Wollert PSP
Integrated Water Management Strategy

18 July 2012

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Acknowledgements and Recognition

Issue Date	Revision No	Author	Checked	Approved
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Executive Summary

CPG has been engaged by City of Whittlesea in consultation with the Growth Area Authority (GAA) to prepare an Integrated Water Management Strategy (IWMS) and provide recommendations for the proposed Wollert Precinct Structure Plan located within the Northern Growth Corridor. The following is a summary of CPG's investigations for the Wollert IWMS:

<u>Integrated Water Management Objectives</u>

The objective of this report has been to identify various sustainable water management systems and practices across a range of scales and sources to produce an integrated outcome. These outcomes are to protect and enhance the Wollert PSP site waterways and their surrounding environments by:

- Minimising potable water consumption
- Minimising the impacts of increased runoff
- Minimising the increase in pollutants from runoff
- Utilising a range of alternate sources (rainwater, stormwater, recycled water, grey water)
- Implementing a number of measures for water quality treatment and reuse

As identified previously in this report, this can be achieved through a multitude of initiatives and ideologies that combine to produce the water management strategy

<u>Water Sensitive Cities Approach</u>

To reiterate the approach there are three themes of foundation upon which its ideologies are based including:

- Cities as Water Supply Catchments
- Cities providing Ecosystem Services
- Cities comprising Water Sensitive Communities

Based on these three water sensitive city themes CPG has further defined these themes into four meaningful elements of an IWMS. The four elements are as follows:

- Conveyance and Flood Mitigation
- Waterway Health
- Alternate Water Sources
- Urban Planning and Community Values

Conveyance and Flood Mitigation

The following is a summary of the recommendations given for each of the major catchments within Wollert PSP study area and is as follows:

- Findon Creek
  Adopt the retardation and drainage reserve Option 3, as presented in Appendix A on drawing 137599G01-5.
  This includes:
  - 3 retarding basins, refer to Section 5.1.2 for hydrologic discussion
  - Constructed waterways of various hydraulic widths refer to Section 5.2.1 for hydraulic discussion
  - Enhancement of Natural waterways, refer to Section 5.2.1 for hydraulic discussion

Drawing No.	Retarding Basin Name	Volume (kL)	Area (m^2)	Maximum Depth (m)
137599G01-5	RB1	39,500	20,500	3.5
	RB2	23,800	13,300	3
	RB3	57,100	40,000	2

Drawing No.	Tributary Name	Width (m)	Constructed	Natural
137599G01-5	A	35	X	
	B	35	X	
	C	55	X	
	D	40	X	
	E	40	X	
	F	40	X	
	G	40	X	
	H	30	X	
	I	40		X
	J	30	X	

- Edgars Creek
  Adopt the retardation and drainage reserve Option 1, as presented in Appendix B on drawing 137599G02-3.
  This includes:
  - 2 retarding basins, refer to Section 5.1.4 for hydrologic discussion
  - Constructed waterways of various hydraulic widths, refer to Section 5.2.3 for hydraulic discussion
  - Enhancement of Natural waterways, refer to Section 5.2.3 for hydraulic discussion

Drawing No.	Retarding Basin Name	Volume (kL)	Area (m^2)	Maximum Depth (m)
137599G02-3	RB1	60,400	50,800	3
	RB2	30,600	23,500	1.5

Drawing No.	Tributary Name	Width (m)	Constructed	Natural
137599G02-3	A	45	X	
	B	200		X

– Curly Sedge Creek
  Adopt no retardation works and significant waterway works. Refer to Section 5.1.6 for full discussion of analysis.

Waterway Health

- Creating a growling grass frog conservation zone where identified will seek to protect the waterway corridor health and its inhabitants. Rather than this being seen as an isolated zone separate from development of the rest of the site, integrating this with recreational infrastructure such as bike paths, park benches and walkways could create the centrepiece around which a sustainable community can be established.
- The reduction of the frequency with which runoff reaches the waterway will help protect it from the negative environmental impacts associated with increased runoff instances.
- The minimisation of any increase in flow and maintaining the means by which it filters down through to the rivers and creeks will also protect the waterways health.
- This reduction of flow frequency and runoff can be achieved through the capturing of roof water at allotment level using rainwater tanks and ‘choke’ points in the flow path including retarding basins and wetlands that are strategically placed for maximum efficiency.
- The reduction in pollutants entering our waterways.

Stormwater Quantity

- As this report has touched on their are two objectives with respect to stormwater quantity
  - Stormwater runoff frequency
  - Stormwater runoff flow rate

- It is recommended that runoff frequency be reduced to as few days as possible and runoff flow rate be limited to 1.5 times pre-development flow rate.
- This Integrated Stormwater Management Strategy outlines the use of Water Sensitive Urban Design treatment measures to address both of these issues regarding Stormwater Quantity. It has recommended an arrangement of rainwater tanks at allotment scale, infiltration systems and raingardens at the streetscape level, with retarding basins and wetlands at on a precinct scale to achieve this. The implementation of open space irrigation tanks will also act as reducer of both frequency and flow rate by diverting flow into storage for reuse.
- The Flow Frequency results (for details refer section 10) are as follows:

Scenario	**Flow Frequency (days/yr)**
Pre-development	9
Pre-development + 15 days	24
Post-development (no treatment)	105
Post-development (Recommended IWMS)	68

<u>Stormwater Quality</u>

- Water Sensitive Urban Design is has the objectives, which are also adopted for this report, that include the following:
    - 70% reduction of total Gross Pollutant loads
    - 80% reduction of total Suspended Solids
    - 45% reduction of total Nitrogen
    - 45% reduction of total Phosphorus
- This is achieved through the implementation of a 'train' of treatment measures across a assortment of scale that include the following:
    - Rainwater tanks located at lot scale.
    - Rain gardens on street scale
    - Stormwater harvesting at open space locations
    - Infiltration systems for removal of pollutants
    - Sedimentation basins, wetlands located within retarding basins and other strategically identified points within the catchment.

<u>Alternative Water Sources</u>

The percentage breakdown of all water sources to be used within the Wollert development is as follows:

Alternative Water Source	% use within Wollert
Potable	29%
Rainwater/Stormwater	22%
Recycled Water	49%

- Alternate Water Sources include recycled water (Class A), stormwater and rainwater.
- Utilising these alternate sources reduces the demand for potable within the Wollert PSP site.
- Rainwater tanks installed at an allotment level can be reused for hot water in the shower with a potential saving of 20% per lot per annum.
- Stormwater tanks under active open spaces can be used for irrigation providing savings of up to 8% of the total Wollert site potable water demands, before filtering through the soil into infiltration systems where pollutants are further removed prior to entering natural waterways.
- Recycled water from the Aurora Craigieburn West treatment facility will be used as an alternate source for purposes of garden watering, toilet flushing, fire fighting and laundry use as well as open space irrigation to top up supply levels in periods of low rainfall.
- Grey water, Sewer mining and Aquifer recharge systems were all regarded as not viable or suitable for the Wollert development.

<u>Urban Planning & Community Values</u>

There is the option to place infiltration systems at an allotment level (ie. Rain gardens), however there have been a number of issues with its implementation in the past which include:

- o Regular unclogging is required to maintain them and who should bear the costs associated with this maintenance
- o Their proximity to neighbouring homes
- o Issues surrounding house foundation compromise due to soil saturation
- o The home owner removing the system
- o Amount of space they take up in the backyard
- o Infiltration rates are too low for them to function effectively

Due to these concerns this IWMS will not be recommending their inclusion in the overall strategy for stormwater management.

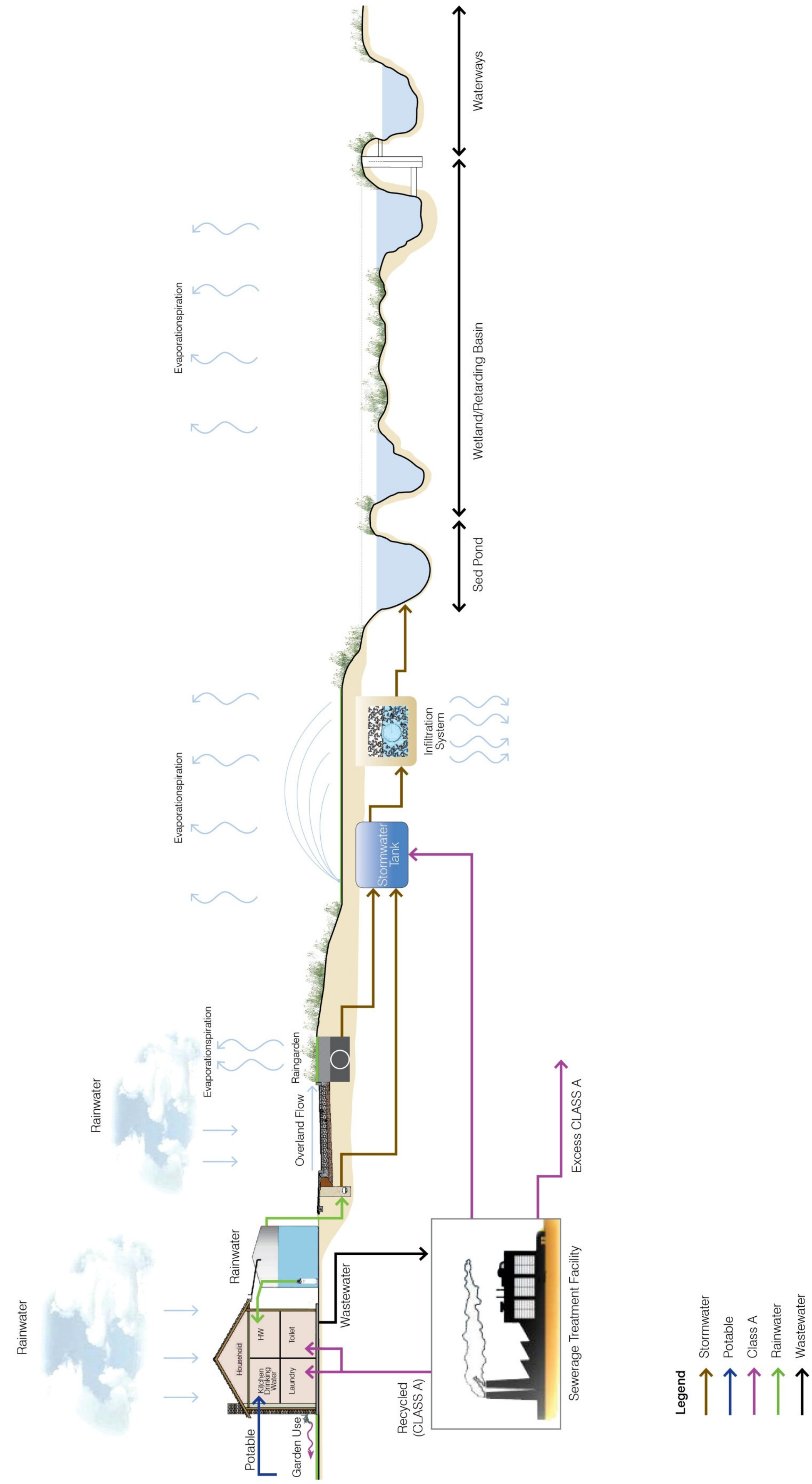
- Strategic placement of the stormwater harvesting tanks is key in the proposed IWMS to avoid excessive and costly infrastructure to divert runoff into storage tanks for irrigation. Consideration needs to given as to where to place open space land use within the Wollert PSP to maximise efficiency.

- Integrating WSUD within the development should also consider the community values by creating public spaces that the community is proud of and can form a sense of attachment. The development should encourage bringing people to the water rather than fencing it off and creating a disconnection to these public spaces. Utilising such techniques such as boardwalks, information boards, activity nodes around these treatments will promote community engagement with the WSUD elements within the development.

Issues

There are a number of issues surrounding the implementation of the Wollert PSP Integrated Water Management Strategy which include the following:

- Soil Infiltration rates for this report was assumed at 3.6mm/hour. However due to the unique properties of soil in Whittlesea City Council lands, this figure can be as low as <0.01mm/hour in some areas of the Wollert PSP and only further geotechnical investigation can substantiate these numbers. If they are found to be significantly low, any treatments that utilise infiltration as a means to treat stormwater runoff may not be efficient enough for implementation.
- There are several arrangements for the recommended ‘treatment trains’ that can be put into practice including a ‘centralised’ approach where an end of line stormwater harvesting tank and infiltration system is installed to service all of the Wollert PSP site open space irrigation requirements through a network of pipes, or a ‘decentralised’ approach whereby numerous smaller tanks are located throughout the precinct to irrigate the open space in that immediate area. While both are proven to be effective in reaching the targets of this paper, further feasibility study needs to be conducted in order to find the most efficient balance of the recommended approaches.
- Department of Health has concerns with ensuring the quality of rainwater when captured for the purposes of hot water use also at an allotment scale and further investigation and discussion is required to ensure all parties are satisfied.



Integrated Water Management Strategy Schematic

Contents

Figures

Tables

1 Introduction

CPG has been engaged by City of Whittlesea in consultation with the Growth Area Authority (GAA) to prepare an Integrated Water Management Strategy and provide recommendations for the proposed Wollert Precinct Structure Plan located within the Northern Growth Corridor.

An Integrated Water Management Strategy is an important part of the planning process and its incorporation into the Precinct Structure Plan will ensure efficient and sustainable water management within a development framework.

This report will outline a number of strategies to achieve a desirable outcome as depicted in Figure 1 below.

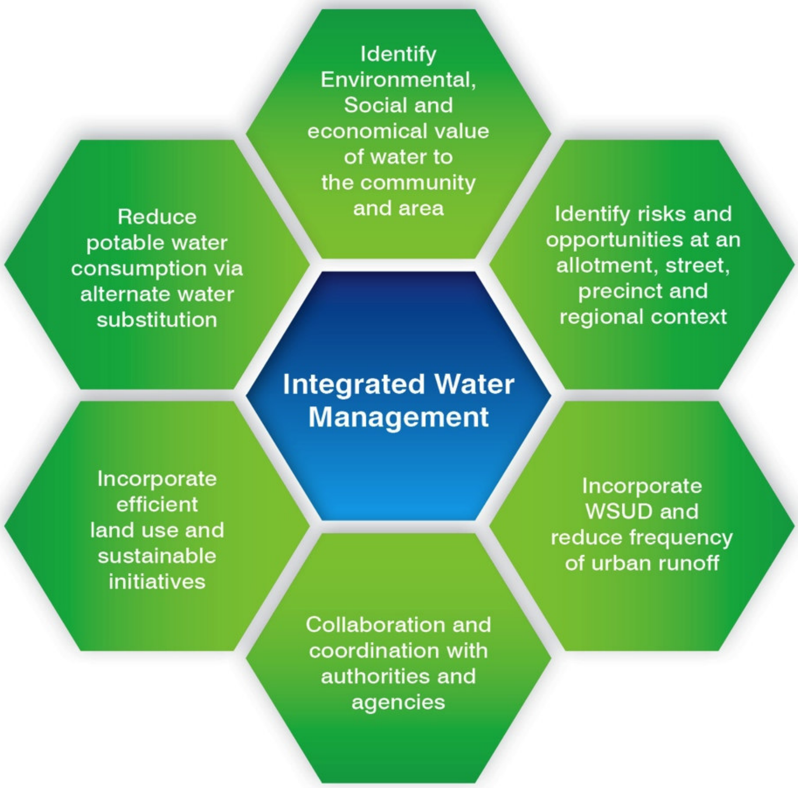


Figure 1 – IWMS Outcomes

Ultimately this report is aimed at improving Victoria's local environments and urban liveability, while providing resilient and flexible water services to its inhabitants.

1.1 Background

The Wollert site is located within the City of Whittlesea and is approximately 1433 hectares in size. It is bordered by Curly Sedge Creek to the West, Craigieburn Road East along the South, Summerhill Road to the north and Bindts Road to the East (see Figure 2).

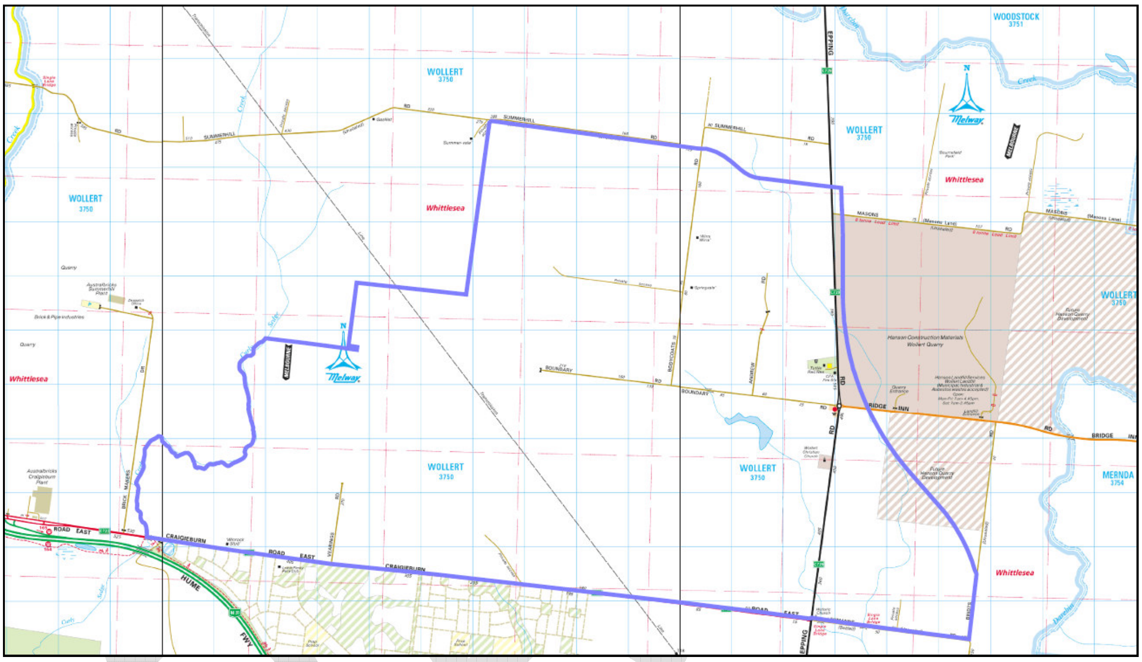


Figure 2 - Locality Plan

The Wollert PSP encompasses three major catchments namely:

- Findon Creek
- Edgars Creek
- Curly Sedge Creek

The land currently sits inside the Urban Growth Boundary and is primarily rural farm area. A large dam is located on Findon Creek just south of Boundary Road and based on observations on site is manmade. The topography of the site slightly undulates and has grades in the order of 1 – 5%.

The Department of Sustainability and Environment (DSE) have prepared a draft report in 2011 which outlined a Sub-regional Species Strategy for the Growling Grass Frog and has indicated that Findon Creek and Edgars Creek comprise a Category 2 habitat and Category 1 habitat respectively.

At this stage, investigations such as geotechnical, flora and fauna, cultural heritage and geomorphology have yet to be completed.

1.2 Scope

The Integrated Water Management Strategy report will help shape and influence the future Precinct Structure Plan for the land by identifying the opportunities to utilise the existing topography arrangement, examine land use and its impacts and ways to best mitigate them. The target outcome is to manage all aspects of water (ie potable, stormwater and wastewater) and utilise this resource to achieve a sustainable development structure.

This report will look at several scenarios across a range of elements listed in the integrated water management model and make recommendations at a high level for measures that could be implemented to consolidate developmental impacts on the Wollert site. As a result it can use the outlined strategy to help shape the urban framework for future development.

2 Strategic Context

There has been a major push from both government and industry to implement strategies inline with the Water Sensitive City approach. Figure 3 below illustrates the consistent and committed effort required across the board to secure our water's future.

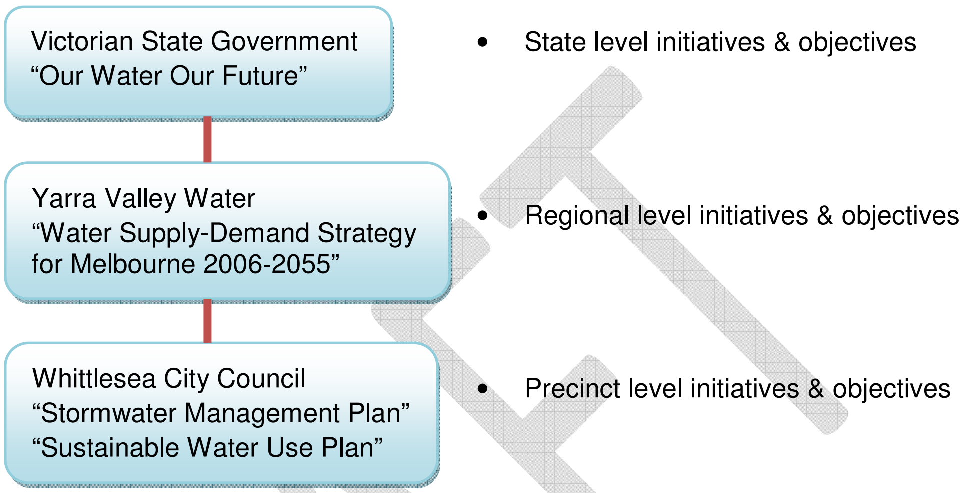


Figure 3 - Scales of Water Management Strategies

The three tiers of government above play an integral part on forming the Wollert PSP policy that is ultimately adopted as the Sustainable Water Management Strategy.

Federal and State government initiate large scale projects that seek to alleviate the issues of water shortage and quality on a state scale, for example the desalination plant on the Bass Coast near Wonthaggi. The water authority applies policy at a regional level and implements strategies for a balance on supply and demand within their catchment, for example the Aurora Craigieburn West recycled water project. It is then the council who set policy at a precinct scale in line with their own sustainable water management plans.

It is important that all levels of administration have a synergy between their strategies and initiatives to ensure that they are complimentary to each other. Consideration must be given to these reports from all hierarchy of government to ensure the recommendations and initiatives put forward for the Wollert PSP are aligned with the goals and objectives of the overall strategies.

3 The IWMS Approach

The two largest challenges facing Melbourne are that of an ever-increasing population and climate change that threaten our country's standard of living and quality of life. For this Integrated Water Management Strategy we will be adopting a Water Sensitive City approach. The notion of a Water Sensitive City seeks to strategically plan and implement measures to alleviate issues such as the risk of flooding, water security and conservation, and the degradation of our urban waterways through a combined effort from government, industry and community.

To achieve these goals based on the Water Sensitive Cities approach this report will focus on the three themes of a Water Sensitive City, which are:

- Cities as Water Supply Catchments – providing access to water through a diversity of sources at several supply scales
- Cities providing Ecosystem Services – building structural frameworks to supplement and support natural environments
- Cities comprising Water Sensitive Communities – communities being water sensitive through their decision making and behaviours

Whilst the concept of Water Sensitive Cities in Australia has featured in several government policies, including the Victorian Government's Green Paper on Climate Change Adaption in June 2009, it remains largely undefined as to how to achieve this outcome.

Based on these three water sensitive city themes CPG has further defined these themes into four meaningful elements of an IWMS. These four elements will then be separately analysed, thereby understanding how each of these elements can work together in harmony. The four elements are as follows:

- Conveyance and Flood Mitigation
- Waterway Health
- Alternate Water Sources
- Urban Planning and Community Values

By integrating the above items, this strategy will seek to leverage off the strengths, weaknesses and opportunities of each of these elements to provide a synergetic system that produces an overall efficient and effective water management system.

3.1 IWMS Assumptions

The main assumptions that underpin the strategy for Wollert PSP have been listed below as follows:

- Average medium sized house uses 113L/day of hot water.
- Average medium lot size is 400m²
- Average medium lot roof surface area 240m²
- There are 15 lots to every hectare
- Open space equates to 10% of total site area
- Average oval size is 1.5 hectares
- Ovals account for 50% of total open space
- Soil infiltration rate equates to 3.6mm/hour **
- Garden water use is lost, therefore no excess runoff

<u>Note</u>
** YVW have indicated that infiltration rates for the area are likely to be as low as 0.01mm/hr, therefore soil permeability tests need to be carried out within the Wollert area to obtain representative infiltration rates and therefore further inform the strategy.

4 Climate Change Impacts

Before beginning the detailed investigations of the IWMS, a discussion is required regarding the effects of climate change to further underpin the rationale behind these works. If you are a believer in climate change or not, the one thing we can not deny is Australia's climate and rainfall are highly variable with Australia having the lowest rainfall of the seven continents (besides Antarctica).

There has been an abundance of speculation as to whether we are in the midst of a climate change that threatens our way of life. While nothing is for certain, over the past decade we have certainly seen the pressures placed on our community when we are ill prepared for an extended drought.

When looking at Victoria's rainfall over the latest 10 year period as outlined in the report "Our Water Our Future (2007)" prepared by the Victorian State Government, we see an alarming observation of a decline in our average rainfall. Among the other trends specified in the report there was a:

- Reduction in rainfall
- Reduction in river inflows
- Increase in temperatures
- Reduction in soil moisture content

To dismiss the facts or refuse to action against the effects of a climate shift could prove disastrous. Looking below (see Figure 4) at one of our driest winter seasons to date in 2006, it is imperative that we plan and take action towards securing our water's future.

Melbourne's Autumn/Winter rainfall over the past 10 years has also seen a steep decline from the Capital's average since recording began over 100 years ago. It is important to safeguard our community from these negative impacts as a result of the climate shift should it become an irreversible trend. Figure 5 indicates the reduction in flow into Melbourne's storages over the past decade as a result of reduced rainfall.

Figure 4 - Victorian Rainfall, Winter 2006

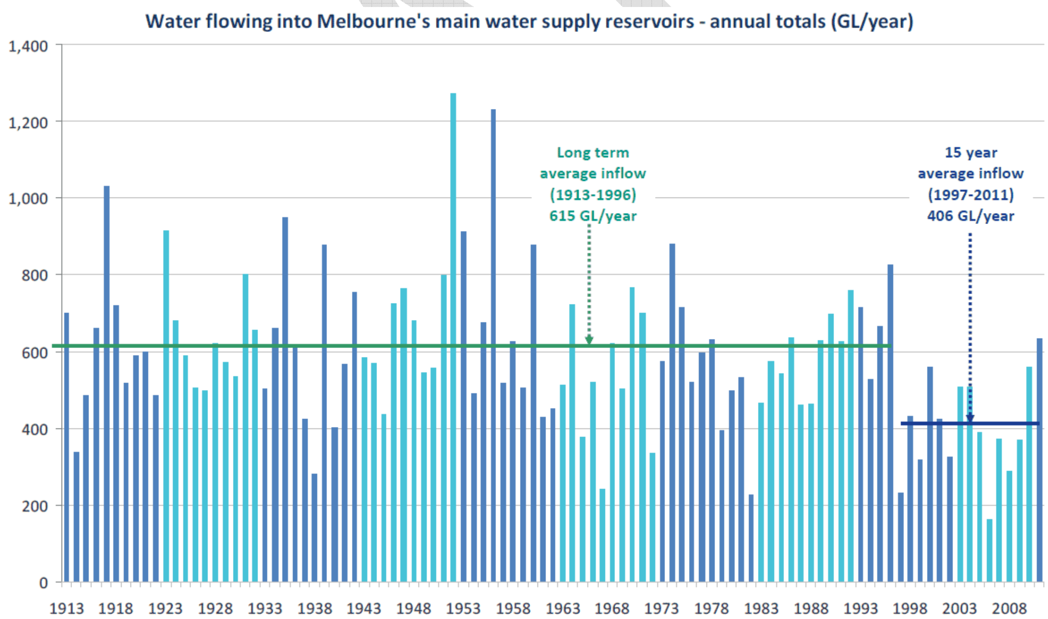


Figure 5 - Melbourne Storage Inflows, 1913-2011

As with any new development, there comes an increased demand for water and this reduction in our potable source combined with a surge in usage requires strategic water management planning and action to ensure a viable, sustainable development.

5 Flood Mitigation and Conveyance

As described earlier the Wollert precinct encompasses three major catchments as follows:

- Findon Creek
- Edgars Creek
- Curly Sedge Creek

The Conveyance and Flood Mitigation investigations of the above three catchments will be broken up into two key sections, hydrological analysis (flow predictions and flood mitigation requirements) and hydraulic analysis (conveyance requirements).

A high level schematic design for conveyance and flood mitigations requirements will be developed, including the alignment and location of drainage reserves and location and size of retarding basins.

This analysis then forms part of the holistic integrated water management strategy, which will bring the conveyance and flood mitigation requirements together with such elements as waterway health objectives.

5.1 Hydrologic Analysis

The Hydrological analysis involves the review of the existing catchment characteristics, development of RORB models (runoff-routing modelling software) and associated catchment plans for each catchment. RORB models allow for an understanding of the flows generated at key locations within the catchment and their timing at certain Annual Recurrence Intervals (ARI). For the analysis of the Wollert PSP, these include, the flows in major reaches, flows in and out of existing and proposed retarding basins, and most importantly, flows leaving the Wollert PSP region.

5.1.1 Fraction Impervious Values

A key element in the generation of design flows is the impervious fraction of the sub-areas modelled within RORB. These fraction impervious values, when combined with the calibration for each model and reach types, set the principles for the RORB model to generate flows. The following Table 1 shows the fraction impervious values adopted for the various land use zones for each of the catchments.

Table 1- Fraction Impervious Values

Growth Corridor Plan Category	Fraction Impervious
Findon Creek Catchment	
Rural	0.1
Residential/Mixed Use	0.75
Commercial/Industrial	0.9
Unencumbered Open Space (15%of Residential)	0.1
Encumbered Open Space	0.1
Edgars Creek Catchment	
Rural	0.1
Residential	0.75
Unencumbered Open Space (15%of Residential)	0.1
Encumbered Open Space	0.1
Curly Sedge Creek Catchment	
Rural	0.0
Residential	0.6
Industrial	0.9
Mixed Use	0.8

Each of the Calibrations for the RORB models includes the rural fraction impervious values as shown above. The calibration of each model ensures that the rural flows generated correspond to either gauged pre developed flows or calculated flows.

Each of the developed catchment models has been broken up using the zones shown on the North Growth Corridor Plan (Appendix D).

In the case of Findon and Edgars Creek, the residential area shown on the North Growth Corridor Plan has been separated into the wholly residential area and unencumbered open space that is associated with the residential area. As such, a fraction impervious value is given for both. The fraction impervious values chosen for the Findon and Edgars Creek are those recommended by "Melbourne Waters Guidelines for the use of MUSIC" (refer Appendix H).

For the Curly Sedge Creek Catchment, a large portion of the catchment has been assigned as open space, utilities or overlaid with biodiversity values (GAA 2012). It is understood that the utilities overlay will likely manifest as buffer areas for the gas transfer station, while biodiversity values and open space will remain at or near their natural state. For this reason, and to keep the RORB models consistent, only the impervious fraction values of residential, urban and industrial areas have been altered in the post-development model. The fraction impervious values chosen for the Curly Sedge Creek are those recommended by the Growth Areas Authority (GAA 2011).

5.1.2 Findon Creek Catchment

- **Findon Creek Catchment Characteristics**

  The Findon Creek catchment is approximately 1,930ha in size, of which the proposed Wollert PSP area occupies approximately 890ha of the upper reaches.

  Melbourne Water Corporation (MWC) has supplied the Findon Creek RORB model as adopted for development within the Findon Creek catchment. The catchment plan for this can be seen in Appendix A.

  In order to effectively model proposed and existing retarding basins within the Findon Creek catchment, CPG have remodelled and re calibrated the Findon Creek RORB model to ensure a minimum 4 sub catchments upstream of proposed retarding basin sites. Appendix A shows the RORB catchment plan and calculations adopted for the Findon Creek model.

  Within the Wollert PSP area, there is an existing dam that in all modelling of the Findon Creek catchment to date is said to act as a retarding basin. From site visits by CPG, the actual retardation ability of the dam seems compromised as the dam looks to fill with water without any low flow outlet. This results in the dam being filled to capacity, with only small additional retardation storage available above the water level in the dam before the whole dam overtops. This would result in very little actual retardation as the peak flows would simply overtop the dam and proceed downstream.

  Nevertheless, to maintain consistency with previous studies, the existing dam has been modelled using RORB to generate the rural flows as discussed below. The existing conditions flows generated will form the basis of the discharge limit for developed flows as a result of urbanisation within the Wollert PSP area. This will ensure peak flows from the Wollert site do not adversely affect downstream developments.

- **Findon Creek RORB Models**

  RORB models have been developed for the Findon Creek catchment as follows:
  - Existing Conditions
  - Developed Conditions with No Retardation
  - Developed Conditions with Retardation Option 1
  - Developed Conditions with Retardation Option 2
  - Developed Conditions with Retardation Option 3

- **Findon Creek Design Rainfall**

  In accordance with MWC, the adopted design rainfall parameters are that of Epping as shown below (Table 2).

Table 2 - Findon Creek Catchment Rainfall Parameters

AR&R Parameter	Value
1hr 2yr	19.50
12hr 2yr	3.9
72hr 2yr	1.1
1hr 50yr	39
12hr 50yr	7.3
72hr 50yr	2.25
Skew	0.35
F2	4.29
F50	14.90
Zone	1

– **Calibration Process**
The revised RORB model is calibrated to the existing flows as generated by the MWC RORB model. The values for m, Initial Loss (IL) and Runoff Coefficient (RoC) are the same as to the MWC RORB model, with Kc being changed to match flows to the existing MWC RORB model.

This has resulted in the below parameters (refer Table 3) being adopted for the CPG RORB model.

Table 3 - Findon Creek RORB Calibration Parameters

RORB Parameter	Value
Kc	8.92
m	0.8
IL (mm)	15mm
100yr Volumetric Runoff Coefficient - RoC	0.6

– **Design Flows**
Design flows have been generated from the various RORB models.

The flows generated from the existing conditions RORB model set the peak discharge limits for the Wollert PSP area. This is because all development that has been undertaken downstream of the Wollert PSP area has assumed that the area would only generate pre-developed flows. This is partly due to expansions of the Urban Growth Boundary (UGB) over the past years.

Appendix A and Table 4 below show the peak flows generated from the various development scenarios.

Table 4 - Findon Creek Peak Flow RORB Results

Location	Peak Existing Q_{100} Flows (Refer G01-1) (m^3/sec)	Peak Ultimate Un-Retarded Q_{100} Flows (Refer G01-2) (m^3/sec)	Peak Ultimate Retardation Option 1 Q_{100} Flows (Refer G01-3) (m^3/sec)	Peak Ultimate Retardation Option 2 Q_{100} Flows (Refer G01-4) (m^3/sec)	Peak Ultimate Retardation Option 3 Q_{100} Flows (Refer G01-5) (m^3/sec)
Existing Dam Inflow	27.6	41.1	-	-	-
Existing Dam Outflow	25.6	39.1	-	-	-
Dam RB (RB3) Inflow	-	-	41.1	-	-
Dam RB (RB3) Outflow	-	-	39.1	-	-
RB1 Inflow	-	-	46.9	34.7	27.4
RB1 Outflow	-	-	28.8	28.7	23.3
RB2 Inflow	-	-	16	16	13.8
RB2 Outflow	-	-	11.2	11.2	9.2
RB3 Inflow	-	-	-	42.6	34.3
RB3 Outflow	-	-	-	19.1	16.3
Wollert PSP boundary A	29.7**	46.8	29.3***	29.1***	29.4***
Wollert PSP boundary B	11.2**	16.0	11.2***	11.2***	10.4***
Combined Flow Downstream of Wollert PSP	42.8**	65.1	42.0***	42.7***	42.2***

**forms discharge limit for Wollert PSP area
***flows to be no greater than discharge limits from existing conditions flows

When comparing the ultimate un-retarded flows to the existing flows, it is evident that retardation is required to maintain peak flows from the catchment to at or below the discharge limit.

As a high level study of retardation opportunities, each of the retardation options presented represent a typical ‘on line’ approach. That is, where the retarding basin retards the main creek flows. This can be considered suitable where the existing creek line is able to be reconstructed. However, significant reconstruction is only suitable where the ecological values are not of significance to protect the current form of the creek.

In the upper reaches of the waterways, the extent to which the retarding basins are ‘on line’ is reduced. As studies progress and the retarding basin locations are finalised, smaller ‘off line’ retarding basins could be included to compliment the ‘on line’ basins shown. This would require further breaking up of the RORB model sub catchments and recalibration.

The Department of Sustainability and Environment (DSE) 2011 Draft Report on the Sub-regional Species Strategy for the Growling Grass Frog indicates that Findon Creek comprises of Category 2 habitat. Category 2 means that other suitable habitat requiring offset is required if cleared. Refer to Appendix E.

In the interest of maintaining the original Creek habitat and minimising disturbance to the existing creeks, offline retardation options may be adopted. This will involve the adoption of multiple retarding basins for a number of the sub catchments within the catchment.

Each of the smaller retarding basins will retard flows prior to entering the creek lines, thus allowing for fewer disturbances to the creeks in order to provide flow conveyance capacity.

5.1.3 Findon Creek Retardation Recommendation

In order to establish the most suitable flood mitigation option, the 3 options as discuss previously have been presented.

In order to best utilise the land and strategically locate the retarding basins to have maximum effect, Option 3 is recommended as the preferred retardation option for Findon Creek. The Retarding Basin sizes are as follows (Table 5).

Table 5 - Findon Creek Recommended Retardation Basin Sizes

Drawing No.	Retarding Basin Name	Volume (kL)	Area (m^2)	Maximum Depth (m)
137599G01-5	RB1	39,500	20,500	3.5
	RB2	23,800	13,300	3
	RB3	57,100	40,000	2

The retarding basins are shown in Appendix A on drawing 137599G01-5.

5.1.4 Edgars Creek Catchment

– **Edgars Creek Catchment Characteristics**

The Edgars Creek Catchment is to the west of the Findon Creek catchment and the Wollert PSP forms the upper most reaches of the catchment.

Melbourne Water Corporation (MWC) has supplied the Edgars Creek RORB model as adopted for development within the Edgars Creek catchment. The catchment plan for this can be seen in Appendix B.

This model has been used to determine flows generated from the catchment up to the Wollert PSP boundary.

– **Edgars Creek RORB Models**
RORB models have been developed for the Findon Creek catchment as follows:

- Existing Conditions
- Developed Conditions with No Retardation
- Developed Conditions with End of Line Retardation

– **Edgars Creek Design Rainfall**
In accordance with MWC, the adopted design rainfall parameters are that of Edwards Lake as shown below (Table 6).

Table 6 - Edgars Creek Catchment Rainfall Parameters

AR&R Parameter	Value
1hr 2yr	19.20
12hr 2yr	3.8
72hr 2yr	1.1
1hr 50yr	39.5
12hr 50yr	7.2
72hr 50yr	2.20
Skew	0.35
F2	4.29
F50	14.90
Zone	1

– **Calibration Process**
As per the MWC suppled RORB model for Edgars Creek the adopted RORB parameters are as below (Table 7).

Table 7 - Edgars Creek RORB Calibration Parameters

RORB Parameter	Value
Kc	8.3
m	0.8
IL (mm)	15
100yr Volumetric Runoff Coefficient	0.6

- **Design Flows**
  Design flows have been generated from the various RORB models as outlined above.

  The flows generated from the existing conditions RORB model set the peak discharge limits to Edgars Creek for the Wollert PSP area. This is because all development that has been undertaken downstream of the Wollert PSP area has assumed that the area would only generate pre-developed flows. This is partly due to expansions of the Urban Growth Boundary (UGB) over the past years.

  Appendix B and Table 8 show the peak flows generated from the various development scenarios.

Table 8 - Edgars Creek Peak Flow RORB Results

Location	Peak Existing Q_{100} Flows (Refer G02-1) (m^3/sec)	Peak Ultimate Un-Retarded Q_{100} Flows (Refer G02-2) (m^3/sec)	Peak Ultimate End of Line Retardation Q_{100} Flows (Refer G02-3) (m^3/sec)
RB1 Inflow	-	-	15.2
RB1 Outflow	-	-	4.3
RB2 Inflow	-	-	8.4
RB2 Outflow	-	-	3.1
Wollert PSP boundary C	4.3**	15.2	4.3***
Wollert PSP boundary D	3.1**	8.4	3.1***

**forms discharge limit for Wollert PSP area
***flows to be no greater than discharge limits from existing conditions flows

As for the Findon Creek catchment, retardation is required to ensure that flows leaving the Wollert PSP area do not exceed the peak discharge limits as set by the pre-developed flow rates.

Again the retardation option presented in the above table is for an end of line, on line retarding basin.

With reference to Appendix E, within the Wollert PSP area Edgars Creek is shown to have a Category 1 Growling grass Frog Habitat. This represents a strategically important habitat area that requires protection, typically in the form of a 100m buffer each side of the creek centreline, a total of a 200m wide habitat zone. This presents a restriction in constructing an end of line retarding basin due to not being able to undertake bulk earthworks within the frog protection area. In order to provide retardation capacity within the frog corridor, major filling works would be required either side of the protection zone to provide freeboard to road and lots.

As for the Findon Creek Catchment, adopting off line retarding basins for the sub catchments of Edgars Creek should be investigated. This will allow for retardation of peak flows to be done prior to discharge to Edgars Creek.

5.1.5 Edgars Creek Retardation Recommendation

Due to the existing landform of the Edgars Creek catchment within the Wollert PSP study area, no further retardation options were presented other than that shown in Appendix B, drawing 137599G02-3 and as discussed above.

The option presented (Table 9 below) depicts two end of line retarding basins that retard flows to pre-developed levels.

As mentioned above, adopting off line retarding basins within the upper reaches of the catchment could be investigated in later studies to reduce the size of the end of line retarding basins. This would require a more in-depth analysis of the catchment.

Table 9 - Edgars Creek Recommended Retarding Basin Sizing

Drawing No.	Retarding Basin Name	Volume (kL)	Area (m²)	Maximum Depth (m)
137599G02-3	RB1	60,400	50,800	3
	RB2	30,600	23,500	1.5

5.1.6 Curly Sedge Creek Catchment

The Curly Sedge Creek catchment is approximately 2000ha in size, of which the western edge of the proposed Wollert PSP area occupies approximately 200ha of the upper reaches. This catchment is a tributary of the Merri Creek. The intended land use of this portion of the Wollert PSP area is a mix of residential development and land categorised as having biodiversity values and therefore not being developed.

As no RORB model has been supplied, CPG has developed a RORB model of the Curly Sedge Creek catchment from its uppermost reaches to the Wollert PSP boundary, an area of approximately 1460ha. This RORB model has been calibrated against approximate peak discharge flows calculated using regional methods. The RORB catchment plan, characteristics and working calculations can be seen in Appendix C.

- **Curly Sedge Creek RORB Models**
  RORB models have been developed for the Curly Sedge Creek catchment as follows:
  - Existing Conditions
  - Developed Conditions with No Retardation

- **Design Rainfall**
  Utilising the Bureau of Meteorology IFD generator, design rainfall parameters for the Curly Sedge Creek catchment have been identified, shown below (Table 10).

Table 10 - Curly Sedge Creek Catchment Rainfall Parameters

AR&R Parameter	Value
1hr 2yr	19.66
12hr 2yr	4.0
72hr 2yr	1.08
1hr 50yr	39.93
12hr 50yr	7.24
72hr 50yr	2.29
Skew	0.33
F2	4.30
F50	14.97
Zone	1

- **Calibration Process**
  A number of approximate regional methods are utilised to generate peak discharges against which to calibrate the RORB model. The value for m remains at the RORB default, while Initial Loss (IL) and Continuing Loss (CL) are set to correspond to the values recommended in AR&R. K_c is set initially at the default RORB value and then adjusted to match peak discharge flows at the identified catchment boundary.

  This has resulted in the below parameters (Table 11) being adopted for the CPG RORB model.

Table 11 - Curly Sedge Creek RORB Parameters

RORB Parameter	Value
Kc	7.90
m	0.8
IL (mm)	15
CL (mm/hr)	2.5

These RORB models allow for an understanding of the flows generated at key locations within the catchment. For the analysis of the Wollert PSP, these include flows in major reaches, the flows at the catchment boundary to the north, flows at the confluence at the catchment boundary to the west and flows leaving the Wollert PSP region (the specified catchment boundary).

- **Design Flows**
  Design flows have been generated from the various RORB models (Table 12).

  The flows generated from the existing conditions RORB model set the peak discharge limits for the Wollert PSP area. This is because all development that has been undertaken downstream of the Wollert PSP area has assumed that the area would only generate pre-developed flows. This is partly due to expansions of the Urban Growth Boundary (UGB) over the past years.

  Appendix C shows the locations of the peak flows generated from the pre- and post-development scenarios.

Table 12 - Curly Sedge Creek Peak Flow RORB Results

Location	Peak Existing Q_{100} Flows (Refer G04-1) (m^3/sec)	Peak Ultimate Un-Retarded Q_{100} Flows (Refer G04-2) (m^3/sec)
Major confluence to north	18.92	19.32
Scheme boundary (north)	22.56	22.92
End of west reach	10.63	10.75
Confluence/scheme boundary (west)	34.65	35.58
Scheme boundary (outflow)	35.96	37.06

With the current configuration of post-development land use, it appears that the impact on peak discharge flows at the scheme boundary is relatively small. Given that some of the increase occurs in reaches outside the Wollert PSP, residential development within the Wollert PSP boundary is likely to contribute less than a $1m^3$/s increase to the peak ultimate Q_{100} flows.

5.1.7 Curly Sedge Creek Retardation Recommendation

It is considered that retardation measures are unnecessary within the Wollert PSP boundary from a flow magnitude perspective due to the relatively small increase in peak flows from pre- to post-development land use. However, from a stormwater quality and flow frequency perspective, it is likely that WSUD treatments will need to be implemented in association with the residential development taking place within the Curly Sedge Creek catchment boundary. WSUD measures will be required to ensure that urban run-off treatment occurs to satisfy the water quality requirements of Clause 56, and will have the additional impact of reducing the magnitude and frequency of post-development flows reaching the Curly Sedge Creek.

5.2 Hydraulic Analysis

The purpose of Hydraulic Analysis is to understand the necessary hydraulic widths for the various drainage reserves that are required to convey the 100 year ARI flows.

The drainage reserves shown in Appendices A, B and C will ultimately be required to act as a waterway corridor. These reserves will be designed in accordance with Melbourne Water's Waterway Corridors Guidelines and Constructed Waterways Guidelines.

Depending on the existing landform, the waterway corridor may take the form of the existing natural waterway or be formed as a constructed waterway. Melbourne Waters Draft Waterway Corridors Guidelines discuss the natural and constructed waterways and the determination of the reference and setback widths.

Natural Waterway corridors are as shown below, in which the 100year ARI flows are typically contained within the top of bank and the bank lines set a reference point to set out the riparian and buffer zones. As shown in Figure 6 the total of all these elements forms the total waterway corridor width.

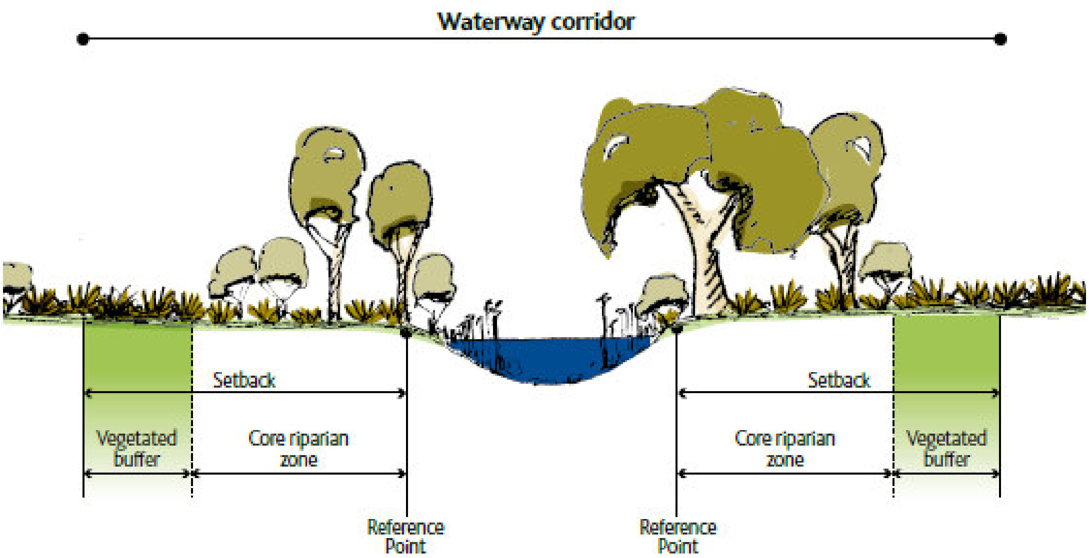


Figure 6 - Typical Natural Waterway, MWC Waterway Guidelines

All natural waterway extents shown as part of this study are to the extent of the hydraulic width only. That is, the actual width of flow with an additional 600mm of free board.

Typically this will set the reference point for the natural waterway, from which the additional setbacks can be derived. However, as discussed in the Draft Waterway

Corridors Guidelines, Melbourne Water can give advice as to the reference points to be adopted.
Where the natural waterway does not have sufficient capacity to contain the 100year ARI flows, and there is no significant overlay, Appendices A, B and C show constructed waterways.

As for the natural waterway, the total corridor width of a constructed waterway is made up of the hydraulic width with additional setbacks as shown in Figure 7.

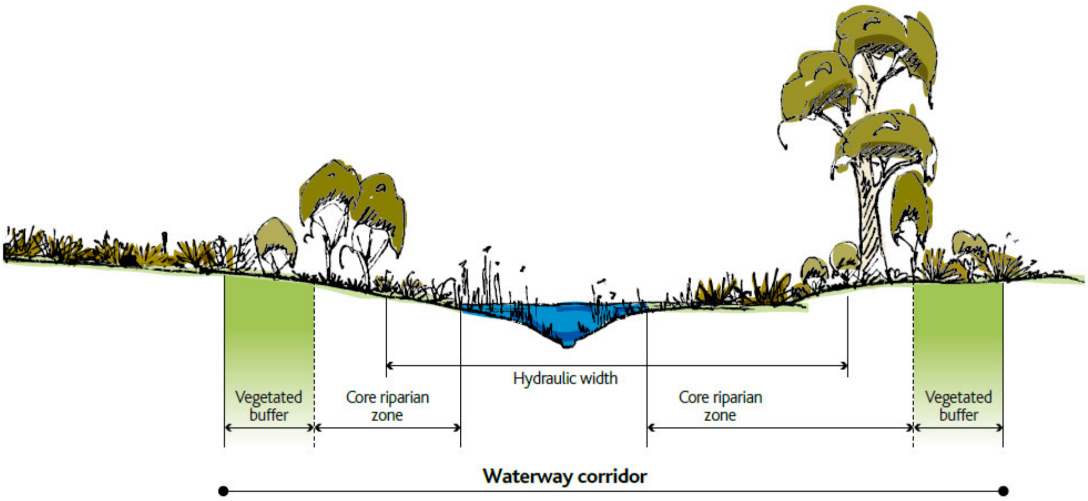


Figure 7 - Typical Constructed Waterway, MWC Waterway Guidelines

All constructed waterway extents shown as part of this study are to the extent of the hydraulic width only. That is, the actual width of flow with an additional 600mm of free board.

To estimate the hydraulic width, manning's channel flow calculations have been done based on existing channel grades and a formed channel to determine a suitable flow width. This flow width with an additional 600mm freeboard forms the total hydraulic width.

The Draft Waterway Corridors Guidelines give guidance on relating the hydraulic width to the corridor width. This allows for the total waterway corridor width to be derived.

5.2.1 Findon Creek Catchment

Within the Wollert PSP area, the Findon Creek catchment has a number of existing creeks and waterway depressions.

The design flows generated from the RORB models allow for hydraulic modelling of the two major existing creeks in the catchment. This will represent a likely inundation extent for the waterways within the catchment, and provide guidance to the total reserve widths required.

Using Lidar survey, HECRAS has been used to model the inundation of these reaches using the peak design flows for various development scenarios.

Appendix A shows the inundation extents of the 1 in 100 year ARI storm events for the existing waterways.

It is evident that especially in the upper reaches of the catchments, the existing channel is breached and flows extend to the floodplain. In these areas it is clear that if the natural channel form is maintained, an extremely wide reserve width or filling either side would be required to minimise the width of inundation. For this reason, as shown Appendix A, formed constructed waterways with hydraulic widths as shown will be required to convey 100 year ARI storm flows to the creeks. For the Eastern tributary, the proposed Outer Metropolitan Ring Road (OMR) will result in the tributary having to be realigned via a drainage reserve to suit as shown on the plans.

The eastern tributary has a small section as shown where the natural waterway has sufficient capacity to convey the developed 100year ARI storm flows. In this area, the natural waterway will be preserved with the hydraulic width shown on the plan.

5.2.2 Findon Creek Channel Width Recommendation

Table 13 - Findon Creek Channel Width Recommendation

Drawing No.	Tributary Name	Width (m)	Constructed	Natural
137599G01-5	A	35	X	
	B	35	X	
	C	55	X	
	D	40	X	
	E	40	X	
	F	40	X	
	G	40	X	
	H	30	X	
	I	40		X
	J	30	X	

5.2.3 Edgars Creek Catchment

Within the Wollert PSP area, the Edgars Creek catchment has 2 existing creeks to be utilised as drainage reserves.

The design flows generated from the RORB models allow for hydraulic modelling of the existing creeks and waterway depressions as above. This will represent a likely inundation extent for the various waterways within the catchment should these depressions be adopted as natural drainage reserves, and provide guidance to the hydraulic widths required. The HECRAS model has been extended sufficiently upstream and downstream to provide appropriate boundary conditions.

Using Lidar survey, HECRAS has been used to model the inundation of these reaches using the peak design flows for various development scenarios.

Appendix B shows the inundation extents of the 1 in 100 year ARI storm events for the existing waterways.

More pronounced than for the Findon Creek Catchment, it is evident that the bank full capacity of the existing depressions is capable of minor flows only. This is due to being in the upper reaches of the catchment and only rural flows ever being conveyed via the depressions resulting in a lack of definition and subsequent capacity as discussed in Section 5.2.6.

There are 2 major drainage lines shown, the Western and Eastern Edgars Creek tributaries:

- Western Edgars Creek Tributary
  As shown in Appendix B, due to a significant lack of capacity in the existing western Edgars Creek tributary, a constructed waterway is required to contain and transfer the 100 year ARI flows through the catchment. The hydraulic width required is shown on in Appendix B.

- Eastern Edgars Creek Tributary
  The eastern Edgars Creek tributary also has a significant lack of capacity to convey the 100 year ARI flows in a constructed sense. However, despite the lack of capacity in this upper reach of Edgars Creek, the Category 1 Growling grass Frog Habitat designation as shown in Appendix E that overlays this tributary will require a total 200m wide buffer, free of hard engineered development. In adopting this, only enhancement of the natural waterway will be permitted to allow for adequate flow capacity within eastern tributary. This will allow for the 100 year ARI inundation width to be reduced, however the 200m wide reserve will remain. The 200m buffer will also allow for space provision for water quality elements, as discussed in later Water Quality Sections.

5.2.4 Edgars Creek Channel Width Recommendation

Table 14 - Edgars Creek Channel Width Recommendation

Drawing No.	Tributary Name	Width (m)	Constructed	Natural
137599G02-3	A	45	X	
	B	200		X

5.2.5 Curly Sedge Creek Catchment

The Wollert PSP encompasses approximately 204ha of the Curly Sedge Creek catchment. Curly Sedge Creek forms the western boundary of the Wollert PSP boundary.

As discussed in the hydrologic modelling for Curly Sedge Creek, the increase in the peak design flows for Curly Sedge Creek are negligible for the developed conditions to that of rural conditions. As such the natural waterway will have capacity to convey the un-retarded developed flows from the Wollert PSP area and no changes to the hydraulic capacity of Curly Sedge Creek will be required.

In addition to the existing capacity of the natural waterway, there is an existing biodiversity significant corridor along Curly Sedge Creek that will protect the natural waterway corridor from modification and development, such that the existing capacity will be maintained.

5.2.6 Local Drainage

The drainage strategy for the proposed internal development should be based on the major/minor approach. The minor drainage system is the network that is capable of carrying runoff from minor storms (typically gutter and pipe systems). The major system comprises the planned and unplanned drainage flow paths that convey runoff from major storms. The word "major" does not relate to catchment size but to the size of the storm or rainfall event.

The subdivisional drainage will be constructed to standards agreed with Whittlesea City Council and Melbourne Water in accordance with the minor / major drainage system philosophy. The minor drainage system will typically be designed to accommodate a 1 in 5 year average recurrence interval event (ARI). The major drainage system will be designed for an average recurrence interval (ARI) of 100 years. Where land use is to be industrial, a minor drainage system is to cater for the 1 in 10 year ARI storm event.

The Precinct Structure Plan for Wollert can accommodate overland flows through the provision of roadways or drainage reserves. Future subdivision and urban design layouts should carefully consider the orientation and provision of local road reserves so that they can function as overland flow paths in order to minimise the need for drainage reserves.

An approximation of the expected internal overland flows was carried out to determine where drainage reserves may need to begin. The following equation was used to determine the overland flow:

$$Q_{overland} = Q_{100} - (0.8 * Q_{pipe})$$

An analysis of a typical 16m wide road reserve was carried out to determine its flow capacity based on Melbourne Water's safety criteria and GAA's Engineering Design and Construction Manual for Subdivision in Growth Areas, 2011. Based on a range of expected grades from 0.5-2%, the maximum road reserve overland flow capacity ranged from 1.2 – 2.5m^3/s. A wider road reserve could be used to increase the overland flow capacity of the road reserve.

Within the Wollert PSP area, there based on the above guidelines, the potential exists to utilise multiple road reserves to convey overland flows across the Findon Creek and Edgars Creek floodplains to the creeks themselves.

However, utilising the multiple road reserves will not be sufficient to convey the overland flows to the creeks. In this case, drainage reserves would be required within the floodplains.

The ultimate urban design layout will determine the starting location of the drainage reserves, which will begin once the capacity of the road network to convey 100 year overland gap flows is exceeded. Careful consideration to the urban design layout should be considered during planning phases to determine more definitely the extent required of the drainage reserves. The starting location for the drainage reserves will depend the number of road reserves acting as overland flow paths, the road reserve widths and how these interact with the existing land form.

As shown for the Findon Creek Catchment in Appendix A and the Edgars Creek Catchment in Appendix B, drainage reserves are shown to convey storm flows across the floodplain to the lower reaches of the creeks.

The widths as shown on the drawings have been derived from the calculated urban flows and average floodway longitudinal grade.

The exact form of the drainage reserves will need to be established in consideration of a number of factors including:

- Existing flora and fauna
- Geomorphology (currently being undertaken by SKM on behalf of MW)
- Melbourne Water and Council maintenance requirements
- Cultural heritage elements
- Integration with WSUD and overall development plan objectives

In addition to the upgrade of drainage reserves, culvert upgrades will be required at Boundary Road, Epping Road and Craigieburn East Road. These will need to consider the redevelopment of the roads and timing thereof.

5.2.7 Development / Creek Interface

All future residential allotments adjacent to floodways, wetlands or retarding basins shall be set at the 100 year flood level plus freeboard (typically 600mm).

As per Melbourne Water guidelines for constructed waterways, footpath and shared paths adjacent to the waterways are to be constructed above the 10 year flood level.

5.3 Issues

The information provided by the conveyance and flood mitigation investigation helps to shape the Integrated Water Management Strategy by determining the size requirement and location of retardation basins. This also provides an opportunity to integrate them with water quality and management techniques to produce an efficient, effective and aesthetically pleasing overall water management system.

The need for retardation to manage flood protection in the Findon and Edgars Creek systems. How sensitive is downstream development to an increase in peak flows? Investigation suggests that some areas downstream would be at risk of flooding if no retardation is in place with the proposed development. If retardation is required the options are:

- Utilise basins proposed in Melbourne Water's Developer Services Schemes
- Utilise Roads as Retarding Basin Embankments
- Consider on-line storages on each of the Findon and Edgars Creeks
- Consider off-line retarding basins should be considered to compliment the on-line retarding basins.

Careful urban design is required to allow for the conveyance of overland flows and delay the onset of drainage reserves. The urban design layout should be done to allow for suitable conveyance of overland flows to authority standards.

Further environmental studies are required on the existing waterways and the existing dam to determine the extent of redevelopment that can be undertaken.

The OMR is proposed to run over the top of an existing tributary of Findon Creek. The realignment of the tributary is to be considered to allow for continued drainage service to the development, together with environmental studies.

5.4 Flood Mitigation and Conveyance Recommendation

The recommendations for each of the major catchments within Wollert PSP study area are as follows:

- Findon Creek
  Adopt the retardation and drainage reserve Option 3, as presented in Appendix A on drawing 137599G01-5.
  This includes:
  - 3 retarding basins, refer to Section 5.1.2 for hydrologic discussion
  - Constructed waterways of various hydraulic widths refer to Section 5.2.1 for hydraulic discussion
  - Enhancement of Natural waterways, refer to Section 5.2.1 for hydraulic discussion

Drawing No.	Retarding Basin Name	Volume (kL)	Area (m^2)	Maximum Depth (m)
137599G01-5	RB1	39,500	20,500	3.5
	RB2	23,800	13,300	3
	RB3	57,100	40,000	2

Drawing No.	Tributary Name	Width (m)	Constructed	Natural
137599G01-5	A	35	X	
	B	35	X	
	C	55	X	
	D	40	X	
	E	40	X	
	F	40	X	
	G	40	X	
	H	30	X	
	I	40		X
	J	30	X	

- Edgars Creek
  Adopt the retardation and drainage reserve Option 1, as presented in Appendix B on drawing 137599G02-3.
  This includes:
  - 2 retarding basins, refer to Section 5.1.4 for hydrologic discussion
  - Constructed waterways of various hydraulic widths, refer to Section 5.2.3 for hydraulic discussion
  - Enhancement of Natural waterways, refer to Section 5.2.3 for hydraulic discussion

Drawing No.	Retarding Basin Name	Volume (kL)	Area (m²)	Maximum Depth (m)
137599G02-3	RB1	60,400	50,800	3
	RB2	30,600	23,500	1.5

Drawing No.	Tributary Name	Width (m)	Constructed	Natural
137599G02-3	A	45	X	
	B	200		X

– Curly Sedge Creek
  Adopt no retardation works and significant waterway works. Refer to Section 5.1.6 for full discussion of analysis.

6 Waterway Health

Melbourne is a city expanding – it is estimated that by 2030 Melbourne's population will increase by one million, and with that expansion comes urban development that encompasses formerly untouched rural landscapes.
Where previously stormwater would permeate the soil and produce a steady sub-surface flow, traditional development methods produce new impervious surfaces such as housing roofs, concrete sidewalks and asphalt roads that convey the water through a drainage scheme into the delicate ecosystem that is our creeks and rivers, increasing the frequency of surface runoff.

While there are current guidelines in place as to the quality of the stormwater that we allow into our waterways as outlined in "Urban Stormwater Best Practice Guidelines" (see Figure 8), there is still simply too much urban runoff entering our creeks and rivers from urban development.

Pollutant	Receiving water objective:	Current best practiceperformance objective:
Post construction phase:		
Suspended solids (SS)	Comply with SEPP (eg. not exceed the 90thpercentile of 80 mg/L) (1)	80% retention of the typical urban annual load
Total phosphorus (TP)	Comply with SEPP (eg. base flow concentration not to exceed 0.08 mg/L) (2)	45% retention of the typical urban annual load
Total nitrogen (TN)	Comply with SEPP (eg. base flow concentration not to exceed 0.9 mg/L) (2)	45% retention of the typical urban annual load
Litter	Comply with SEPP (eg. no litter in waterways) (1)	70% reduction of typical urban annual load (3)

Figure 8 - Urban Stormwater Best Practice Guidelines

To better manage this issue there is a requirement to mimic the natural environment by implementing measures that not only treat the water but retard the flow to counter the problem of increased impervious surfaces runoff through construction. In order to achieve this in an urbanised environment we need to provide systems that separate the continuous flow of overland stormwater to enable the necessary time for it to be treated and infiltrate the surface in much the same way as the pre-developed rural scenario.

Studies have shown there is a direct link between 'catchment effective imperviousness' and the health of the surrounding waterway. This also provides an opportunity to reutilise the captured runoff for cost and potable usage savings on applications such as personal home use at an allotment level, roadside landscape irrigation at a precinct scale, and parkland irrigation on a regional scale.

6.1 Water Sensitive Urban Design

Water Sensitive Urban Design (WSUD) is a relatively new concept that aims to improve the quality of stormwater prior to its entering our rivers and waterways. This is done by implementing one or a number of treatment measures to remove pollutants from the stormwater discharge. Developers are now required to use WSUD practices to achieve best practice guidelines in any new development in accordance with the requirements of Clause 56.07 of the Victorian Planning Provisions. The aims of WSUD are outlined below:

- Protect natural waterways within urban development
- Protect water quality of natural waterways through removal of pollutants at proximity to the source
- Reduce stormwater quantity and frequency of flows.
- Integrate stormwater treatments with the surrounding landscape
- Treat rainwater locally as it flows to reduce the requirement for large infrastructure ventures downstream
- Add value while reducing development costs and the overall cost of drainage infrastructure

Water Sensitive Urban Design seeks to integrate Best Planning Practice (ie. design) with Best Management Practice (ie. technology) to identify the constraints and conditions of the proposed site and recommend a multi-faceted drainage system that will achieve its set outcomes. This system will include measures across a spectrum of scale from allotment through to streetscape and precinct.

As described above WSUD can assist in improving the health of our waterways and as such we need to define the objectives of WSUD and as such further discuss the two major attributes, stormwater quantity and stormwater quality.

6.2 Stormwater Quantity

The use of WSUD for improving stormwater quantity aspects is not widely used however the Best Practice Guidelines do recognise stormwater quantity through the following target:

- Maintain discharges for the 1.5 year ARI event at pre-development levels.

This is target is not widely enforced however with the current research with regards to urban flow frequency a new paradigm has been created for WSUD. This section will discuss the aspects of stormwater quantity and how WSUD can be used to assist this aspect of waterway health.

6.2.1 Flow Frequency

Flow Frequency with relation to urban development refers to the rate of reoccurrence at which runoff from impervious surfaces enters and disturbs the waterways compared to the same surfaces in their previous natural (grass and forested) state. The objective of Flow Frequency Reduction is to restrict any increase in the number of these occurrences as much as possible. This strategy will aim to use WSUD to reduce the urban flow frequency in addition to improving stormwater quality aspects.

6.2.2 Flow Rate

The other concern with respect to urban development is the volumetric rate at which flow enters our natural creeks and rivers. Flow rate refers to the volume of fluid which passes through a surface per given time. It is the developer's responsibility to ensure that this flow rate does not exceed a certain level above pre-development. Flow rates within the Wollert PSP will be managed through retarding basins as detailed in section 4 of this report. Flow rate is relevant with respect to WSUD as such treatments as wetlands may be located within retarding basins. Integrating WSUD into flood mitigation elements provides a useful use of space and thus provides multiple benefits for the one area.

6.2.3 Pre-Development Runoff Days

Prior to urbanisation of any rural area there is a rate of reoccurrence at which rainfall from the sites catchments flows into the local waterways. The number of days at which this occurs per year is referred to as the total annual pre-development runoff days. Matching this number of pre-development runoff days in post development is the optimal outcome of the Wollert PSP IWMS. Based on Appendix B in the FAWB guidelines, the pre-development flow frequency was modelled using MUSIC. For new urban developments an idealist target has been set by Melbourne Water and the DSE as follows:

Urban Flow Frequency Target = Pre-development runoff days + 15 days.

Table 15 - Pre-development Flow Frequency Days

Scenario	Flow Frequency (days/yr)
Pre-development	9
Pre-development + 15 days	24

Based on this Wollert will aim to reduce the flow frequency to 24 days which will be discussed further within this strategy.

6.2.4 Flow Frequency Reductions within Wollert

For developments to efficiently reduce stormwater flow frequency a combination of Evapotranspiration, infiltration and stormwater reuse are required. Reducing flow frequency to pre-development levels within the Wollert PSP site may pose some difficulties based on the heavy clay soils expected in this region. This will potentially hinder the ability of infiltration treatment measures in attaining their intended objectives.

Soil samples taken by DCE at the Kallkallo development have revealed ground conditions to be largely silty clay that is almost impermeable at extremely shallow depths and has recorded infiltration rates as little as less than 0.01mm per hour. It is unknown at this stage whether Wollert will experience similar permeability levels, however CPG expect it to be similar. Evapotranspiration in this case will play a larger role to mitigate the urban stormwater impacts on our waterways. It is the objective of this Integrated Water Management Strategy to achieve pre-development run-off days as described above, however to what degree it can will be discuss in the following sections.

For the purposes of this report a value of 3.6mm per hour has been adopted to conduct the modelling of treatment effectiveness. Without the known soil properties further investigation will be required to determine the suitability of infiltration systems.

Based on the above assumptions CPG will address the impacts of urban flow frequency and flow rate we will integrate the use of Water Sensitive Urban Design (WSUD) treatment measures with the natural landscape to develop this Integrated Water Management Strategy within the Wollert Precinct Structure Plan.

6.3 Stormwater Quality

WSUD is predominately know for treating water quality and therefore this section will outline the approach As this report mentions previously, there is a set of best practice guidelines that outline stormwater quality performance objectives and our proposal for the Wollert Precinct Structure Plan will seek to attain these results through a number of measures. The Best Practice Guidelines are outline below:

- 70% reduction of total Gross Pollutant loads
- 80% reduction of total Suspended Solids
- 45% reduction of total Nitrogen
- 45% reduction of total Phosphorus

6.3.1 Stormwater Quality Approach

To treat the site we have considered the entire Wollert PSP as one body. That is to say, the entire landscape is to be treated to the best practice guidelines prior to stormwater leaving the land perimeter. This will ensure that the site as a whole will meet requirements and any shortcomings in treatment in one area can be corrected through overcompensation in another for a desired weighted total.

This outcome was achieved through the computer modelling software package MUSIC (Model for Urban Stormwater Improvement Conceptualisation). The model establishes a result based on parameters entered into the system and catchments created. The output indicates the amount of pollutants produced, the performance of the treatment measures and the pollutant load generated once the catchment is treated.

This software enables us to optimise the size and arrangement of the selected treatment measures to produce an output that achieves the most favourable results in terms of stormwater quality, flow frequency reduction, flow rate minimisation, reliability, cost and size. These results have been achieved through utilisation of Water Sensitive Urban Design methods across a range of spatial scales from allotment level, streetscape through to neighbourhood and estate.

6.3.2 Clause 56.07 Requirements within Wollert

As Clause 56.07 is the only state planning policy to enforce water quality objectives this section will define the minimum requirements for the Wollert development as to identify a base case scenario. The further sections will identify all the further opportunities and then finally bring them all together in one cohesive strategy.

A MUSIC model was setup utilising Melbourne City rainfall data with a reference year of 1966 as per the MWC MUSIC Guidelines. The initial MUSIC model utilised large sedimentation basins (SB) and wetlands (RB) at the ‘end of line’ to meet best practice guidelines as to first gauge the size and effectiveness at this high level. This has long been the traditionally the approach for water quality treatment although as already discussed in this strategy, treatments should be located at all spatial scales. This enables more efficient land use and mimics natural conveyance and treatment methods throughout the development.

Based on the traditional end of line approach, 1.8% of the entire Wollert area would be dedicated purely to these two treatment measures. Further refinement was carried out by adding rain gardens throughout the site at a streetscape level (Assumed 0.1% of the catchment area for rain garden sizing/contribution) for the in conjunction with wetlands and sedimentation basins located within the earlier identified Retarding basins and other strategic locations. This enabled a land ‘saving’ of approximately 11.2ha by reducing the total land requirements of water quality treatment measures while still achieving Clause 56 targets.

Results of this can be viewed in Table 16 below:

Table 16 - MUSIC Results, Base Case (Clause 56)

MUSIC Results – End of Line Method						
Total Sedimentation Basin Size (m²)	Total Wetland Size (m²)	Total Rain garden Size (m²)	TSS Reduction (%)	TP Reduction (%)	TN Reduction (%)	GP Reduction (%)
10900	247000	0	80.2	67.8	45.4	94.7
MUSIC Results – Distributed Method						
7700	127600	10850	82.3	64.3	45.1	99.2

While this approach has identified the base case scenario, more is required to address the flow frequency and potable water conservation. The following sections will now identify alternative water sources and the water balance followed by integration of all the IWMS elements as to finalise the strategy.

7 Alternative Water Sources

Source substitution is the use of alternative sources of water treated to a level appropriate for their end use. Alternate water sources of appropriate quality will reduce reliance on potable water within the Wollert PSP. There are many possible alternative sources of water, although not all will be practical or safe for use due to the community/commercial nature of the facilities and potential public exposure. Below (Figure 9) is an outline from Whittlesea City Council's "Sustainable Water Use Plan (2006)" for the recommended uses for potable and alternative water sources for the community:

	Use					
Water quality	**Kitchens/ drinking**	**Toilet High contact e.g. flushing**	**Showers**	**Restricted access irrigation**	**Clothes washing / Laundry**	**Vehicle washing**
Potable	✓	✓	✓	✓	✓	✓
Rainwater – Hot	N/R	N/R	✓	N/R	✓	N/R
Rainwater - Cold	N/R	✓	✓	✓	✓	✓
Greywater				✓		
Class A reuse water		✓		✓	✓	✓
Swimming pool backwash		✓		✓	✓	

LEGEND:

✓	Acceptable
✓	Potentially Acceptable
	Unacceptable
N/R	Not Recommended
	Not Approved by relevant Authority ie: EPA, DHS

Figure 9 – Hierarchy of Water within City of Whittlesea

This matrix provides a useful tool in identifying areas where alternate water sources can be supplemented for potable demand in the home environment for the Wollert PSP.

7.1 Supply

Yarra Valley Water will be supplying potable, recycled water (class A) and sewer infrastructure to the Wollert PSP area. In addition to these services being provided we will review the other alternate water sources that could form part of this IWMS. A separate study has been commissioned by GAA to carry out the servicing strategies, therefore refer to the Utilities Infrastructure Servicing Assessment dated 14th May 2012 for further information. This section does not intend to inform the servicing assessment however discusses the opportunities, constraints and uses within the Wollert PSP.

7.1.1 Potable Water

Whilst pricing in the water industry has moved towards a “user pays” philosophy, the water pricing arrangements still do not reflect the true or total cost for water. The pricing of water is based on a financial analysis rather than an economic analysis. As result environmental and social externalities (eg waterway health) are not fully accounted for in the water pricing index.

In Figure 10 from Yarra Valley Water’s “Water Plan 2009/10 – 2012/13 (2008)” it is apparent how much residential potable water tariffs have and will continue to increase. This increase means alternative water sources will only become a more feasible option.

	EXISTING 2008/09 PRICE	PROPOSED 2009/10 PRICE	PROPOSED 2012/13 PRICE
Water fixed charge (per year)	$75.54	$89.89	$128.42
Water usage charge (per kilolitre) Step 1 (0 – 440 litres per day)	$1.0192	$1.2128	$1.7326
Step 2 (441 – 880 litres per day)	$1.1957	$1.4229	$2.0327
Step 3 (881+ litres per day)	$1.7666	$2.1023	$3.0032
Sewer fixed charge (per year)	$184.54	$219.60	$313.72
Sewage disposal charge (per kilolitre)	$1.3181	$1.5685	$2.2408

Figure 10 - Tariff Structures and Prices for Residential Water and Sewerage Customers ($ January 2009 Levels)

Not only are there financial benefits to sourcing water from alternative resources, there is also the issue of water scarcity. As we have discussed previously, there has been a significant downturn in the amount of rainfall our catchments receive each year. An Integrated Water Management Strategy can help reduce our reliance on potable water and alleviate pressures of uncertainty as to how our potable supplies are going to be sustained.

7.1.2 Recycled Water

There is an existing Aurora Craigieburn West recycled water facility available to service the Wollert PSP area. It is capable of providing Class A recycled water for the purpose of reuse on a range of requirements at the allotment level including toilet flushing, residential garden watering, laundry use and fire fighting as well as open space irrigation at a precinct level.

As stormwater harvesting is less reliable than recycled water, there lies an opportunity to balance recycled water with harvested stormwater to provide 100% alternate water source to potable, while protecting our waterways. Recycled water can produce a saving up to approximately 70ML per year through open space irrigation alone. Combining this with Class A recycled water substituting potable use at an allotment scale, approximately 1028ML can be substituted for potable water across the entire Wollert PSP district each year.

7.1.3 Stormwater / Rainwater

The Wollert PSP area receives approximately 665.2mm of rainfall each year on average. While the development will increase the amount of impervious surface and stormwater runoff, it also provides the ability to treat the site as an urban water supply catchment and harness this for consumption benefits.

The estimated total annual runoff produced from the Wollert PSP catchment is approximately 5900ML. Of this approximately 1300ML of this is roof water which can be captured at the source for reuse at an allotment scale. The remainder of the stormwater will runoff as overland flow and/or within the urban drainage system. The urban drainage system can be diverted to logically placed stormwater harvesting storage systems where this can be utilised for irrigation.

Yarra Valley Water has indicated that the option of alternate hot water supply in their customers' homes is acceptable. They do however take exception to rainwater being harvested for the purposes of laundry, toilet flushing and garden watering use at an allotment level as it competes with use of recycled water. As a result it is the position of this Integrated Water Management Strategy that rainwater harvesting be limited to hot water use only. Should Council and Melbourne Water seek to pursue greater diversity of rainwater harvesting; further discussion will be required to consider all social, economic and environmental factors.

There is however a concern from the Department of Health with regards to the quality of the rainwater being harvested. While there is the requirement that the water is treated to a certain level prior to its use (via hot water service), there are a number of questions raised as to how to ensure the water can meet these stringent standards at all times. Again further analysis and discussion will be required to ensure all parties are satisfied.

Capturing and storing of stormwater and rainwater can often be difficult especially if the urban development has not planned to utilise stormwater for such uses as open space irrigation. As it rains less in the summer months and yet we require more irrigation demands at this time, reliability of stormwater and rainwater harvesting systems can be diminished. Non-seasonal demands are the most beneficial demand for stormwater/rainwater systems, however this is not always available. These issues can results in larger infrastructure requirements and hence financially they become less attractive.

The Wollert IWMS has identified a non-seasonal demand and will discuss the importance of appropriate urban form to assist in better water management. Also as the development will have the benefit of utilising recycled water this alternate water source can be used to bolster the diminished reliability in periods of low rainfall.

The reliabilities of stormwater and rainwater harvesting have been calculated using MUSIC and rainfall data spanning 1990-2010, as opposed to a single rainfall reference year as this is typical for stormwater quality calculations. Melbourne has seen an extended period of drought over the past decade and utilising information from this period enables the Integrated Water Management Strategy to propose a more robust and reliable stormwater / rainwater harvesting system that will better cope with any downturn in rainfall within Wollert's catchments. The water balance in section 8 will provide further details as to how stormwater and rainwater will be integrated into the Wollert IWMS.

7.1.4 Grey Water and Sewer Mining

There is the potential to incorporate grey water and sewer mining source substitution however due to the fact that there is recycled water available within the Wollert site it is deemed unnecessary and will not be recommended for inclusion in the Integrated Water Management Strategy.

7.1.5 Aquifer Recharge and Recovery

An Aquifer is 'an underground layer of water-bearing permeable rock or unconsolidated materials (gravel, sand or silt) from which groundwater can be usefully extracted using a water well.' Aquifer Recharge is the process by which stormwater permeates the surface into an underlying Aquifer, and Aquifer Recovery is the harnessing of this water for potable use.

Southern Rural Water manages licences to take and use groundwater. It has a number of responsibilities in accordance with the *Water Act 1989* such as water allocations; including assessing applications according to policies, environmental sustainability, and impacts on Victoria's water resources.

The IWMS has identified Aquifer recharge and recovery within Wollert is not suitable. This is can be shown in Figure 11 as the Lower Tertiary Aquifer Managed Aquifer Recharge (MAR) Storage Potential is not suitable for Aquifer storage within the Wollert area.

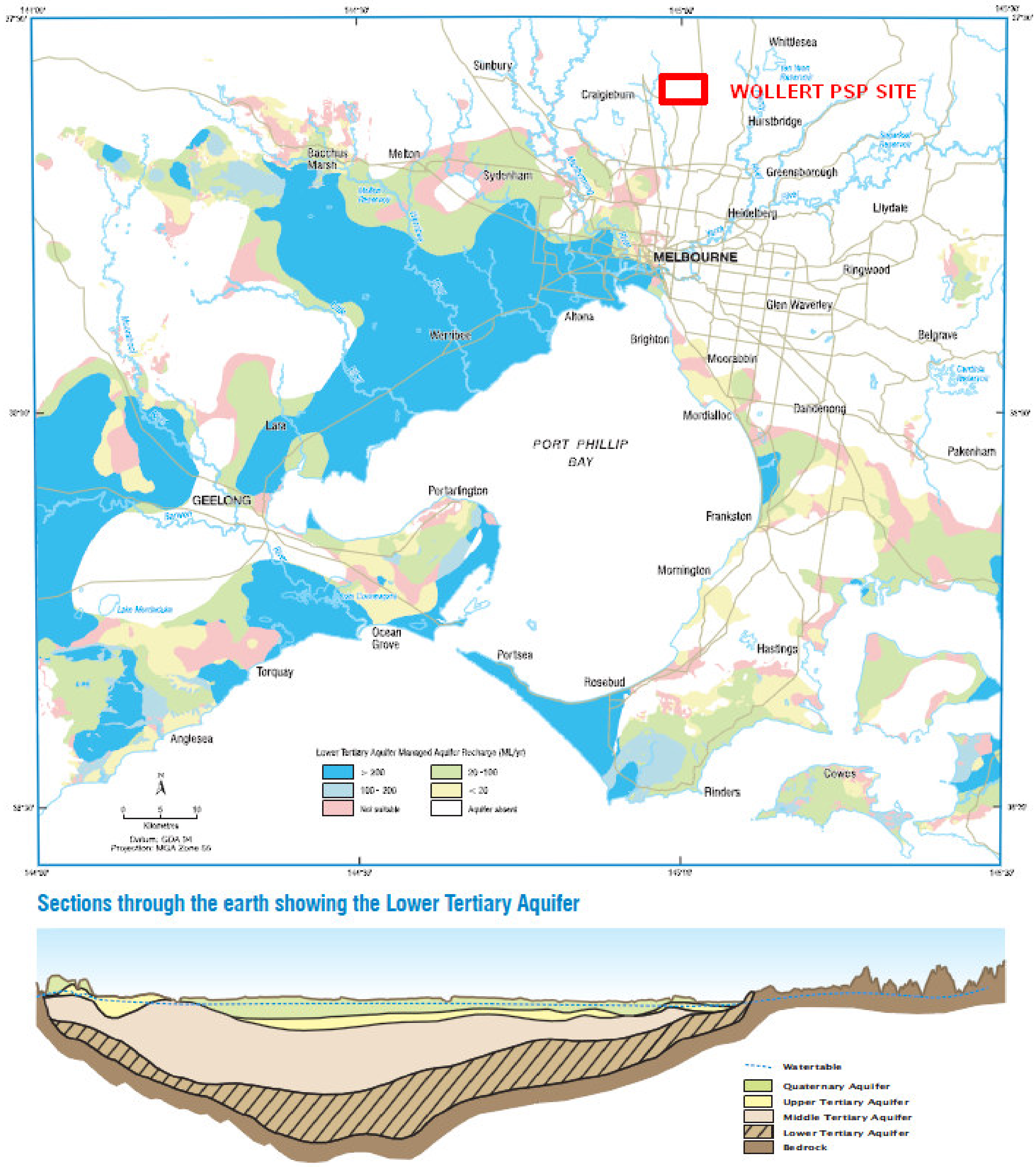


Figure 11 - Lower Tertiary Aquifer Managed Aquifer Recharge (MAR) Storage Potential

In addition to this, Figure 12 shows that any Upper Tertiary Aquifer near the Wollert PSP will yield only less than 1 litre per second.

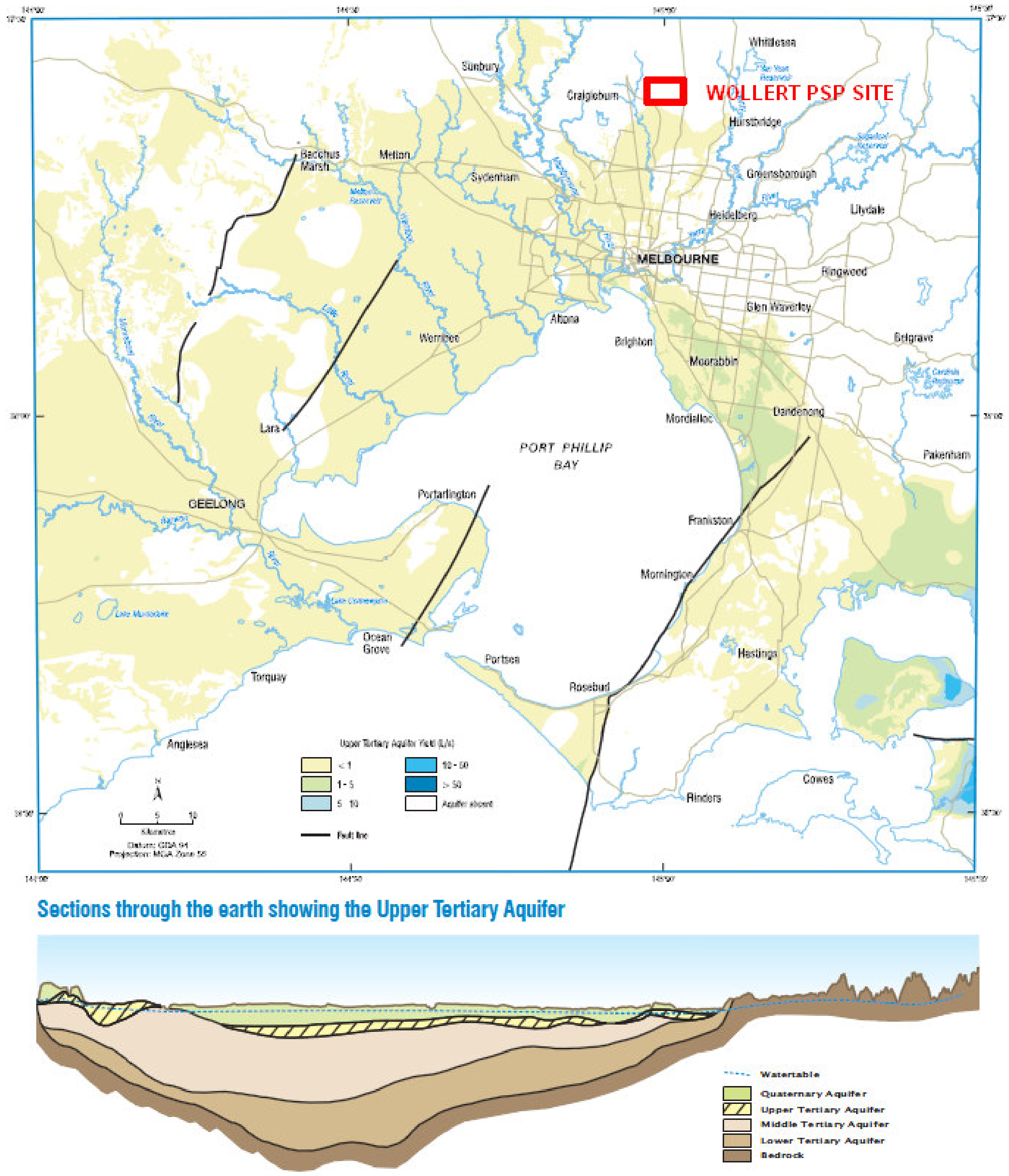


Figure 12 - Upper Tertiary Aquifer Yield

7.2 Demand

7.2.1 Residential Demand

The following key residential water demands are from the “North Growth Area Integrated Water Cycle Management Plan”:

- Toilet flushing at 50L/house/day
- Hot Water at 113L/house/day
- Laundry at 58L/house/day
- Garden Watering at 147L/house/day

These figures are based on a medium sized house with 3 occupants. The average medium sized household annual water requirement equates to 180kL. Assuming there are 15 lots per hectare, the total Wollert PSP site demand for household water will be approximately 1522ML per year. All demands above are based on use of water efficient appliances.

7.2.2 Open Space Irrigation

The land use for the Wollert PSP has not been identified at this point, however typically 10% of total site area is dedicated to open space. For the purposes of this report it is assumed that half of this 10% is devoted to active open space and the other half passive. When we talk of irrigating active open space, it does not reference irrigating from title boundary to title boundary. Instead it is assumed that only 70% is effective irrigation. Utilising these assumptions the maximum amount of active open space that requires irrigation will not exceed approximately 50 hectares. Below is how this number is reached:

- Total site 1433 hectares
- 10% of total site equates to 143.3ha
- 50% of this figure is the active open space which equates to 71.65ha
- 70% of this figure is effective irrigation which equates to 50ha

The irrigation demand for a hectare of active open space will be approximately 3.5ML per year. Based on this the overall volume requirement for open space irrigation per year will be approximately 177ML.

7.2.3 Demand Management

In addition to source substitution is demand management. To achieve this within the Wollert PSP demand management should concentrate on reducing potable and recycled water consumption rather than stormwater/rainwater as there is an inherent benefit to waterway health when utilising these alternate sources. As discussed above all demands are based on using water efficient appliances, therefore this is already an entrenched demand management technique. Demand management of potable water can be implemented in a number of others ways including:

- Water pricing.
- Influencing the community's habits and attitudes towards water use.
- Reduction in potable water supply pressure.
- Warm season grasses used for turf areas
- Efficient irrigation techniques

9 Urban Planning & Community Values

To ensure there is a synergy between the recommended measures there is a need to implement them in the correct order and position. This will require some strategic placement of amenities during the planning phase to extract the maximum effectiveness of each element of the IWMS (refer Appendix G).

Figure 13 below illustrates the importance of strategic locating of open space to be irrigated with stormwater. Doing so maximises the ability to 'capture' stormwater for the purpose of watering any sports fields or 'active' open space in the immediate area. By allocating the open space and subsequent treatment measures near the natural flow path of overland stormwater runoff, less costly infrastructure is required to divert the runoff to its desired destination.

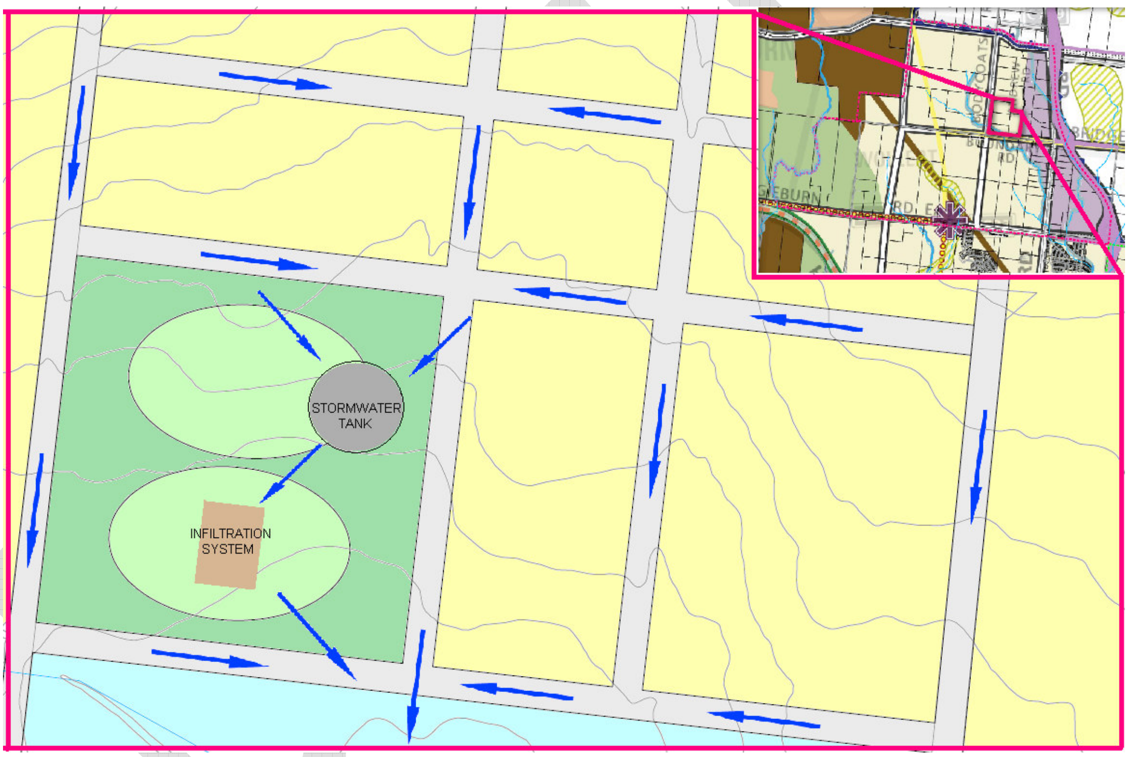


Figure 13 - Strategic Location of Open Space as Shown in MUSIC

Planning treatments at the allotment level has generated much discussion recently. The placement of rain gardens/infiltration systems at the allotment level has been trialled with success in some areas of Melbourne and hence has been investigated as a possible part of the Wollert Integrated Water Management Strategy. The main objective of this is to further disconnect the impervious area from the catchment and therefore reduce the urban flow frequency. Further analysis has revealed this to be an impracticable option at this stage due to several issues identified:

- Poor infiltration properties of the soil will reduce their effectiveness
- It becomes an encroachment on the home owners land and potentially reducing their developable area
- There are issues surrounding the location of rain gardens from the building footings including neighbouring buildings
- There is no way to ensure rain gardens are not removed, damaged or destroyed by the home owner
- Regulation and enforcement of Maintenance issues.

Integrating WSUD within the development should also consider the community values by creating public spaces that the community is proud of and can form a sense of attachment. The development should encourage bringing people to the water rather than fencing it off and creating a disconnection to these public spaces. Utilising such techniques such as boardwalks, information boards, activity nodes around these treatments will promote community engagement with the WSUD elements within the development.

10 Water Balance

The development of the Wollert PSP site will produce an increased pressure on our water resources. The aim of this Integrated Water Management Strategy is to recommend a reliable system where individual treatments recommended compliment each other's strengths while minimising their weaknesses. By utilising multiple alternate water sources we are able to significantly reduce reliance on potable water and at the same time treat rainfall runoff to within best practice guidelines and control the flow frequency and flow rate at which it enters the waterways.

Stormwater supply vastly surpasses Wollert's overall demand by 370%, however reliability of stormwater and rainwater harvesting systems can be still problematic due to the vulnerability with respect to rainfall. Figure 14 below illustrates that with increased tank size comes an increased reliability that the tank can service the irrigation requirements. The relationship between tank size increase and tank reliability is not linear creating a point at which the levelised cost of increasing the size of the tank is not justified. For this Integrated Water Management Strategy a reliability of 60% for the open space stormwater tanks is recommended with the additional 40% of demand to be supplied by recycled water. This will avoid constructing unnecessarily large and costly infrastructure that provides only a modest return.

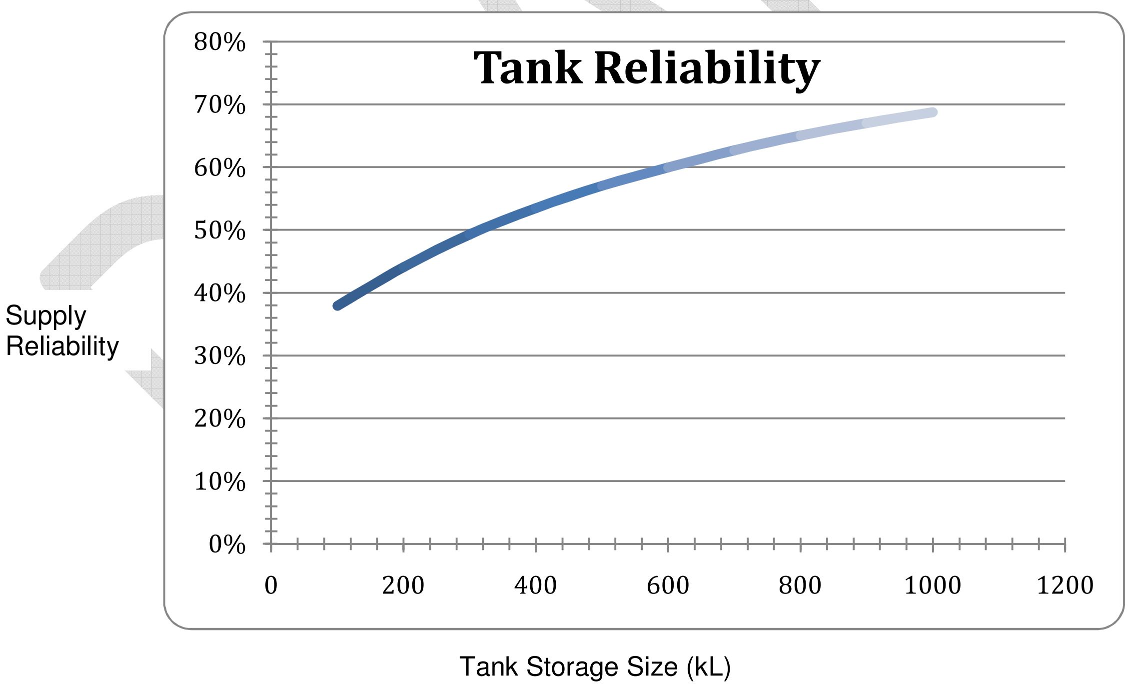


Figure 14 - Typical Stormwater Tank Size vs. Reliability Relationship

The combination of stormwater harvesting with the use of recycled water will seek to improve the unpredictability of supply such that the entire demand can be met by alternate sources to potable water. This scenario is achieved through supplying the base demand from stormwater harvested into large underground tanks that when storage levels are close to depleted, engage a recycled water irrigation system as a replacement until such time that its stormwater stocks are replenished. This arrangement is illustrated below (Figure 15) and has been modelled using the MUSIC software to identify suitable tank sizes to match the requested reliability based on location and irrigation demands.

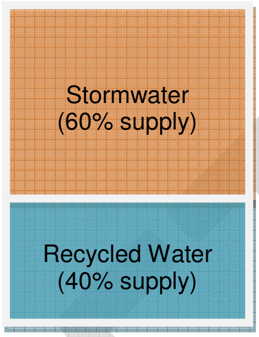


Figure 15 - Stormwater / Recycled Water Open Space Irrigation Balance

While this initiative can reduce total site potable demand by up to 8%, there are other measures that can be implement to further increase this number.

In addition to stormwater tanks harvesting runoff for the purpose of open space irrigation, Figure 9 also highlights an opportunity to reduce potable demand at an allotment scale. Rainwater tanks have been identified in this report as a potential alternative solution to potable water for hot water use in the shower. A 2kL tank installed on an average sized home has the potential to supply hot water for a residential use at a reliability of 90% when this scenario is modelled in MUSIC. This seeks to further reduce potable demand by 20% in the average home each year.

It is important to note that this strategy seeks to not only meet minimum requirements with respect to the water quality targets, but to exceed this accomplishment and minimise flow frequency and flow rate. That is to say; only rain gardens, sedimentation basins and wetlands are required to achieve the best practice guidelines (refer Figure 8 from previously), but by implementing rainwater tanks, open space irrigation tanks and infiltration systems we can further treat the water and seek to minimise any increase in flow frequency and flow rate as a result of the site's development.

The base case MUSIC model evaluated in section 5.3.2 of this report was modified to incorporate the following additions as described above:

- 2kL rainwater tanks for hot water use at the allotment level
- Stormwater harvesting systems at strategically located open space reserves

- Infiltration systems taking overflows from the stormwater harvesting systems

Table 17 below is the water quality output from this strategy's recommended water management system after further investigation utilising MUSIC software which incorporates these additional initiatives to exceed minimum requirements of Clause 56 as discussed in section 5.3.2.

Table 17 - IWMS Recommended System Results

MUSIC Results – IWMS Recommended System						
Total Sedimentation Basin Size (m^2)	Total Wetland Size (m^2)	Total Raingarden Size (m^2)	Total Suspended Solids Reduction (%)	Total Phosphorus Reduction (%)	Total Nitrogen Reduction (%)	Goss Pollutants Reduction (%)
7700	56500	10900	84.3	68.9	52.9	99.9

Table 18 below highlights the increase in the number of days of runoff per annum as a result of an increase in impervious surfaces without any water treatment measures implemented.

Table 18 - Flow Frequency Results, MUSIC

Scenario	Flow Frequency (days/yr)
Pre-development	9
Pre-development + 15 days	24
Post-development (no treatment)	105
Post-development (Recommended IWMS)	68

Under existing conditions, there are only 9 days of runoff per year. With development as planned, there will be a further 96 days of runoff per year if no attenuation measures are put in place. These extra flow days will increase disturbance to the natural environment and its inhabitants and should to be addressed in order to protect the ecosystem.

Through the addition of rainwater tanks, stormwater harvestings tanks and infiltration systems to the base case; we were able to decrease the number of runoff days. Due to the wetlands discharging extended detention depth flows over 72 hour periods, the number of runoff days, as indicated by MUSIC (refer Appendix G), increases compared to the untreated development scenario. However, based on Figure 16 below, it can be seen that days where flow does not exceed $0.07m^3/s$ are a function of the extended detention depth drawing down, and therefore runoff days below this number are essentially base flow, which can be excluded giving an 'effective' flow frequency of 68 days.

Figure 16 also indicates that WSUD treatments have reduced the peak discharge rates released from the site and thereby further reducing the impact on receiving waterways. It should also be noted that the MUSIC analysis has not included retardation basins which could further reduce peak flows when integrated with WSUD treatments.

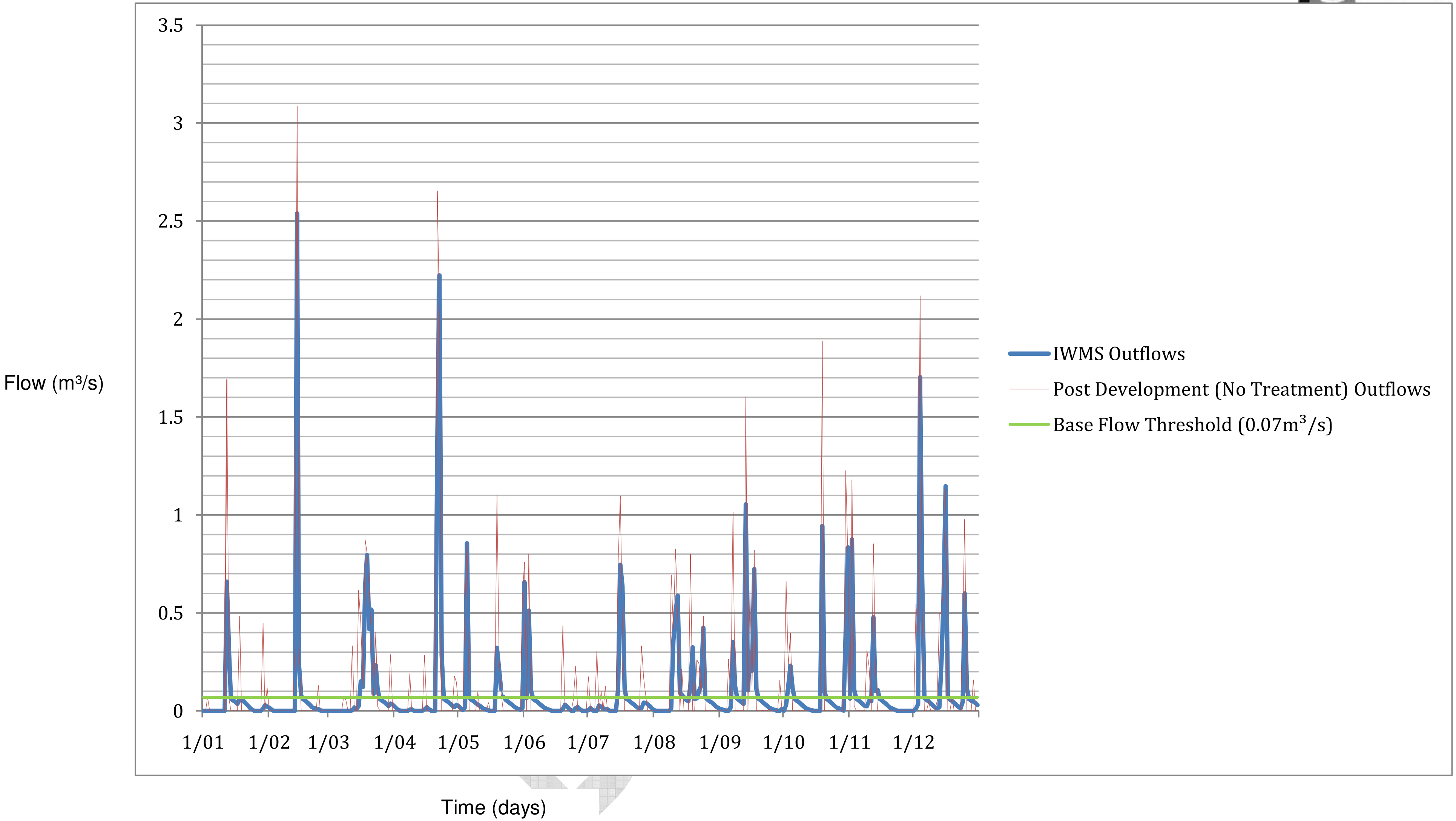


Figure 16 - Flow Frequency Graph

For the purposes of the water balance, Industrial zoning has been treated the same as Residential zoning ie. 15 lots per hectare. This is in line with Yarra Valley Waters “North Growth Area IMCW”. Refer Appendix F

These recommendations and the overall water balance of the Wollert PSP site have been illustrated below in Figure 17. The water balance of the Wollert development proposes a Potable / Rainwater-Stormwater / Recycled weighting of 29%, 22% and 49% respectively (refer Table 19)

Table 19 - % Water Source use within Wollert

Water Source	% use within Wollert
Potable	29%
Rainwater/Stormwater	22%
Recycled Water	49%

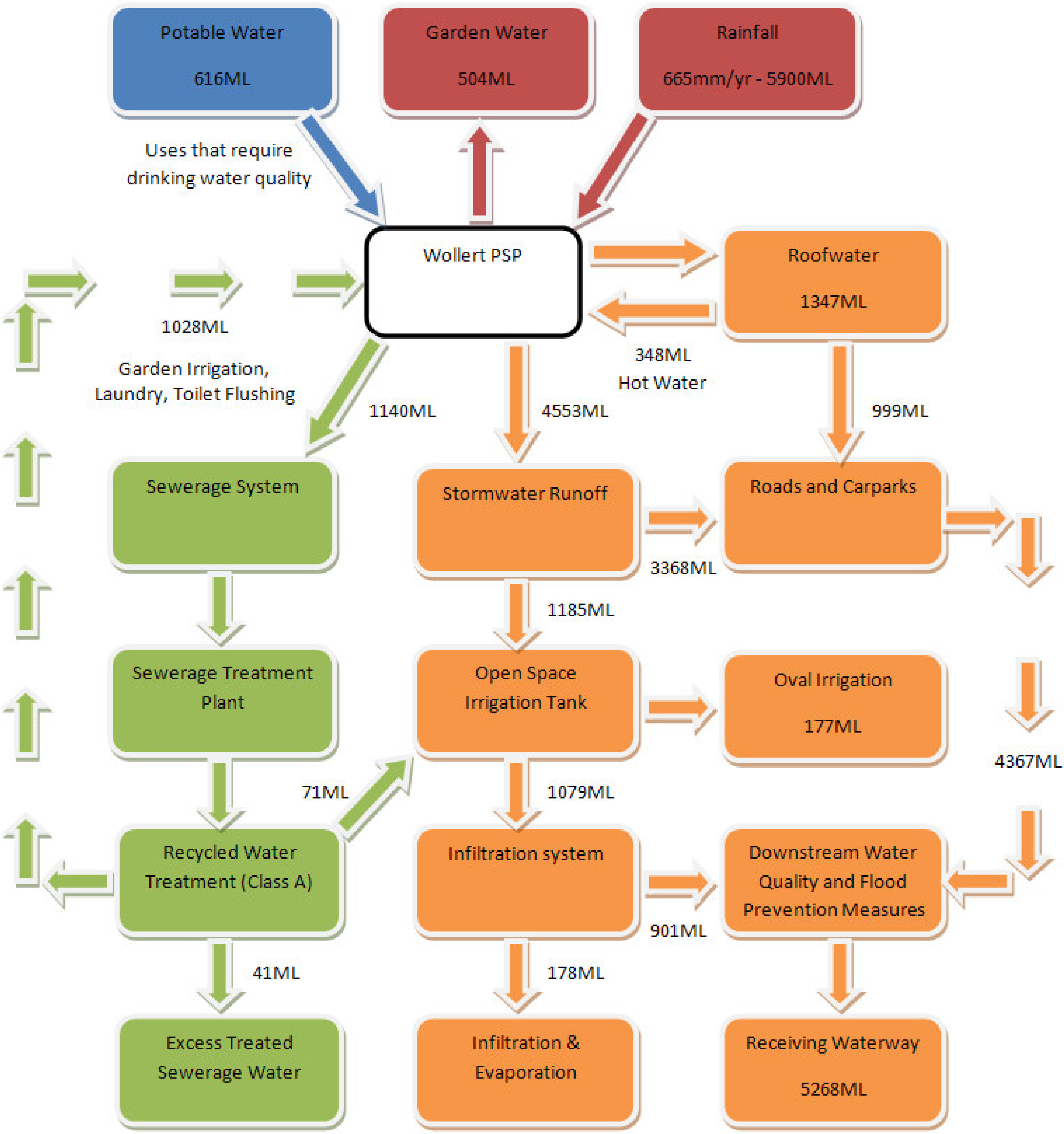


Figure 17 - Indicative Urban Water Cycle for Wollert PSP

11 IWMS Water Balance Recommendations

The successful implementation of this integrated water management strategy has been based upon identifying the synergies between individual strategies/elements (Conveyance & Flood Mitigation, Waterway Health, Alternate Water sources and urban planning & community values) in order to provide an integrated outcome (refer Figure 18). Based on the findings of this report our key recommendations are as follows:

Alternative Water Source	% use within Wollert
Potable	29%
Rainwater/Stormwater	22%
Recycled Water	49%

- Recycled Water at allotment level for Laundry, toilet and garden use.
- Potable water at allotment level for Kitchen and basins.
- 2kL Rainwater tanks at allotment level as an alternative to potable for hot water use
- Raingardens at a streetscape level to treat and retard stormwater
- Stormwater harvesting tanks at precinct level for use as open space irrigation with the Aurora Craigieburn West recycled water facility to provide any additional requirements
- Target 60% stormwater and 40% recycled water for all key open space irrigation systems
- Infiltration Systems under the open space that treat and infiltrate the stormwater.
- Sedimentation Basins and Wetlands at regional scales.
- Integrate sedimentation basins and wetlands with identified retarding basin locations
- Ensure community values are aligned with intended WSUD treatments
- Influence the community’s habits and attitudes towards water use.

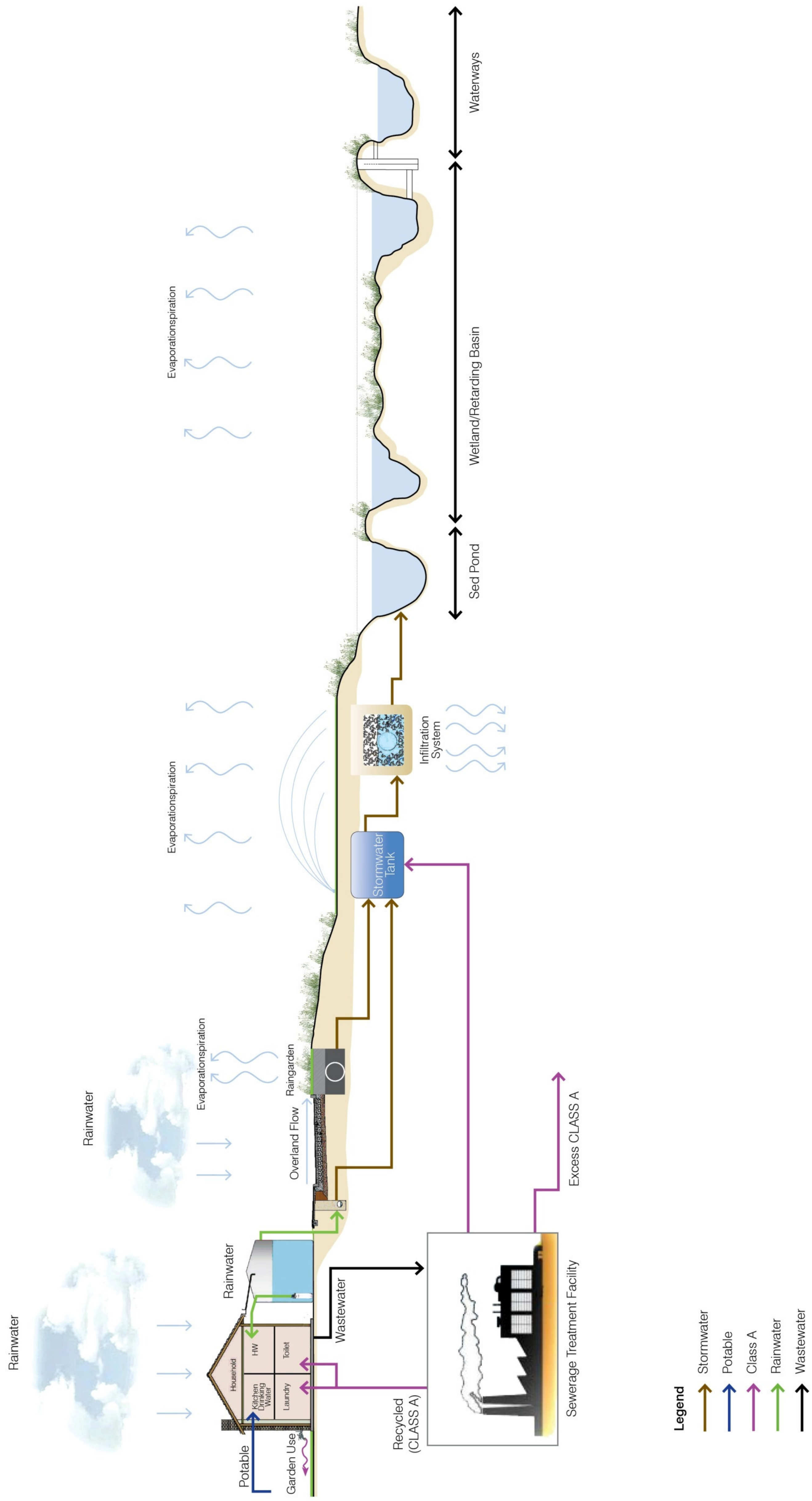


Figure 18 - Integrated Water Management Strategy Schematic Summary

Integrated Water Management Objectives

The objective of this report has been to identify various sustainable water management systems and practices across a range of scales and sources to produce an integrated outcome. These outcomes are to protect and enhance the Wollert PSP site waterways and their surrounding environments by:

- Minimising potable water consumption
- Minimising the impacts of increased runoff
- Minimising the increase in pollutants from runoff
- Utilising a range of alternate sources (rainwater, stormwater, recycled water, grey water)
- Implementing a number of measures for water quality treatment and reuse

As identified previously in this report, this can be achieved through a multitude of initiatives and ideologies that combine to produce the water management strategy

Water Sensitive Cities Approach

To reiterate the approach there are three themes of foundation upon which its ideologies are based including:

- Cities as Water Supply Catchments
- Cities providing Ecosystem Services
- Cities comprising Water Sensitive Communities

Based on these three water sensitive city themes CPG has further defined these themes into four meaningful elements of an IWMS. The four elements are as follows:

- Conveyance and Flood Mitigation
- Waterway Health
- Alternate Water Sources
- Urban Planning and Community Values

Conveyance and Flood Mitigation

The following is a summary of the recommendations given for each of the major catchments within Wollert PSP study area and is as follows:

– Findon Creek
  Adopt the retardation and drainage reserve Option 3, as presented in Appendix A on drawing 137599G01-5.
  This includes:
  – 3 retarding basins, refer to Section 5.1.2 for hydrologic discussion

- Constructed waterways of various hydraulic widths refer to Section 5.2.1 for hydraulic discussion
- Enhancement of Natural waterways, refer to Section 5.2.1 for hydraulic discussion

Drawing No.	Retarding Basin Name	Volume (kL)	Area (m²)	Maximum Depth (m)
137599G01-5	RB1	39,500	20,500	3.5
	RB2	23,800	13,300	3
	RB3	57,100	40,000	2

Drawing No.	Tributary Name	Width (m)	Constructed	Natural
137599G01-5	A	35	X	
	B	35	X	
	C	55	X	
	D	40	X	
	E	40	X	
	F	40	X	
	G	40	X	
	H	30	X	
	I	40		X
	J	30	X	

- Edgars Creek
  Adopt the retardation and drainage reserve Option 1, as presented in Appendix B on drawing 137599G02-3.
  This includes:
  - 2 retarding basins, refer to Section 5.1.4 for hydrologic discussion
  - Constructed waterways of various hydraulic widths, refer to Section 5.2.3 for hydraulic discussion
  - Enhancement of Natural waterways, refer to Section 5.2.3 for hydraulic discussion

Drawing No.	Retarding Basin Name	Volume (kL)	Area (m²)	Maximum Depth (m)
137599G02-3	RB1	60,400	50,800	3
	RB2	30,600	23,500	1.5

Drawing No.	Tributary Name	Width (m)	Constructed	Natural
137599G02-3	A	45	X	
	B	200		X

– Curly Sedge Creek
Adopt no retardation works and significant waterway works. Refer to Section 5.1.6 for full discussion of analysis.

<u>Waterway Health</u>

- Creating a growling grass frog conservation zone where identified will seek to protect the waterway corridor health and its inhabitants. Rather than this being seen as an isolated zone separate from development of the rest of the site, integrating this with recreational infrastructure such as bike paths, park benches and walkways could create the centrepiece around which a sustainable community can be established.
- The reduction of the frequency with which runoff reaches the waterway will help protect it from the negative environmental impacts associated with increased runoff instances.
- The minimisation of any increase in flow and maintaining the means by which it filters down through to the rivers and creeks will also protect the waterways health.
- This reduction of flow frequency and runoff can be achieved through the capturing of roof water at allotment level using rainwater tanks and 'choke' points in the flow path including retarding basins and wetlands that are strategically placed for maximum efficiency.
- The reduction in pollutants entering our waterways.

<u>Stormwater Quantity</u>

- As this report has touched on their are two objectives with respect to stormwater quantity
  - Stormwater runoff frequency
  - Stormwater runoff flow rate
- It is recommended that runoff frequency be reduced to as few days as possible and runoff flow rate be limited to 1.5 times pre-development flow rate.
- This Integrated Stormwater Management Strategy outlines the use of Water Sensitive Urban Design treatment measures to address both of these issues regarding Stormwater Quantity. It has recommended an arrangement of rainwater tanks at allotment scale, infiltration systems and raingardens at the streetscape level, with retarding basins and wetlands at on a precinct scale to achieve this. The implementation of open space

irrigation tanks will also act as reducer of both frequency and flow rate by diverting flow into storage for reuse.

- The Flow Frequency results (for details refer section 10) are as follows:

Scenario	Flow Frequency (days/yr)
Pre-development	9
Pre-development + 15 days	24
Post-development (no treatment)	105
Post-development (Recommended IWMS)	68

Stormwater Quality

- Water Sensitive Urban Design is has the objectives, which are also adopted for this report, that include the following:
    - 70% reduction of total Gross Pollutant loads
    - 80% reduction of total Suspended Solids
    - 45% reduction of total Nitrogen
    - 45% reduction of total Phosphorus
- This is achieved through the implementation of a 'train' of treatment measures across a assortment of scale that include the following:
    - Rainwater tanks located at lot scale.
    - Rain gardens on street scale
    - Stormwater harvesting at open space locations
    - Infiltration systems for removal of pollutants
    - Sedimentation basins, wetlands located within retarding basins and other strategically identified points within the catchment.

Alternative Water Sources

The percentage breakdown of all water sources to be used within the Wollert development is as follows:

Alternative Water Source	% use within Wollert
Potable	29%
Rainwater/Stormwater	22%
Recycled Water	49%

- Alternate Water Sources include recycled water (Class A), stormwater and rainwater.
- Utilising these alternate sources reduces the demand for potable within the Wollert PSP site.
- Rainwater tanks installed at an allotment level can be reused for hot water in the shower with a potential saving of 20% per lot per annum.

- Stormwater tanks under active open spaces can be used for irrigation providing savings of up to 8% of the total Wollert site potable water demands, before filtering through the soil into infiltration systems where pollutants are further removed prior to entering natural waterways.
- Recycled water from the Aurora Craigieburn West treatment facility will be used as an alternate source for purposes of garden watering, toilet flushing, fire fighting and laundry use as well as open space irrigation to top up supply levels in periods of low rainfall.
- Grey water, Sewer mining and Aquifer recharge systems were all regarded as not viable or suitable for the Wollert development.

<u>Urban Planning & Community Values</u>

There is the option to place infiltration systems at an allotment level (ie. raingardens), however there have been a number of issues with its implementation in the past which include:

- o Regular unclogging is required to maintain them and who should bear the costs associated with this maintenance
- o Their proximity to neighbouring homes
- o Issues surrounding house foundation compromise due to soil saturation
- o The home owner removing the system
- o Amount of space they take up in the backyard
- o Infiltration rates are too low for them to function effectively

Due to these concerns this IWMS will not be recommending their inclusion in the overall strategy for stormwater management.

- Strategic placement of the stormwater harvesting tanks is key in the proposed IWMS to avoid excessive and costly infrastructure to divert runoff into storage tanks for irrigation. Consideration needs to given as to where to place open space land use within the Wollert PSP to maximise efficiency.
- Integrating WSUD within the development should also consider the community values by creating public spaces that the community is proud of and can form a sense of attachment. The development should encourage bringing people to the water rather than fencing it off and creating a disconnection to these public spaces. Utilising such techniques such as boardwalks, information boards, activity nodes around these treatments will promote community engagement with the WSUD elements within the development.

<u>Issues</u>

There are a number of issues surrounding the implementation of the Wollert PSP Integrated Water Management Strategy which include the following:

- Soil Infiltration rates for this report was assumed at 3.6mm/hour. However due to the unique properties of soil in Whittlesea City Council lands, this figure can be as low as <0.01mm/hour in some areas of the Wollert PSP and only further geotechnical investigation can substantiate these numbers. If they are found to be significantly low, any treatments that utilise infiltration as a means to treat stormwater runoff may not be efficient enough for implementation.
- There are several arrangements for the recommended 'treatment trains' that can be put into practice including a 'centralised' approach where an end of line stormwater harvesting tank and infiltration system is installed to service all of the Wollert PSP site open space irrigation requirements through a network of pipes, or a 'decentralised' approach whereby numerous smaller tanks are located throughout the precinct to irrigate the open space in that immediate area. While both are proven to be effective in reaching the targets of this paper, further feasibility study needs to be conducted in order to find the most efficient balance of the recommended approaches.
- Department of Health has concerns with ensuring the quality of rainwater when captured for the purposes of hot water use also at an allotment scale and further investigation and discussion is required to ensure all parties are satisfied.

12 References

Melbourne Water Website –
http://www.melbournewater.com.au/Default.asp?bhcp=1

Melbourne Water WSUD Website –
http://www.melbournewater.com.au/content/planning_and_building/water_sensitive_urban_design/water_sensitive_urban_design.asp

Centre for Water Sensitive Cities –
http://www.watersensitivecities.org.au/

Little Stringybark Creek Website –
http://www.urbanstreams.unimelb.edu.au/

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Our Water, Our Future, Victorian Government, June 2007

Sustainable Water Use Plan, Whittlesea City Council, 2006

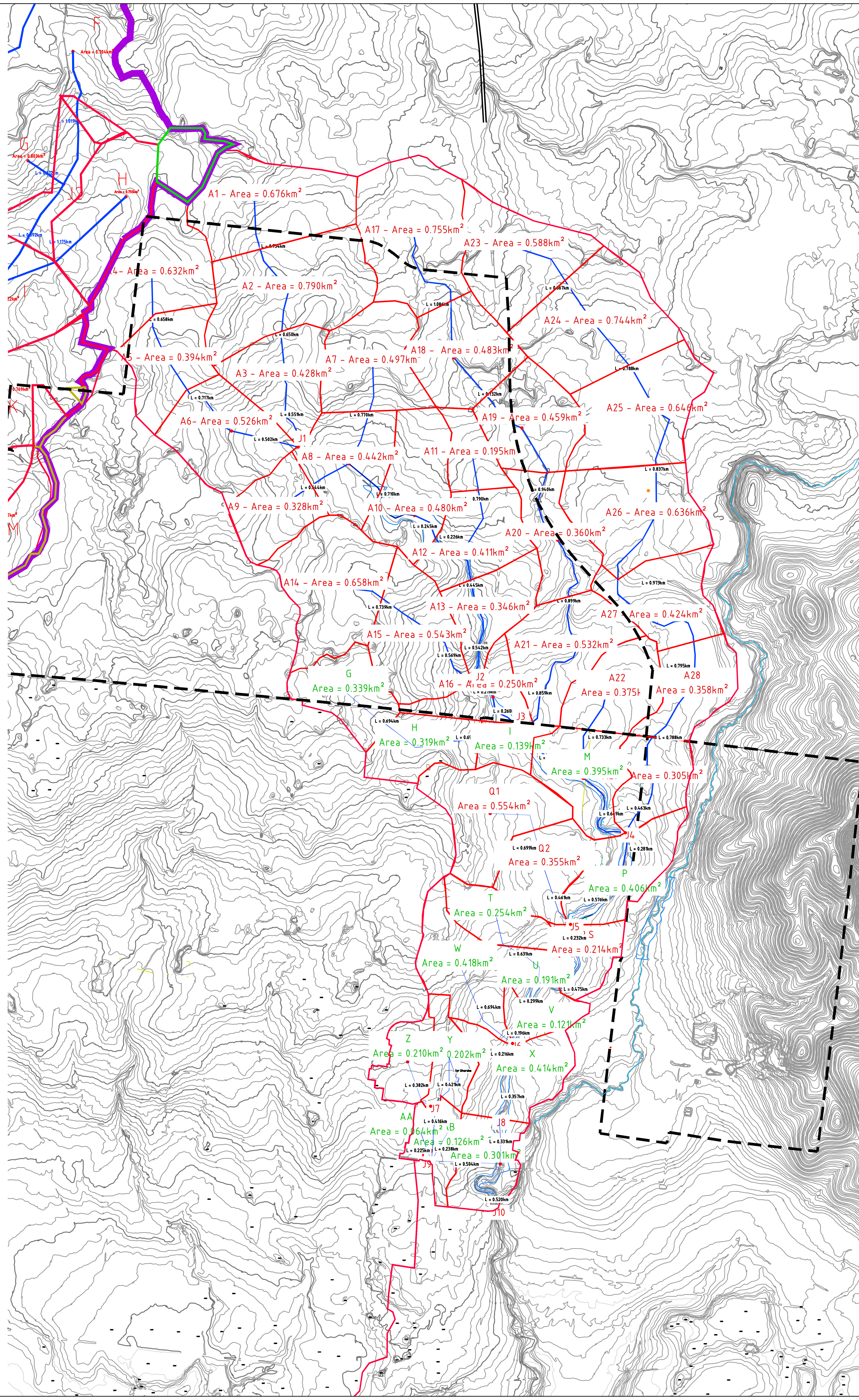
Water Plan 2009/10 – 2012/13, Yarra Valley Water, November 2008

Sub-regional Species Strategy for the Growling Grass Frog, DSE, November 2011

Stormwater Management Plan 2012-17, Whittlesea City Council, 2012

Utilities Infrastructure Servicing Assessment, CPG Australia, 14th May 2012

Appendix A: Findon Creek Hydrological / Hydraulic Outputs



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WOLLERT PSP
RORB CATCHMENT PLAN
FINDON CREEK
WHITTLESEA CITY COUNCIL & GAA
WHITTLESEA CITY COUNCIL

Rev A
Drg No 137599D01-1

Rev	Amendments	App'd	Date
A	CATCHMENT ANALYSIS ISSUE	L.H.	16/03/12

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- QUARRY HILLS PSP BOUNDARY
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WOLLERT PSP
FINDON CREEK
EXISTING CONDITIONS
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WHITTLESEA CITY COUNCIL

Rev A
Drg No 137599G01-1

LEGEND

- WOLLERT PSP BOUNDARY
- QUARRY HILLS PSP BOUNDARY
- 100YR INUNDATION EXTENT

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DEVELOPED CONDITIONS - NO RETARDATION
WHITTLESEA CITY COUNCIL & GAA
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Rev A
Drg No 137599G01-2

LEGEND

- WOLLERT PSP BOUNDARY
- QUARRY HILLS PSP BOUNDARY
- 100YR INUNDATION EXTENT

Rev	Amendments	App'd	Date
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WOLLERT IWMS
WOLLERT PSP
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RETARDATION OPTION 1
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Rev	Amendments	App'd	Date
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WOLLERT PSP
FINDON CREEK
RETARDATION OPTION 2
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Drg No 137599G01-4

LEGEND

WOLLERT PSP BOUNDARY
QUARRY HILLS PSP BOUNDARY
100YR INUNDATION EXTENT

Rev	Amendments	App'd	Date
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FINDON CREEK
RETARDATION OPTION 3
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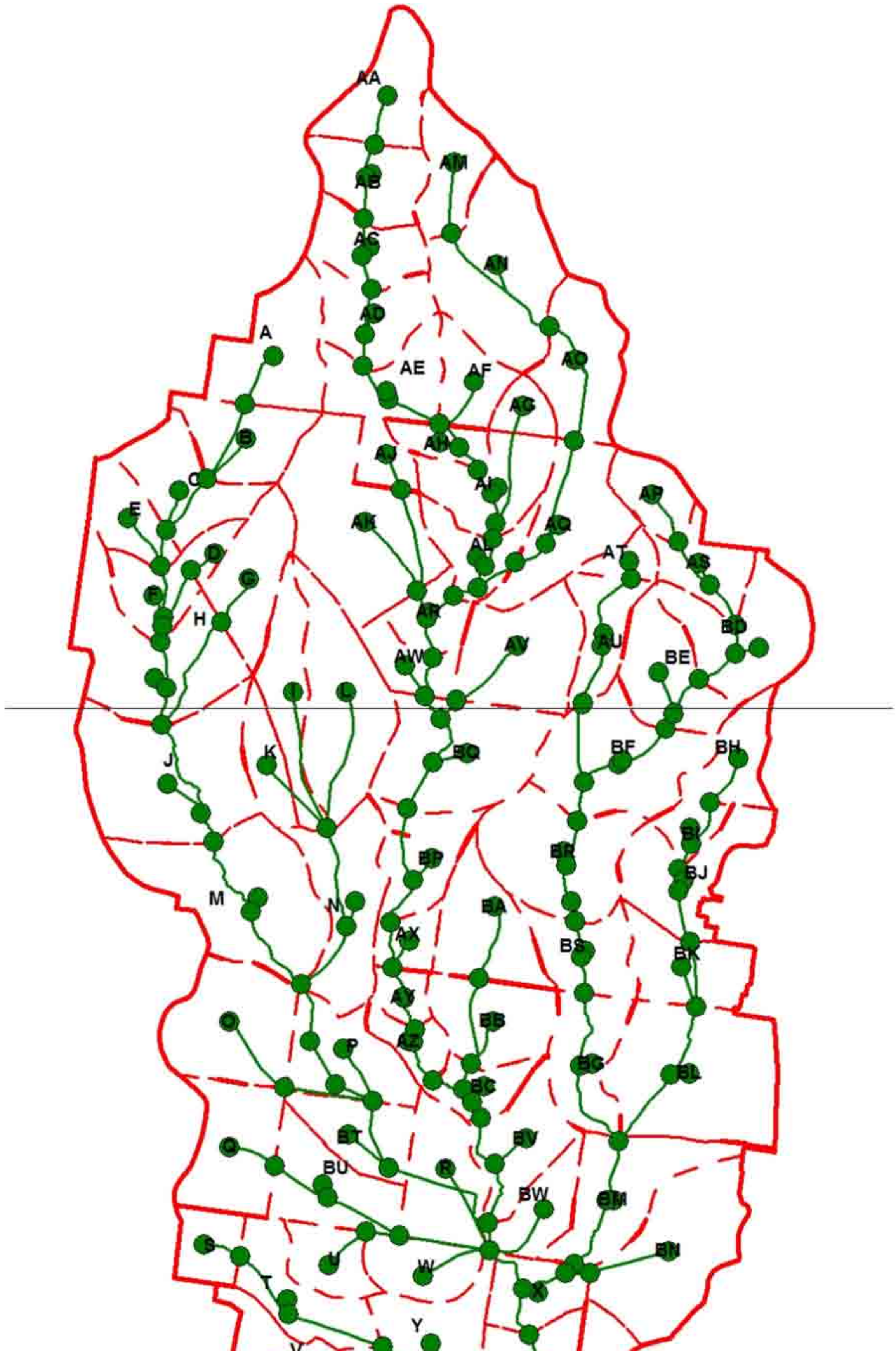
Appendix B: Edgars Creek Hydrological / Hydraulic Outputs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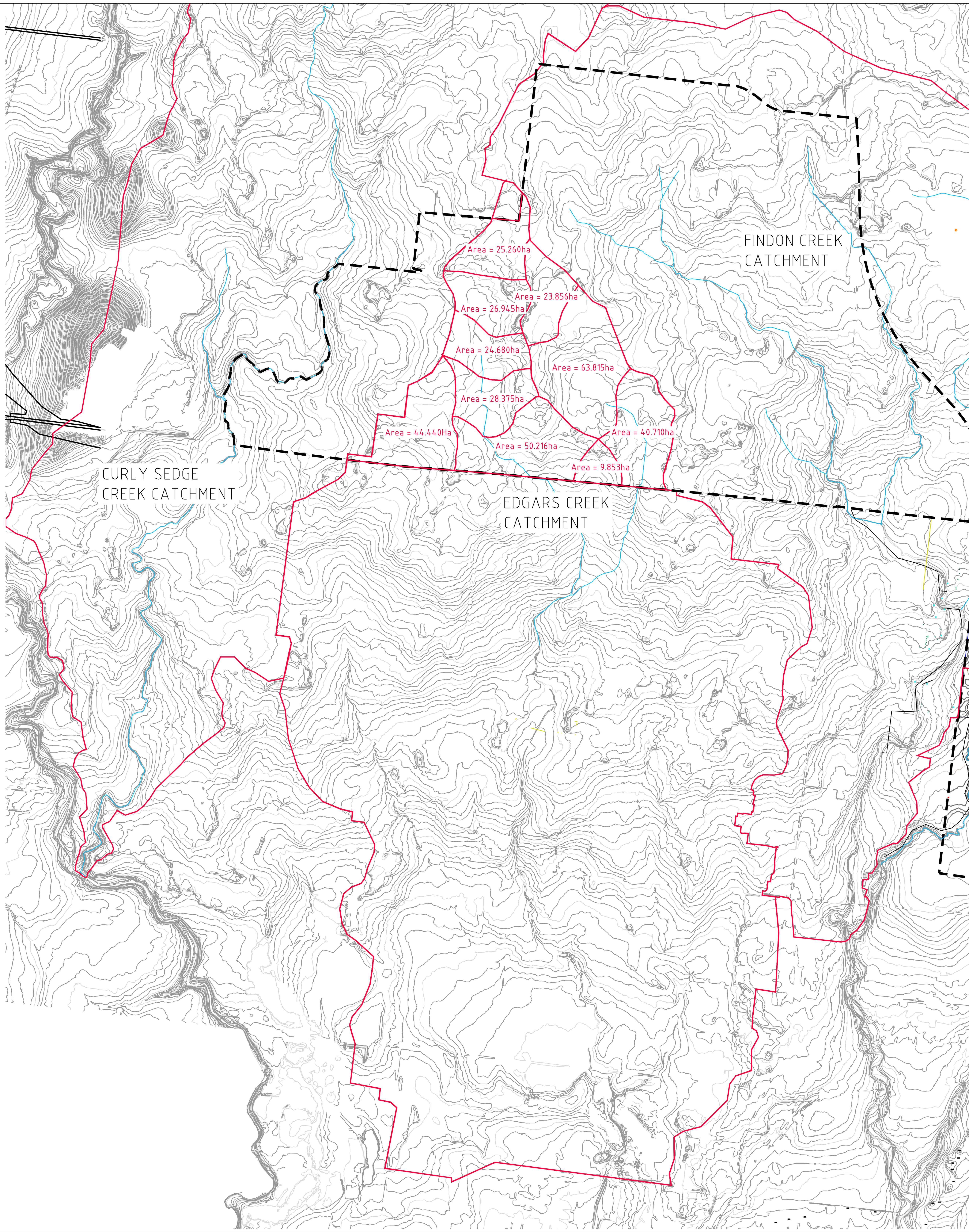

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EDGARS CREEK

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Rev	Amendments	App'd	Date
A	CATCHMENT ANALYSIS ISSUE	L.H.	16/03/12

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Rev	Amendments	App'd	Date
A	CATCHMENT ANALYSIS ISSUE	L.H.	16/03/12

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Drg No 137599G02-2

LEGEND:
100 YR INUNDATION EXTENT
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Rev	Amendments	App'd	Date
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WOLLERT PSP
EDGARS CREEK
END OF LINE RETARDATION OPTION
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Drg No 137599G02-3

Appendix C: Curly Sedge Creek Hydrological / Hydraulic Outputs

Rev	Amendments	App'd	Date
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WOLLERT PSP
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CURLY SEDGE CREEK
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Drg No 137599D03-1

Rev	Amendments	App'd	Date
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WOLLERT IWMS
WOLLERT PSP
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EXISTING CONDITIONS
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LEGEND
WOLLERT PSP BOUNDARY
QUARRY HILLS PSP BOUNDARY

Rev	Amendments	App'd	Date
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CURLY SEDGE CREEK
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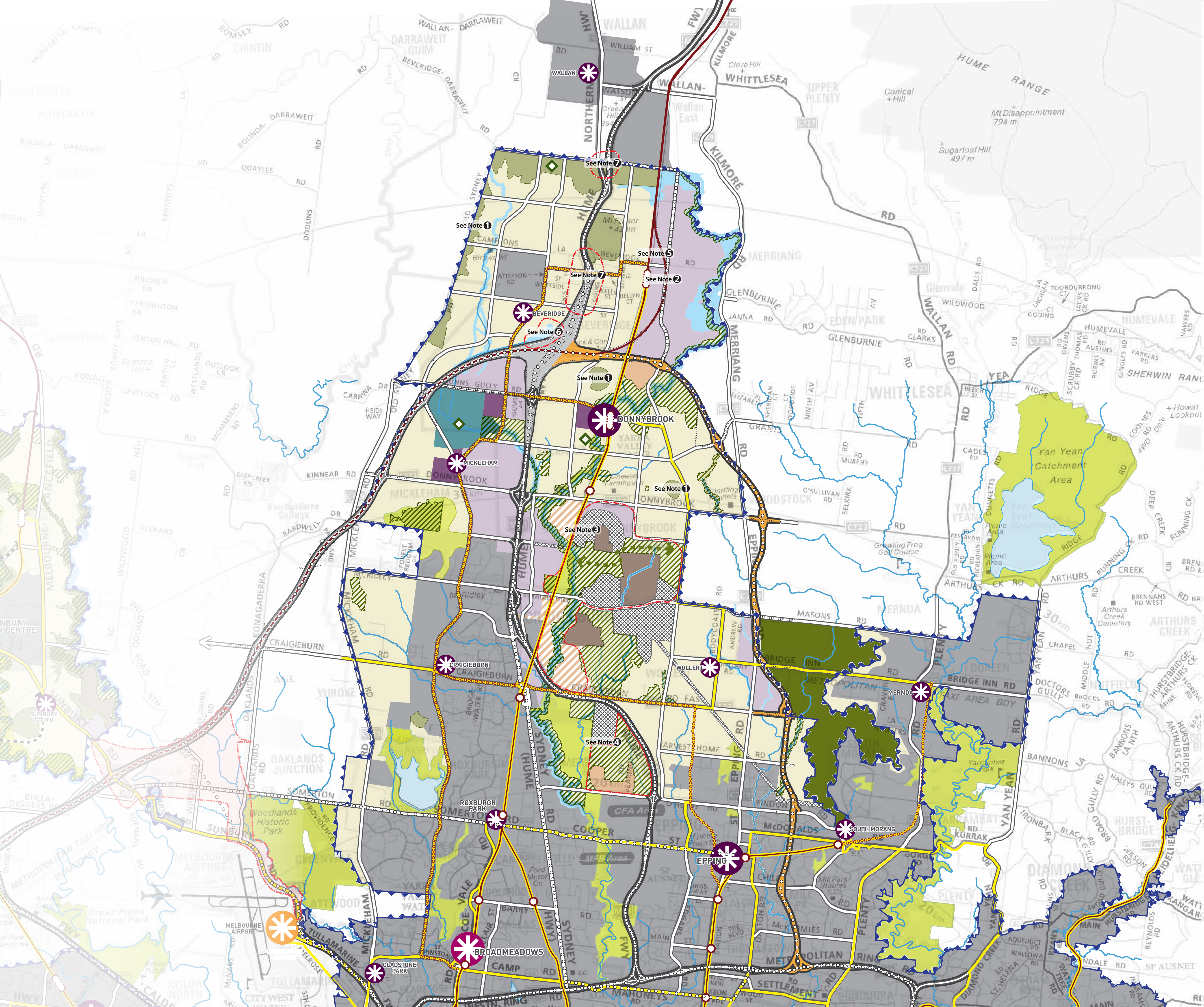
Appendix D: North Growth Corridor Plan



NORTH GROWTH CORRIDOR PLAN

- Existing Urban
- Urban Growth Boundary
- Freeway
- Arterial Road
- E6 Road Reserve
- Principal Freight Network
- Railway Line
- Rail Station
- Opportunity for future Rail Station
- Principal Public Transport Network
- High Capacity Public Transport
- Specialised Town Centre
- Central Activity Area
- Principal Town Centre
- Major Town Centre
- Industrial
- Business
- Business with Residential
- Residential
- Proposed Regional Open Space
- Existing Open Space
- Regional Active Open Space (under investigation)
- Biodiversity Values
- Potential Biodiversity Link (to be further investigated)
- Landscape Values
- Non-urban/Utilities
- Potential Urban
- Urban - Land Use to be determined
- Quarry
- Retarding Basins
- Rivers & Creeks
- Waterway Corridor
- Investigation Area
- Investigation Area link to airport

Inclusion of arterial roads in the plans does not indicate a commitment to funding or declaration as a state arterial road

Infrastructure items shown are indicative and will require further investigation

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growth areas AUTHORITY

NOTES

1. Potential for review of RCZ through Precinct Structure Plan process
2. Potential Future Interstate Freight Terminal
3. Boundary and size of Sewage Treatment Plant to be determined
4. Conservation boundary to be finalised through Precinct Structure Plan process
5. Potential rail stabling
6. Water Management site subject to further investigation
7. Intersection requiring further investigation

Appendix E: DSE Figure 1c: North Growth Area – Growling Grass Frog

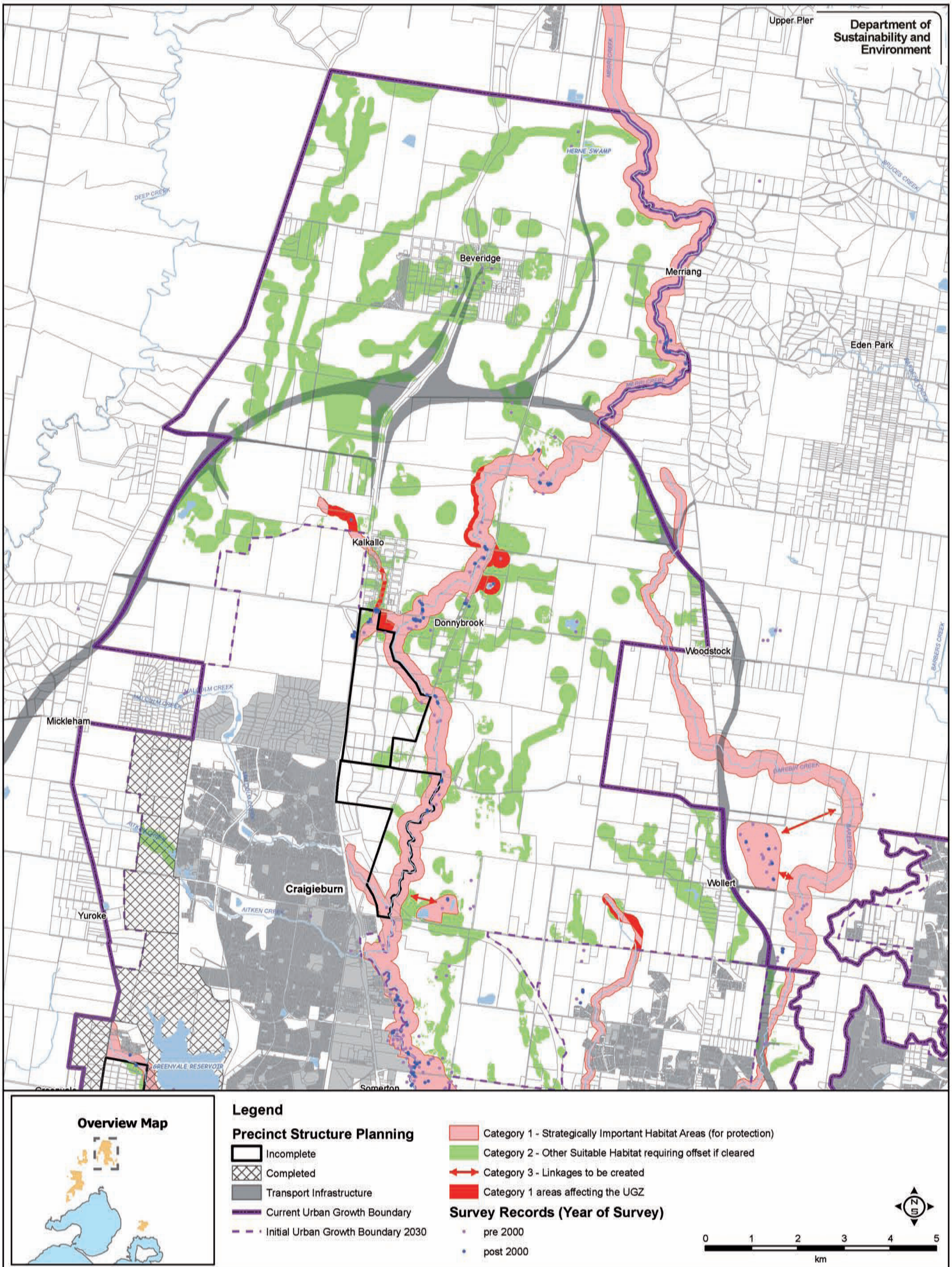

Figure 1c: North Growth Area – Growling Grass Frog

Important habitat areas, linkages and suitable habitat for Growling Grass Frog

GDA

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State Government Victoria

Appendix F: North Growth Area IWCM

3.5 Water Demands (Potable And Non Potable)

Residential household water demands were calculated using the YVW Demand Builder Tool[4]. This tool is underpinned by data collected from YVW's Residential End Use Measurement Study (2004)[5] and the Appliance Stock Survey (2007)[6]. The Water Efficiency Labelling Standards (WELS)[7] consumption values for new appliances were also used.

Table 7 – Residential Demand Assumptions

	Average Daily Demand (L/house/day)			
End Use	Small House	Medium House	Large House	Usage Category
Toilet	33	50	50	Non potable
Hot water	76	113	113	Potable
Laundry	42	58	58	Non potable
Dishwasher	7	9	9	Potable
Taps	57	79	79	Potable
Miscellaneous	8	9	9	Potable
Garden Watering	73	147	220	Potable
Car Washing	1	1	1	Non potable
Internal Contingency	45	64	64	Potable
External Contingency	22	44	66	Potable / Non potable
Average Winter Demand (L/house/day)	268	382	382	
Average Summer Demand (L/house/day)	364	574	669	
Average Annual Demand * (L/house/day)	324	494	549	
Persons Per House	2	3	3	
Average Annual Demand * (L/person/day)	162	165	183	

* Assumes a 7 month summer irrigation period

Table 8 - Average Daily Flows To Sewer (Dry Weather)

End Use	Small House	Medium House	Large House
Land size (m^2)	315	450	655
Household flow to sewer *	235	338	338
Non-rainfall dependant infiltration **	24	34	50
Total (L/hh/day)	259	372	387

* Assumes 50% of tap and miscellaneous use is for human consumption and does not flow to sewer

** Assumes 35% of the sewerage system is located below the groundwater table

For employment land, an average water demand of 6,450L/Ha/day and an average daily flow to sewer of 5,805L/Ha/day was assumed. This demand is roughly equivalent to 15 residential lots per Ha.

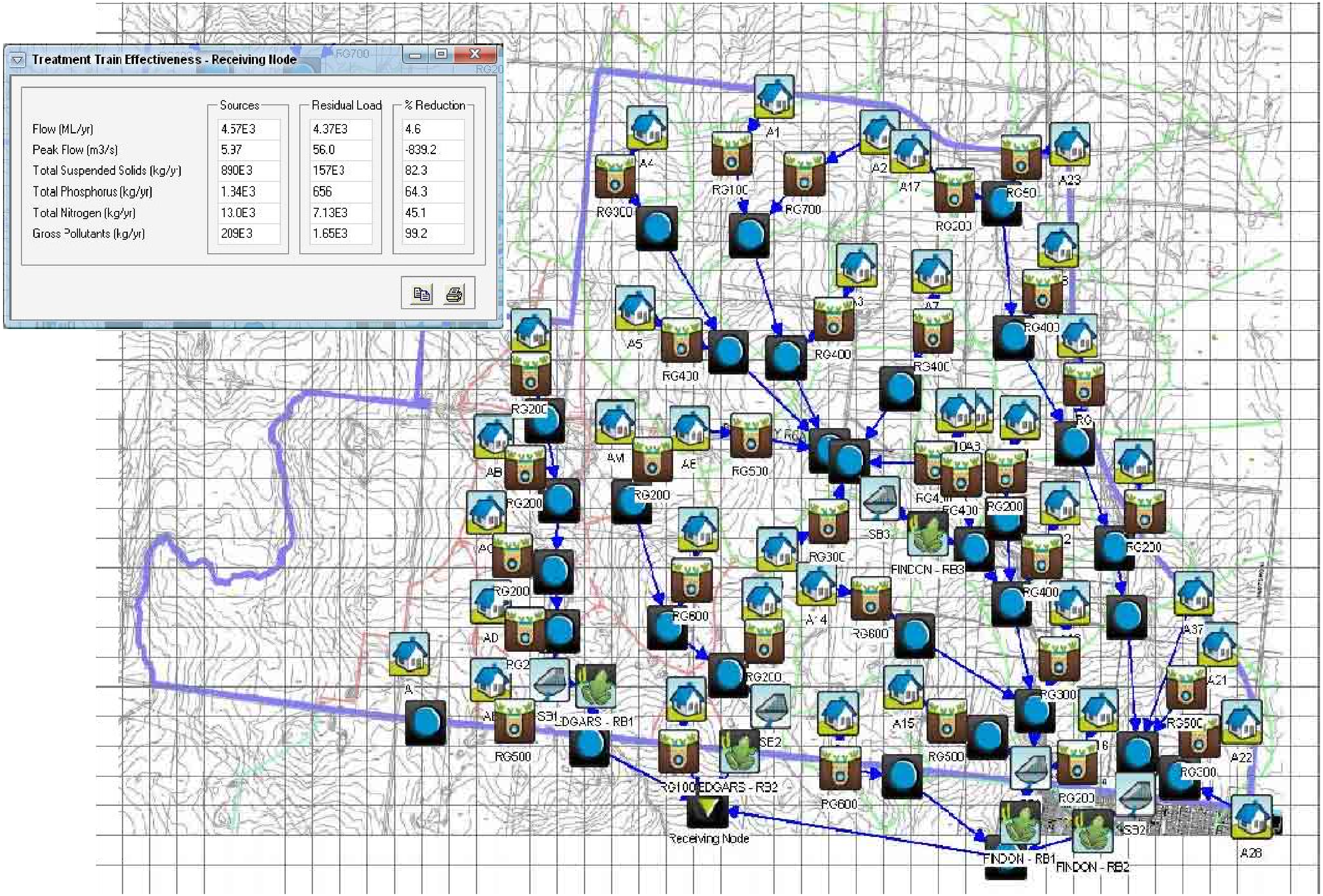
[4] Yarra Valley Water (2009) "Water And Sewer Demand Builder", Yarra Valley Water

[5] Roberts, P. (2004) "Residential End Use Measurement Study", Yarra Valley Water

[6] Athuraliya, A., Gan, K., and Roberts, P. (2007) "Appliance Stock Survey", Yarra Valley Water

[7] Standards Australia (2005) "AS6400 – Water Efficient Products – Rating And Labelling", Table D1

Appendix G: Wollert PSP MUSIC Outputs


Treatment Train Effectiveness - Receiving Node
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Residual Load
% Reduction
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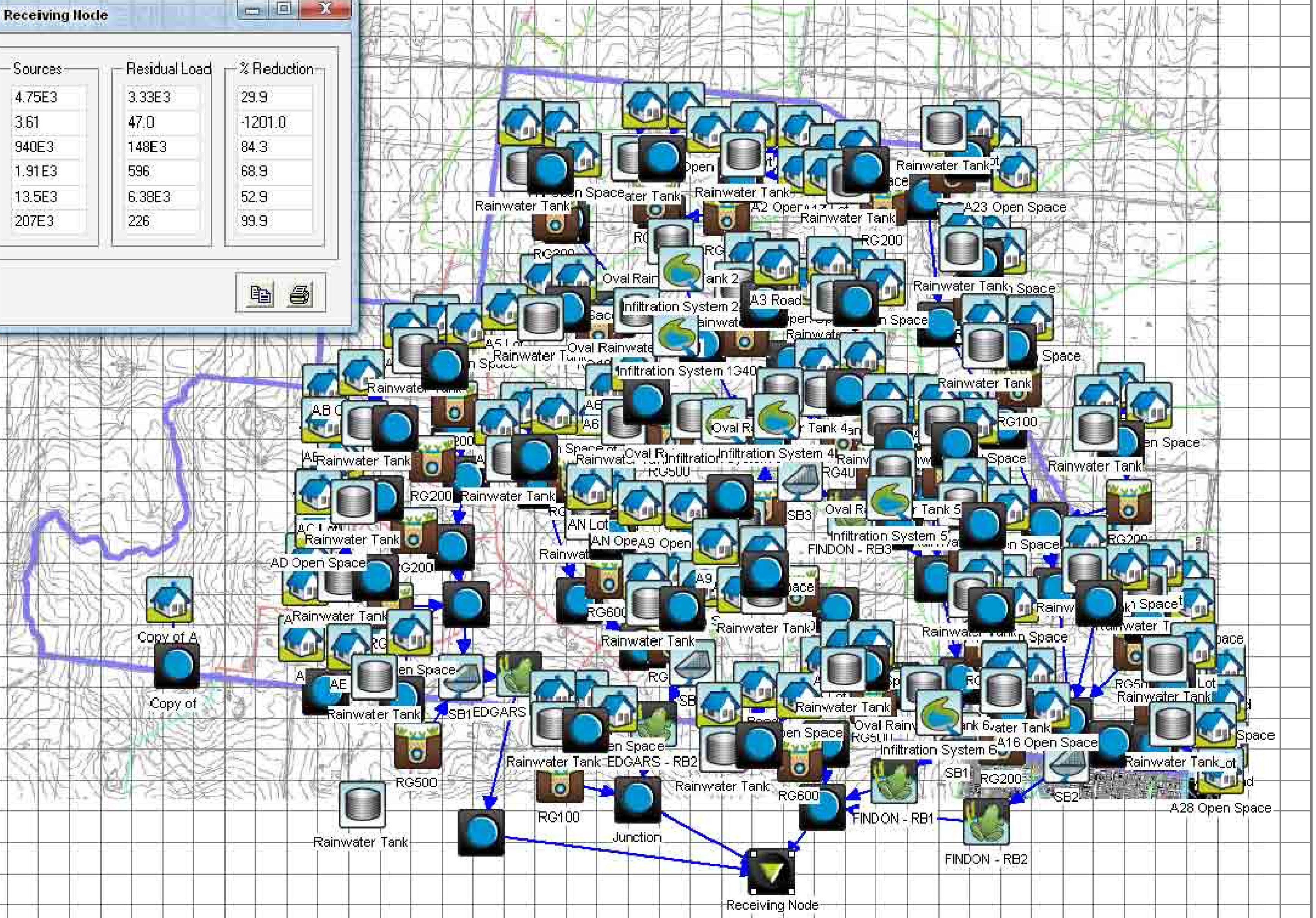
Peak Flow (m3/s) 5.37 56.0 -839.2
Total Suspended Solids (kg/yr) 890E3 157E3 82.3
Total Phosphorus (kg/yr) 1.34E3 656 64.3
Total Nitrogen (kg/yr) 13.0E3 7.13E3 45.1
Gross Pollutants (kg/yr) 209E3 1.65E3 99.2
Receiving Node
FINDON - RB1
FINDON - RB2
FINDON - RB3
EDGARS - RB1
EDGARS - RB2
SB3
SE2
A1
A2
A5
A15
A17
A23
A28
A37
A22
A21

Treatment Train Effectiveness - Receiving Node

	Sources	Residual Load	% Reduction
Flow (ML/yr)	4.75E3	3.33E3	29.9
Peak Flow (m3/s)	3.61	47.0	-1201.0
Total Suspended Solids (kg/yr)	940E3	148E3	84.3
Total Phosphorus (kg/yr)	1.91E3	596	68.9
Total Nitrogen (kg/yr)	13.5E3	6.38E3	52.9
Gross Pollutants (kg/yr)	207E3	226	99.9



Stormwater Tank Reliability - 6ha Open Space Demand

tank size (kL)	reference year	demand (kL/year)	reliability (%)	reliability increase (%)
100	1966	21194.3	36.59	
200	1966	21194.3	46.37	9.78
300	1966	21194.3	53.38	7.01
400	1966	21194.3	59.50	6.12
500	1966	21194.3	64.59	5.09
600	1966	21194.3	69.03	4.44
700	1966	21194.3	72.78	3.75
800	1966	21194.3	75.10	2.32
900	1966	21194.3	77.13	2.03
1000	1966	21194.3	79.15	2.02
100	1990-2010	21194.3	37.91	
200	1990-2010	21194.3	44.07	6.16
300	1990-2010	21194.3	49.29	5.22
400	1990-2010	21194.3	53.44	4.15
500	1990-2010	21194.3	57.01	3.57
600	1990-2010	21194.3	59.92	2.91
700	1990-2010	21194.3	62.67	2.75
800	1990-2010	21194.3	65.00	2.33
900	1990-2010	21194.3	67.02	2.02
1000	1990-2010	21194.3	68.75	1.73

	Flow			
Date	Pre-Developed	No Treatment	IWMS System	IWMS System - Base Flow
1/01/1966	0	0	0.0000001	0
2/01/1966	0	0	0	0
3/01/1966	0	0.06966873	0	0
4/01/1966	0	0	0	0
5/01/1966	0	0	0	0
6/01/1966	0	0	0	0
7/01/1966	0	0	0	0
8/01/1966	0	0	0	0
9/01/1966	0	0	0	0
10/01/1966	0	0	0	0
11/01/1966	0	0	0	0
12/01/1966	0	1.69155688	0.66033953	0.66033953
13/01/1966	0	0.05945065	0.30541525	0.30541525
14/01/1966	0	0	0.06213204	0
15/01/1966	0	0	0.05396655	0
16/01/1966	0	0	0.04550995	0
17/01/1966	0	0	0.03627035	0
18/01/1966	0	0.48489438	0.05804221	0
19/01/1966	0	0	0.05785703	0
20/01/1966	0	0	0.04828979	0
21/01/1966	0	0	0.03779251	0
22/01/1966	0	0	0.02626936	0
23/01/1966	0	0	0.0139983	0
24/01/1966	0	0	0.00600558	0
25/01/1966	0	0	0.00093911	0
26/01/1966	0	0	0	0
27/01/1966	0	0	0	0
28/01/1966	0	0	0	0
29/01/1966	0	0.44959556	0.01197345	0
30/01/1966	0	0	0.0283257	0
31/01/1966	0	0.1189013	0.02082297	0
1/02/1966	0	0	0.01688284	0
2/02/1966	0	0	0.0067611	0
3/02/1966	0	0	0.0007049	0
4/02/1966	0	0	0	0
5/02/1966	0	0	0	0
6/02/1966	0	0	0	0
7/02/1966	0	0	0	0
8/02/1966	0	0	0	0
9/02/1966	0	0	0	0
10/02/1966	0	0	0	0
11/02/1966	0	0	0	0
12/02/1966	0	0	0	0
13/02/1966	0	0.32047618	0.00044143	0
14/02/1966	0.68214384	3.08840912	2.53908924	2.53908924
15/02/1966	0	0.35577501	0.23459243	0.23459243
16/02/1966	0	0	0.07608363	0.07608363
17/02/1966	0	0	0.05843315	0

18/02/1966	0	0	0.05041809	0
19/02/1966	0	0	0.04171447	0
20/02/1966	0	0	0.03215243	0
21/02/1966	0	0	0.0206997	0
22/02/1966	0	0	0.0138712	0
23/02/1966	0	0	0.00975068	0
24/02/1966	0	0.1300483	0.00861176	0
25/02/1966	0	0	0.00285668	0
26/02/1966	0	0	0	0
27/02/1966	0	0	0	0
28/02/1966	0	0	0	0
1/03/1966	0	0	0	0
2/03/1966	0	0	0	0
3/03/1966	0	0	0	0
4/03/1966	0	0	0	0
5/03/1966	0	0	0	0
6/03/1966	0	0	0	0
7/03/1966	0	0	0	0
8/03/1966	0	0.07431328	0	0
9/03/1966	0	0.05573495	0.00009627	0
10/03/1966	0	0	0	0
11/03/1966	0	0	0	0
12/03/1966	0	0.33162318	0.00387383	0
13/03/1966	0	0	0.01754445	0
14/03/1966	0	0	0.0094238	0
15/03/1966	0	0.61494269	0.02386522	0
16/03/1966	0	0.44773772	0.15108319	0.15108319
17/03/1966	0	0.11890131	0.1224738	0.1224738
18/03/1966	0	0.87411039	0.63653729	0.63653729
19/03/1966	0	0.80444166	0.79489098	0.79489098
20/03/1966	0	0.61494269	0.41740545	0.41740545
21/03/1966	0	0.35484609	0.51644543	0.51644543
22/03/1966	0	0.07059765	0.08777892	0.08777892
23/03/1966	0	0.40407867	0.23207899	0.23207899
24/03/1966	0	0.02229399	0.10567377	0.10567377
25/03/1966	0	0	0.06055247	0
26/03/1966	0	0	0.05274928	0
27/03/1966	0	0	0.04442114	0
28/03/1966	0	0	0.03539046	0
29/03/1966	0	0	0.02499804	0
30/03/1966	0	0.28703518	0.03719254	0
31/03/1966	0	0	0.03208137	0
1/04/1966	0	0	0.02102399	0
2/04/1966	0	0	0.00973096	0
3/04/1966	0	0	0.00314952	0
4/04/1966	0	0	0.00017755	0
5/04/1966	0	0	0	0
6/04/1966	0	0.00464459	0	0
7/04/1966	0	0	0	0
8/04/1966	0	0.19042788	0.00611736	0

9/04/1966	0	0	0.0082474	0
10/04/1966	0	0	0.00092363	0
11/04/1966	0	0	0	0
12/04/1966	0	0	0	0
13/04/1966	0	0	0	0
14/04/1966	0	0	0	0
15/04/1966	0	0.28424843	0.00765497	0
16/04/1966	0	0	0.01938363	0
17/04/1966	0	0	0.00851596	0
18/04/1966	0	0	0.00135804	0
19/04/1966	0	0	0.00000462	0
20/04/1966	0	0	0	0
21/04/1966	0	2.65391434	1.36639124	1.36639124
22/04/1966	1.6923341	1.97470863	2.22247402	2.22247402
23/04/1966	0	0	0.28565563	0.28565563
24/04/1966	0	0	0.0619595	0
25/04/1966	0	0	0.05405963	0
26/04/1966	0	0	0.04597787	0
27/04/1966	0	0	0.0372671	0
28/04/1966	0	0	0.02764403	0
29/04/1966	0	0.17742304	0.01851687	0
30/04/1966	0	0.1467688	0.03155374	0
1/05/1966	0	0.01207591	0.02466479	0
2/05/1966	0	0	0.01346303	0
3/05/1966	0	0	0.0045961	0
4/05/1966	0	0.55734988	0.01851252	0
5/05/1966	0	0.86110556	0.85550577	0.85550577
6/05/1966	0	0	0.06744622	0
7/05/1966	0	0	0.05713762	0
8/05/1966	0	0	0.04938748	0
9/05/1966	0	0	0.04105841	0
10/05/1966	0	0.09567839	0.03209014	0
11/05/1966	0	0	0.02612221	0
12/05/1966	0	0	0.01603326	0
13/05/1966	0	0	0.01089208	0
14/05/1966	0	0	0.00695736	0
15/05/1966	0	0.04180124	0.00265999	0
16/05/1966	0	0	0.00017235	0
17/05/1966	0	0	0	0
18/05/1966	0	0	0	0
19/05/1966	0	1.10076603	0.32274481	0.32274481
20/05/1966	0	0.26845685	0.2108233	0.2108233
21/05/1966	0	0.0956784	0.11128002	0.11128002
22/05/1966	0	0	0.07271565	0.07271565
23/05/1966	0	0	0.05782152	0
24/05/1966	0	0	0.05005314	0
25/05/1966	0	0	0.04170872	0
26/05/1966	0	0	0.03273224	0
27/05/1966	0	0	0.02249422	0
28/05/1966	0	0	0.01462015	0

29/05/1966	0	0	0.01043414	0
30/05/1966	0	0	0.00649044	0
31/05/1966	0	0.58893303	0.01691094	0
1/06/1966	0	0.75892475	0.65797129	0.65797129
2/06/1966	0	0	0.06408402	0
3/06/1966	0.35358328	0.80094181	0.51227163	0.51227163
4/06/1966	0	0	0.10451365	0.10451365
5/06/1966	0	0	0.06118954	0
6/06/1966	0	0	0.05354828	0
7/06/1966	0	0	0.04553566	0
8/06/1966	0	0	0.03693993	0
9/06/1966	0	0	0.02755332	0
10/06/1966	0	0	0.01769464	0
11/06/1966	0	0	0.01254453	0
12/06/1966	0	0	0.00864234	0
13/06/1966	0	0	0.00462158	0
14/06/1966	0	0	0.00078737	0
15/06/1966	0	0	0.00000546	0
16/06/1966	0	0	0	0
17/06/1966	0	0	0	0
18/06/1966	0	0	0	0
19/06/1966	0	0.43194616	0.0108478	0
20/06/1966	0	0	0.03082294	0
21/06/1966	0	0	0.02116173	0
22/06/1966	0	0	0.00996033	0
23/06/1966	0	0	0.00184016	0
24/06/1966	0	0.05852174	0.00005691	0
25/06/1966	0	0.22851344	0.01378042	0
26/06/1966	0	0	0.0203661	0
27/06/1966	0	0	0.00941825	0
28/06/1966	0	0	0.00137146	0
29/06/1966	0	0	0.00001982	0
30/06/1966	0	0	0	0
1/07/1966	0	0.17463628	0.00402351	0
2/07/1966	0	0	0.01340659	0
3/07/1966	0	0	0.0032916	0
4/07/1966	0	0	0.0001185	0
5/07/1966	0	0.30561351	0.00191648	0
6/07/1966	0	0	0.02717164	0
7/07/1966	0	0.09846514	0.02108757	0
8/07/1966	0	0	0.01258184	0
9/07/1966	0	0.12540372	0.00876484	0
10/07/1966	0	0	0.00759929	0
11/07/1966	0	0	0.00072458	0
12/07/1966	0	0	0.00000003	0
13/07/1966	0	0.00092892	0	0
14/07/1966	0	0	0	0
15/07/1966	0	0.75149342	0.11185898	0.11185898
16/07/1966	0	1.09797922	0.7463989	0.7463989
17/07/1966	0.16878094	0.43178288	0.63636999	0.63636999

18/07/1966	0	0	0.11441817	0.11441817
19/07/1966	0	0	0.06085572	0
20/07/1966	0	0	0.0531992	0
21/07/1966	0	0	0.0451732	0
22/07/1966	0	0	0.03655949	0
23/07/1966	0	0	0.02709387	0
24/07/1966	0	0	0.01744223	0
25/07/1966	0	0	0.01248686	0
26/07/1966	0	0.33162317	0.01398207	0
27/07/1966	0	0.16720496	0.04255886	0
28/07/1966	0	0.07245549	0.04071371	0
29/07/1966	0	0	0.03390018	0
30/07/1966	0	0	0.02367738	0
31/07/1966	0	0	0.01257734	0
1/08/1966	0	0	0.00254823	0
2/08/1966	0	0	0.00003797	0
3/08/1966	0	0	0	0
4/08/1966	0	0	0	0
5/08/1966	0	0	0	0
6/08/1966	0	0	0	0
7/08/1966	0	0	0	0
8/08/1966	0	0	0	0
9/08/1966	0	0.69482951	0.01461114	0
10/08/1966	0	0.41708349	0.35761505	0.35761505
11/08/1966	0.02891026	0.82680618	0.50463564	0.50463564
12/08/1966	0.22493177	0.46110871	0.58830384	0.58830384
13/08/1966	0	0.00185784	0.09300387	0.09300387
14/08/1966	0	0.21365078	0.08207128	0.08207128
15/08/1966	0	0	0.07034856	0.07034856
16/08/1966	0	0	0.05635052	0
17/08/1966	0	0	0.04838655	0
18/08/1966	0	0.80165491	0.1337247	0.1337247
19/08/1966	0	0	0.3246558	0.3246558
20/08/1966	0	0	0.06245456	0
21/08/1966	0	0.26102553	0.06441436	0
22/08/1966	0	0.24244719	0.1016542	0.1016542
23/08/1966	0	0.08081573	0.12862652	0.12862652
24/08/1966	0	0.48396546	0.42498602	0.42498602
25/08/1966	0	0	0.07037607	0.07037607
26/08/1966	0	0	0.05783362	0
27/08/1966	0	0	0.05012062	0
28/08/1966	0	0	0.04182422	0
29/08/1966	0	0	0.03289078	0
30/08/1966	0	0	0.02266196	0
31/08/1966	0	0	0.01496713	0
1/09/1966	0	0	0.01082037	0
2/09/1966	0	0	0.00680248	0
3/09/1966	0	0	0.00233199	0
4/09/1966	0	0	0.00006373	0
5/09/1966	0	0.26474119	0.00141733	0

6/09/1966	0	0.05387715	0.02058463	0
7/09/1966	0	1.01716351	0.35076624	0.35076624
8/09/1966	0	0	0.12560502	0.12560502
9/09/1966	0	0.00185783	0.06084066	0
10/09/1966	0	0	0.05309331	0
11/09/1966	0	0	0.04492586	0
12/09/1966	0	0	0.03611625	0
13/09/1966	0	1.60330982	1.0547324	1.0547324
14/09/1966	0	0	0.10485298	0.10485298
15/09/1966	0	0.61401378	0.30081826	0.30081826
16/09/1966	0	0.13004831	0.2047312	0.2047312
17/09/1966	0.3857071	0.82063106	0.72379085	0.72379085
18/09/1966	0	0	0.11201844	0.11201844
19/09/1966	0	0	0.06084716	0
20/09/1966	0	0	0.05310662	0
21/09/1966	0	0.00185784	0.04494026	0
22/09/1966	0	0	0.03613165	0
23/09/1966	0	0	0.026243	0
24/09/1966	0	0.00836025	0.01659705	0
25/09/1966	0	0	0.01202439	0
26/09/1966	0	0	0.0080358	0
27/09/1966	0	0	0.00372403	0
28/09/1966	0	0	0.00030516	0
29/09/1966	0	0.15512905	0	0
30/09/1966	0	0	0.00976353	0
1/10/1966	0	0	0.0010384	0
2/10/1966	0	0.66231743	0.02955211	0
3/10/1966	0	0.23501587	0.12673978	0.12673978
4/10/1966	0	0.39571841	0.23104856	0.23104856
5/10/1966	0	0	0.11380524	0.11380524
6/10/1966	0	0	0.06053299	0
7/10/1966	0	0	0.05269564	0
8/10/1966	0	0	0.0443289	0
9/10/1966	0	0	0.03524086	0
10/10/1966	0	0	0.02471304	0
11/10/1966	0	0	0.01555743	0
12/10/1966	0	0	0.01131735	0
13/10/1966	0	0	0.00719533	0
14/10/1966	0	0	0.00251334	0
15/10/1966	0	0	0.00003091	0
16/10/1966	0	0	0	0
17/10/1966	0	0	0	0
18/10/1966	0	0	0	0
19/10/1966	0	1.88662932	0.94465441	0.94465441
20/10/1966	0	0	0.10032361	0.10032361
21/10/1966	0	0	0.05990781	0
22/10/1966	0	0	0.05208741	0
23/10/1966	0	0	0.04367243	0
24/10/1966	0	0	0.03452302	0
25/10/1966	0	0	0.02384098	0

26/10/1966	0	0	0.01518276	0
27/10/1966	0	0	0.01102805	0
28/10/1966	0	0	0.00689413	0
29/10/1966	0	0	0.00218332	0
30/10/1966	0	1.22709865	0.4070895	0.4070895
31/10/1966	0	0.79050789	0.83434572	0.83434572
1/11/1966	0	0	0.06372434	0
2/11/1966	0	1.17972391	0.87499853	0.87499853
3/11/1966	0	0.02600962	0.10793977	0.10793977
4/11/1966	0	0	0.06133263	0
5/11/1966	0	0	0.05340509	0
6/11/1966	0	0	0.04492337	0
7/11/1966	0	0	0.03567901	0
8/11/1966	0	0	0.02490766	0
9/11/1966	0	0.30840025	0.02368066	0
10/11/1966	0	0.22201097	0.05259777	0
11/11/1966	0	0	0.04976639	0
12/11/1966	0	0.85274531	0.47782285	0.47782285
13/11/1966	0	0.2090062	0.10131355	0.10131355
14/11/1966	0	0	0.10792027	0.10792027
15/11/1966	0	0	0.06125541	0
16/11/1966	0	0	0.05333293	0
17/11/1966	0	0	0.04488639	0
18/11/1966	0	0	0.03567665	0
19/11/1966	0	0	0.02492465	0
20/11/1966	0	0	0.01544685	0
21/11/1966	0	0	0.01118428	0
22/11/1966	0	0	0.00696823	0
23/11/1966	0	0	0.00208409	0
24/11/1966	0	0	0.00000026	0
25/11/1966	0	0	0	0
26/11/1966	0	0.00185783	0	0
27/11/1966	0	0	0	0
28/11/1966	0	0	0	0
29/11/1966	0	0	0	0
30/11/1966	0	0	0	0
1/12/1966	0	0	0	0
2/12/1966	0	0.54527396	0.01208283	0
3/12/1966	0	0.37992682	0.03519548	0
4/12/1966	0.04664444	2.11909691	1.704348	1.704348
5/12/1966	0.06730776	0.50761419	0.67061505	0.67061505
6/12/1966	0	0	0.06577573	0
7/12/1966	0	0	0.05622044	0
8/12/1966	0	0.04830365	0.04804414	0
9/12/1966	0	0	0.03914595	0
10/12/1966	0	0	0.02923403	0
11/12/1966	0	0	0.0179259	0
12/12/1966	0	0.05294825	0.01274869	0
13/12/1966	0	0.49604139	0.01859313	0
14/12/1966	0	0.49882814	0.25895687	0.25895687

15/12/1966	0	0.64095235	0.56165137	0.56165137
16/12/1966	0	1.1295624	1.14700976	1.14700976
17/12/1966	0	0	0.0691462	0
18/12/1966	0	0	0.05727974	0
19/12/1966	0	0.07152657	0.04952356	0
20/12/1966	0	0	0.04104055	0
21/12/1966	0	0	0.03135294	0
22/12/1966	0	0	0.01978938	0
23/12/1966	0	0	0.01336789	0
24/12/1966	0	0.43937747	0.04423327	0
25/12/1966	0	0.97814906	0.5996109	0.5996109
26/12/1966	0	0	0.11458907	0.11458907
27/12/1966	0	0	0.05998904	0
28/12/1966	0	0	0.05205769	0
29/12/1966	0	0.15791578	0.04789989	0
30/12/1966	0	0	0.04046608	0
31/12/1966	0	0	0.0304377	0
days without runoff	356	260	68	297
days with runoff	9	105	297	68

A	PRELIMINARY ISSUE FOR DISCUSSION	L.H.	16/04/12
Rev	Amendments	App'd	Date

LEGEND

WOLLERT PSP BOUNDARY
QUARRY HILLS PSP BOUNDARY
100YR INUNDATION EXTENT

file name 137599G05 Wetland & Open Space.dwg layout name G05-1Scale 1:10000,A1
file location G:\13\137599\ACAD
plotted by Sean Durston-Ryan plot date 18/7/2012 3:07 PM
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Standard Drawing RDA1-CPG - Version 20090518

Horizontal 0 100 200 300 400 500
Vertical 0 100 200 300 400 500

Designed 16/03/12
N. GREEN
Checked ----
PENDING
Authorised ----
PENDING

Map Reference MELWAY 389 B10
Sheet Number 05-1
Drg Status PRELIMINARY

CPG ABN 55 050 029 635
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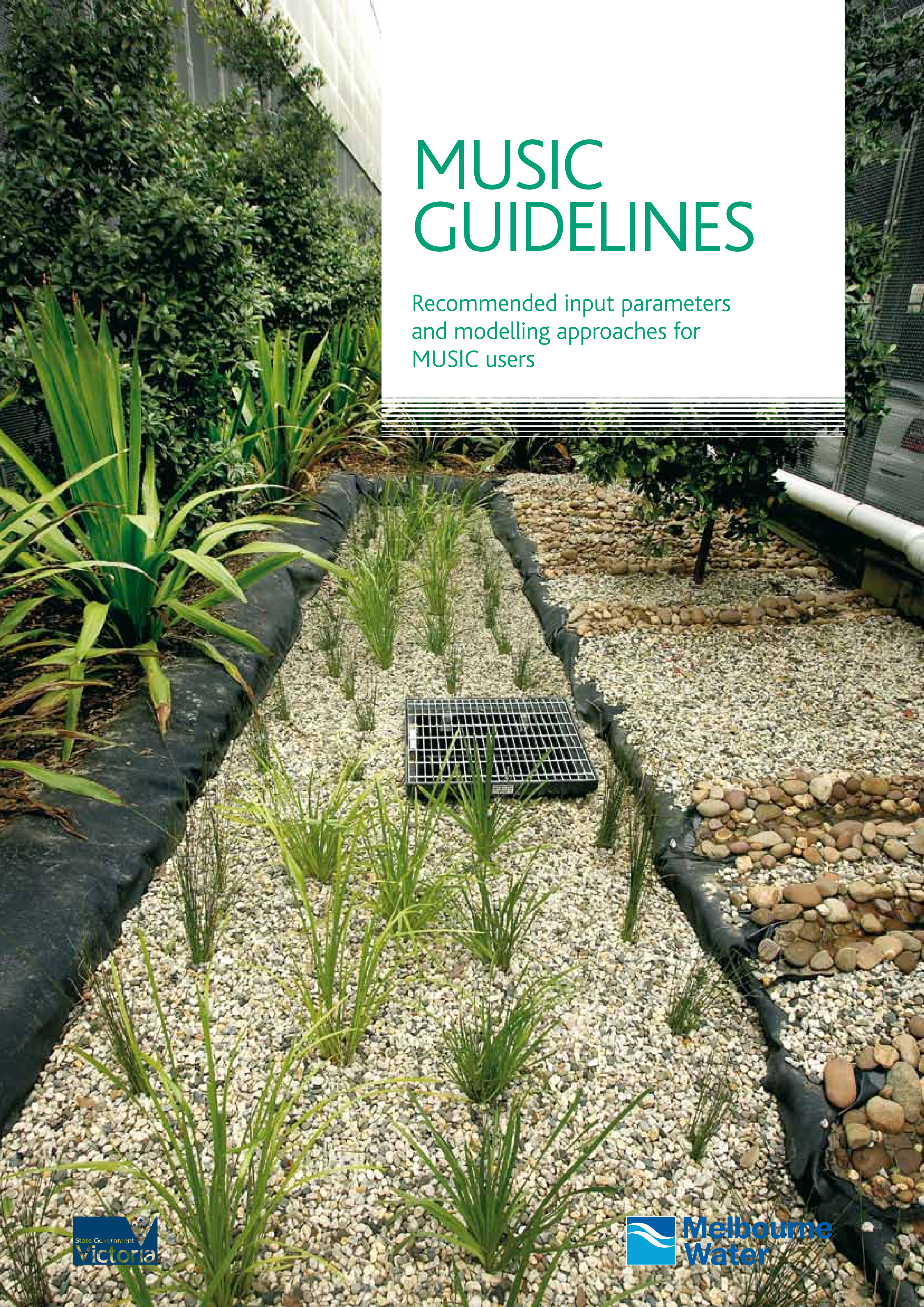
WOLLERT IWMS
WOLLERT PSP
WOLLERT IWMS
WETLAND AND OPEN SPACE LAYOUT PLAN
WHITTLESEA CITY COUNCIL & GAA
WHITTLESEA CITY COUNCIL

Rev A
Drg No 137599G05-1

Appendix H: Melbourne Water Guidelines for the Use of MUSIC

MUSIC GUIDELINES

Recommended input parameters and modelling approaches for MUSIC users



State Government Victoria

Melbourne Water

INTRODUCTION

Model for Urban Stormwater Improvement Conceptualisation (MUSIC) was developed by eWater. MUSIC is a conceptual design tool. The program can be used to estimate pollutant generation from a catchment and to demonstrate the performance of stormwater quality improvement systems.

Generally Melbourne Water requires treatment of stormwater so that annual pollutant loads achieve targets set out in the Best Practice Environmental Management Guidelines (BPEMG), these are:

- 45% reduction in Total Nitrogen (TN) from typical urban loads
- 45% reduction in Total Phosphorus (TP) from typical urban loads
- 80 % reduction in Total Suspended Solids (TSS) from typical urban loads
- 70% reduction in Litter from typical urban loads
- Maintain discharges for the 1.5 year ARI event at pre-development levels

There are however many cases where individual treatment measures will have different targets, for instance if the receiving aquatic ecosystem is identified as being of very high value, then Melbourne Water may require a higher treatment level.

The design intent for any treatment system must be clearly documented and discussed with Melbourne Water early in the conceptual design stage. Melbourne Water uses MUSIC to assess the impacts of proposed development against performance targets. If alternative methods or models are used, the developer must demonstrate to Melbourne Water's satisfaction that performance targets can be achieved.

This document provides guidance on input parameters and modelling approaches for MUSIC that are recommended by Melbourne Water.

PURPOSE OF THIS DOCUMENT

This document is aimed at supporting those submitting MUSIC models to Melbourne Water. The objectives are to:

- Ensure a consistent scientifically based approach is applied to MUSIC models
- Provide guidance on methods specific to the Melbourne region without inhibiting innovative modelling approaches.
- Reduce the time taken by Melbourne Water in assessing models.

This document should be read in conjunction with the MUSIC Users Manual. Users of these guidelines are expected to know how to use MUSIC software and are sufficiently trained in the use of MUSIC software.

This document is not a design guideline and should be read in conjunction with appropriate design guidelines, eg. *WSUD Engineering Procedures: Stormwater* (Melbourne Water, 2005).

1. RAINFALL DATA & EVAPOTRANSPIRATION

Use of meteorological data within MUSIC is a balance between accurate representation and computing time. Testing has shown that the use of rainfall data from an appropriately selected year of rainfall data can represent the long-term metrological record. Six rainfall stations across Melbourne have been selected to reflect the rainfall gradient shown in Figure 1 below. The Representative years were selected as the best match of long-term records in terms of mean annual rainfall, distribution of rainfall and 90th percentile of rainfall. Melbourne Water recommends that results obtained by the "reference year" method be compared with long term rainfall records as a final check.

The rainfall distribution map can be used to determine the appropriate weather station, in order to better determine which station is appropriate; a large-scale version of the map is also available at the Melbourne Water website.

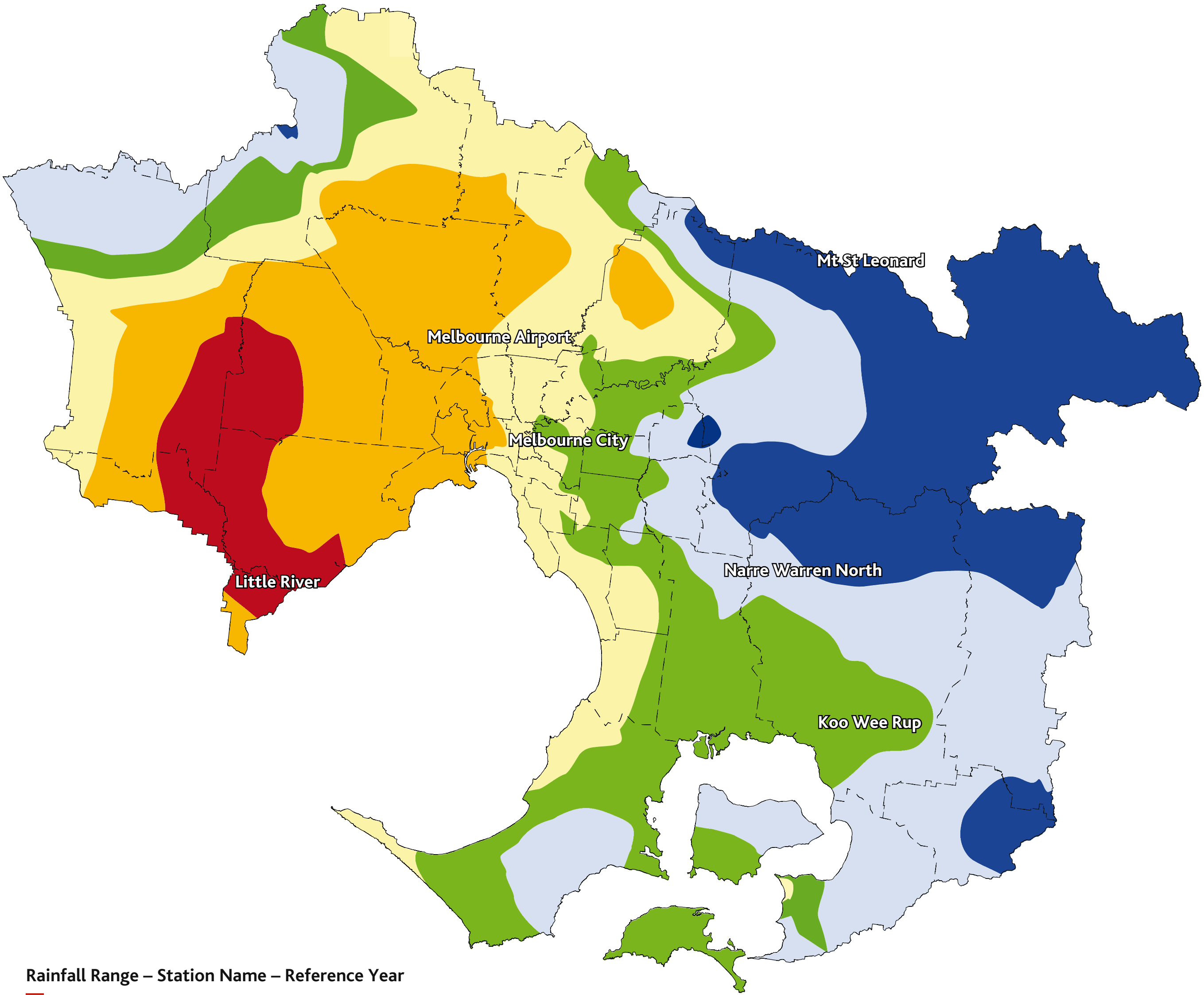
Rainfall data is available from the Bureau of Meteorology www.bom.gov.au. Templates for the six rainfall stations selected to reflect the rainfall gradient across metropolitan Melbourne are available at melbournewater.com.au.

All models created from January 2011 onwards must use either Melbourne Water's recommended rainfall templates or appropriate local rainfall. Use of alternative rainfall data is permitted if it can be demonstrated that the selected rainfall data is high quality and representative of the area to which it is being applied.

Table 1. Weather station, Mean Annual Rainfall range, reference year

Weather Station	Mean Annual Rainfall (mm) range	Reference year
Little River	400 - 500	2004
Melbourne Airport	500 - 650	1996
Melbourne City	650 - 750	1966
Koo Wee Rup	750 - 850	2004
Narre Warren North	850 - 1100	1998
Mt St Leonard	1100 - 2100	1998

RAINFALL DISTRIBUTION – GREATER MELBOURNE



Rainfall Range – Station Name – Reference Year

- 400mm to 500mm – Little River – 2004
- 500mm to 650mm – Melbourne Airport – 1996
- 650mm to 750mm – Melbourne City – 1966
- 750mm to 850mm – Koo Wee Rup – 2004
- 850mm to 1100mm – Narre Warren North – 1998
- 1100mm to 2100mm – Mount St Leonard – 1998

2. TIMESTEP

The timestep must be equal to or less than:
i. the Time of Concentration of the smallest Sub-Catchment, and
ii. the shortest detention time (under design flows) of the treatment measures being modelled.

Where either of these would be less than 6 minutes, the model should be run using a 6 minute interval.

3. HYDROLOGIC ROUTING

Hydrologic routing should be used where appropriate to reflect the Time of Concentration of the Catchment as calculated using a recognised procedure. The applicant may choose not to apply routing to reduce the complexity of the model. Generally this will result in the performance of treatment systems being underestimated.

4. SOILS

In MUSIC the pervious area properties default to Brisbane properties. These will need to be altered to reflect Melbourne properties as documented in the MUSIC User Manual. Any deviation from the Melbourne parameters listed in the MUSIC User Manual should be described in the report provided with the model. Supporting evidence should also be provided.

The MUSIC User Manual lists the following pervious area properties for Melbourne:

Soil Store Capacity = 30mm Field Capacity = 20mm

5. LOSSES FROM THE SYSTEM

The exfiltration rate specified in treatment nodes relates to the seepage rate in mm/hr of the soil surrounding the treatment systems. This does not refer to the hydraulic conductivity of any of the soils contained within the actual treatment systems. The exfiltration rate adopted in any treatment nodes that is more than 0mm/hr must be supported by a geotechnical report.

6. POLLUTION CONCENTRATION DATA

The default values for TSS, TP and TN are to be used, unless additional data is available. Any new data must be published and demonstrate that there is a significance difference between the new data and the default data. Changes to default pollutant concentrations must be confirmed by Melbourne Water in writing.

The Serial Correlation (R squared) is to be set to zero for TSS, TP and TN if using a single reference year of rainfall data. This applies to MUSIC Version 4 models only.

7. FRACTION IMPERVIOUS

Ideally models should be calibrated using local flow data. However in most cases information is not available to achieve this. Where the model cannot be calibrated using local flow data, the following table indicating the fraction impervious for different land uses can be used as a guide. Consideration should be given to the catchment modelled and where it fits within the range provided. This table may not be applicable to all catchments.

It should be noted that these figure are total fraction impervious whereas MUSIC requires the effective fraction impervious. Use of these figures may result in overestimation of more frequent flows in some cases.

Any significant deviation from these figures must be supported by relevant information (i.e. long term flow data that enables calibration of the model)

Zone	Zone Code	Brief Description/Examples	Normal Range	Typical Value
Residential Zones:				
Residential 1 & 2 Zone	R1Z	Moderate range of densities. (Allotment size $800m^2$ – $4000m^2$)	0.40 - 0.50	0.45
	R2Z	Normal densities. (Allotment size $500m^2$ – $800m^2$)	0.50 - 0.70	0.60
		Medium densities. (Allotment size $350m^2$ – $500m^2$)	0.70 - 0.80	0.75
		High densities. (Allotment size <$350m^2$)	0.80 - 0.95	0.85
Low Density Residential Zone	LDRZ	Low densities (0.4 ha min.)	0.10 - 0.30	0.20
Mixed Use Zone	MUZ	Mix of residential, commercial, industrial and hospitals.	0.60 - 0.90	0.70
Township Zone	TZ	Small townships with no specific zoning structures.	0.40 - 0.70	0.55
Industrial Zones:				
Industrial 1 Zone	IN1Z	Main zone to be applied in most industrial areas.	0.70 - 0.95	0.90
Industrial 2 Zone	IN2Z	Large industrial zones away from residential areas.	0.70 - 0.95	0.90
Industrial 3 Zone	IN3Z	Buffer between Zone 1 and Zone 3.	0.70 - 0.95	0.90
		• for garden supplies/nurseries.	0.30 - 0.60	0.50
		• for quarries.	0.10 - 0.30	0.20
Business Zones:				
Business 1 Zone	B1Z	Main zone to be applied in most commercial areas.	0.70 - 0.95	0.90
Business 2 Zone	B2Z	Offices and associated commercial uses.	0.70 - 0.95	0.90
Business 3 Zone	B3Z	Offices, manufacturing industries and associated uses.	0.70 - 0.95	0.90
Business 4 Zone	B4Z	Mix of bulky goods retailing and manufacturing industries.	0.70 - 0.95	0.90
Business 5 Zone	B5Z	Mix of offices and multi-dwelling units.	0.70 - 0.95	0.90
Rural Zones:				
Rural Zone	RUZ	Main zone to be applied in most rural areas.	0.05 - 0.20	0.10
Environmental Rural Zone	ERZ	Rural areas with specific environmental considerations.	0.05 - 0.20	0.10
Rural Living Zone	RLZ	Predominantly residential use in rural environment.	0.10 - 0.30	0.20

Zone	Zone Code	Brief Description/Examples	Normal Range	Typical Value
Public Land Zones:				
Public Use Zone		Use of land for public purposes		
• Service and Utility	PU1Z	• power lines, pipe tracks and retarding basins.	0.00 - 0.10	0.05
		• reservoirs.	0.40 - 0.60	0.50
• Education	PU2Z	• schools and universities.	0.60 - 0.80	0.70
• Health and Community	PU3Z	• hospitals.	0.90 - 0.80	0.70
• Transport	PU4Z	• railways and tramways.	0.60 - 0.80	0.70
• Cemetery / Crematorium	PU5Z	• cemeteries and crematoriums.	0.50 - 0.70	0.60
• Local Government	PU6Z	• libraries, sports complexes and offices/depots.	0.50 - 0.90	0.70
• Other Public Use	PU7Z	• museums.	0.50 - 0.80	0.60
Public Park and Recreation Zone	PPRZ	Main zone for public open space, incl golf courses.	0.00 - 0.20	0.10
Public Conservation and Resource Zone	PCRZ	Protection of natural environment or resources.	0.00 - 0.05	0.00
Road Zone – Category 1	RDZ1	Major roads and freeways.	0.60 - 0.90	0.70
Road Zone – Category 2	RDZ1	Secondary and local roads.	0.50 - 0.80	0.60
Special Purpose Zones:				
Special Use Zone	SUZn	Development for specific purposes.	0.50 - 0.80	0.60
Comprehensive Development Zone	CDZn	Large and complex developments – residential.	0.40 - 0.80	0.50
Urban Floodway Zone	UFZ	Land identified as part of an active floodway.	0.00 - 0.05	0.00
Capital City Zone	CCZn	Special Use Zone for land in Melbourne's central city.	0.70 - 0.90	0.80
Docklands Zone	DZn	Special Use Zone for land in Docklands area.	0.70 - 0.90	0.80
Commonwealth Land:				
Commonwealth Land	CA	Army barracks, CSIRO.	0.50 - 0.80	0.60

Note: Values included in this table relate only to the average imperviousness of a land-use type. They are not runoff coefficients and should not be used as runoff coefficients. Refer to the Australian Rainfall and Runoff (Engineers Australia, 2001) for the difference between fraction impervious and runoff coefficients.

8. STOCHASTIC VERSUS MEAN GENERATED DATA

Stochastically generated data is always to be used, except where there is a requirement to examine behaviour for a particular storm event or set of operating conditions.

9. SOURCE NODES

Any Agricultural & Forest nodes must be submitted as independent subcatchments, parkland within an urban development will usually be modelled as an urban node. The uncertainties associated with the defaults used for agricultural nodes are significantly higher than those for urban nodes. In most cases the use of urban nodes, with low fraction impervious, will be preferable to the use of agricultural nodes.

10. K, C*, C**

Melbourne Water must approve any changes to these parameters in writing. Any data used to modify these parameters must be published data, and be appropriate for the circumstances being modelled.

11. INSTREAM WORKS

Any works within receiving waters (such as pool and riffle systems) shall not be included into any treatment train models. Waterways in Development Services Schemes shall not be included into any treatment models.

Online wetland treatment trains are acceptable if they comply with Melbourne Water's Constructed Wetland Guidelines.

12. GPT'S

No treatment should be attributed to a GPT unless it is supported by reliable studies. Nitrogen reductions from GPT's shall not be included in the overall performance of the treatment train.

13. WETLANDS

To access design guidelines for constructed wetland systems please refer to the Melbourne Water publication 'Constructed Wetlands Guidelines' (Melbourne Water, 2010). This document is available as a PDF download from Melbourne Water's web page.

A minimum of 80% coverage of emergent macrophytes is required within the normal water level surface area of the wetland.

The extended detention depth can vary up to a maximum of 500mm, unless otherwise approved.

The detention time in the macrophyte extended detention zone is recommended to be 72 hours, with not less than a 48 hour detention time.

Additional requirements for wetlands can be found in Melbourne Water's Constructed Wetland Guidelines, http://www.melbournewater.com.au/content/planning_and_building/information_for_developers/guidelines_for_developers.asp

14. LAKES

MUSIC is not a suitable model for in-lake processes, other than water balance assessments. Guidance on this topic can be found in the Melbourne Water publication "*Constructed Shallow Lake Systems for Developers*". This document is available as a PDF download from Melbourne Water's web page.

15. REUSE

A reuse master plan must be provided which is to be signed off by all relevant authorities (Local Government, Melbourne Water). Calculations should be provided to support reuse volumes.

Reuse used to contribute to treatment train performance must have demands that are reliable, eg. toilet flushing. Irrigation of a residential block is encouraged, however will not be accepted as demand for reuse in a model due to the high variability of this demand.

For reuse to be accepted as part of a MUSIC model there needs to be a suitable agreement between the relevant stakeholders relating to the reuse.

Use of reuse to contribute to treatment performance should be modelled in accordance with the "Rainfall Data & Evapotranspiration" and "Timestep" sections of these guidelines. Use of a different timestep and a number of consecutive rainfall years should be considered when determining the optimum size of the storage unit.

16. SWALES

Suggested vegetation heights

- **Grass swale** (mowed) height range: 10 – 100mm
- **Vegetation** (not mowed): 100 – 400mm

In the case where unmown vegetation is being used, the proponent should identify what type of vegetation is proposed, and how it will be managed within the landscape and maintenance requirements of the development. Waterways within developments cannot be deemed as swales and shall not be included in the treatment train model.

17. BIORETENTION SYSTEMS

Bioretention systems used in models must be supported by a specification of the filter media for the system included in the design. The specification should comply with the specification requirements listed in the *"Stormwater Biofiltration Systems: Adoption Guidelines"* (FAWB, 2009)

The hydraulic conductivity of the filter media used in the model should match the specification. An acceptable range of the hydraulic conductivity of a bioretention system is 100mm/hr – 400mm/hr. A geotechnical report may be required to support the selection of the exfiltration rate if the system is not lined.

If using MUSIC Version 3 or the media filtration system node in MUSIC Version 4, the median particle diameter size should match the specification. The filter media depth should not include the transition layer and the drainage layer.

If using MUSIC Version 4, the portion of organic material in the filter, the TN content of filter media and the Orthophosphate content of the filter media should also match the specification provided with the model. If the system is to be vegetated with effective nutrient removal plants, a vegetation specification is to be provided with the design. The filter media depth should not include the transition layer and the drainage layer unless there is a submerged zone. The porosity of the filter media and a submerged zone, if present, should represent the materials listed in the specification.

Consideration should be given to the extended detention depth selected for bioretention systems. The depth should be safe for construction, operation and maintenance of the system. If the system has a longitudinal slope, it will not have a uniform extended detention depth and an average should be selected.

18. PERMEABLE PAVEMENT

Permeable pavement should be modelled as per the manufacturer's guidelines. Documentation supporting the modelling must be submitted for review.

19. IMPORTED DATA NODES

Supporting documentation will be required to demonstrate the use of any imported data nodes in models.

20. GENERIC TREATMENT NODES

Generic treatment nodes should not be used unless supported by supplementary models or if modelling as per a treatment manufacturer's guidelines with supporting documentation.

Generic treatment nodes can be used to simulate the splitting of flows. Appropriate documentation must be provided to justify the split of flows if used to simulate this.

SUBMISSION REQUIREMENTS

The functional design report for the project should incorporate the following information for systems modelled with MUSIC:

Summary

- Summary of treatment performance in terms of:
  1. Mean annual load reduction for TSS, TP and TN
  2. % reduction of each treatment device
  3. % reduction of total treatment system
- Description of the function and intent of the treatment system.
- Catchment details.
- Description of how fraction impervious was calculated (what figures were used for different zonings).
- Description of and documentation for any departure from the Melbourne Water "MUSIC Inputs" document.
- A plan to an identifiable scale clearly depicting the catchment / s contributing to the treatment systems.
- Drawings depicting the design of the system.
- Specification for the treatment systems.
- Vegetation specification for bioretention systems.

Model

- Sqz model of catchment with treatment measures.
- Sqz model of catchment without treatment measures.
- Description of rainfall/ET data used (should be one of MW's reference years)
- If available an electronic copy of the catchment and subcatchment used in MapInfo or other approved format. If an electronic copy is not available a hard copy is acceptable.

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Designed and produced by Equest Design.

ISBN 978-1-921603-87-7 (print)
ISBN 978-1-921603-88-4 (web)

Melbourne Water

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