 70%, 60% and 10% respectively based on Table 8.3. A sample catchment is shown on Plate 8.3.
- All residential areas have been modelled as "urban" as defined by the NSW EPA pollutant summary table. See table in Appendix C.
- Due to the absence of "Roads" within the NSW EPA pollutant summary table, all "Roads" have been modelled as per NSW MUSIC guidelines.
- Due to the absence of Parks or Open Space within the EPA pollutant summary table, all "Parks" have been modelled as "Forest".
- Rainwater tanks have been conservatively excluded given the "urban" node does not give the ability to breakdown areas into "roof" areas.

- Raingarden sizes are kept consistent with those included in Scenario 1. The Orthophosphate Content of the filter media has been set in all raingardens at 36.9 mg / kg in order to achieve desired targets.

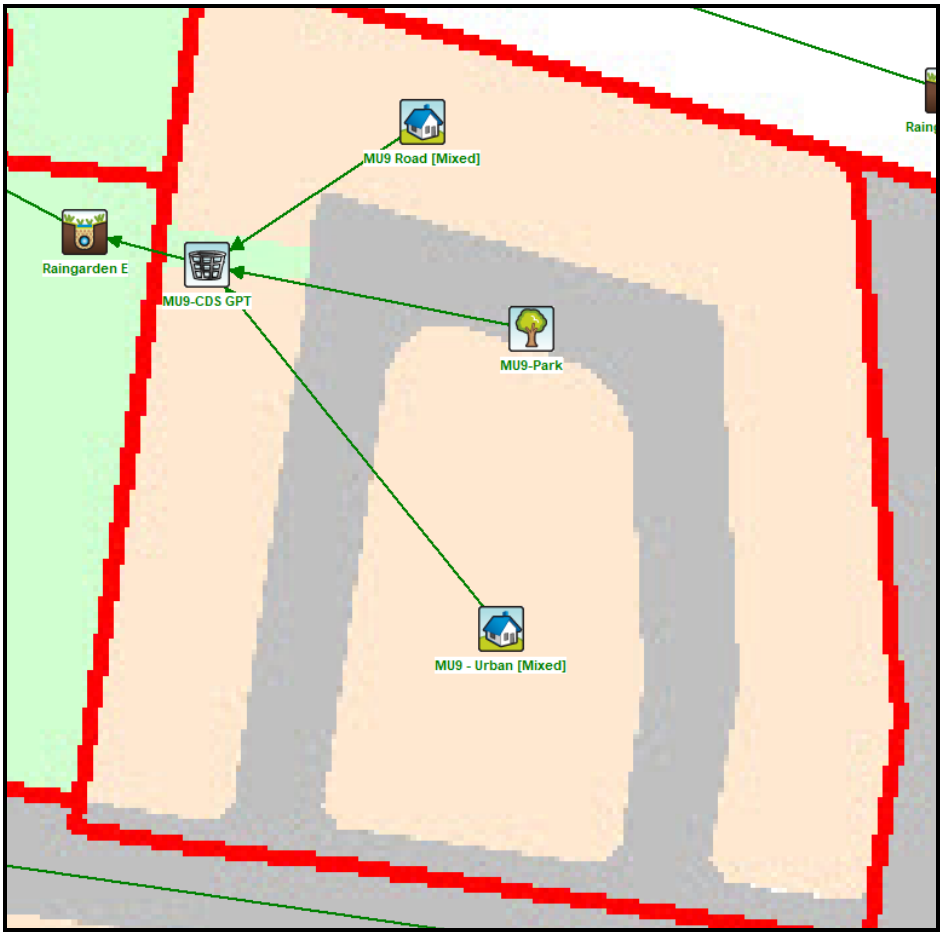


Plate 8.3: MUSIC Layout – Sample Catchment (HRC) (110384_MU04_EPA (All Weather).sqz)

8.3.4 Scenario 3 – Modelling to suit HRC requirements (Dry Condition)

The Scenario 3 model is identical to Scenario 2 but considers the "driest" year only within the rainfall data set (1967-1973) used in the assessment. This scenario will assess the influence of drought conditions on discharge concentrations across Wilton Junction.

The year 1968 was selected as the "driest" year within the 6 minute dataset used in Scenario 2. The total annual rainfall of 506.5 mm is well below the median rainfall of 822 mm. Refer to Table 8.4 for average yearly rainfall used in this assessment.

Table 8.4– Rainfall statistics (1967-1973 Whitlam Centre, Liverpool)

Rainfall Statistics (1967-1973)	
mean annual rainfall (mm)	822
Year	**annual rainfall (mm)**
1967	871.6
1968	**506.5**
1969	1165.3
1970	825.4
1971	658.1
1972	893.4
1973	873.4

The adjusted range of rainfall data was then incorporated within the MUSIC model.

8.4 Proposed Devices

The Proposed WCM Strategy for Stage 1 of Wilton South East Precinct includes the following "treatment train" of devices:

- 3kL rainwater tank on each lot.
- Gross pollutant traps at each discharge point to basin or raingarden.
- Eight (8) bio-retention raingardens with a total filter area of approximately 5,240 m^2 – generally co-located within detention basins plus an additional standalone device at the entry road.
- On-lot treatment (GPT with raingarden or proprietary devices) for the future commercial area.

Refer to Figure 4.1 in Appendix A show the location of Water Quality devices.

8.5 Modelling Results

Iterations have been undertaken within each of the MUSIC models to ensure that each raingarden device is sized to satisfy both HRC and Wollondilly Shire Council requirements.

The sizes of raingarden devices are summarised in Table 8.5 below and are shown on Figure 4.1. Sections 8.5.1 to 8.5.3 present the findings of the assessment with discussion.

Table 8.5 - Summary of Minimum Raingarden Sizes

Raingarden ID	Location	Filter Area (m^2)
A	Basin 4A	1,110
B	Basin West	360
C	Basin 4B	2,170
D	Commercial	410
E	Basin 4B	170
F	Entry	30
G	Basin East	910
H	Basin 4B	80

Each raingarden treatment nodes adopted in *MUSIC* included an extended detention depth of 0.3m and a high flow bypass set at the 3 month ARI event.

8.5.1 Scenario 1 Results (based on Wollondilly Shire Council requirements)

The combined performance of the Proposed WCM devices across Stage 1, when compared against Council's WQOs is summarised below in Table 8.6.

Table 8.6 - Summary of Scenario 1 MUSIC Results

Pollutant	Total Developed Source Nodes	Minimum Reduction Required	Total Residual Load from Site	Total Reduction Achieved	Target Reduction Required	Total Reduction Achieved
	(kg/yr)	(kg/yr)	(kg/yr)	(kg/yr)	(%)	(%)
TSS	51400	43690	7720	43680	85.0%	85.0%
TP	96.9	63.0	29.4	67.5	65.0%	69.7%
TN	652	417.3	283	369.0	45.0%	56.6%
Gross Pollutants	7610	6849	197	7413	90.0%	97.4%

Results demonstrate that the minimum pollutant removals are achieved for Total Suspended Solids, Total Phosphorus and Total Nitrogen.

8.5.2 Scenario 2 and 3 Results (based on HRC requirements)

Results of Scenario 2 and 3 demonstrate that the concentration WQOs specified by the EPA are achieved.

Table 8.7 - Summary of Scenario 2 and 3 MUSIC Results

	Concentration (mg/L)			
	TSS	TP	TN	Flow (ML/yr)
RECOMMENDED DRY WEATHER INDICATIVE WATER QUALITY OBJECTIVES[1]				
Mixed Use Rural Areas and Sandstone Plateau WQOs (Dry Weather)	-	0.035	0.7	
AVERAGE POLLUTANT DISCHARGE CONCENTRATIONS - DERIVED FROM MUSIC				
Scenario 2 - Site Developed as per EPA requirements[2]	2.44	0.035	0.439	267
Scenario 3 - Site Developed under dry weather conditions[3]	1.62	0.026	0.309	140

Notes

1. Dry Weather Water Quality Objectives Specified by HRC for the Hwakesbury Nepean River System (1998)
2. Based on Nutrient Generation Rates for various landuses provided by the EPA 25/7/13
3. Rainfall data run under the most dry year (1968) from the dataset

8.5.3 Discussion

The *MUSIC* modelling demonstrates that the combination of rainwater tanks, gross pollutant traps, bio-retention raingardens will, when configured according to the "treatment train" proposed for Stage 1 Wilton South East Precinct, reduce the priority pollutant loads to the required minimum concentration targets for a *"Mixed Use Rural & Sandstone Plateau"* as nominated by the EPA and the Healthy Rivers Commission.

It is important to note that the MUSIC results presented for Scenario 2 in this report are for "All Weather" conditions, yet still achieve the "dry weather" condition targets under Scenario 3 as stipulated in the HRC documentation.

Similarly, the more traditional pollutant removal targets (85%, 65%, 45%) which are likely to be included in the DCP for the area have also been achieved. Consequently, the WCM Strategy proposed comfortably achieves the required water quality objectives.

9 SUMMARY/CONCLUSION

This report details the investigations and presents the results of the WCM Strategy to support the Stage 1 DA at Wilton South East Precinct.

The proposed WCM Strategy for the development of Stage 1 will consist of:

- 3kL rainwater tank on each lot.
- Gross pollutant traps at each discharge point to basin or raingarden.
- Four (4) detention basins with a total active storage of approximately 17,420 m^3 (in the 1% AEP flood event).
- Eight (8) bio-retention raingardens with a total filter area of approximately 5,240 m^2 – generally co-located within detention basins plus an additional standalone device at the entry road.
- On-lot treatment (GPT with raingarden or proprietary devices) for the future commercial area.
- Swale / channel from the outlet of Basin 4A and 4B through to the existing culverts under Picton Road. Configuration to include flow splits as discussed in Section 7.2 to match pre-post at each culvert location.

Results demonstrate that the proposed detention basins will ensure that peak post development discharges are restricted to less than the pre development levels at all key comparison locations.

Water quality results also show that the proposed 'treatment train' of devices (rainwater tanks, gross pollutant traps and raingardens) will, when configured in accordance with the Strategy deliver the Water Quality Objectives set by both NSW EPA and Wollondilly Shire Council and the envisaged Growth Centre DCP. The proposed works are provided on engineering design drawing set by BG&E Consultants.

This strategy also sets out the framework for the future Stages 2-6 to ensure WSC are provided with the initial vision for water management within WSEP.

We see that this WCM Strategy provides the necessary modelling details to support the Stage 1 DA submission. If you require any additional information, please do not hesitate to contact the undersigned on (02) 4720 3340.

Yours faithfully

J. WYNDHAM PRINCE

DAVID CROMPTON

Manager – Stormwater and Environment

10 REFERENCES

1. Australian Rainfall and Runoff (ARR, 1987)

2. Catchment Management Authority (CMA, 2015) *NSW MUSIC Modelling Guidelines* (Ref: R.B17048.001.05.landscape.docx dated August 2015)

3. Engineers Australia (EA, 2007) *Australian Runoff Quality: A Guide to Water Sensitive Urban Design*

4. Healthy Rivers Commission (HRC, 1998*) Independent Inquiry into the Hawkesbury Nepean River System* (dated August, 1998)

5. J. Wyndham Prince (JWP, 2014) *Water Cycle Management Strategy – Wilton Junction* (Rev B dated 16th June 2014)

6. NSW Office of Water (NOW, 2012) *Riparian Corridor Guidelines.*

7. Willing & Partners Pty. Ltd. (1994). Runoff Analysis & Flow Training Simulation. Detailed Documentation and User Manual, Version 4.0

8. Willing & Partners Pty. Ltd. (1996). Runoff Analysis & Flow Training Simulation. Addendum, Version 5.0

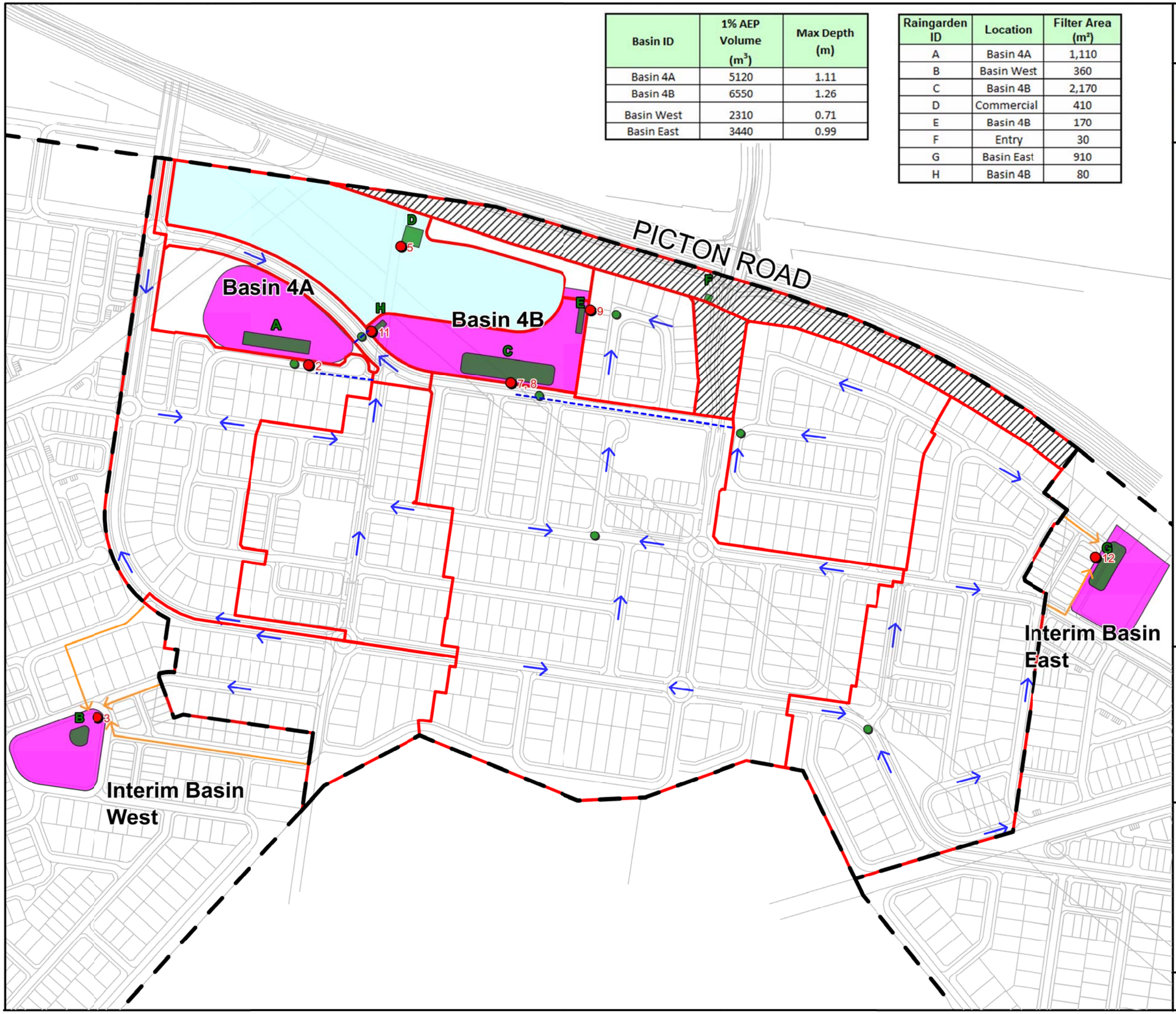
9. Wollondilly Shire Council DCP (WSC, 2011) - *Wollondilly Development Control Plan 2011*

10. Wollondilly Shire Council (WSC, 2016) – *Wollondilly Design Specification – Subdivision and Engineering Standards*

APPENDIX A – Figures

Basin ID	1% AEP Volume (m^3)	Max Depth (m)
Basin 4A	5120	1.11
Basin 4B	6550	1.26
Basin West	2310	0.71
Basin East	3440	0.99

Raingarden ID	Location	Filter Area (m^2)
A	Basin 4A	1,110
B	Basin West	360
C	Basin 4B	2,170
D	Commercial	410
E	Basin 4B	170
F	Entry	30
G	Basin East	910
H	Basin 4B	80



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LEGEND

- Catchment
- Bypass Area
- Stage 1 Raingarden
- Stage 1 Basin
- Flows to Basin
- 11 GPT / GPT ID
- Local Sag
- Piped flows only
- Commercial (On lot treatment)
- Overland Flow

N W E S

Scale 1: 4,000 @ A3

200 0 200 m

Figure 4.1
Wilton SE Precinct

Stormwater Concept Plan

File Name: 110384 Fig4.1 SWMS
Date : 19/12/18 Issue : A

Stage	Basin	Volume (m³)
Stage 1	4A	5,120
	4B	6,550
	St 1 Total	**11,670**
Stage 2	1	5,000
	1A	2,500
	2	4,500
	3A	6,000
	3B	
	3C	
	St 2 Total	**18,000**
Stage 3	5	16,000

Stage	Raingarden	Filter Area (m²)
Stage 1	A (Basin 4A)	1,110
	C (Basin 4B)	2,170
	D (Commercial)	410
	E (Basin 4B)	170
	F (Entry)	30
	H (Basin 4B)	80
	St 1 Total	**3,970**
Stage 2	1	840
	1A	400
	2	830
	3	1,010
	Roadside Swale 4A	20
	St 2 Total	**3,100**
Stage 3	5	3,810
	6	310
	St 3 Total	**4,120**
	Total	**11,210**

Roadside Swale 4A
CORRIDOR
Basin 4A
Basin 4B
PICTON ROAD
Basin 3
RAIL
Stage 2
Stage 1
Basin 2
Basin 1a
Basin 1
FUTURE
Basin 5
Raingarden 6
Stage 3

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LEGEND

- Future co-located OSD basin/raingardens with indicative size
- Future raingarden (No OSD)
- Commercial / Industrial (On lot treatment)
- Existing pipe / culvert
- Existing flowpath
- Proposed Future Easement / Flowpath
- Stage 1 Basin
- Stage 1 Raingarden
- GPT at lowpoint
- Catchment
- Staging Boundary

Notes
* Trunk Drainage Corridor assumed to be required at 15Ha
* Future Detention Basin Volumes are based on preliminary XP-RAFTS modelling. 12d modelling is required to confirm exact configuration.
* Future Raingardens based on preliminary MUSIC modelling.

N
W E
S

Scale 1: 7,000 @ A3

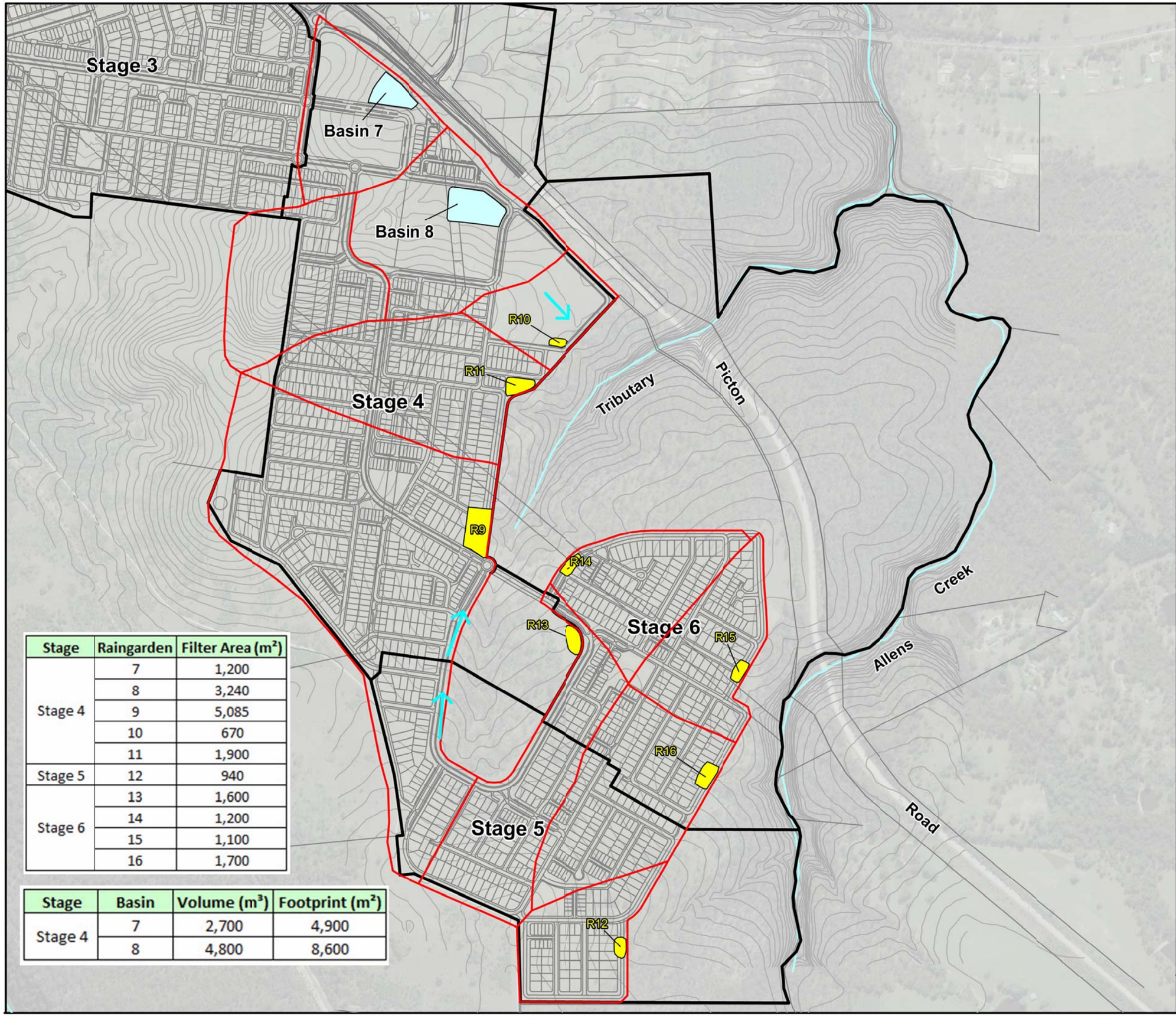
200 0 200 m

Figure 6.1
Wilton SE Precinct

Preliminary Stormwater Concept

Stages 1-3

File Name: 110384 Fig6.1 Stage 1-3
Date : 19/12/18 Issue : A



Stage	Raingarden	Filter Area (m²)
Stage 4	7	1,200
	8	3,240
	9	5,085
	10	670
	11	1,900
Stage 5	12	940
Stage 6	13	1,600
	14	1,200
	15	1,100
	16	1,700

Stage	Basin	Volume (m³)	Footprint (m²)
Stage 4	7	2,700	4,900
	8	4,800	8,600

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LEGEND

- Future co-located OSD basin/raingardens with indicative size
- Future raingarden (No OSD)
- Contributing Catchment
- Staging Boundary
- Proposed Catchment Diversion

Notes
* Detention Basin Volumes and Footprints are based on preliminary XP-Rafts modelling. Footprints claculated with assumed average depth of 0.7 m and additional 25% for batters and curtilage.
* Raingarden sizes are based on percentage of catchment calculations. Filter areas assumed at 1.5% of contributing catchment.

N W E S

Scale 1: 8,000 @ A3

200 0 200 m

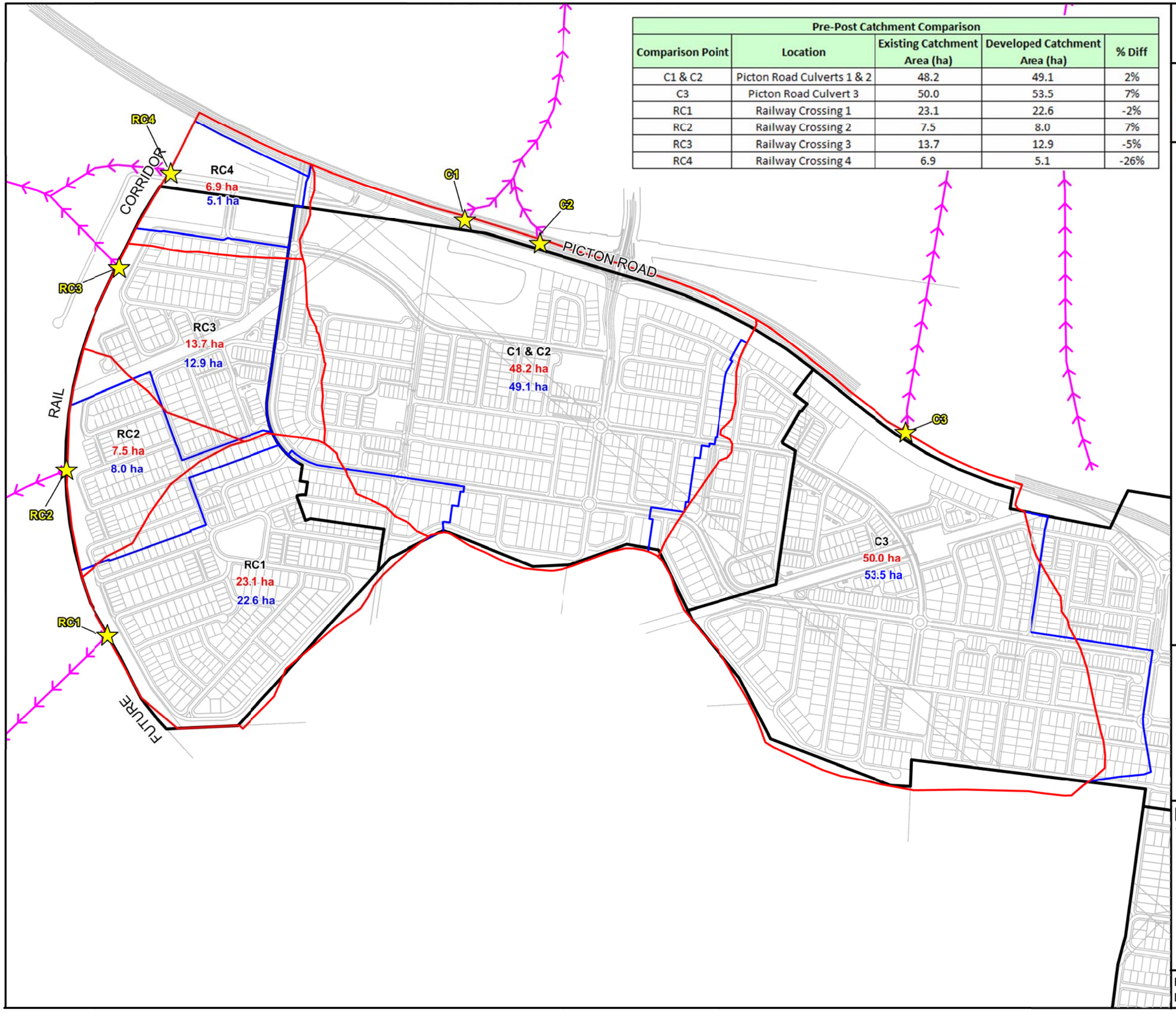
Figure 6.2
Wilton SE Precinct

Preliminary Stormwater Concept

Stages 4-6

File Name: 110384 Fig6.2 Stage 4-6
Date : 19/12/18 Issue : A

Pre-Post Catchment Comparison				
Comparison Point	Location	Existing Catchment Area (ha)	Developed Catchment Area (ha)	% Diff
C1 & C2	Picton Road Culverts 1 & 2	48.2	49.1	2%
C3	Picton Road Culvert 3	50.0	53.5	7%
RC1	Railway Crossing 1	23.1	22.6	-2%
RC2	Railway Crossing 2	7.5	8.0	7%
RC3	Railway Crossing 3	13.7	12.9	-5%
RC4	Railway Crossing 4	6.9	5.1	-26%



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LEGEND

- Staging Boundaries
- Existing Catchment
- Developed Catchment
- C3 — Catchment ID
- 50.0 ha — Existing Catchment Area
- 51.2 ha — Developed Catchment Area
- Existing flowpath
- Comparison Point

Note: developed catchments external to the Stage 1 development have been assumed based on BEW gradings and preliminary road and lot layouts of future stages.

N
W E
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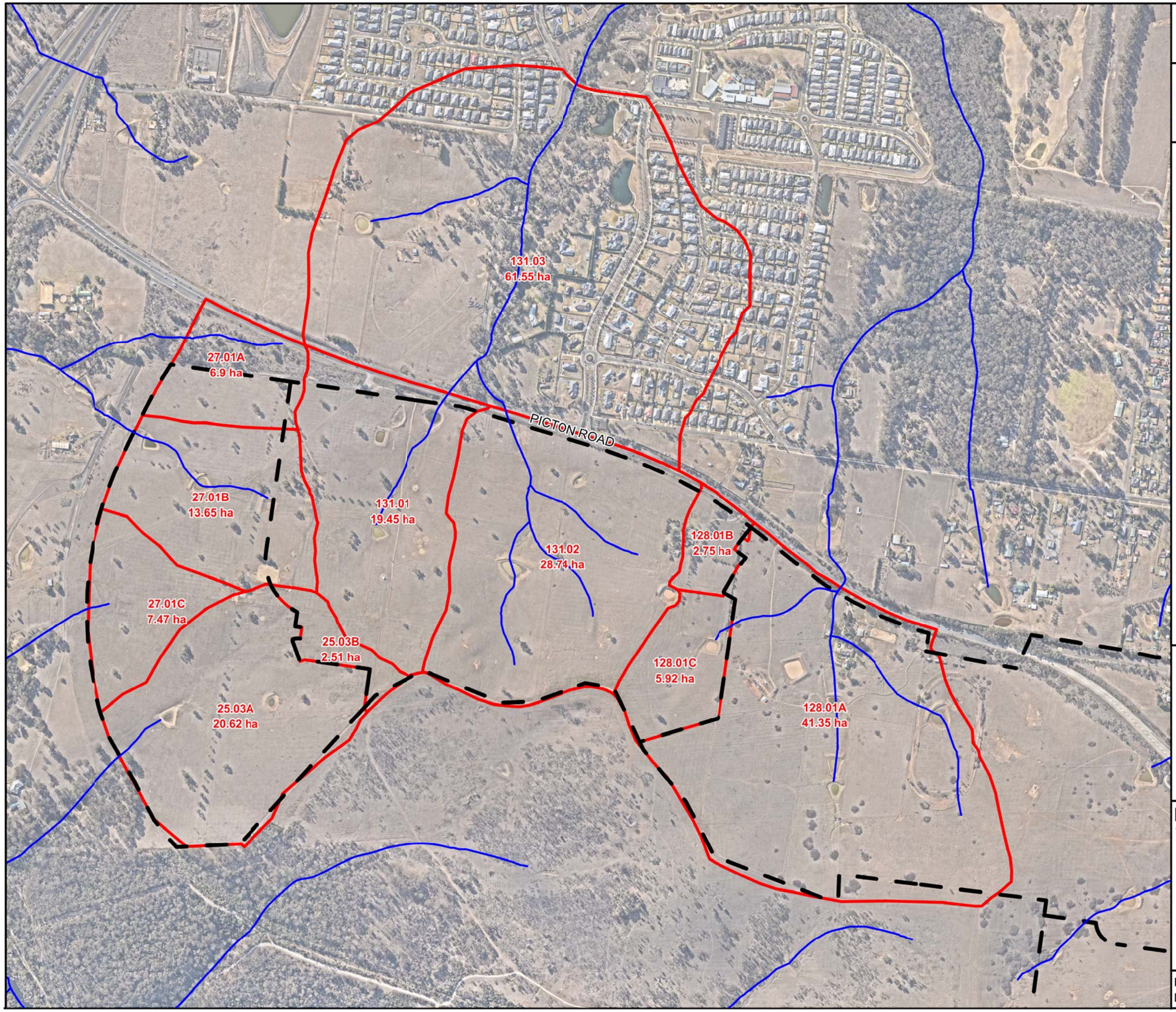
Scale 1: 7,000 @ A3

200 0 200 m

Figure 6.3
Wilton SE Precinct

Pre-Post Catchment Comparison

File Name: 110384 Fig6.3 Cat Comparison
Date : 20/12/18 Issue : A



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LEGEND

- Catchment
- Stage Boundaries
- Watercourse

N
W E
S

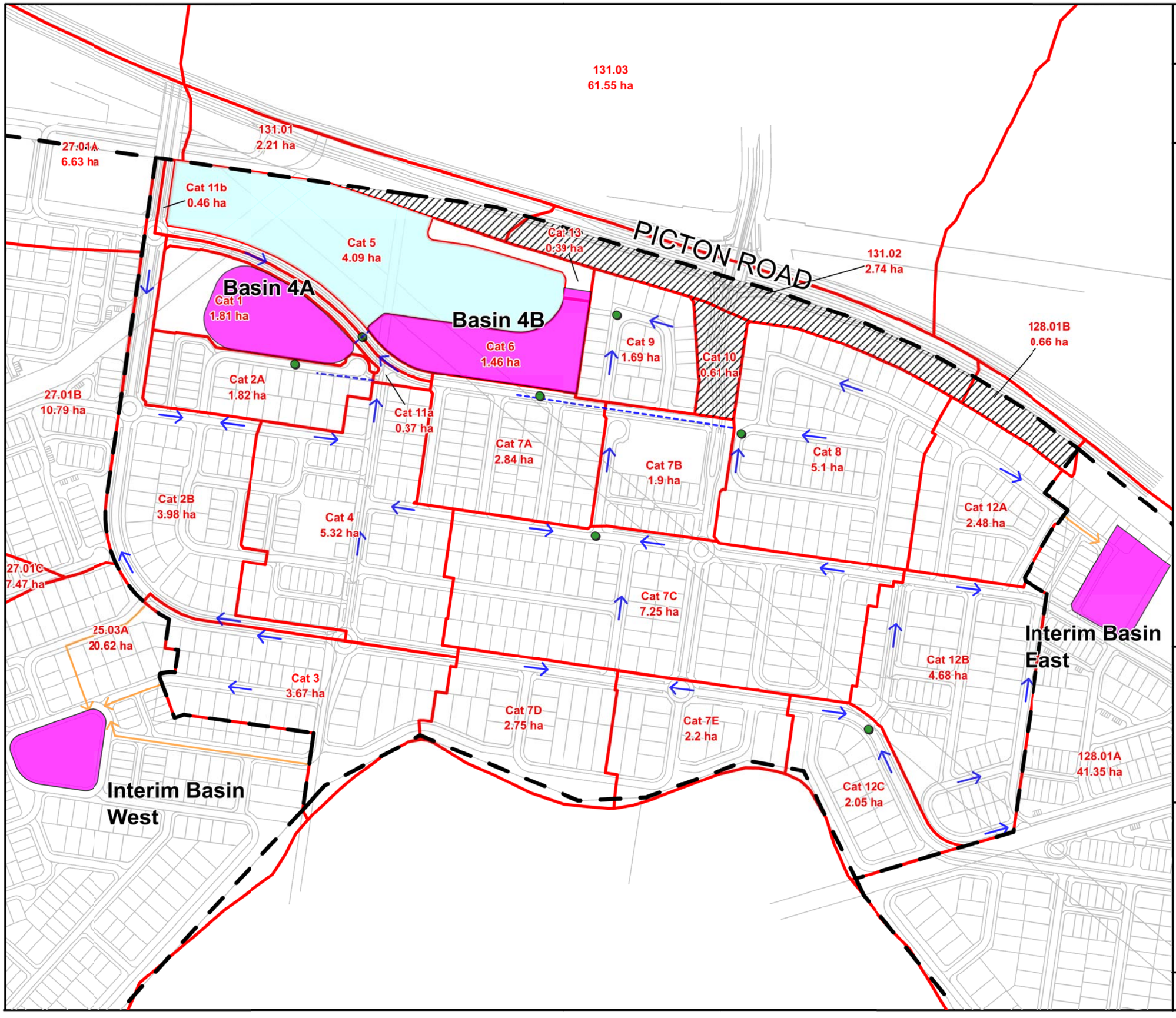
Scale 1: 8,000 @ A3

200 0 200 m

Figure 7.1
Wilton SE Precinct

Existing (XP-RAFTS)
Catchment Plan

File Name: 110384 Fig7.1 Ex Cats
Date : 19/12/18 Issue : A



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LEGEND

- Catchment
- Bypass Area
- Stage Boundaries
- Stage 1 Basin
- Flows to Basin
- Local Sag
- Piped flows only
- Commercial (On lot OSD)
- Overland Flow

N
W E
S

Scale 1: 4,000 @ A3

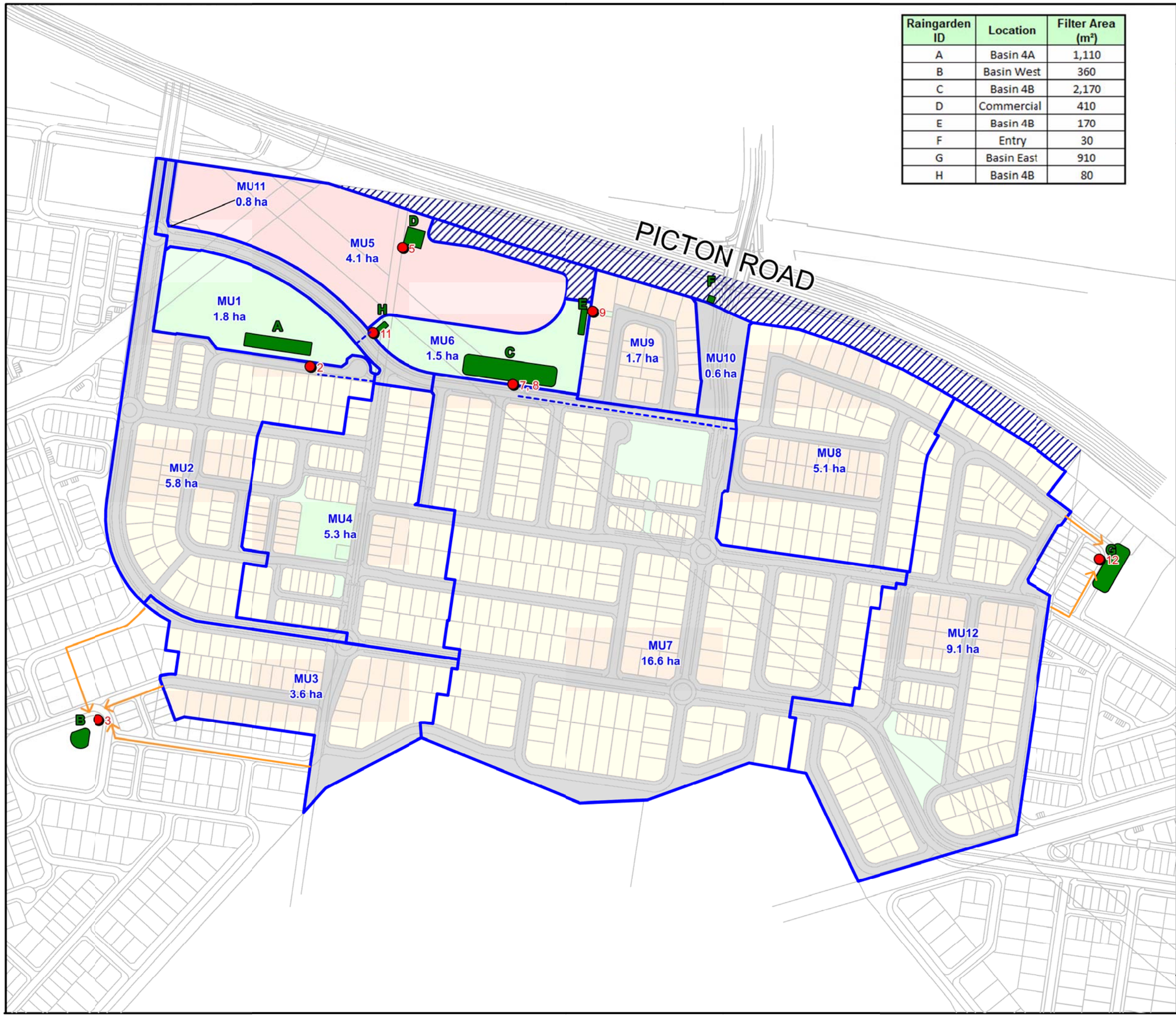
200 0 200 m

Figure 7.2
Wilton SE Precinct

Developed (XP-RAFTS)
Catchment Plan

File Name: 110384 Fig7.2 Dev Cats
Date : 19/12/18 Issue : A

Raingarden ID	Location	Filter Area (m²)
A	Basin 4A	1,110
B	Basin West	360
C	Basin 4B	2,170
D	Commercial	410
E	Basin 4B	170
F	Entry	30
G	Basin East	910
H	Basin 4B	80



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LEGEND

- Catchment
- Bypass Area
- Stage 1 Raingarden
- Flows to Basin
- 11 GPT / GPT ID
- Piped flows only
- Residential
- Open Space
- Road Reserve
- Commercial

N W E S

Scale 1: 4,000 @ A3

200 0 200 m

Figure 8.1
Wilton SE Precinct

MUSIC Catchment Plan

File Name: 110384 Fig8.1 MUSIC
Date : 19/12/18 Issue : A

Figure from Wilton Juntion WCM Strategy (JWP, 2014)

Opportunity to consolidate with upgrade to Wilton Township

Opportunity to consolidate (if desired). Receives larger catchment.

Opportunity to consolidate (if desired). Filling of perimeter road required.

Opportunity to consolidate (if desired). Receives larger catchment.

Likely Location of Proposed Regional Detention Basin

Opportunity to consolidate (if desired). Receives larger catchment.

Filling required at edges (i.e perimeter road) to grade to raingarden (typ)

Opportunity to consolidate (if desired). However is located at existing dam

Opportunity to consolidate (if desired). Receives larger catchment.

Opportunities to consolidate (if desired).

Opportunity to consolidate (if desired). Removal of existing dam and some filling required.

LEGEND

- Bingara Gorge (Excluded)
- Redirected Catchment
- Lake System
- Raingarden and Flow Direction
- Possible Additional Raingarden (if required)
- Existing Dam (opportunity to include raingarden)
- Proposed Regional Detention Basin
- MUSIC Catchment

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N E S W

Scale 1: 30,000 @ A3

1000 0 m

9708_Figure 5 (Stormwater Concept Plan)

FIGURE 5

Wilton Junction
Water Cycle Management Strategy
Stormwater Concept Plan

Revision: E Dated 30/05/14

APPENDIX B – XP RAFTS Input Details

B.1 XP-RAFTS Parameters

As discussed in Section 6.1, parameters for XP-RAFTS modelling have been adopted consistent with the 'base case' modelling which underlied the overall WCM Strategy (JWP, 2014). Initial and Continuing Loss parameters which are adopted are listed in Table B.1

TABLE B.1 - ADOPTED INITIAL AND CONTINUING LOSSES

	Initial Loss	Continuing Loss
Impervious	2.5 mm	0 mm/hr
Pervious	15 mm	2.5 mm/hr
Bingara Gorge Impervious	11.5 mm	2.5 mm/hr

It is noted that these are slightly different to the parameters listed in Council's Draft DCP 2018, however are consistent with all modelling to date for the Greater Wilton Junction Release Area.

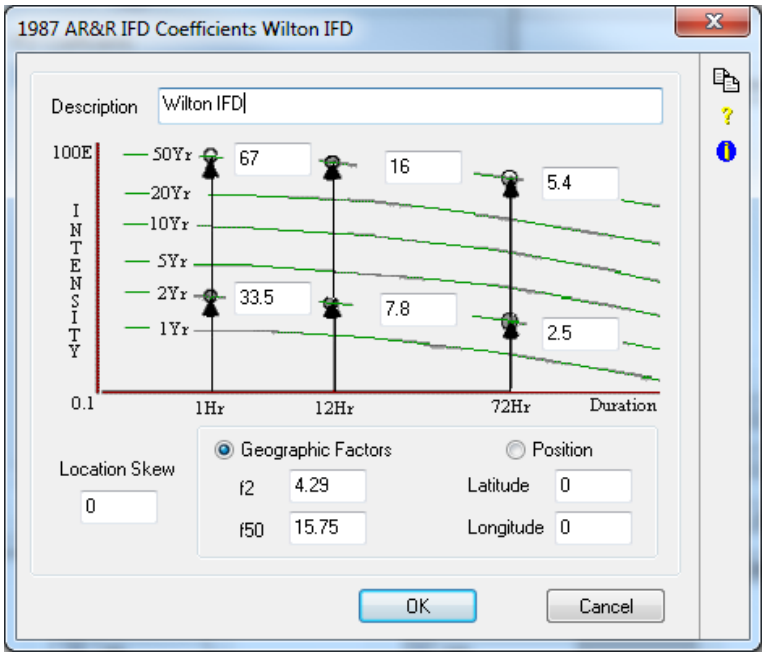
B.2 Roughness Coefficients "n"

As the regional catchment is dominated by natural bushland, a Manning's roughness coefficient of 0.05 is generally adopted for modelling across the Greater Wilton Junction Release Area, however, parts of the contributing catchments are influenced by some development. Adjustments are made in accordance with the amount of development within each catchment and are consistent with the values provided below in Table B.2:

TABLE B.2 - ADOPTED MANNING'S 'N' ROUGHNESS COEFFICIENT

Catchment Condition	Adopted Pern Value
Urban Impervious	0.015
Urban Pervious	0.025
Open Space Pervious	0.035
Rural Pervious	0.045
Bush Pervious	0.05

B.3 Rainfall IFD



B.4 Stage-Discharge Relationships

Basin 4B

Level	Discharge (m^3/s)
210	0
210.21	0.2
210.31	0.4
210.39	0.6
210.47	0.8
210.54	1
210.54	1
210.67	1.4
210.74	1.6
210.82	1.8
210.9	2
211.2	2.59

Basin 4A

Level	Discharge (m^3/s)
210.95	0
211.3	0.2
211.47	0.4
211.61	0.6
211.75	0.8
211.88	1
211.88	1
212.18	1.4
212.37	1.6
212.58	1.8
212.83	2
214.25	2.88

Basin West

Level	Discharge (m^3/s)
219.69	0
220.01	0.12
220.19	0.23
220.35	0.33
220.64	0.47
220.99	0.58
221.19	0.64

Basin East

Level	Discharge (m^3/s)
220	0
220.39	0.35
220.61	0.71
220.79	0.98
221.2	1.41

B.5 Basin Stage - Volume

Basin 4B

Level	Volume
210	0
210.1	382.169
210.2	788.32
210.3	1218.483
210.4	1672.684
210.5	2150.953
210.6	2653.316
210.7	3179.801
210.8	3730.437
210.9	4305.25
211	4904.27
211.1	5527.524
211.2	6175.039

Basin 4A to overflow

Level	Volume
210.95	0
211	180.856
211.1	552.146
211.2	936.293
211.3	1333.393
211.4	1743.546
211.5	2166.85
211.6	2603.404
211.7	3053.307
211.8	3561.692
211.9	4155.761
212	4770.081
212.1	5404.816
212.2	6060.13

Basin West

Level	Volume
219.688	0
219.7	33.636
219.8	317.624
219.9	616.393
220	929.956
220.1	1258.327
220.2	1601.472
220.3	1958.887
220.4	2329.971
220.5	2714.23
220.6	3111.171
220.7	3520.389
220.8	3941.602
220.888	4321.114

Basin East

Level	Volume
220	0
220.1	305.31
220.2	619.67
220.3	943.207
220.4	1276.05
220.5	1618.326
220.6	1970.165
220.7	2331.695
220.8	2703.044
220.9	3084.34
221	3475.711
221.1	3877.287
221.2	4289.194

B.6 Developed Areas

	MapInfo Area									
Catchment	Total Area	Park	Road	Commercial	Residential	Forest	Impervious Area	Pervious Area	Fraction Impervious	Slope
131.01	2.21								5%	7.1%
131.02	2.74								5%	7.7%
131.03	61.55								5%	5.0%
128.01A	41.35								5%	6.7%
128.01B	0.66								5%	6.5%
25.03A	20.62								5%	3.8%
27.01A	6.63								5%	5.5%
27.01B	10.79								5%	4.9%
27.01C	7.47								5%	4.8%
Cat 1	1.81	1.81	0	0	0	0	0.18	1.63	10%	1.0%
Cat 10	0.61	0	0.61	0	0	0	0.43	0.18	70%	4.1%
Cat 11a	0.37	0	0.37	0	0	0	0.26	0.11	70%	4.2%
Cat 11b	0.46	0	0.46	0	0	0	0.32	0.14	70%	4.2%
Cat 12A	2.48	0	0.76	0	1.72	0	1.56	0.92	63%	2.9%
Cat 12B	4.68	0.32	1.76	0	2.59	0	2.82	1.86	60%	5.5%
Cat 12C	2.05	0	0.99	0	1	0.07	1.30	0.75	63%	8.0%
Cat 13	0.39	0.39	0	0	0	0	0.04	0.35	10%	1.0%
Cat 2A	1.82	0	0.5	0	1.31	0	1.14	0.68	62%	3.8%
Cat 2B	3.98	0	2.07	0	1.9	0	2.59	1.39	65%	2.4%
Cat 3	3.67	0	1.29	0	2.28	0.1	2.28	1.39	62%	6.3%
Cat 4	5.32	0.44	1.71	0	3.17	0	3.14	2.18	59%	5.5%
Cat 5	4.09	0	0	4.09	0	0	3.68	0.41	90%	7.1%
Cat 6	1.46	1.46	0	0	0	0	0.15	1.31	10%	1.0%
Cat 7A	2.84	0	0.95	0	1.89	0	1.80	1.04	63%	6.9%
Cat 7B	1.9	0.6	0.86	0	0.44	0	0.93	0.97	49%	4.3%
Cat 7C	7.25	0	2.26	0	4.99	0	4.58	2.67	63%	3.6%
Cat 7D	2.75	0	1.08	0	1.48	0.2	1.66	1.09	61%	5.4%
Cat 7E	2.2	0	0.93	0	1.16	0.1	1.36	0.84	62%	7.6%
Cat 8	5.1	0	1.23	0	3.87	0	3.18	1.92	62%	4.7%
Cat 9	1.69	0.02	0.45	0	1.22	0	1.05	0.64	62%	1.5%
Total	**210.94**	5.04	18.28	4.09	29.02	0.47				

Developed - Links

Location	Length	time (min) (at 1.5m/s)
B4b-dmy5	55	0.6
dmy8-7C	191	2.1
12C-12B	320	3.6
12B-BEast	95	1.1
12A-BEast	65	0.7
3-BWest	93	1.0
11B-B4B	265	2.9
11A-11B	23	0.3
dmy5-dmy4	214	2.4
7C-7B	139	1.5
8-7B	144	1.6
7B-7A	80	0.9
10-dmy5	136	1.5
4-dmy9	85	0.9
9-B4B	30	0.3
dmy5-131.02	48	0.5
2B-2A	172	1.9
B4A-dmy6	242	2.7
Beast-128.01A	110	1.2
128.01B-128.01A	217	2.4
BasinWest - 25.03A	282	3.1

B.7 Existing Areas

Catchment	Area	Fraction Impervious	Slope
131.01	19.45	5%	7.1%
131.02	28.74	5%	7.7%
131.03	61.55	5%	5.0%
128.01A	41.35	5%	6.7%
128.01B	2.75	5%	6.5%
128.01C	5.92	5%	10.9%
25.03A	20.62	5%	3.8%
25.03B	2.51	5%	9.0%
27.01A	6.9	5%	5.5%
27.01B	13.65	5%	4.9%
27.01C	7.47	5%	4.8%
Total	**210.9**		

APPENDIX C

APPENDIX C – MUSIC Modelling Parameters and Report

10.1.1 NSW EPA Pollutant Concentrations

Event Mean Concentration (mg/L)

Constituent	Urban	Peri-urban	Mining & Quarrying	Cropping	Grazing	Horticulture	Forest
TN	1.9	2	2.2	3	1.7	3	0.7
NO_x	0.88	0.76	0.84	1.14	0.65	1.14	0.175
TKN	1.02	1.24	1.36	1.86	1.05	1.86	0.525
NH_4	0.114	0.082	0.091	0.123	0.07	0.123	0.0136
TP	0.2	0.22	0.45	0.3	0.2	0.4	0.05
FRP	0.093	0.085	0.174	0.116	0.077	0.154	0.015
TSS	120	45	100	40	40	70	40

Dry Weather Concentration (mg/L)

Constituent	Urban	Peri-urban	Mining & Quarrying	Cropping	Grazing	Horticulture	Forest
TN	0.9	0.9	0.8	0.8	0.8	0.8	0.2
NO_x	0.21	0.2	0.18	0.18	0.18	0.18	0.05
TKN	0.69	0.7	0.62	0.62	0.62	0.62	0.15
NH_4	0.058	0.048	0.043	0.043	0.043	0.043	0.0136
TP	0.09	0.09	0.05	0.05	0.05	0.05	0.01
FRP	0.037	0.025	0.014	0.014	0.014	0.014	0.005
TSS	16	15	20	20	20	20	6

10.1.2 Rainfall Data

The *MUSIC* model is able to utilise rainfall data based on 6 minute, hourly, 6 hourly and daily time steps. In accordance with those recommendations from the *MUSIC* User Manual (CMA, 2010), a 6 minute rainfall data set has been selected for the subject site.

To select the appropriate dataset, rainfall records were obtained from the Bureau of Meteorology. The 6 minute data sets which are currently available for rainfall stations closest to Wilton were investigated. Results indicate that the data sets only have limited years available as well as extended periods of missing data.

The 6 minute data obtained for Liverpool between the years 1967 – 1973 was analysed and found to be a fair representation of the long term statistical data for the Wilton Area (Picton) and was therefore adopted in this study. The station used and the years of record selected are tabulated below.

TABLE C.1 – RAINFALL DATA

Station No.	Location	Years of Record	Type of Data
67035	Liverpool (Whitlam Centre)	1967-1973	6 minute

A summary of the model rainfall data set (Liverpool 1967 – 1973) and that obtained from the Bureau of Meteorology for close the site (Picton 1880 - 2013) is shown below in Table C.2

TABLE C.2 – SUMMARY OF RAINFALL DATA FOR THE SITE

Property	MUSIC Model Data Set (Liverpool) (1967-1973)	Bureau of Meteorology Data (Picton) (1880-2013)
Mean Yearly Rainfall (mm)	821.8	804.8
Highest Yearly rainfall (mm)	1159.5	1723.2
Lowest Yearly rainfall (mm)	503	303.2
Decile 1 rainfall (mm)	595.7	508.7
Decile 5 (median) rainfall (mm)	848.3	759.7
Decile 9 rainfall (mm)	998	1126.8
Mean No. Rain Days	115	97.1
Mean No. Rain Days > 1mm	80	71.3
Mean No. Rain Days > 10mm	23	21.4
Mean No. Rain Days > 25mm	7	7.1

The rainfall data summarised in Table C.2 indicates that the data set used in the *MUSIC* modelling is a reasonable representation of long term statistical data. This is considered to be a conservative approach for the sizing of water quality devices since rainfall is typically higher for the adopted modelling dataset.

The rainfall and evapo-transpiration data for the period analysed is shown on the graph which is provided in Plate C.1

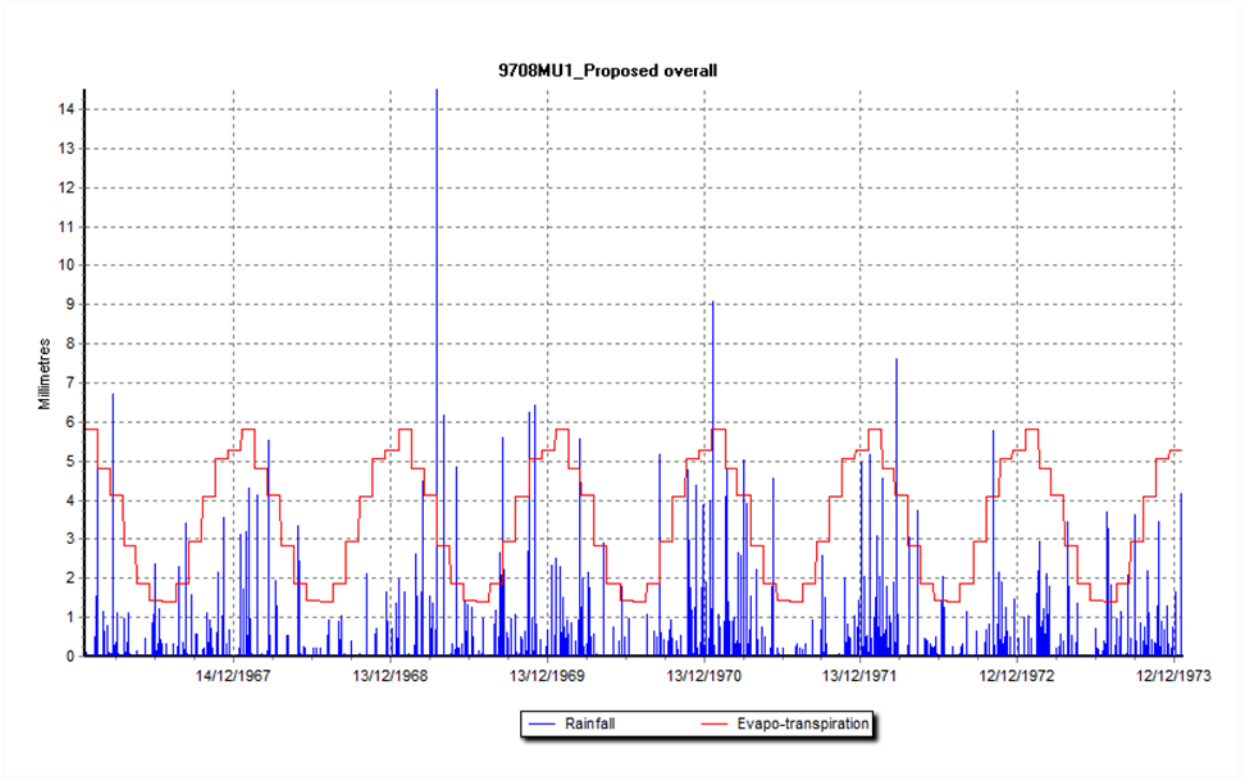


Plate C.1 – Rainfall and Evapo-transpiration Data for Liverpool (1967-1973)

10.1.3 Soil / Groundwater Parameters and Pollutant Loading Rates

The soil / groundwater parameters and pollutant loading rates adopted for the urban catchments of Wilton Junction are based on the recommended parameters in the *NSW MUSIC Modelling Guidelines* (CMA, 2015) assuming Blacktown (bt) clay soil texture consistent with the desktop geotechnical study undertaken by Douglas Partners for the wider Wilton Junction site. 'Light Clay' parameters adopted from the guidelines.

10.1.4 Orthophosphate Content of the Raingarden Filter Media

Bio-retention Raingardens consist of a filtration bed with either gravel or sandy loam media and an extended detention zone typically from 100-300 mm deep designed to detain and treat first flush flows from the upstream catchment. They typically take the form of an irregular bed (raingarden) or a linear swale (bio-swale) and are located within the verge area of a road reserve or extend within the bushland corridors or other open space areas. The surface of the bio-retention system can be grassed or mass planted with water tolerant species. Filtration beds of bio-retention systems are typically 0.5 to 0.6 metres deep.

Bio-retention Raingardens provide an effective means of removing nutrients from stormwater runoff and are proposed across Wilton Junction. An important component of their performance is associated with the *"Orthophosphate Content of the Media"* (which is measured in mg/kg). Based on experience and standard practice, the Orthophosphate content adopted conventionally is 40 mg / kg (the MUSIC default).

It is however noted that lower values of orthophosphate content can be achieved for particular filtration media. Recent test results of filter media provided by supplier's such as "Benedict Industries" demonstrate orthophosphate content for filter media as low as 9.3 mg/kg and 28.9 mg/kg.

Subsequent advice from the MUSIC software developers also indicates that the default rates in MUSIC (i.e. 40 mg/kg) are only a guide, the *"concentration can be adjusted and set to the value of the media supplied".*

Therefore, there is a significant opportunity to specify a filter media mix with a lower orthophosphate content across all raingardens in order to comply with the water quality targets. That is, improving the water quality treatment at raingardens in order to effectively remove TP from both stormwater and treated effluent prior to discharge to the environment.

TABLE C.3 - MUSIC CATCHMENT AREAS (DIGITALLY MEASURED)

	Catchment Division					
Catchment	Total Catchment Area (ha)	School	Residential Lot Area (ha)	Road Area (ha)	Open Space	Commercial
1	1.81		0	0	1.81	0
2	5.79		3.22	2.58	0	0
3	3.57		2.28	1.29	0	0
4	5.32		3.17	1.71	0.44	0
5	4.09		0	0	0	4.09
6	1.46		0	0	1.46	0
7	16.64		9.96	6.08	0.6	0
8	5.10		3.87	1.23	0	0
9	1.69		1.22	0.45	0.02	0
10	0.61		0	0.61	0	0
11	0.83		0	0.83	0	0
12	9.14		5.31	3.51	0.32	0
	56.05	0	29.03	18.29	4.65	4.09

TABLE C.4 - MUSIC CATCHMENTS (INPUTS TO MUSIC)

	Input to MUSIC for NSW Guidelines model only
	Input to MUSIC for EPA model only
	Input to MUSIC for all models

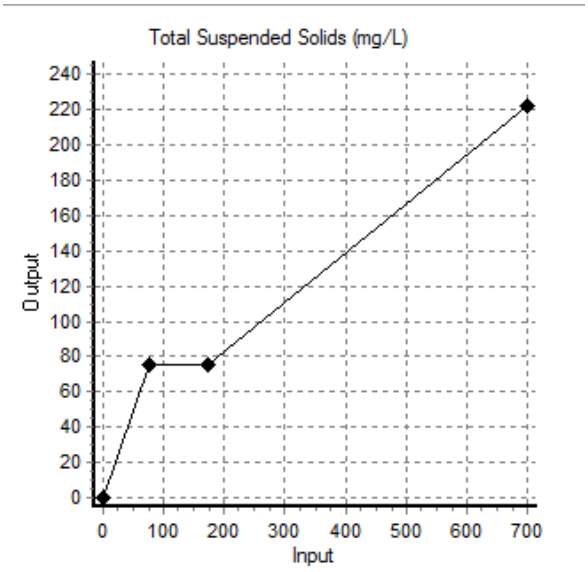
Node Inputs								
Road (ha)	School	Roof to Tank (ha)	Roof Bypass (ha)	Urban Impervious	Urban Pervious	Park	Commercial	Urban
0.00		0.00	0.00	0.00	0.00	1.81	0.00	0.00
2.58		0.81	0.81	0.32	1.29	0.00	0.00	3.22
1.29		0.57	0.57	0.23	0.91	0.00	0.00	2.28
1.71		0.79	0.79	0.32	1.27	0.44	0.00	3.17
0.00		0.00	0.00	0.00	0.00	0.00	4.09	0.00
0.00		0.00	0.00	0.00	0.00	1.46	0.00	0.00
6.08		2.49	2.49	1.00	3.98	0.60	0.00	9.96
1.23		0.97	0.97	0.39	1.55	0.00	0.00	3.87
0.45		0.31	0.31	0.12	0.49	0.02	0.00	1.22
0.61		0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.83		0.00	0.00	0.00	0.00	0.00	0.00	0.00
3.51		1.33	1.33	0.53	2.12	0.32	0.00	5.31
18.29	0.00	7.26	7.26	2.90	11.61	4.65	4.09	

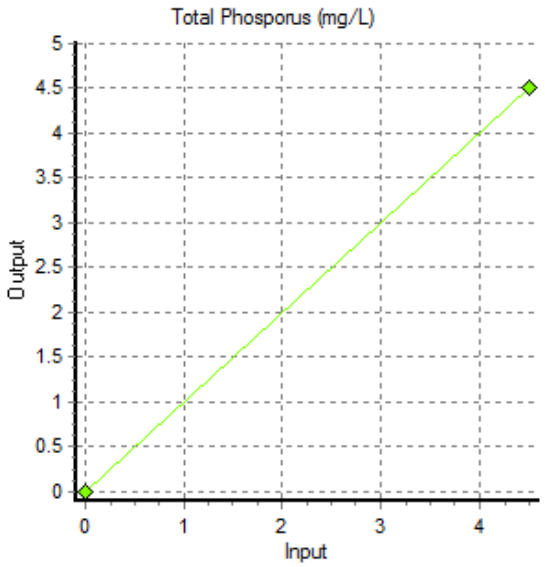
TABLE C.5 - MUSIC MODELLING (RAINWATER TANKS)

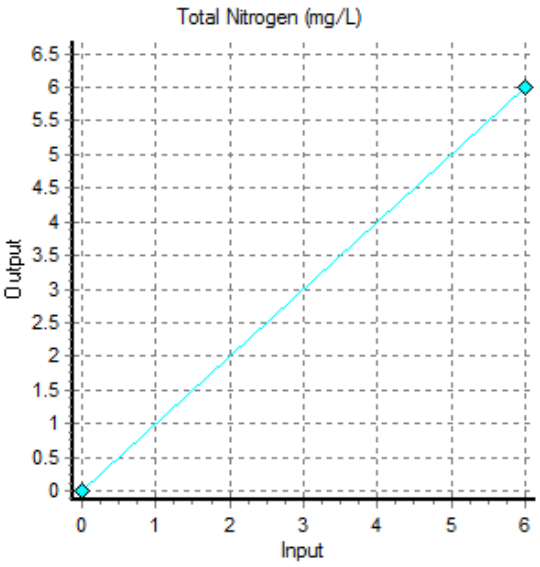
10 yr ARI 5 min. rainfall intensity	142	mm/hr		Assumed tank volume	3	kL
Assumed Daily demand	351.6	litres/house /day		Assumed useable tank volume	2.4	kL
Overflow Pipe diameter	50	mm		Assumed tank height	1.5	m
Area overflow pipe	0.001963495	m^2				

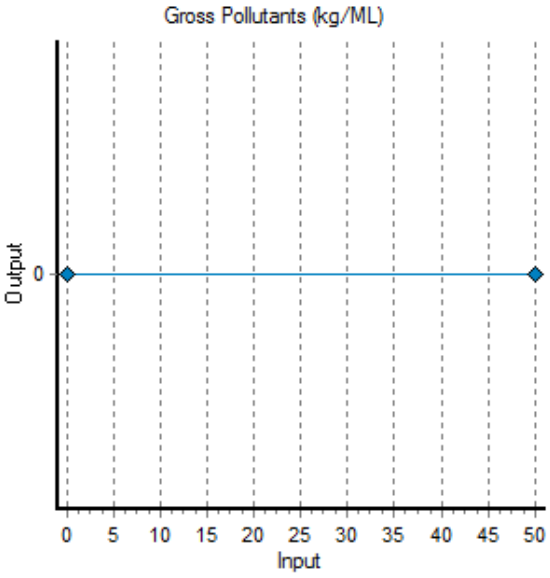
				MUSIC INPUTS - Rainwater tank						
	Dwellings	Total Roofed Area	Roof to Tank for Re-Use	High Level Bypass	Tank Volume	Tank Area	Overflow Pipe Diameter	Annual Demand	Daily Demand	Equivalent Overflow Pipe Area
	(No.)	(ha)	(ha)	Flow on roof to tank (m^3/s)	(m^3)	(m^2)	(mm)	(kL/yr)	(kL/day)	(m^2)
1	0	0.00	0.00	0.000	0	0	0	0.0	0	0.0
2	81	1.61	0.81	0.318	194	130	450	4198.2	28	0.2
3	48	1.14	0.57	0.225	115	77	346	2487.8	17	0.1
4	96	1.59	0.79	0.313	230	154	490	4975.7	34	0.2
5		0.00	0.00	0.000	0	0	0	0.0	0	0.0
6		0.00	0.00	0.000	0	0	0	0.0	0	0.0
7	219	4.98	2.49	0.982	526	350	740	11350.8	77	0.4
8	95	1.94	0.97	0.382	228	152	487	4923.9	33	0.2
9	28	0.61	0.31	0.120	67	45	265	1451.2	10	0.1
10		0.00	0.00	0.000	0	0	0	0.0	0	0.0
11		0.00	0.00	0.000	0	0	0	0.0	0	0.0
12	129	2.66	1.33	0.524	310	206	568	6686.1	45	0.3

Gross Pollutant Parameters (adopted in MUSIC)









APPENDIX D – GPT Maintenance Schedule

J Wyndham Prince Pty Ltd

GROSS POLLUTANT TREATMENT DEVICE MAINTENANCE SCHEDULE - CDS UNIT

Wilton South East Precinct - Stage 1 GPTs

MAINTENANCE ACTION	FREQUENCY	RESPONSIBILITY	PROCEDURE
GPT Unit			
Visually inspect main storage chamber	Monthly (or after significant storm event ≥20 mm)	Maintenance Contractor	Remove access hatch of the CDS unit main lid and inspect the visible parts of the screen for obstruction by debris.
Inspect for depth of sediment captured	Monthly (or after significant storm event ≥20 mm)	Maintenance Contractor	Remove access hatch of the CDS unit main lid and use sediment depth measurement device (probe) as indicated in the CDS Operation and Maintenance Manual. Sediment removal is required if sump is at 75% capacity or greater (should not be allowed to reach 100% capacity).
Inspect for obstructions within device	Monthly (or after significant storm event ≥20 mm)	Maintenance Contractor	Remove access hatch of the CDS unit main lid and visually inspect chamber and inlet/outlet pipe locations for blockages or obstructions.
Remove captured litter and sediment	As necessary through inspection advice (Quarterly, or after a total of 20 mm or more of rainfall has fallen within a 24 hour period, whichever comes first, or immediately after oil or hazardous material spillage).	Maintenance Contractor	Litter removal is required if the unit is at 75% of its storage capacity or greater. Removal of litter to be carried out using an eductor truck or clam shell unit with tip truck as detailed in CDS Operation and Maintenance Manual.
Inspect area around device for subsidence	Annually	Maintenance Contractor	Check along drainage lines and at pit locations for subsidence likely to indicate leakages and/or piping.
Inspect for secure fixture of internal fittings in chamber	Annually	Maintenance Contractor	Annual inspections involve dewatering of the unit and checking the condition of the screen, diversion chamber, weir, lids and any other features of the unit (includes fittings & securing bolts) as well as the general integrity of unit.
Check outlet opening dimensions are correct and retain solid edges	Five Yearly	Maintenance Contractor	Compare dimensions to design as shown in Work-As-Executed plans and ensure edges are not pitted or damaged.

APPENDIX E – Letter from DPI Water

Department of Primary Industries
Water

Contact: Janne Grose
Phone: 02 8838 7505
Email: janne.grose@dpi.nsw.gov.au

Our ref: V15/3876#72, OUT17/19013
File No:
Your Ref:

12 May 2017

Ms Zoe Sadiq
Senior Precinct Planner
NSW Department of Planning and Environment
GPO Box 39
SYDNEY NSW 2000

zoe.sadiq@planning.nsw.gov.au

Dear Ms Sadiq

Re: Wilton South East Precinct – Rezoning of land owned by Walker Corporation

Thank you for seeking comments on the rezoning planning proposal for the Wilton South East Precinct. DPI Water has reviewed the documents provided and provides comments at Attachment A.

For further information please contact Janne Grose, Water Regulation Officer at DPI Water (Parramatta office) on **t:** (02) 8838 7505; **e:** janne.grose@dpi.nsw.gov.au

Yours sincerely

Irene Zinger
Regional Manager - Metro,
Water Regulation

ATTACHMENT A

Wilton South East Precinct Rezoning Planning Proposal

The Department of Primary Industries, Water (DPI Water) has reviewed the rezoning proposal documents for the Wilton South East Precinct (WSEP) including:

- Wilton South East Precinct Planning Proposal - July 2016 (WSEPPP)
- Wilton Indicative Layout Plan - dated 8 May 2017 (ILP)
- Wilton Priority Growth Area Land Zoning map - dated 10 May 2017
- Wilton South East Precinct - Stream Order mapping – dated 27 March 2017
- Wilton South East Precinct Ecology reports:
  - Cumberland Ecology – proposed Development at Walker Corporation lands (dated 8 July 2016)
  - Cumberland Ecology - Additional information for proposed development on Walker Corporation lands at Wilton (dated 13 September 2016)
  - Cumberland Ecology – Further Additional information for proposed development on Walker Corporation lands at Wilton (option C) (dated 9 November 2016)
- J. Wyndham Prince (June 2014) Wilton Junction Water Cycle Management Strategy (WJWCMS)
- Addendum to Integrated Water Cycle Management Strategy - dated 7 December 2016 (AIWCMS)

DPI Water provides the following comments.

Protection of Watercourses and Riparian Land

DPI Water recommends an aerial photograph is provided that shows the remnant native riparian within the Wilton South East Precinct (WSEP) and overlays the watercourses to be maintained, removed and which are yet undetermined in the(WSEP.

The WJWCMS notes Wilton Junction includes a large number of 1st and 2nd order watercourses not considered to be rivers and proposed for removal and/or to be replaced by urban drainage infrastructure (section 9.7, page 32). In relation to watercourses mapped within the WSEP, DPI Water has reviewed:

- Figure 4 – Riparian Plan (Appendix A of the WJWCMS)
- Figure 13 – Photo Locations (Appendix G of the WJWCMS)
- the photos of watercourses proposed for removal in the WSEP (Appendix G of the WJWCMS).

DPI Water supports in principle the watercourse mapping that has been undertaken for the WSEP and the determination of 'rivers' under the *Water Management Act 2000*.

Riparian offsetting will be required for any watercourses that are identified as 'rivers' and that are proposed for removal.

Online Detention Basin

The AIWCMS indicates an online detention basin is proposed to be located within the upper reach of Allens Creek with an approximate total volume of 35 000 m^3 (i.e. 35 ML) on the Walker Corporation land. The WJWCMS notes the DPI Water (2012) Guidelines permit online detention basins on 1st and 2nd order streams (section 7.5, page 21). The DPI Water Guidelines outline that online basins must:

- be dry and vegetated
- be for temporary flood detention only with no permanent water holding
- have an equivalent VRZ for the corresponding watercourse order
- not be used for water quality treatment purposes.

The WJWCMS indicates the proposed works for the basin will be limited to a single embankment and weir and therefore the impact on native vegetation is not anticipated to be significant. It also notes the basin is for detention only and it is not intended to provide water quality treatment (section 11.7 of WJWCMS, page 48). The proponent needs to clarify if the proposed online basin is consistent with the other above requirements of the DPI Water guideline.

The WJWCMS notes the on-line basin is to be located approximately 200 m upstream of Picton Road (section 10.7, page 39). Allens Creek is a 2nd order stream at this location. The WJWCMS shows the basin is proposed to be located in remnant native vegetation (see Figure 10 in Appendix A). The creek and the surrounding riparian vegetation appear to be in good condition at this location. Strong justification needs to be provided for constructing an online basin at this location as the basin will disturb the bed and banks of Allens Creek and the embankment and weir would result in the clearing of native riparian vegetation (see Section 11.7, page 48). It would also appear that this area is proposed to be zoned E2 – Environmental Conservation (see Figure 8, page 10 of WSEPPP.

The WJWCMS notes that Wollondilly Shire Councils DCP sets out a number of objectives for the management of stormwater pollutants including: "*stormwater detention and treatment systems shall be constructed off-line of any watercourse, regardless of the order of the stream*", and that Council's DCP position is superseded by the DPI Water Guidelines (see Section 7.2.2, page 19). DPI Water's Controlled Activity Guidelines do not override the requirements of other government authorities including Council's planning instrument.

DPI Water recommends:

- all suitable offline areas are reviewed before presenting an online detention basin option
- the proposed basin location should avoid areas of remnant vegetation which are to be retained in the WSEP
- the proposed basin should avoid E2 zoned land.

Treatment/evaporation lakes

The WWPRPP indicates a large lake is proposed to be located in the Wilton West precinct (WWP) for the treatment of wastewater generated by the Wilton New Town. DPI Water is providing comments on the lake in its submission on the WWP.

Bioretention Raingarden Systems

The WJWCMS indicates bio-retention raingardens will be located where possible in the APZ or within the outer 50 % of the riparian corridors (section 12.2.3, page 57). The WJWCMS shows a raingarden is proposed within the WSEP (see Figure 12 in Appendix A). Based on Figure 13 a 'river' is not located at this location. Should any raingardens encroach into riparian corridors this area of encroachment will need to be offset elsewhere along the watercourse.

Wilton Indicative Layout Plan

The watercourses and riparian corridors that are proposed to be retained all appear to be located in areas identified on the ILP as 'environmental conservation'. DPI Water supports the retention of watercourses within the environmental conservation areas but suggests an overlay map is provided which locates:

- the creeks that are proposed to be retained
- the proposed riparian corridor setbacks along the watercourses
- the ILP footprint
- the proposed location of the online detention basin.

to confirm that the creeks/riparian corridors are in areas identified on the ILP as 'environmental conservation' and whether the proposed online basin is located with the environmental conservation area.

Wilton Junction Masterplan

The watercourses to be retained in the WSEP appear to be located in areas identified on the Wilton Junction Masterplan as 'existing vegetation' and 'local open space' (Figure 21 of WSEPPP, page 33). It is suggested

- the Masterplan locates the creeks and the proposed riparian corridor setbacks along these watercourses
- the legend to the Masterplan identifies the riparian corridors as 'environmental conservation' to be consistent with the ILP

Proposed Land Zoning Map

The draft land zoning map appears to zone the watercourses which have been identified as 'rivers' and which are to be retained as Environmental Conservation (E2). DPI Water supports the proposed E2 zoning as it reflects the environmental sensitivity of the watercourses/riparian corridors. The provision of an overlay map which locates:

- the creeks that are proposed to be retained
- the proposed riparian corridor setbacks along the watercourses
- the proposed zoning

would confirm if all the creeks/riparian corridors are to be zoned E2.

Groundwater and Groundwater Dependent Ecosystems

The WJWCMS notes that a comprehensive geotechnical report was undertaken by Douglas Partners to assess the impact on groundwater on the site (Section 12.9, page 63). It indicates a more specific geotechnical assessment will need to be undertaken which focuses on the treated effluent disposal areas (section 13.1, page 66).

There is potential for impacts to Groundwater Dependent Ecosystems (GDEs) to occur with development of Wilton Junction. There needs to be an understanding of the groundwater environment and how it relates to surface water.

The potential impact on groundwater and GDEs should be addressed as part of the precinct planning to ensure that the location of sites likely to have ongoing environmental impact (eg playing fields with effluent irrigation facility have been thoroughly assessed in regard to the underlying hydrogeology, in particular consideration of potential groundwater discharge to bounding deeply incised rivers and its contribution to their base flow needs to be specifically addressed. It is recommended groundwater monitoring is undertaken across the WSEP site – there needs to be at least 3 nested bore sites established in the WSEP, each with a shallow and deep piezometer on it – there may need to be more monitoring sites established depending on what is found.

A comprehensive hydrogeological evaluation as agreed with DPI Water should be undertaken as part of precinct planning for the site which considers as a minimum:

- an established groundwater monitoring network which should be installed at the earliest opportunity preferably immediately
- a prolonged period of groundwater level and quality from the monitoring bore network
- the existing groundwater situation (for example the watertable and flow directions)
- an assessment of springs or other discharge features
- the potential impact of future development of the site on the groundwater system and GDEs.

End of Attachment A