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STORMWATER MANAGEMENT STRATEGY

McPherson Precinct Structure Plan (PSP 1055)

March 2016

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Contents

Figures

Tables

1 Introduction

Alluvium Consulting Australia Pty Ltd (Alluvium) has been engaged by the Regional Planning Authority (MPA) to prepare a stormwater management strategy (SWMS) to inform the McPherson Precinct Structure Plan - PSP 1055 (McPherson PSP or PSP 1055) and ultimately to inform Melbourne Water's Development Services Scheme (DSS) process.

The integration of water management at this stage of the planning process provides the opportunity to optimise the urban design outcomes associated with water services, the local environment and open space. The objective of this SWMS is to provide strategies for managing:

- Stormwater quantity
- Stormwater quality, and
- Existing and constructed waterways

Through meeting these objectives, this SWMS acts as a critical component of the development servicing strategy and ensures stormwater is managed in accordance with best practice requirements. Information with respect to key drainage assets is provided at a concept design level.

Alluvium acknowledge that the MPA has a very clear charter to maximise land take for development whilst still providing an appropriate solution for the environment and community. As such, Alluvium has endeavoured to develop an option that honours this direction.

1.1 Reference material

- Assessment of Drainage Strategy for PSP 53 and the Overall Cardinia Creek Catchment, Stormy Water Solutions and Neil Craigie Pty Ltd and Pat Condina & Assoc (2012)
- Stormwater Management Strategy for PSP 55 – Clyde East, Alluvium (2013)
- Thompsons Road PSP 53 and Clyde Creek PSP 54 Stormwater Management Strategy (SWMS), Craigie (2013)
- Stormwater Management Strategy for PSP 55 – Clyde East for Mirvac, Alluvium (May 2013)
- St Germain Masterplan, Thompsons Road, Clyde North, Beveridge Williams (11 August 2014)
- Thompsons Road Precinct Structure Plan, MPA (2014)
- Clyde North Precinct Structure Plan, MPA (2011)
- Thompsons Road, St Germain Developments, Alluvium (2013)
- Cardinia Road Employment Precinct Stormwater Management Plan Revision A, Stormy Water Solutions (2008)
- Cardinia Investigation Area T5/T6, Officer Road Drain / Gum Scrub Creek Catchment Investigation, Stormy Water Solutions (2009)
- Clyde North PSP Surface Water Management Aspects, Version 4 Final, Craigie (2009)
- Casey Growth Area Planning – Assessment of the Risk to Water Dependent Environmental Values from the Development of the Casey Growth Area (Part A – Clyde Creek/Western Outfall Drain and Muddy Gates Drain), SKM (2012)
- Mirvac Indicative Masterplan Setout (Beveridge Williams, November 2015)

2 Site overview

2.1 Context

McPherson PSP covers an area of approximately 946 ha, and is located about 50 kilometres south east of Melbourne's Central Business District. It is situated within the Westernport Bay catchment and confined by Cardinia Creek to the north east, Muddy Gates Lane and McCormacks Road to the east, Ballarto Road to the south and Smiths Lane and Bells Road to the west (Figure 1). The land has been cleared and is predominately used for agricultural purposes.

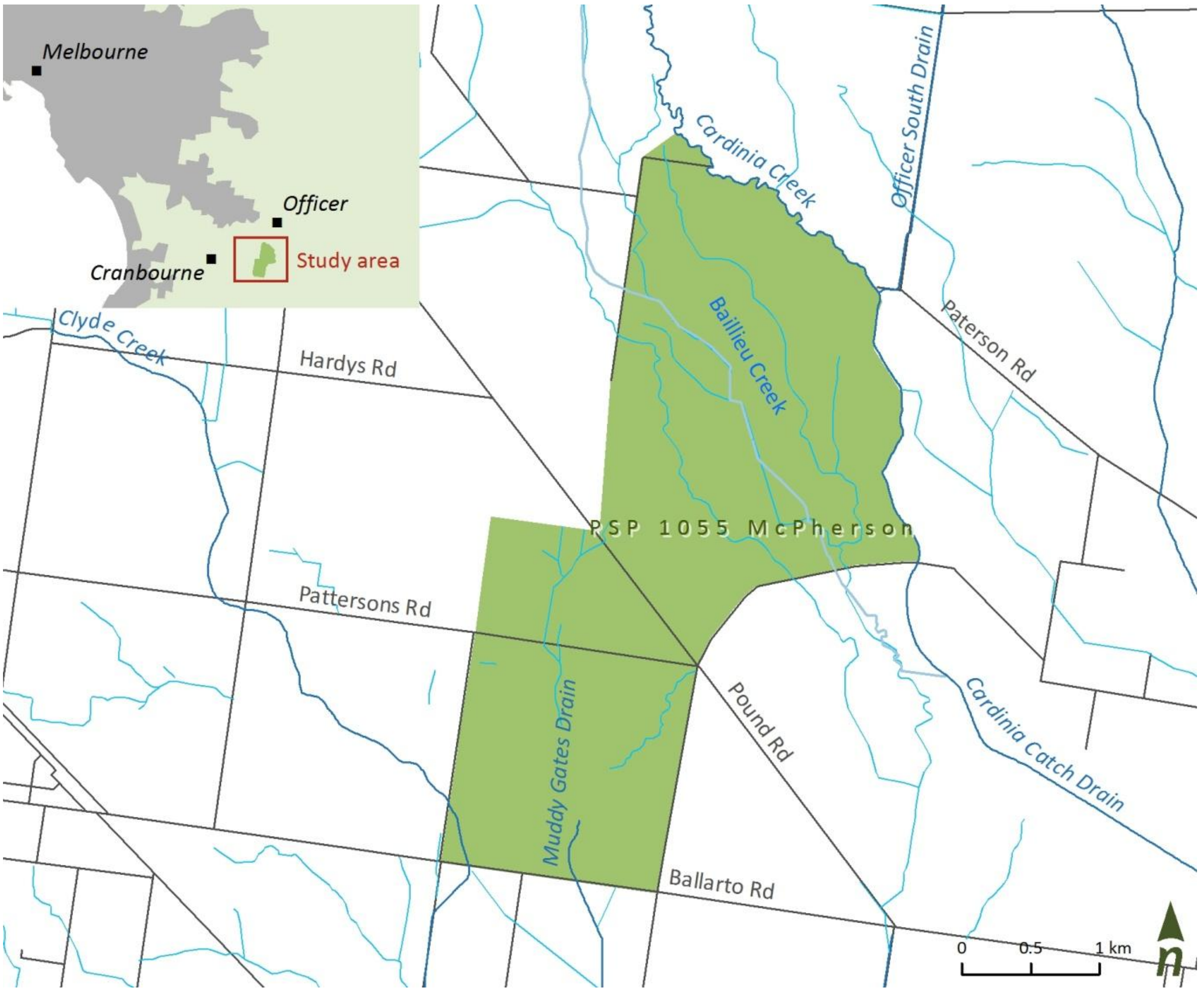


Figure 1. *Location of the study area*

Two waterways pass through the middle of the precinct; Baillieu Creek and Muddy Gates Drain:

- Baillieu Creek flows through the northern part of PSP before discharging into Cardinia Creek at the southern end of the PSP boundary. The Baillieu Creek catchment is one of a number of sub-catchments draining into the Cardinia Creek Outfall which passes through the Koo Wee Rup Flood Protection District (KWRFPD) before discharging into Westernport Bay
- The Muddy Gates Drain flows south before discharging into Westernport Bay

Two other waterways interface along the boundary of the precinct; Clyde Creek and Cardinia Creek:

- Clyde Creek passes through the south western corner of PSP 1055 for approximately 500 metres. Similar to Muddy Gates Drain, Clyde Creek flows south from the PSP 1055 boundary before discharging into Westernport Bay.

- Cardinia Creek forms the north eastern boundary of PSP 1055. Cardinia Creek flows through the Koo Wee Rup Flood Protection District (KWRFPD) before discharging into Westernport Bay.

The location of the four major waterways and their catchments are shown in Figure 2.

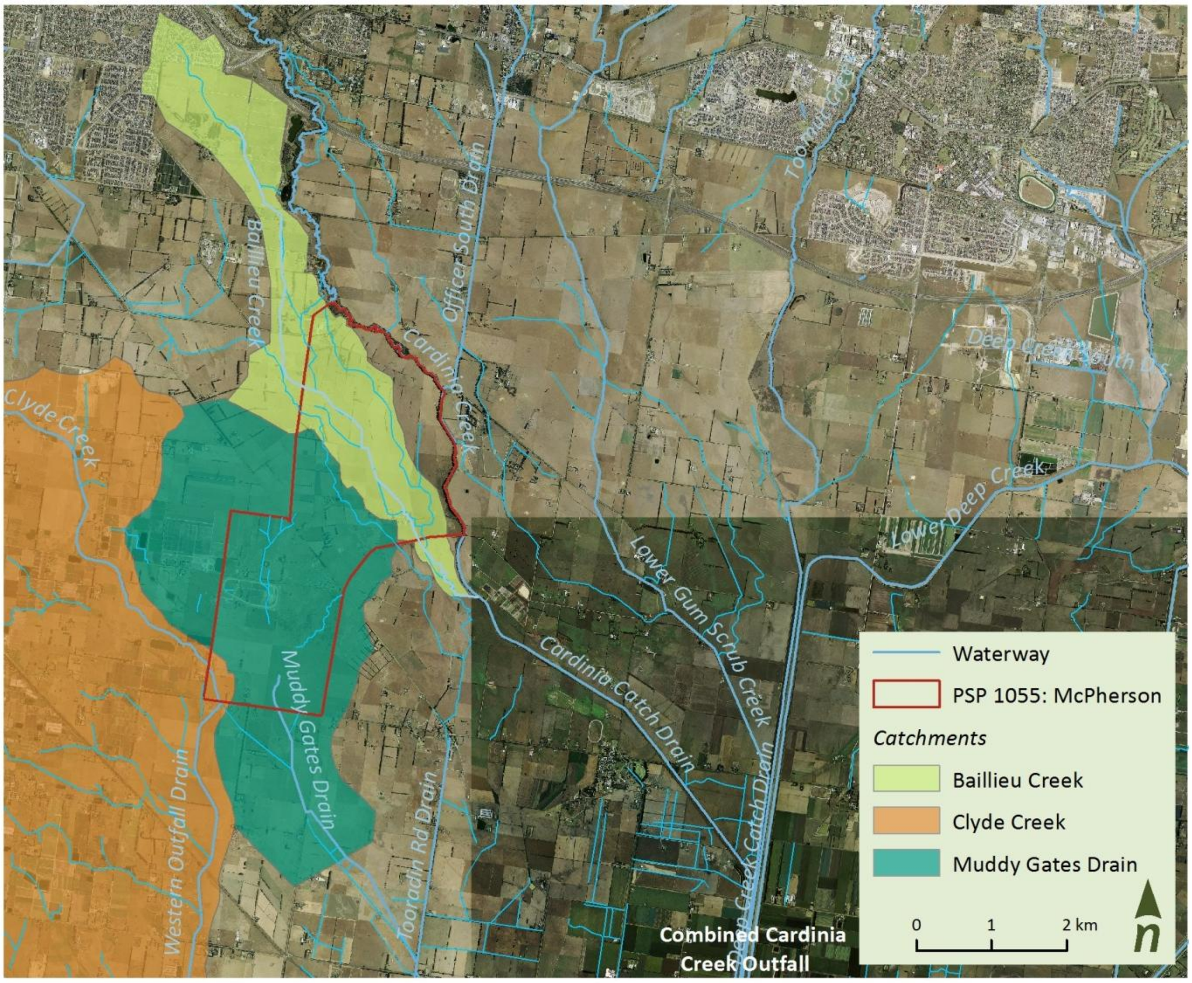


Figure 2. Waterway catchments PSP 55

The study area primarily slopes from north to south. More specifically, the area located in Baillieu Creek largely drains towards Cardinia Creek, whereas, the area to the south, Muddy Gates Drain, flows towards Ballarto Road. A site contour plan is provided in Appendix A.

The site is located in the south east straddling the Casey and Cardinia councils. McPherson PSP abuts Thompson Road PSP (PSP 1053) and Clyde Creek PSP (PSP 1054) to its west and Officer Employment Area PSP (PSP 5) and Clyde North PSP (PSP 13) to its north and north east, respectively (Figure 3). The Officer Employment Area PSP is still to be completed whereas Clyde North PSP, Thompson Road PSP and Clyde Creek PSP have been completed and approved.

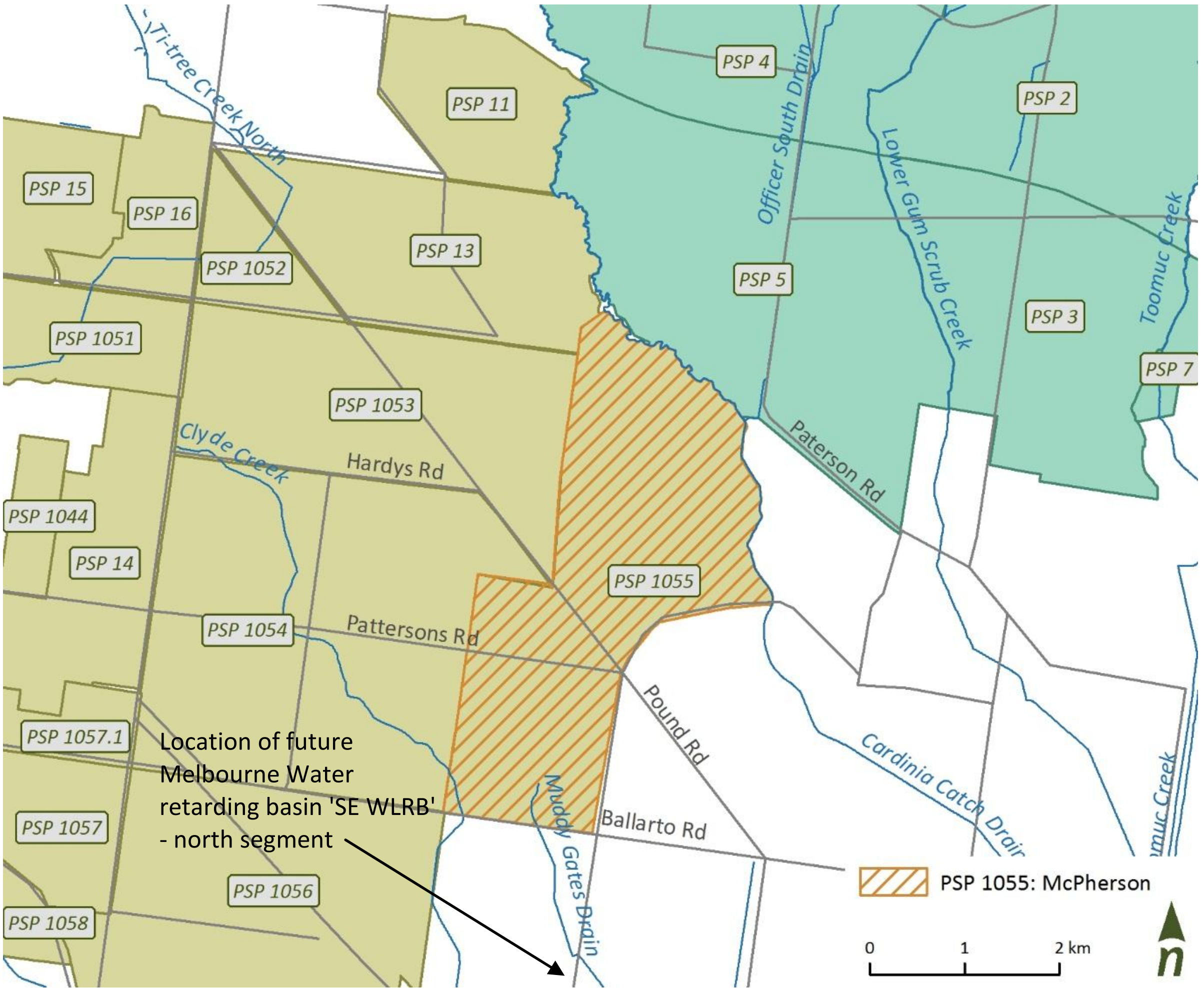


Figure 3. *Location of surrounding PSP's*

The properties surrounding the study area are predominantly farmland. However, as mentioned previously, this entire area has been identified for urban development in the near future. It is important to note that the stormwater from both Thompson Road PSP and Clyde Creek PSP has been designed to outfall through the McPherson PSP and into Melbourne Water's proposed large retarding basin south of Ballarto Road. As such, the SWMS for McPherson PSP has been designed to consider the impact of the upstream PSP's.

Plans illustrating the details of the surrounding PSPs may be viewed in Appendix B.

Currently, the ecological condition of the waterways in the study area is relatively low although significant platypus, dwarf galaxias and floodplain communities occur further upstream along Cardinia Creek. Cardinia Creek in particular also has a patchwork of riparian areas that lead from the bay all the way up to the hills. As a result connectivity is important in the region. The majority of the waterways in the Cardinia Creek catchment are man-made drains with minimal geomorphological value and low water quality. The area has been extensively cleared for agriculture however high value native vegetation does occur adjacent to Western Port Bay. Some high importance fauna exists in the region, such as the EPBC protected Growling Grass Frogs (GGF), Australian Grayling and Dwarf Galaxias. As a result there is a need for the SWMS to cater for vulnerable species, including the GGF, Australian Grayling and Dwarf Galaxias. The major conservation corridor in McPherson PSP exists in the north-east and runs along the length of Cardinia Creek within the PSP.

The SWMS has been designed to provide the potential to facilitate water to the existing and future habitat. More specifically, the strategy will provide stormwater, treated to Best Practice Environmental Management Guidelines (BPEMG), which could be considered as a supply source for the GGF and Dwarf Galaxias within McPherson PSP if required at some future time.

3 Objectives and criteria

3.1 Stormwater quantity and flood management

This section outlines the strategy for managing stormwater management issues and flood risks in PSP 1055. The proposed development will dramatically increase the impervious area, and subsequently the proportion of rainfall which will become surface runoff. It identifies the size and location of mitigation works required to accommodate and offset the impact of urban development on the local and downstream receiving waters.

Baillieu Creek / Cardinia Creek

Flow management principles

The Cardinia Creek is a major watercourse that naturally meanders from its source at Aura Vale Lake to just downstream of Pattersons Road where it enters the Koo-Wee-Rup Flood Protection District (KWRFPD). At this point the waterway takes the form of a straight man-made drain, with a levee on the southern side of the drain that forms the flood protection mechanism for land located to the south of Cardinia Creek in the KWRFPD.

Baillieu Creek is a tributary of the Cardinia Creek, which outfalls to the creek towards the southern boundary of the PSP near McCormacks Road.

The management of the Cardinia Creek system is complex and there have been many reports that have been prepared over the last 5-6 years in relation to the potential impacts of development in the Cardinia Creek catchment. The flow management strategy for the Baillieu Creek component of PSP 1055 is proposed to align with the principles advocated in the Drainage Strategy for the Overall Cardinia Creek Catchment (Stormy Water Solutions & Craigie & Condina, 2012). It is this strategy that recently reviewed and consolidated all of the previous investigations and provided recommendations for a catchment wide strategy from new development within the Cardinia Creek Catchment south of the Pakenham Bypass. This work considered the impacts of peak flow, volumes and levees on the KWRFPD and the most effective and appropriate approaches for managing flows. A key finding that affects the PSP 1055 area is that no flow mitigation is needed to manage run-off in large events up to and including the 100 year ARI event. The airspace above wetland systems will provide storage capacity to offset the impacts on peak flows for smaller flood events (up to the 2 year ARI event). An implied recommendation was that the use of constructed treatment wetlands will be the most appropriate and efficient way of treating storm water quality and quantity within the Cardinia Creek catchment.

In summary the key principles are:

- No retarding basins are required within the Baillieu Creek subcatchment (although they are proposed in the Clyde North PSP).
- Flood mitigation works will be required at the Cardinia Creek Outfall to ensure the 100 year ARI flow is maintained within the leveed outfall and there are no increased flood effects within the KWRFPD.
- Flood mitigation works will be required along Cardinia Creek for about 6 kilometres upstream of the combined Cardinia Creek Outfall to mitigate development effects along this section of the creek.
- Flow management for ecological protection (e.g. 2 year ARI) should be provided. It is expected that this attenuation could be provided as a “by-product” to constructing wetlands for stormwater quality treatment.

Muddy Gates Drain / Clyde Creek
The Stormwater Management Strategy for PSP 1053 and PSP 1054 (Craigie, 2013) investigated the overall catchment for Muddy Gates Drain and Clyde Creek.

For Muddy Gates Drain the key constraint is the capacity of the existing system downstream of Ballarto Road, namely the infrastructure at Muddy Gates Lane and at the railway line further to the south. A summary of the principles associated with Craigie's (2013) strategy is as follows:

- The capacity upstream of Muddy Gates Lane is 5 m^3/s, and at the Railway it is 10 m^3/s. This equates to less than a 10 year ARI event.
- The ability to increase the downstream capacity is very limited due to the existing topography and very flat grades. To offset the impacts of increased discharges from future development and to improve existing flood protection downstream, flood retarding storages are required as follows:
    - Within the PSP's, through the incorporation of flood storage volumes with stormwater quality treatment assets (i.e. sediment ponds and wetlands)
    - Within a very large retarding basin storage, located outside of the Urban Growth Boundary, which is downstream of Ballarto Road. Known as "SE WLRB", this retarding basin would reduce 1 in 100 year flows to the existing capacity of Muddy Gates Lane (5 m^3/s) and the Railway crossing (10 m^3/s).
    - The "SE WLRB" asset would allow all flows up to 0.3 m3/s in Muddy Gates Drain to pass downstream along existing alignments before any flows are diverted into the retarding basin.
- There are no ecological obstacles to construction of new waterways to replace the existing (largely artificial) alignment of Clyde Creek upstream of the GGF corridor.
- There are no ecological obstacles to construction of pipelines and new constructed waterways to replace the existing artificial alignment of Muddy Gates Drain and its tributary drains.
- The design of constructed waterways should aim at maximising potential habitat, recreational and landscape values, in addition to providing flood conveyance at minimum velocities.

3.2 Stormwater quality treatment

In 2011 Melbourne Water engaged SKM to assess the environmental issues in the Casey Growth Area (CGA), which included aquatic ecology, geomorphology, water quality, cultural heritage and groundwater.

In order to meet the receiving water requirements associated with the State Environmental Protection Policy (SEPP), stormwater runoff from urban development is expected to achieve "best practice" treatment. In general these best practice pollutant reduction targets are considered to be:

- 80% reduction in total Suspended Solids loads
- 45% reduction in total Nitrogen loads
- 45% reduction in total Phosphorus loads

The above targets are based upon meeting the requirements of SEPP Schedule F7, which relates to the Yarra and Port Phillip Bay catchment.

However for Western Port Bay, it is necessary to comply with the SEPP Schedule F8 water quality targets. Based upon other modelling in Western Port, the following best practice targets are likely to be required to meet the SEPP F8 requirements:

- 93% reduction in total Suspended Solids loads
- 66% reduction in total Nitrogen loads

- 63% reduction in total Phosphorus loads

Alluvium in consultation with MPA, Melbourne Water, DELWP and EPA undertook an investigation into the practicalities of adopting the SEPP F8 targets and sizing of water quality treatment assets within the Baillieu Creek catchment. The results of the analysis show that an increase in total wetland NWL of approximately 50 to 75% is required over current best practice to meet the SEPP F8 targets. This is due to sediment removal moving beyond the point at which increasing in sediment basin size starts to diminish in terms of return for % TSS removal.

Through review of the results, consultation with stakeholders and consideration of the objectives of the SEPP F8 the following treatment criteria was adopted:

- maintain 20% ratio of sedimentation basin NWL area to wetland NWL area to achieve reduced SEPP F8 TSS reduction target of 85%
- 45% reduction in total Nitrogen loads
- 45% reduction in total Phosphorus loads

Water Sensitive Urban Design (WSUD) provides a holistic approach to stormwater management by focusing on the integration of urban development with the protection of the water cycle. The key principles of WSUD as stated on the Melbourne Water website are:

Protect natural systems - protect and enhance natural water systems within urban developments. Promoting and protecting natural waterways as assets allows them to function more effectively and supports the ecosystems that rely on them.

Integrate stormwater treatment into the landscape - use stormwater in the landscape by incorporating multiple use corridors that maximise the visual and recreational amenity of developments. The natural stormwater drainage system can be utilised for its aesthetic qualities within parklands and walking paths, making use of natural topography such as creek lines and ponding areas.

Protect water quality - improve the quality of water draining from urban development into receiving environment. Through filtration and retention, water draining from urban development can be treated to remove pollutants close to their source. This approach reduces the effect that polluted water can have upon the environment and protects the natural waterways.

Reduce runoff and peak flows - reduce peak flows from urban development by local detention measures and minimising impervious areas. Local detention and retention enables effective land use for flood mitigation by utilising numerous storage points in contrast to the current practice of utilisation of large retarding basins. This approach subsequently reduces the infrastructure required downstream to effectively drain urban developments during rainfall events.

Add value while minimising development costs - minimise the drainage infrastructure cost of the development. The reduction of downstream drainage infrastructure due to reduced peak flows and runoff minimises the development costs for drainage, whilst enhancing natural features such as rivers and lakes that add value to the properties of the area.

Baillieu Creek / Cardinia Creek
The principles established for PSP 1053 and 1054 have set the precedent for the stormwater quality strategy in PSP 1055. A summary of these principles, are as follows:

- Opportunities for surface water management assets do not always match the PSP boundaries. Topographic, environmental and/or cultural/heritage constraints should always be considered when locating assets. It has been agreed by MW/MPA that the strategy should be founded on best matching overall opportunities and constraints (and planning constraints) to locate main drainage assets across the CGA.

- The typical “Best Practice” water quality reduction targets have been achieved at the eastern boundary of PSP 1053 (i.e. TSS 80%, TP 45%, TN 45%).

In addition to best practice treatment of pollutants, Melbourne Water usually requires removal of some suspended solids (typically 60-70% removal) from stormwater pipe outfalls prior to it entering constructed waterways. This protects the low flow channel of the constructed waterway from sedimentation.

A key flood management finding for PSP 1055 in the Cardinia Creek catchment from the Craigie (2013) study was that no flow mitigation is needed to manage run-off in large events up to and including the 100 year ARI event. However the study also identified that flow mitigation for smaller flood events (up to the 2 year ARI event) is required for ecological protection. The Craigie work advised that the airspace above wetland systems will provide sufficient storage capacity to offset the impacts associated with these smaller flood events. Therefore an implied recommendation was that the use of constructed treatment wetlands will be the most appropriate and efficient way of treating stormwater quality and quantity within the Cardinia Creek catchment.

Muddy Gates Drain / Clyde Creek

The principles established for PSP 1053 and 1054 have set the precedent for the stormwater quality strategy in PSP 1055. A summary of these principles, are as follows:

- Opportunities for surface water management assets do not always match the PSP boundaries. Topographic, environmental and/or cultural/heritage constraints should always be considered when locating assets. It has been agreed by MW/MPA that the strategy should be founded on best matching overall opportunities and constraints (and planning constraints) to locate main drainage assets across the CGA.
- Bells Road/Pattersons Road outfall based on 70% TSS removal (and much lower TP and TN removals) within PSP 1053 and the balance to best practice standards downstream in PSP 1055.
- Pound Road outfalls based on 70% TSS removal (and much lower TP and TN removal) within PSP 1053 and 1054 and the balance to best practice standards downstream in PSP 1055.
- Additional treatment further downstream to potentially meet the F8 water quality reduction targets (i.e. TSS 93%, TP 66%, TN 63%). If required this additional treatment will be provided in a major wetland / retarding basin system located south of Ballarto Road between the Western Contour Drain and Muddy Gates Drain.

In addition to best practice treatment of pollutants, Melbourne Water usually requires removal of some suspended solids (typically 60-70% removal) from stormwater pipe outfalls prior to it entering constructed waterways. This protects the low flow channel of the constructed waterway from sedimentation.

4 Catchments

The study area has been divided into catchments, which have in turn been divided into sub-catchments based on likely underground (minor) drainage. Craigie's (2013) catchment and sub-catchment areas were reviewed and used to inform the breakdown of drainage for McPherson PSP. This approach was adopted to maximise consistency between assessments and prioritise efficiency in delivering findings to the MPA. However, the Baillieu Creek area had not been delineated by Craigie (2013) and therefore Alluvium marked the sub-catchment areas considering the topography of the site and the proposed infrastructure. The Mirvac masterplan setout was also used to guide the catchments according to road layout and the constructed waterway location (Beveridge Williams, November 2015). These sub-catchment areas are summarised below (Table 1). The sub-catchments that exist wholly within McPherson PSP are categorised as 'Internal' otherwise they are labelled 'External'. The catchment breakdown is shown graphically in Figure 4.

Table 1. Summary of total area for sub-catchments within and surrounding McPherson PSP

Location	Sub-catchment	Total Area (Ha)
Baillieu Creek [Internal]	1	50.5
	2	27.0
	3	33.7
	4	35.9
	5	47.9
	6	4.7
	7	66.6
	8	132.3
	9	11.9
	10	4.3
Baillieu Creek [External]	11	351.1
	12	99.4
Muddy Gates Drain [Internal]	AQ3	37.4
	AW1	50.7
	AW2	65.5
	AS6	55.4
	AR2	71.4
	AT	24.7
	AU	19.3
	AX	97.3
	AY3	24.4
	AV	72.0
Muddy Gates Drain [External]	AQ1	39.4
	AQ2	46.0
	AY1	29.6
	AS1	45.2
	AS2	34.6
	AS3	49.8
	AS4	38.6
	AS5	13.9
	AR1	30.9
	AY2	57.8
Clyde Creek [Internal]	CC1	8.0

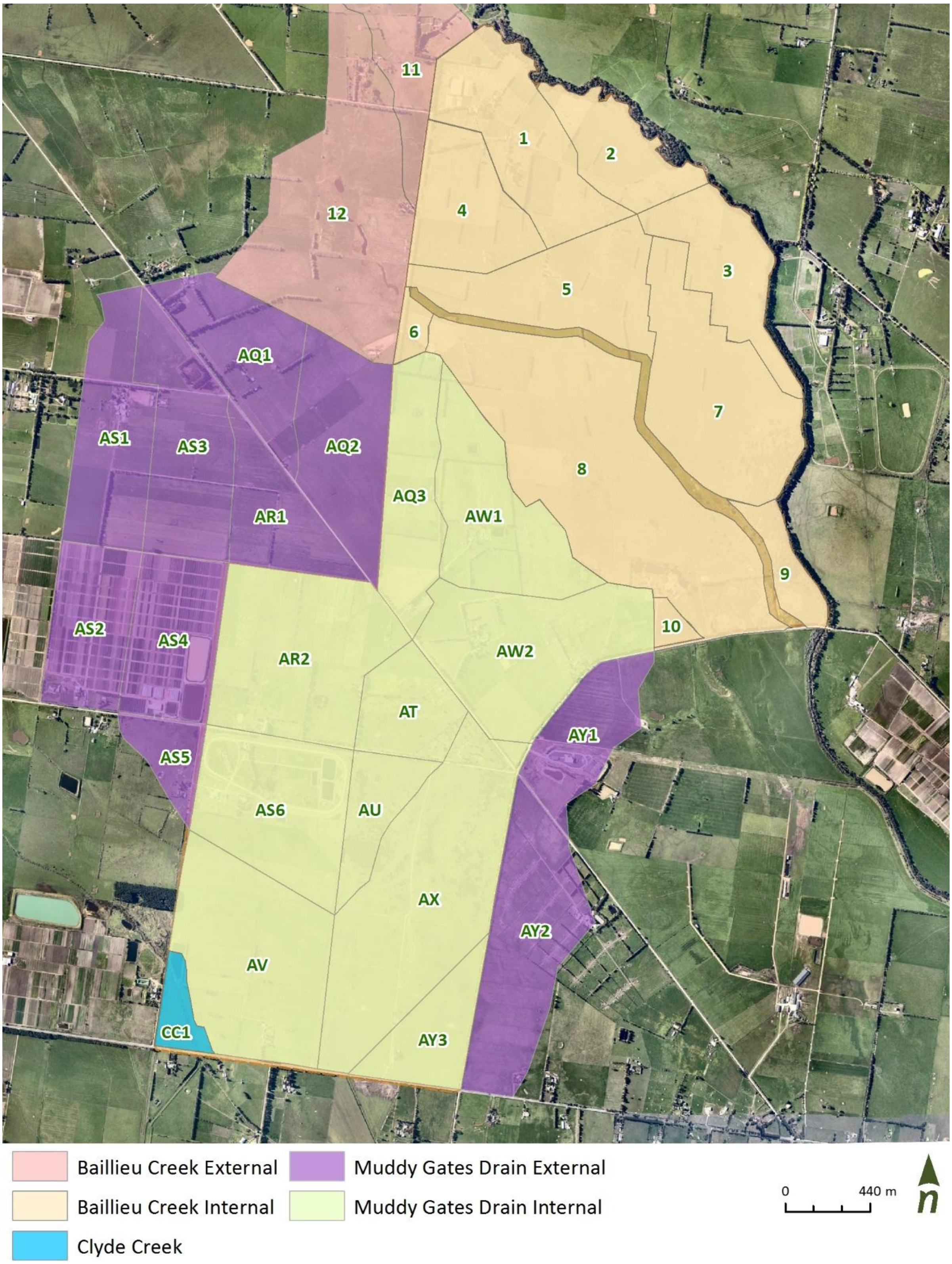


Figure 4. *Sub-catchments in the study area and its immediate surroundings*

5 Hydrologic analysis

5.1 Baillieu Creek / Cardinia Creek

A hydrological analysis of the Baillieu Creek catchment was undertaken to determine the peak 100 year ARI flows expected through PSP 1055 under the proposed development conditions.

The hydrologic modelling software used in this study is RORBWin version 6.15 (Nathan 2010), a Windows version of the industry accepted RORB program (Laurenson & Mein 1997). RORB is a runoff and streamflow routing program that is used to calculate flood hydrographs from rainfall and catchment data.

<u>RORB model development</u>
An existing RORB model for the Cardinia Creek catchment (prepared by Neil Craigie 2012), which extends downstream to the Cardinia Creek and Gum Scrub Creek confluence, was modified to determine the 100 year ARI flows through PSP 1055. The existing model was developed for the Overall Cardinia Creek Drainage Strategy and included 'current conditions' version and a 'developed conditions' version. The 'current conditions' version represents the level of development in the catchment in 2009. The 'developed conditions' version represents the proposed ultimate development conditions in the Cardinia Creek catchment including:

- Development of PSP 1053 and some additional development in the east and south of PSP 1053 within the Baillieu Creek catchment, with fraction imperviousness of 0.6 for future residential areas and 0.9 for future industrial areas;
- Proposed Grasslands and Clay Pit retarding basin in accordance with the Officer South DSS;
- Drainage proposals in accordance with the Officer South DSS.

Two modifications were made to Craigie's model for the purposes of preparing this strategy for PSP 1055:

- The Baillieu Creek subcatchments were refined so that runoff results could be presented at key locations within PSP 1055. The subcatchment areas were based on our understanding of the flow paths through the catchment from the site inspection and desktop analysis.
- The diversion relationship for flow into dams in the upper Baillieu Creek was extended to cater for higher flows. A linear continuance of the relationship was assumed such that for a catchment runoff of 30 m^3/s, 27 m^3/is diverted into the dams.

The RORB parameters adopted in the modified RORB model are the same as the existing model and are shown in Table 2. The modifications described above had an insignificant impact on the RORB model calibration.

The peak 100 year flow at the combined Cardinia Creek and Gum Scrub Creek 'Outfall' under developed conditions is 175.9 m^3/s (Table 3) compared with 173.2 m^3/s from the Craigie RORB model. This minor difference is considered acceptable and may be partly attributed to differences in the Pakenham rainfall parameters which were not explicitly provided with the existing model.

Table 2. RORB parameters adopted

Rainfall station	Pakenham
Initial loss (IL)	10 mm
Runoff coefficient (RoC)	0.6
kc	23
m	0.6

The Baillieu Creek subcatchments included in the revised RORB model are shown in Figure 5. The fraction impervious adopted for most of the catchment was 0.6 to reflect the proposed residential development. The exception is the area of the catchment set aside for the conservation area / regional park (upstream of McCormacks Rd) which will remain as pervious area.

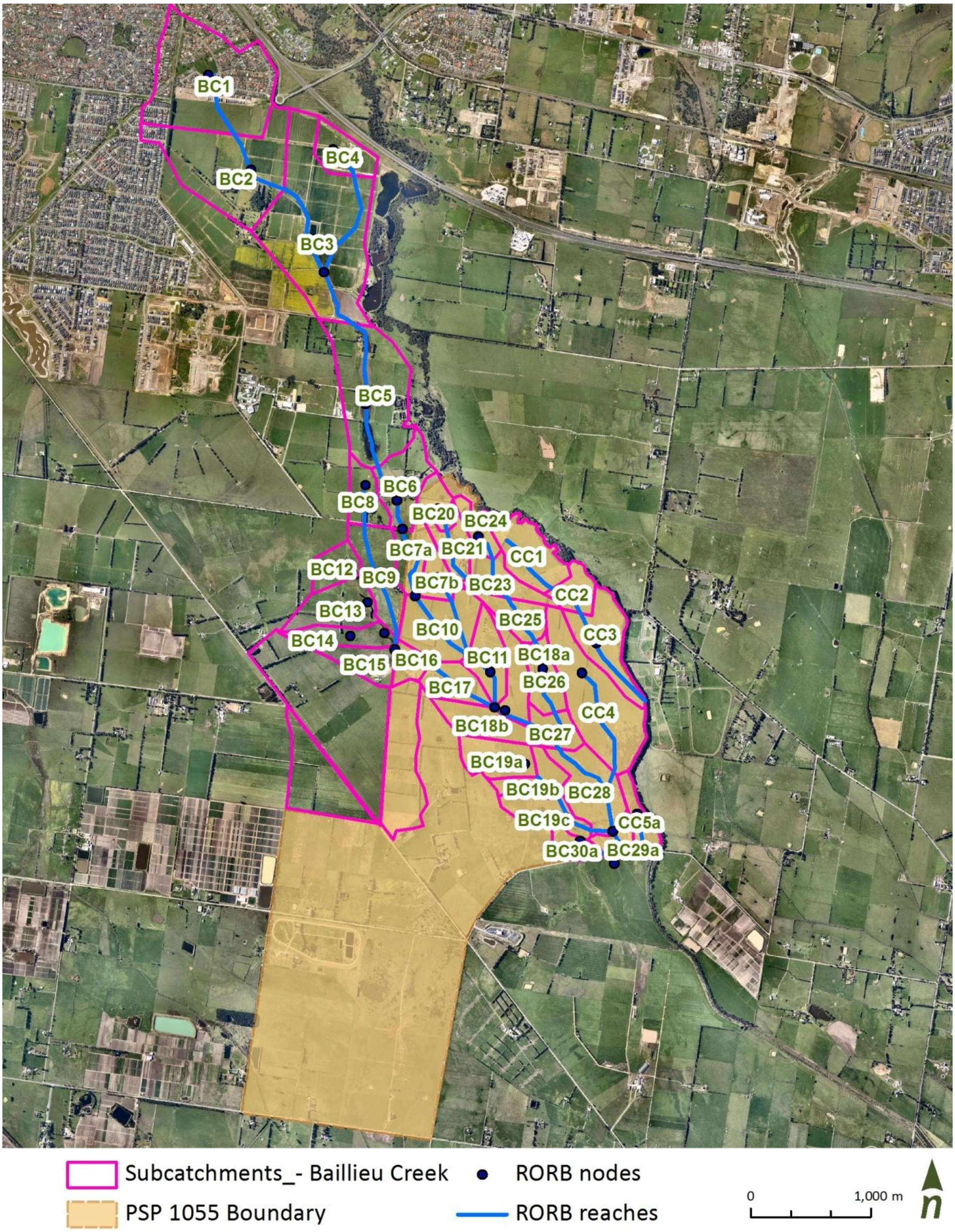


Figure 5. *Baillieu Creek RORB subcatchments*

RORB results

The results of the RORB modelling are outlined below in Table 3.

Table 3. RORB results for Baillieu Creek catchment (developed)

Flow location	Upstream catchment	Peak 100 year flow (proposed development conditions)
Baillieu Ck upstream of PSP 1055	BC7a	5.0
Baillieu Ck upstream of junction with western tributary	BC11	6.5
Western tributary upstream of PSP 1055	BC15	12.0
Western tributary upstream of junction with Baillieu Ck	BC17	11.0
Baillieu Ck downstream of junction with western tributary	BC11 & BC17	14.8
Baillieu Ck upstream of junction with northern tributary	BC18a & BC18b	15.4
Northern tributary upstream of 110 Smiths Lane	BC23	4.3
Northern tributary upstream of junction with Baillieu Ck	BC26	5.0
Baillieu Creek downstream of northern tributary	BC27	19.3
North-eastern tributary runoff	CC4	4.6
Baillieu Creek downstream of north-eastern tributary	BC28	23.3
South-western tributary runoff	BC19c	5.1
Baillieu Ck upstream of Cardinia Ck	BC29a & CC5	27.0
Cardinia Creek downstream of Baillieu Ck	-	139.1
Combined Gum Scrub Ck and Cardinia Ck	-	175.9

5.2 Muddy Gates Drain

A RORB model for the Muddy Gates Drain was provided to Alluvium from Melbourne Water. This included a RORB model for existing conditions and developed conditions. This hydrologic model was based upon the work undertaken by Craigie (2013) for PSP 1053 and 1054.

Adopted RORB parameters for Muddy Gates Drain are shown in Table 4 and the RORB catchment plan is illustrated in Figure 6.

Table 4. Adopted RORB parameters (Muddy Gates Drain)

Parameter	Value
m	0.80
kc	15.41
IL	10
RoC	0.60 (100 year ARI)
	0.30 (5 year ARI)
	0.20 (1 year ARI)

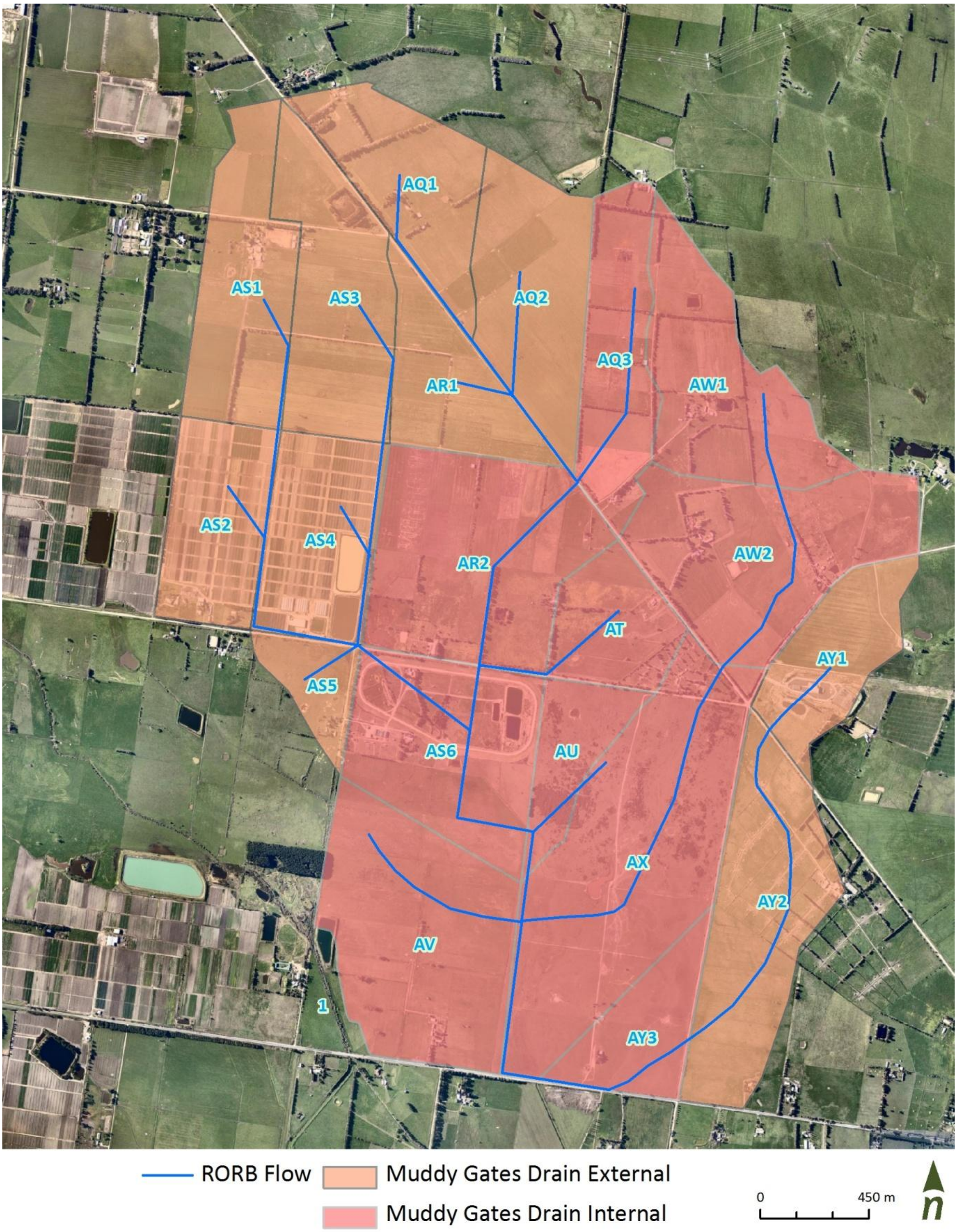


Figure 6. *Muddy Gates Drain RORB subcatchments*

The key design flows that have been determined for existing conditions are provided below in Table 5.

Table 5. Peak Flows for Existing Conditions

Flow location	Existing Conditions 1 year ARI (m3/s)	Existing Conditions 10 year ARI (m3/s)	Existing Conditions 100 year ARI (m3/s)
Pattersons Rd	0.6 (36hr)	1.8 (9hr)	4.9 (12hr)
Ballarto Rd	1.8 (36hr)	6.1 (9 h)	16.5 (12hr)
Confluence downstream of Ballarto Rd	2.0 (36 hr)	6.7 (9hr)	18.0 (12hr)
Railway	2.0 (48 hr)	6.8 (24 hr)	18.1 (12hr)

In order to simulate ultimate developed conditions, the “developed RORB model” for Muddy Gates Drain adopted an impervious fraction of 0.6 (predominately residential) and reach codes that reflected an urbanised catchment. In undertaking the hydrologic analysis, the following elements were considered:

- Land ownership / title boundaries
- The draft Urban Structure Plan with respect to main road infrastructure and open space networks
- The desalination pipeline constraints
- The GGF corridor requirements
- Topographic constraints and opportunities

As highlighted in Section 3.1 of this report, the capacity of the downstream drainage infrastructure at Muddy Gates Lane and the Railway is constrained. As a result, the design response to mitigate this issue is to provide flow management assets (i.e. retarding basins) as part of the development planning process for the catchment. The approach adopted for the proposed strategy is based on the following:

- The inclusion of distributed retarding basins throughout PSP 1055 by incorporating flood storage as part of the sedimentation basins and wetlands that are required for stormwater quality purposes.
- A very large wetland and retarding basin that is located south of Ballarto Road and external to PSP 1055. Known as “SE WLRB” this major asset was considered as part of the PSP 1053 and 1054 investigations.

The review by Alluvium commenced with the location of retarding basin assets (Figure 7) as originally shown in the Craigie (2013) report. Following discussions with the MPA, Alluvium were requested to assess the impact of the removal of “WLRB16” (adjacent to Ballarto Road) for land efficiency reasons. The removal of “WLRB16” results in the following:

- A 2 m^3/s increase above rural conditions for the 100 year ARI peak flow (i.e. 10%) at Ballarto Road
- A 0.2 m^3/s increase for the 100 year ARI peak flow (i.e. <2%) at the Railway

Based upon the above, the removal of “WLRB16” was adopted.

The other key change was that the proposed wetland/retarding basins known as assets “WLRB14 and WLRB15” were consolidated into one asset downstream of Pattersons Road. The retarding basins proposed as part of this SWMS are shown in Figure 8.

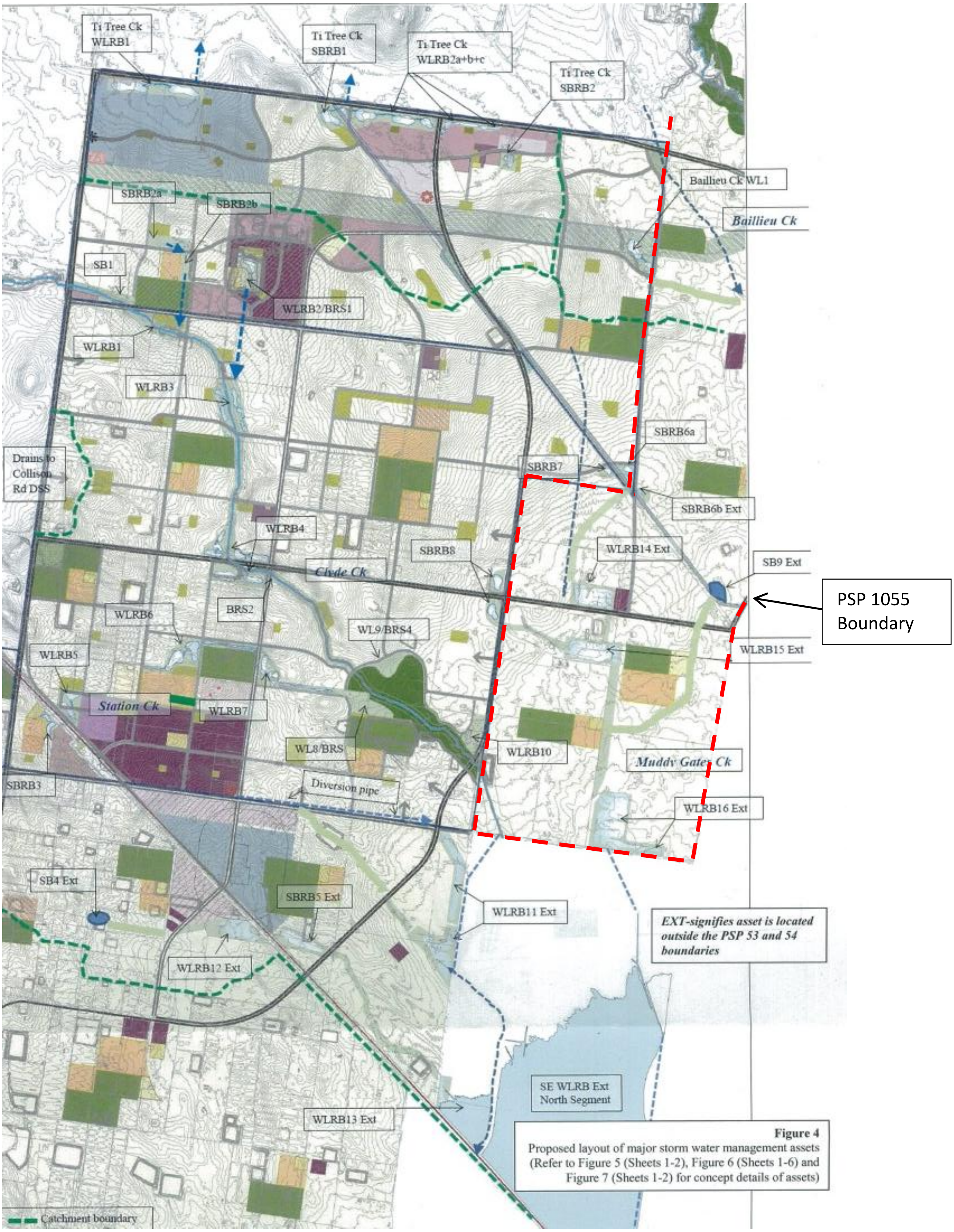


Figure 7. *Retarding basin locations as shown in Craigie (2013)*

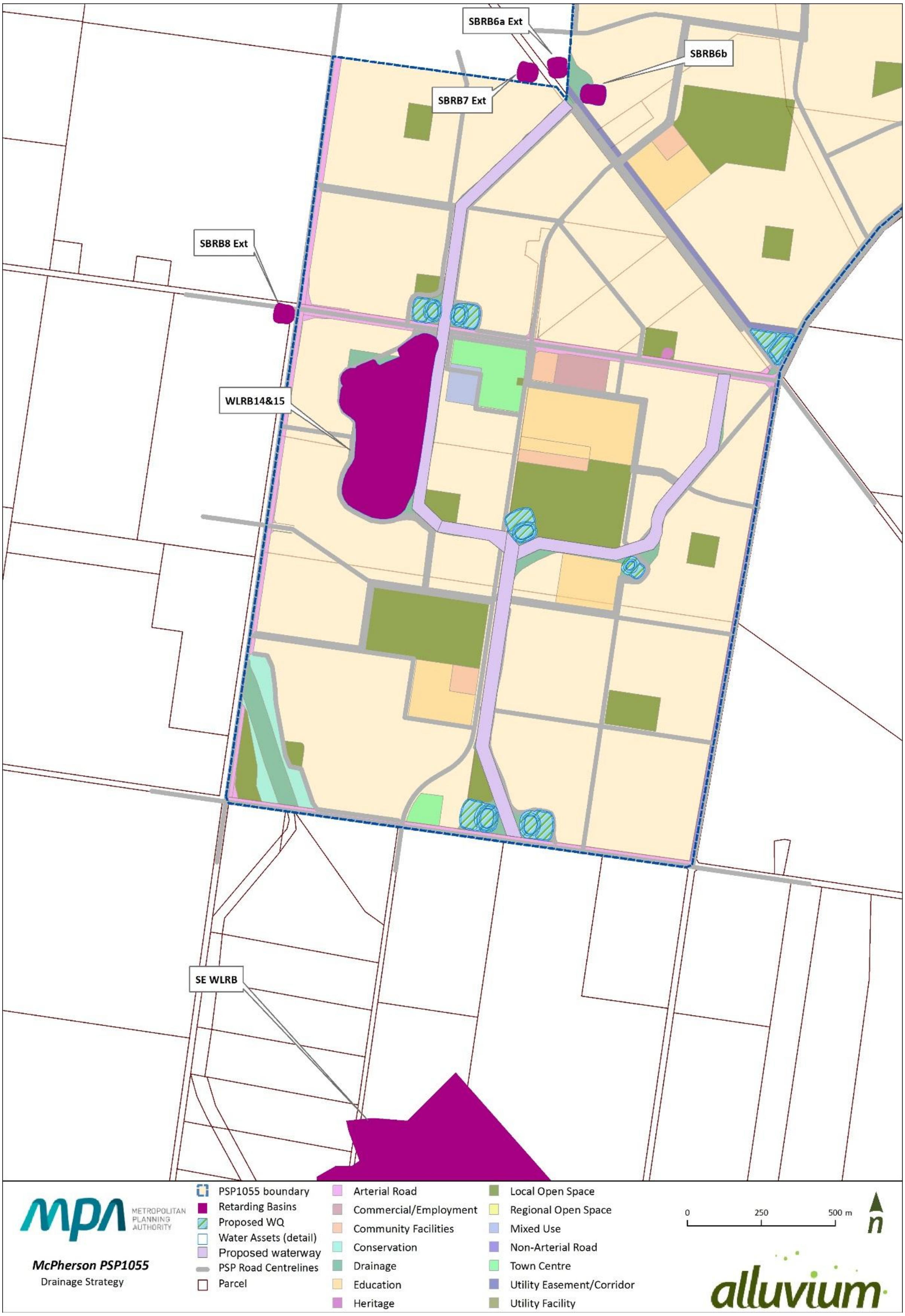


Figure 8. *Retarding basin locations as proposed by Alluvium*

RORB results

The results of the RORB modelling for Muddy Gates Drain are outlined below in Table 6. This includes the proposed sizing requirements for the retarding basin assets.

Table 6. RORB results for Muddy Gates Drain catchment (developed)

Asset	Inflow (m^3/s)	Inflow Duration	Outflow (m^3/s)	Outflow Duration	Peak Storage (m^3)
SBRB6b	10.60	2h	10.38	2h	3600
WLRB_14&15	22.82	2h	13.12	9h	147,000
SBRB7	4.50	20min	2.46	2h	3240
SBRB6a	11.03	25min	7.67	2h	7980
SBRB8	20.33	2h	8.88	4.5h	25,300

Peak flows from SBRB8 have been assed against the ability to contain the gap flows within road reserve. Based on the road width and slope and the maximum allowable nature strip cross-fall of 10%, the capacity that can be contained within the main road reserves is shown in Table 7. This capacity has been determined using HEC-RAS based on the Melbourne Water floodway safety criteria for residential streets used as floodways:

- Manning's 'n' = 0.020
- Average velocity time average depth should be less than 0.35
- Average depth should be less than 0.30 m

At each flow location, the road reserve will adequately contain the gap flows and therefore pass the 100 year flows through the development safely.

Table 7. SBRB8 overland flow

Flow location	Overland flows			Road capacity		
	Minor flows (m3/s)	**Major flows (m3/s)**	**Q_{gap} (m3/s)**	**Road width (m)**	**Slope (%)**	**Road capacity (m3/s)**
SBRB8	3.72	8.8	5.08	16	1.0	4.5 (Exceeded)
SBRB8	3.72	8.8	5.08	20	1.0	5.1 (OK)

6 Proposed stormwater quality treatment system

Alluvium understands that a key principle for the development of McPherson PSP is that all stormwater is to be treated to BPEM before being discharged from the study area. As such, McPherson PSP utilises numerous treatment techniques in order to achieve the targeted reduction in pollutant load concentrations. The following BPEM targes have been adopted:

- 70% removal of the total Gross Pollutant load
- 80% removal of total Suspended Solids (TSS)
- 45% removal of total Nitrogen (TN)
- 45% removal of total Phosphorus (TP)

However for Western Port Bay and the Muddy Gate Drain catchment, the SEPP Schedule F8 water quality targets, based upon other modelling in Western Port, could be as high as the following:

- 93% reduction in total Suspended Solids loads;
- 66% reduction in total Nitrogen loads;
- 63% reduction in total Phosphorus loads.

For Western Port Bay and the Baillieu Creek catchment, the revised SEPP Schedule F8 water quality targets are:

- 85% reduction in total Suspended Solids loads;
- 45% reduction in total Nitrogen loads;
- 45% reduction in total Phosphorus loads.

6.1 Overview and general sizing approach

Alluvium has designed a series of sediment basins and wetlands to treat stormwater resulting from the development of McPherson PSP. There are six wetlands and two sediment basins servicing the Baillieu Creek region and one wetland and 8 sediment basins servicing Muddy Gates Drain. The catchments and stormwater treatment assets have been modelled using MUSIC (Model for Urban Stormwater Improvement Conceptualisation). The MUSIC model estimates the amount of pollutants the catchment produces, the performance of treatment measures and the pollutant load generated once the catchment is treated.

Alluvium utilised a MUSIC model of Muddy Gates Drain that was developed by Craigie (2013) for the PSP 1053 and 1054 SWMS, titled - *PSP 53 and 54 V4 Dec 13 KWR 2004 6 min*. Nonetheless, since this model was originally developed, the drainage catchment boundaries and land use areas and types within the McPherson PSP development have been revised. As such, the model was adjusted to reflect these revisions, and the latest civil layouts that are in development. In addition, a model was created to represent the Baillieu Creek area in order to adequately size treatment facilities.

Fraction Impervious

The fraction impervious value for each land use type has been adopted based on the "Growth Area Authority's Engineering Design and Construction Manual (2011)". The fraction impervious values adopted for MUSIC modelling are shown in Table 8**.**

Table 8. Fraction impervious values adopted for MUSIC modelling

Land Use	Normal Range	Adopted Value
Residential Zone (GRZ and RGZ)	0.5 – 0.7	0.6
Public Use Zone (Service and Utility)	0.2 – 0.3	0.25
Public Use Zone (Education)	0.6 – 0.8	0.7
Public Park and Recreation Zone	0.2 – 0.3	0.25
Public Conservation and Resource Zone	0.05 – 0.25	0.25
Township Centre and Community Facilities	0.6-0.8	0.7

MUSIC

In accordance with Melbourne Water's MUSIC Guidelines, the 2004 Koo Wee Rup rainfall station data was used at a six minute time-step. Schematics of the design treatment system arrangements for each model are shown below (Figure 9 and Figure 10).

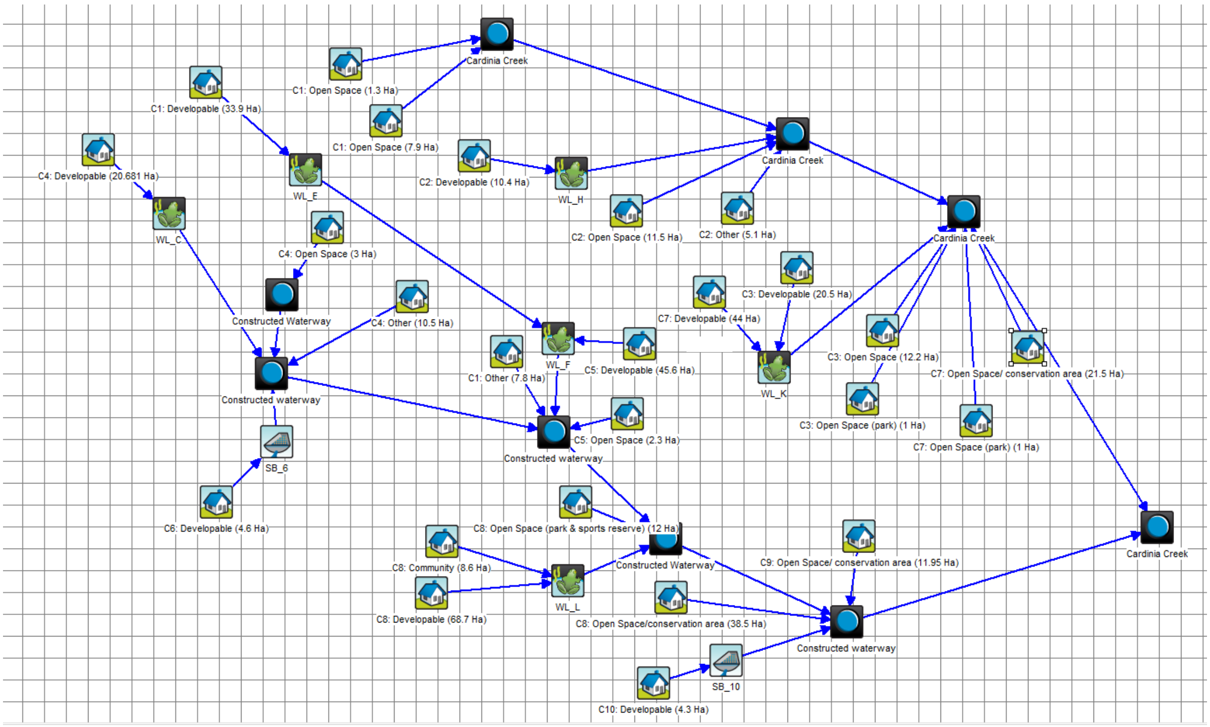


Figure 9. *MUSIC schematic for treatment assets – Baillieu Creek*

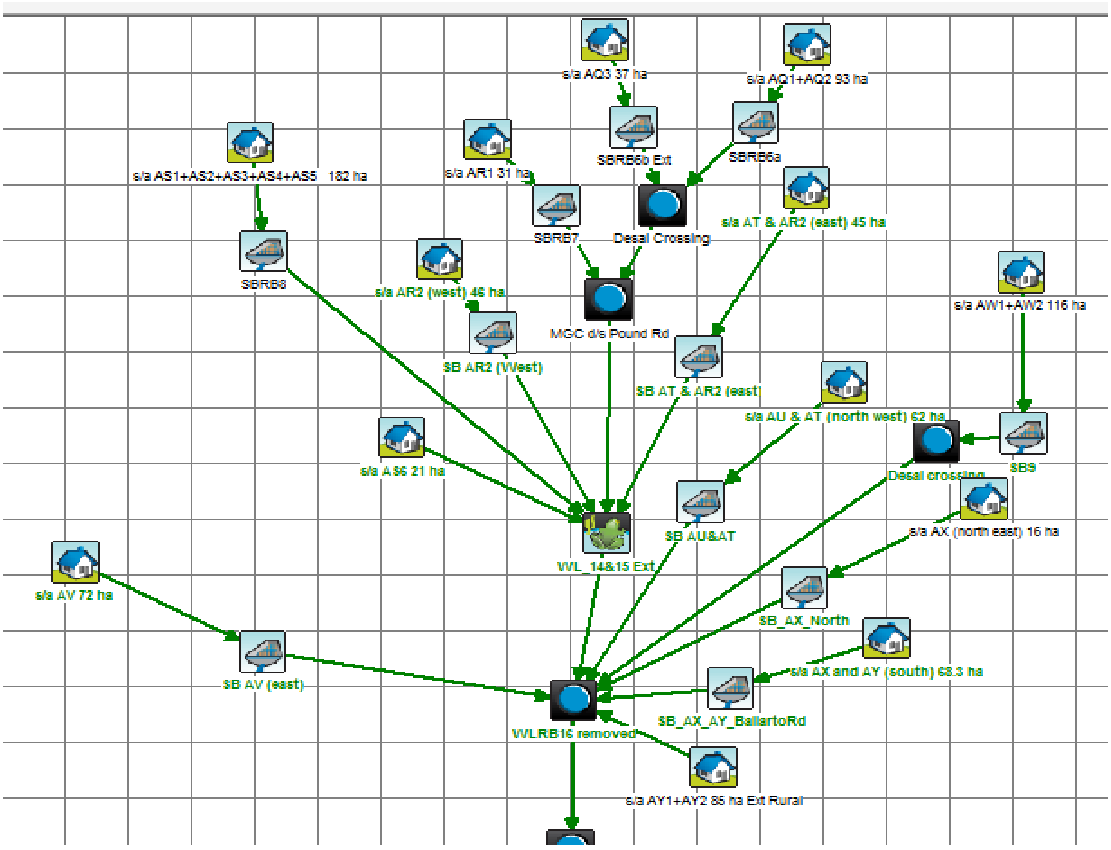


Figure 10. *MUSIC schematic for treatment assets – Muddy Gates Drain*

Sediment Basins

There are 10 sediment basins within McPherson PSP. These sediment basins have been designed to receive runoff from sub-catchments within the PSP as well as outside the development area. They have been sized to achieve at least 60% TSS load reduction prior to discharge to a constructed waterway. The Baillieu Creek sediment basins have been sized to remove 85% TSS. The key input values for sizing of the sediment basin may be viewed in Table 9. The process for determining the required amount of surface water area was based on an iterative process in which only the surface area changed in order to achieve the targeted load reductions. All other inputs remained constant throughout the modelling.

Table 9. Summary of inputs for sediment basin sizing in MUSIC

Input	Value
Surface Area (m2)	Variable
Extended Detention Depth (m)	0.5
Permanent Pool Volume (m3)	= 1.5*(NWL Surface Area)
Initial Volume (m3)	= Permanent Pool Volume
Extended Detention Time (hrs)	~ 12

Wetlands

There are eight wetlands within McPherson PSP. These wetlands have been designed to receive runoff from sub-catchments within the PSP as well as outside the development area. A number of assumptions were made that influenced the sizing and location of the wetlands:

1. The wetlands have been sized to achieve best practice
2. Where possible the runoff from the open spaces in Baillieu Creek will be routed towards Cardinia Creek
3. Minor flows within a sub-catchment will be piped to a wetland for treatment

The key input values for sizing of the wetlands may be viewed in Table 10. An iterative process to determine the required surface area was used in this analysis.

Table 10. Summary of inputs for wetland sizing in MUSIC

Input	Value
Surface Area (m^2)	Variable
Extended Detention Depth (m)	0.35
Inlet Pond Volume (m^3)	= 1.5 * SA$^+$
Permanent Pool Volume (m^3)	= 0.4 * SA
Initial Volume	= Permanent Pool Volume
Extended Detention Time (hrs)	~ 72
Overflow weir width (m)	10

$^+$except where noted

It is important to note the following:

- The extended detention time was set to 0.35m to comply with Melbourne Water guidelines.
- The inlet pond area (NWL) was taken as 20% of the surface area (macrophyte NWL) for all the wetlands within Baillieu Creek. This is a slightly conservative estimation because the simplicity of the calculation doesn't consider the existing batter. This approach is considered to be appropriate for this level of design.
- The inlet pond volume for WL_14&15 Ext was modelled quite differently. This wetland was unique because most of the water entering the wetland will have already been treated by a series of sediment basins, thereby decreasing the demands of the inlet pond within the wetland. Nonetheless, it was determined that an inlet pond of at least 2,000 m^3 was required to ensure that sediment capture efficiency and sediment storage requirements were achieved. Importantly, the wetland was designed as a dual-fed system and therefore two inlet ponds of 1,000 m^3 each were adopted for WL_14&15 Ext.

Sizing of sediment basins and wetlands

A 4 metre wide access track has been included around the entire perimeter of the stormwater treatment assets – both for sediment basins and wetlands. The main purpose for this is to provide ease of access for cleaning and general maintenance. This has been included in the total footprint of the water asset. More specifically, sediment drying areas and battering to existing surface have been allowed for in the total footprint area required.

6.2 Baillieu Creek stormwater treatment assets

Sediment basins

The details of the treatment asset designs are found below (Table 11). The footprint includes the treatment area, batter, freeboard and room for maintenance. The normal water level must ensure free drainage of the subdivision system and also allow for a reasonable fit of the wetland into the existing topography.

The batter slopes above the normal water level have been designed with a maximum grade of 1 in 6. It is assumed that a batter slope of 1 in 8 will apply below the normal water level to a depth of 0.35 m, below which the batter slope can increase to 1:3. This requires a minimum width of 14 m from the normal water level to the edge of the deep pool.

Provision has been made for maintenance requirements. As described above, the sediment basin design allows for a maintenance track, these would typically be 4 metres wide. Provision for sediment dewatering has also been made. These areas assume a depth of 500 mm and allow for the 5 year cleanout sediment volume to be accommodated. These calculations are based on the typical sediment loading rate of 1.6 m^3/ha/yr for a developed catchment.

Table 11. Sediment basin sizing and performance in Baillieu Creek

Asset	Contributing catchment (ha)	Surface Area (m^2)	Total Footprint (m^2)	System Performance (Removal)			
				Total Suspended Solids (%)	Total Phosphorous (%)	Total Nitrogen (%)	Gross Pollutant (%)
SB_6	4.6	700	3,312	85.7	64.4	40.5	100
SB_10	4.3	700	3,322	85.9	62.8	41.5	100

As indicated in Table 11, two dedicated sediment basins were sized for the Baillieu Creek region – one in catchment 6 (SB_6) and the other in catchment 10 (SB_10). Melbourne Water requires that all runoff from a developed area be treated to a minimum standard before it enters a waterway. Therefore, catchment 6 required a sediment basin to treat approximately 4.6 ha of developable area. Similarly, in catchment 10, a sediment basin had to be designed to treat runoff as it was not feasible to route the runoff from catchment 10 into wetland "WL_L", which is located in catchment 8. Both sediment basins were sized to achieve roughly 85% TSS removal, thereby requiring approximately 700m^2 treatment area.

Wetlands:

The details of each wetland design can be found in Table 12. Similar to the sediment basin, the wetland footprint includes the treatment area, extended detention depth, freeboard and room for maintenance. Importantly, the normal water level must ensure free drainage of the subdivision system and also allow for a reasonable fit of the wetland into the existing topography.

The batter slopes above the normal top water level have been designed to have a maximum grade of 1 in 6 in accordance with the draft Melbourne Water wetland design guidelines. It is assumed that a batter slope of 1 in 8 will apply below the normal water level to a depth of 0.35 m, below which the batter slope can increase to 1:3. For the wetland and sediment basin, the length should be at least four times the average width.

The wetlands dewatering areas were designed with the same process that was used for the dewatering areas of the sediment basins.

Table 12. Wetland sizing and performance in Baillieu Creek

Asset	Contributing catchment (ha)	Surface Area (m^2)	Total Footprint (m^2)	Inlet Pond Volume (m^3)	System Performance (Removal)			
					Total Suspended Solids (%)	Total Phosphorous (%)	Total Nitrogen (%)	Gross Pollutant (%)
WL_C	20.7	5,000	16,217	1,500	85.0	72.8	50.6	100
WL_E	33.9	8,000	23,448	2,400	84.1	72.0	50.6	100
WL_H	10.4	2,600	9,727	780	85.9	73.3	52.1	100
WL_F	79.5*	12,000**	16,799	3,600	83.8^	71.4^	49.6^	100^
WL_K	64.4	16,000	37,501	4,800	85.7	73.1	51.7	100
WL_L	77.3	19,000	42,622	5,700	85.1	73.2	51.7	100

*Includes upstream catchment from WL_E
** Results are for the combined wetlands (modelled as one)
^Treatment train effectiveness

Wetlands "WL_C, WL_E and WL_H" are located within the power line easement. The objective was to utilise existing encumbered land for water quality treatment. The sizes of these wetlands were constrained by the need to have at least 30 metres clearance the edge of excavation to the power line towers and also 20 m clearance from the power poles.

Minimum Wetland Widths

Velocity checks had to be performed in order to determine the minimum width of the wetland treatment area. Details of the velocity calculations and flows are provided in Appendix C. A summary of the minimum widths for the sediment basins and wetland zones is shown in Table 13.

Table 13. Minimum widths required for wetlands in Baillieu Creek

Wetland	Sediment Pond Minimum Width (m)	Macrophyte Zone Minimum Width (m)
WL_C	15	27
WL_E	18	37
WL_H	15	21
WL_F+	15 (for each)	76 [38]
WL_K	21	43
WL_L	28	60

+Split into a dual fed system to meet the minimum 3month flow velocity threshold.

The original rational flow calculations indicated that WL_F would need a minimum width of 76m to satisfy the velocity checks - this was considered to be inadequate. Therefore, a dual fed system was deemed to be the preferred approach. Essentially, the wetland was designed so that flows from catchment 1 and the eastern side of catchment 5 will be routed to the eastern entrance of WL_F, whereas, majority of the flows from catchment 5 will be fed into the western entrance of WL_F.

The minimum widths for the sediment ponds was dictated by the minimum requirements in order to maintain design depth and slope standards. For this reason the sediment basins were designed not to have a width of less than 15m. This was an adequate width to ensure the 0.5m/s maximum velocity for the 5 year flows was not exceeded for any of the wetlands. .

Ultimately the widths adopted for the sediment ponds and macrophyte zones was a balance between the velocity checks, and maintaining the width to length ratio of 1 to 4.

A concept design layout for each wetland is provided in Appendix D.

6.3 Muddy Gates Drain stormwater treatment assets

Sediment basins:

The size of the treatment area and the total footprint for each sediment basin in Muddy Gates Drain is shown in Table 14. The process used for sizing dewatering areas in Baillieu Creek was used to determine the dewatering areas in Muddy Gates Drain.

Table 14. Sediment basin sizing and performance in Muddy Gates Drain

Asset	Contributing catchment (ha)	Surface Area (m^2)	Total Footprint (m^2)	System Performance (Removal)			
				Total Suspended Solids (%)	Total Phosphorous (%)	Total Nitrogen (%)	Gross Pollutant (%)
SBRB6b	37	900	5,380	61.5	45.0	19.3	100
SB9	116	2,750	9,980	61.0	44.0	18.5	100
SB_AR2 (East)	45	1,400	7,300	65.7	47.2	21.6	100
SB_AR2 (West)	46	1,400	7,300	66	46.5	21.2	100
SB_AX_North	16	500	4,100	64.8	47.5	20.5	100
SB_AU&AT	62	2,000	9,550	65.5	47.9	20.6	100
SB_AX_BallartoRd	68	2,000	10,100	64.3	45.5	19.2	100
SB_AV	72	2,200	11,700	65.4	45.8	20.6	100

Sediment basin SB6b and SB9 desalination pipe crossing

The desalination pipe depths were analysed near the approximate sediment basin pipe crossings in order to gauge whether there would be sufficient clearance between them. This effects SB6b and SB9. The desalination pipe invert depths and dimensions were provided in the Victorian Desalination Project pipe section plan and longitudinal sections (see Figure 11 and Figure 12 below).

The relevant elevations can be seen in Table 15. The minimum clearance requirement for a waterway crossing based on Melbourne Waters typical Creek Crossing is 900 mm. This includes a minimum 300 mm concrete encasement of the pipe and 600 mm rock protection.

The results indicate that is not sufficient clearance between the desalination pipe and sediment basin NWL to pass a waterway over the top. Adding to this issue is that it doesn't not allow for draining of the SB for maintenance or alternative pipe outlet which would be lower again.

As a result a siphon arrangement will be required for each of the sediment basin outlet in order to cross the desalination pipe. An alternative method could be to construct the SB which an elevated embankment which would raise the Normal Water Levels of the sediment basins. However this method would require large volumes of fill to the surrounding developable area.

Outflows from SB9 are to be piped to waterway No. 6.

Table 15. Desalination pipe levels near SB6b and SB9

	SB6b	SB9
Desalination pipe invert level (m AHD)	12.482	8.912
Desalination pipe outside diameter (mm)	1930	1930
Desalination pipe obvert level (m AHD)	14.412	10.842
Sediment basin surface level (m AHD)	16.5	13.0
Sediment basin normal water level (m AHD)	15.0	11.5
Desalination pipe clearance to SB NWL (mm)	588	658

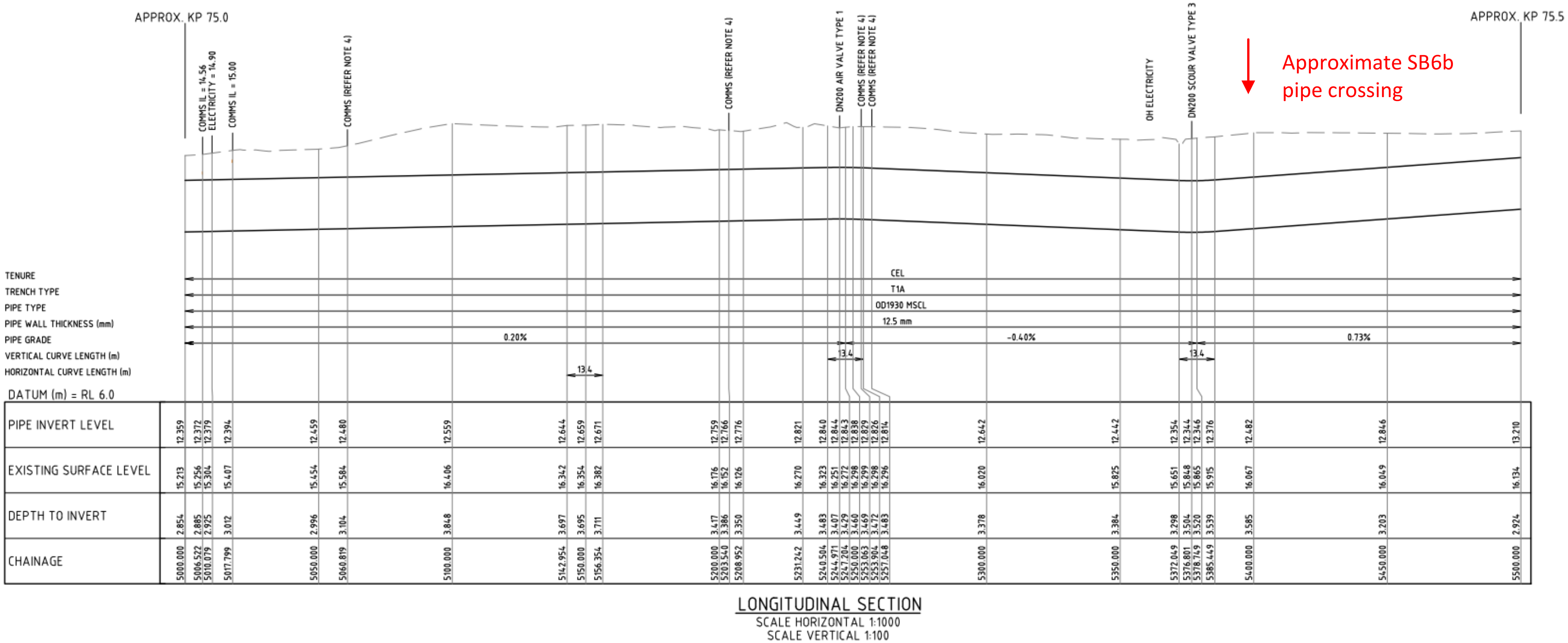


Figure 11. *Longitudinal section of desalination pipe near SB6b (Sheet DG-PBB-HS-3-B-300-3033)*

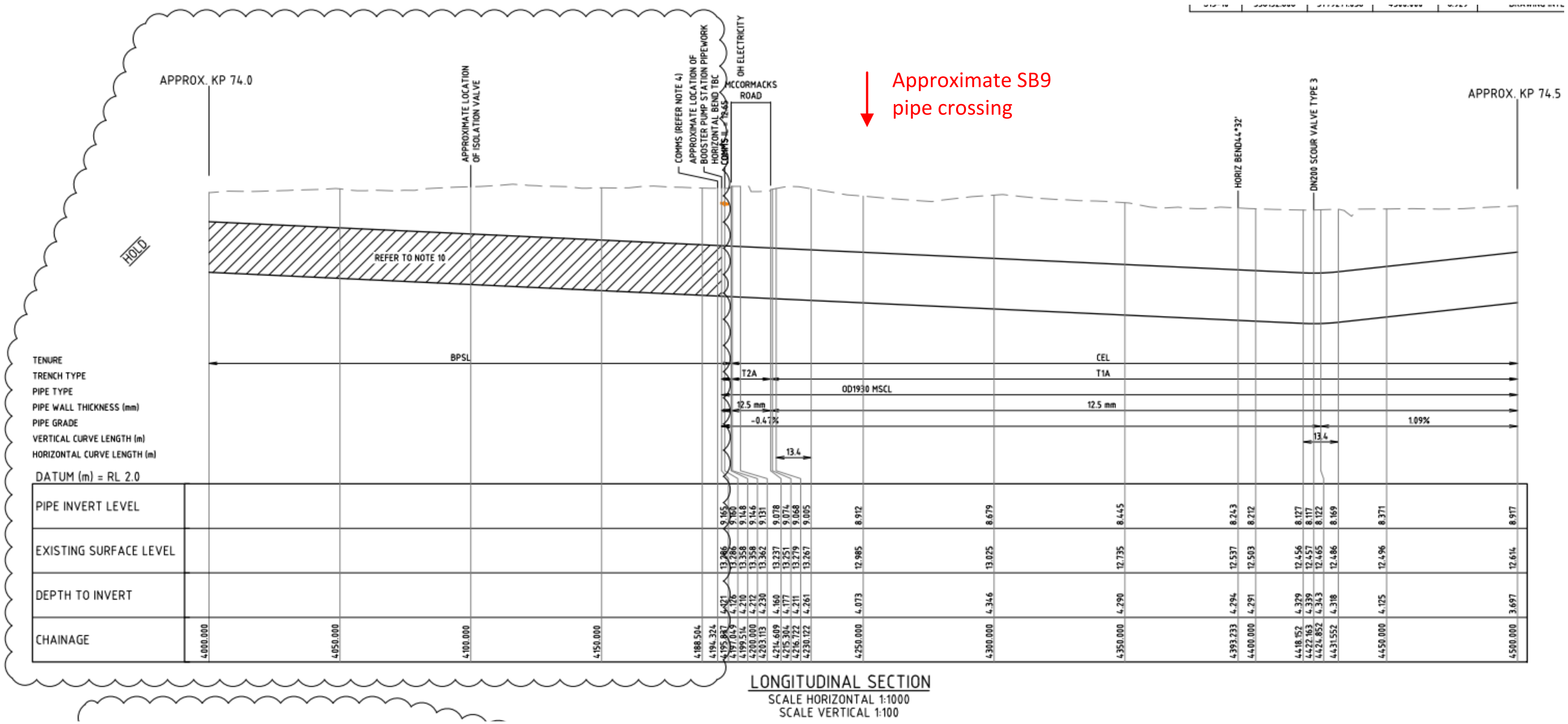


Figure 12. *Longitudinal section of desalination pipe near SB69 (Sheet DG-PBB-HS-3-B-300-3031)*

Wetland: Muddy Gates Drain
The details of each wetland design can be found in Table 16. The process used for sizing wetlands in Baillieu Creek was used to determine the size of wetlands in Muddy Gates Drain.

Table 16. Wetland sizing and performance in Muddy Gates Drain

Asset	Contributing catchment (ha)	Surface Area (m^2)	Total Footprint (m^2)	Inlet Pond Volume (m^3)	System Performance (Removal)			
					Total Suspended Solids (%)	Total Phosphorous (%)	Total Nitrogen (%)	Gross Pollutant (%)
WL_14&15	455	80,000	140,000	2000*	86.2	71.4	44.7	100

*Size factored smaller due to upstream sediment basins

Minimum Wetland Widths
Velocity checks were required to be undertaken for WL_14&15. The same approach was used for Muddy Gates Drain as was implemented for Baillieu Creek. The results may be viewed in Table 17.

Table 17. Minimum width required for WL_14&15 in Muddy Gates Drain

Wetland	Sediment Pond Minimum Width (m)	Macrophyte Zone Minimum Width (m)
WL_14&15 Ext	24 [12]	104 [52]

The wetland “WL_14&15” was designed as a dual-fed system in order to meet the maximum velocity criteria for a 3 month flow. By creating a dual fed system the width of the macrophyte zone could be optimised because less flow would be moving through each branch of the wetland. The wetland is also “split level” to minimise excavation and earthworks. The wetland was also positioned so it butted up to the boundary between the vegetated buffer and the core riparian zone (CRZ) in order to minimise the wetlands land take (see Figure 14).

External Wetland “SE_WLRB”
A large wetland (approximately 126 ha) south of McPherson PSP (named “SE_WLRB”) is planned to be built by Melbourne Water. It is proposed to service numerous surrounding developments. Further, it has the potential to achieve treatment beyond typical best practice in order to meet the higher water quality targets for Westernport. The stormwater from Muddy Gates Drain will flow through to “SE_WLRB”.

Based on the MUSIC modelling, 84.4% total nitrogen would be removed after treatment in SE_WLRB, indicating that development of Muddy Gates Drain will be within acceptable limits. A summary of the full results is shown in Table 18.

Table 18. Performance of “SE WLRB” (south of McPherson PSP)

Asset	Surface Area (m^2)	Total Footprint (m^2)	Inlet Pond Volume (m^3)	System Performance (Removal)			
				Total Suspended Solids (%)	Total Phosphorous (%)	Total Nitrogen (%)	Gross Pollutant (%)
SE WLRB	1000000*	Unknown	0	98.1	93.2	84.4	100

*Values sourced from MUSIC model supplied by Melbourne Water

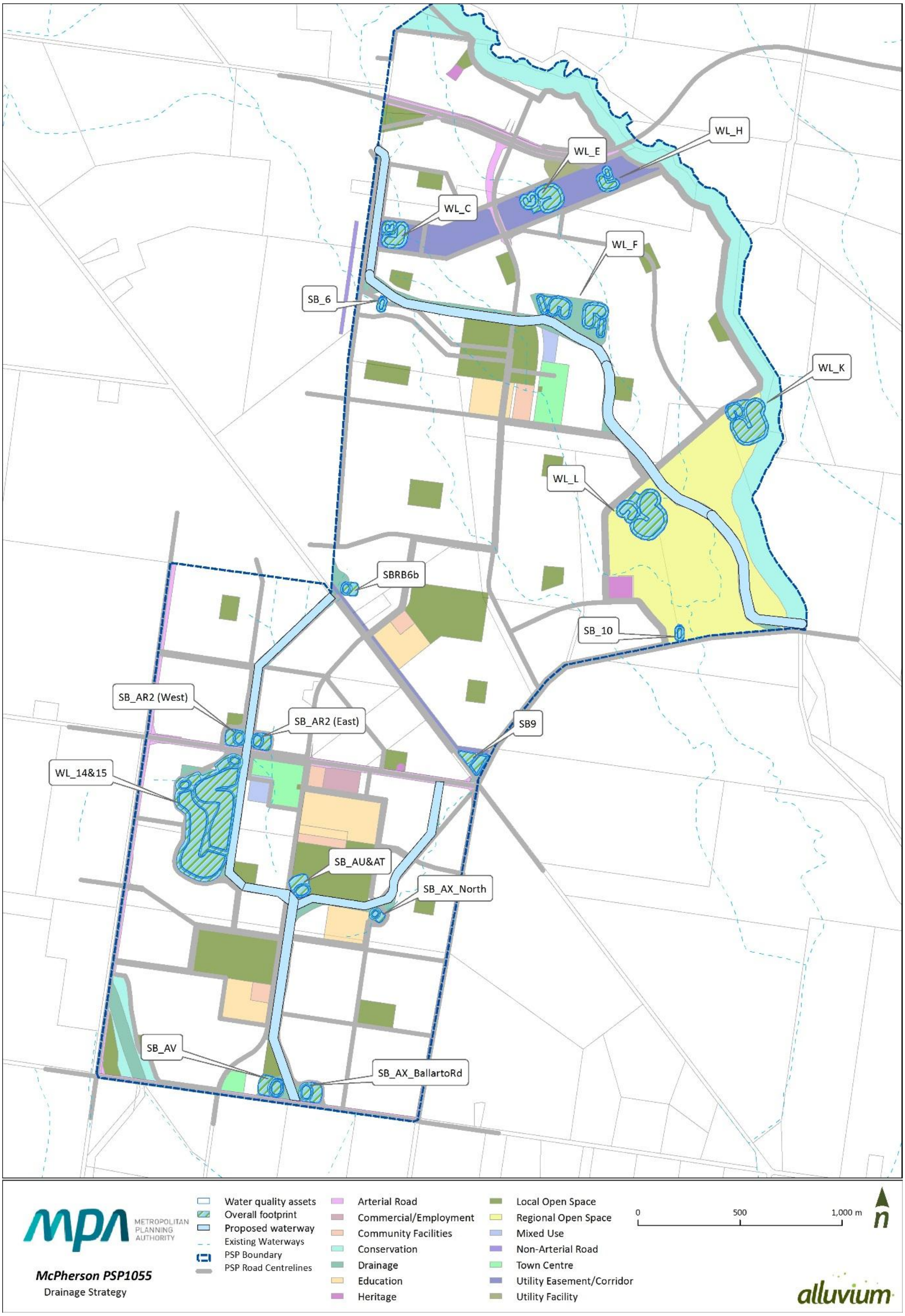


Figure 13. *Proposed stormwater treatment assets*

7 Proposed constructed waterway corridors

7.1 Constructed waterway corridors

Waterways, whether natural or constructed, need to have an appropriate waterway corridor in order to accommodate objectives for flood protection, river health, biodiversity and amenity. A waterway corridor is defined as the waterway channel and its associated riparian zones. The riparian zones consist of two parts: the vegetated buffer and the core riparian zone ('CRZ') (Figure 14).

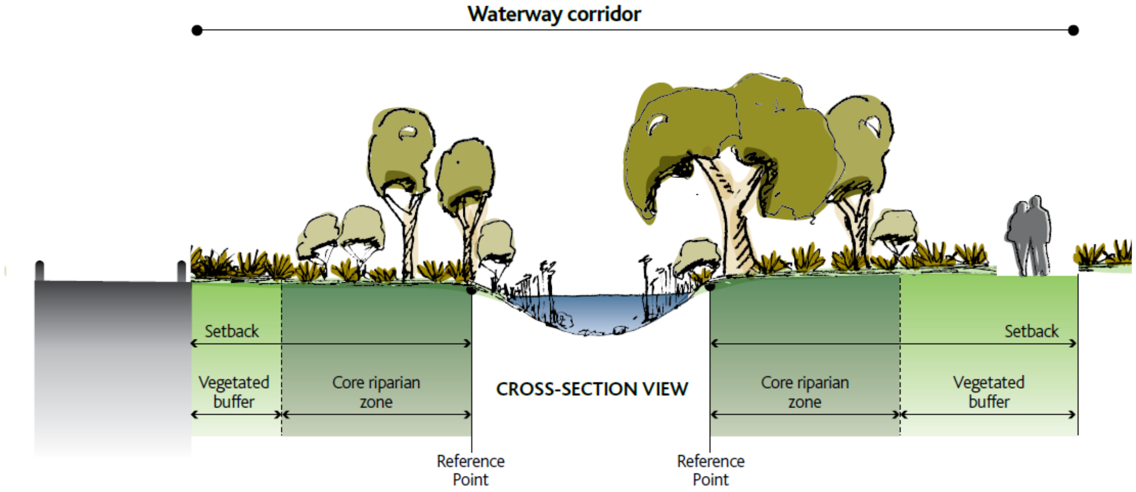


Figure 14. *Example waterway corridor (Melbourne Water's Waterway Corridor Guidelines)*

According to Melbourne Water's Waterway Corridor Guidelines, "assigning a waterway corridor preserves areas of the riparian zone that protect or enhance native vegetation, river health and biodiversity in some cases, the waterway corridor may also be able to support a level of passive recreational use or some stormwater treatment elements".

A fundamental principle is to provide continuity along the CRZ, therefore the strong preference is to locate shared paths and other infrastructure outside of the CRZ. However, the Waterway Corridor Guidelines states that "in some instances, stormwater treatment systems such as constructed wetlands and bio-retention systems may be located within the core riparian zone (subject to Melbourne Water approval) but should form a relatively small proportion of the area of the core riparian zone so as not to degrade its ecological function or put the asset at undue risk from flooding and/or stream migration". In some instances the water treatment infrastructure may be located to form part of the vegetated buffer for short sections of the waterway corridor, subject to Melbourne Water approval. Water treatment infrastructure has been typically located next to waterway corridor but outside the vegetated buffer.

The relevant corridor requirements applied to the constructed waterways designed as part of the McPherson PSP are shown in Figure 15. Alluvium has generally adopted Table 3 (Figure 15) for sizing the waterway corridors, as active edges in the form of roads will be placed along all but two sections of the constructed waterway corridors within the precinct. Table 4 (Figure 15) has therefore been adopted for those remaining two sections (Figure 16).

Table 3. Sliding scale for calculating constructed waterway corridor widths – assumes active edges (roads) that allow vehicle access along entire corridor length, on both sides of the corridor.

HYDRAULIC WIDTH (M)	CRZ WIDTH (M)	VB WIDTH (M)	CORRIDOR WIDTH (M)
5	20	10	30
10	20	10	30
15	25	15	40
20	25	15	40
25	30	15	45
30	30	15	45
35	30	15	45
40	30	20	50
45	35	20	55
50	35	20	55
55	40	20	60
60	40	20	60
65	40	25	65
70	45	25	70

Table 4. Sliding scale for calculating constructed waterway corridor widths – addition of shared trail/maintenance track either side of channel (within vegetated buffer)

HYDRAULIC WIDTH (M)	CRZ WIDTH (M)	VB WIDTH (M)	CORRIDOR WIDTH (M)
5	20	20	40
10	20	20	40
15	20	25	45
20	25	25	50
25	30	25	55
30	30	25	55
35	30	25	55
40	35	25	60
45	35	25	60
50	35	25	60
55	40	25	65
60	40	25	65
65	40	25	65
70	45	25	70

Figure 15. *Constructed Waterway corridor requirements (Melbourne Water's Waterway Corridor Guidelines)*

7.2 Baillieu Creek

A constructed waterway is proposed within the Baillieu Creek catchment. The constructed waterway corridor continues from the Thompsons Road PSP in the north east and discharges into Cardinia Creek at the McCormacks Rd crossing. It has a total length slightly less than 4km and is comprised of three connected sections, named Constructed Waterway #1-#3 (refer to Figure 16). This constructed waterway will be used as the primary discharge location for most of the treatment assets within Baillieu Creek.

Table 19. Baillieu Creek RORB design flows

Location	Flow point	3 month ARI (m3/s)	1 year ARI (m3/s)	5 year ARI (m3/s)	100 year ARI (m3/s)
Baillieu Creek	Constructed Waterway #1	0.44	1.1	2.2	5.5
	Constructed Waterway #2	1.2	3.1	6.1	15.3
	Constructed Waterway #3	2.1	5.1	10.2	25.6

A summary of the various constructed waterway corridors widths may be viewed in Table 20.

Table 20. Constructed waterway corridor widths (Baillieu Creek)

Location	Slope (m/m)	Hydraulic Width (m)	Core Riparian Zone (m)	Vegetated Buffer (m)	Total Corridor Width (m)	Length (m)	Area (ha)
Constructed Waterway #1	300	19.2	25	15	40	750	3.0
Constructed Waterway #2	200	28.1	30	15	45	610	2.8
Constructed Waterway #3a	300	40.0	30	20	50	1860	9.3
Constructed Waterway #3 (adjacent to WL_F)	300	40.0	35	25	60	380	2.3
TOTAL						3600	17.4

7.3 Muddy Gates Drain

In Muddy Gates Drain there will be two separate constructed waterways that are planned to join together slightly north of Ballarto Road between Muddy Gates Lane and Bells Road. One of these constructed waterways will begin near the intersection of Pound Road and Hardys Road and continue to Ballarto Road (Constructed Waterway #4, 5 and 7). The other constructed waterway will begin south of Pattersons Road and join constructed waterway #7 north of Ballarto Road (Constructed Waterway #6).

Table 21. Muddy Gates Drain RORB design flows

Location	Flow point	3 month ARI (m3/s)	1 year ARI (m3/s)	5 year ARI (m3/s)	100 year ARI (m3/s)
Muddy Gates Drain	Constructed Waterway #4	0.9	2.5	4.6	11.6
	Constructed Waterway #5	1.0	2.6	4.8	13.1
	Constructed Waterway #6	1.1	2.4	5.6	10.3
	Constructed Waterway #7	1.4	4.1	6.9	20.8

Table 22. Constructed waterway corridor widths (Muddy Gates Drain)

Location	Slope (m/m)	Hydraulic Width (m)	Core Riparian Zone (m)	Vegetated Buffer (m)	Total Corridor Width (m)	Length (m)	Area (ha)
Constructed Waterway #4	0.0047	19.0	25	15	40	1027	4.1
Constructed Waterway #4a (adjacent to WL_14 and 15)	0.0047	19.0	25	25	50	595	3.0
Constructed Waterway #5	0.0038	20.0	25	15	40	267	1.1
Constructed Waterway #6	0.0038	20.0	25	15	40	1098	4.5
Constructed Waterway #7	0.0028	26.6	30	15	45	985	4.4
TOTAL						4017	17.1

Removal of waterway from SBRB8

Modelled RORB flows from SBRB8 indicate that flows entering PSP1055 will be approximately 8.5 m^3/s in the 100 year ARI event. Based on a 1350 mm diameter pipe with a capacity of approximately 4.2 m3/s the additional gap flow (4.3 m3/s) can be contained within road reserves (overland flow).

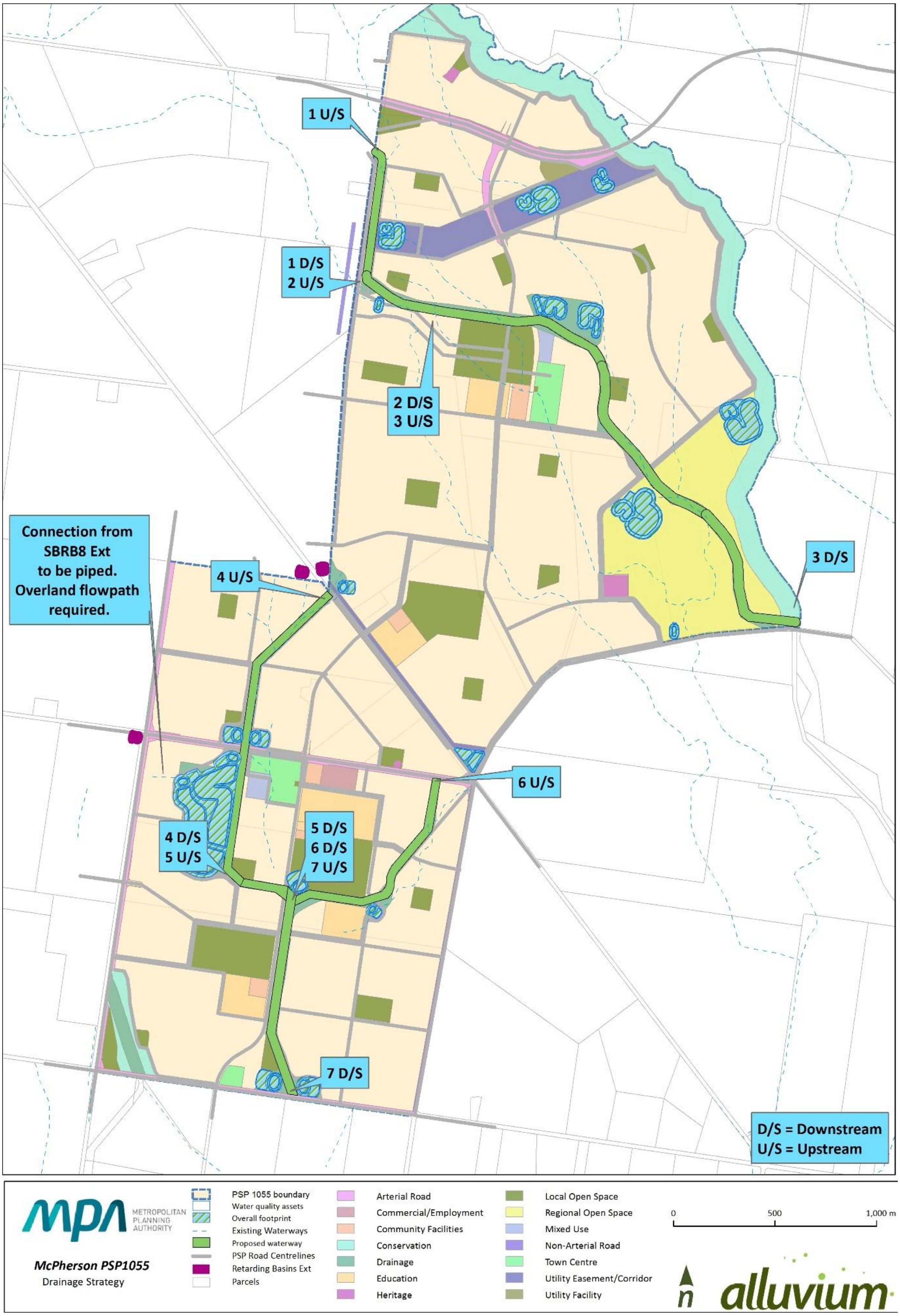


Figure 16. *Proposed constructed waterways*

8 Overall drainage strategy plan for McPherson PSP

A summary of the overall drainage strategy for the McPherson PSP is shown in Figure 17 and Figure 18. A concept design layout for each wetland is provided in Appendix D.

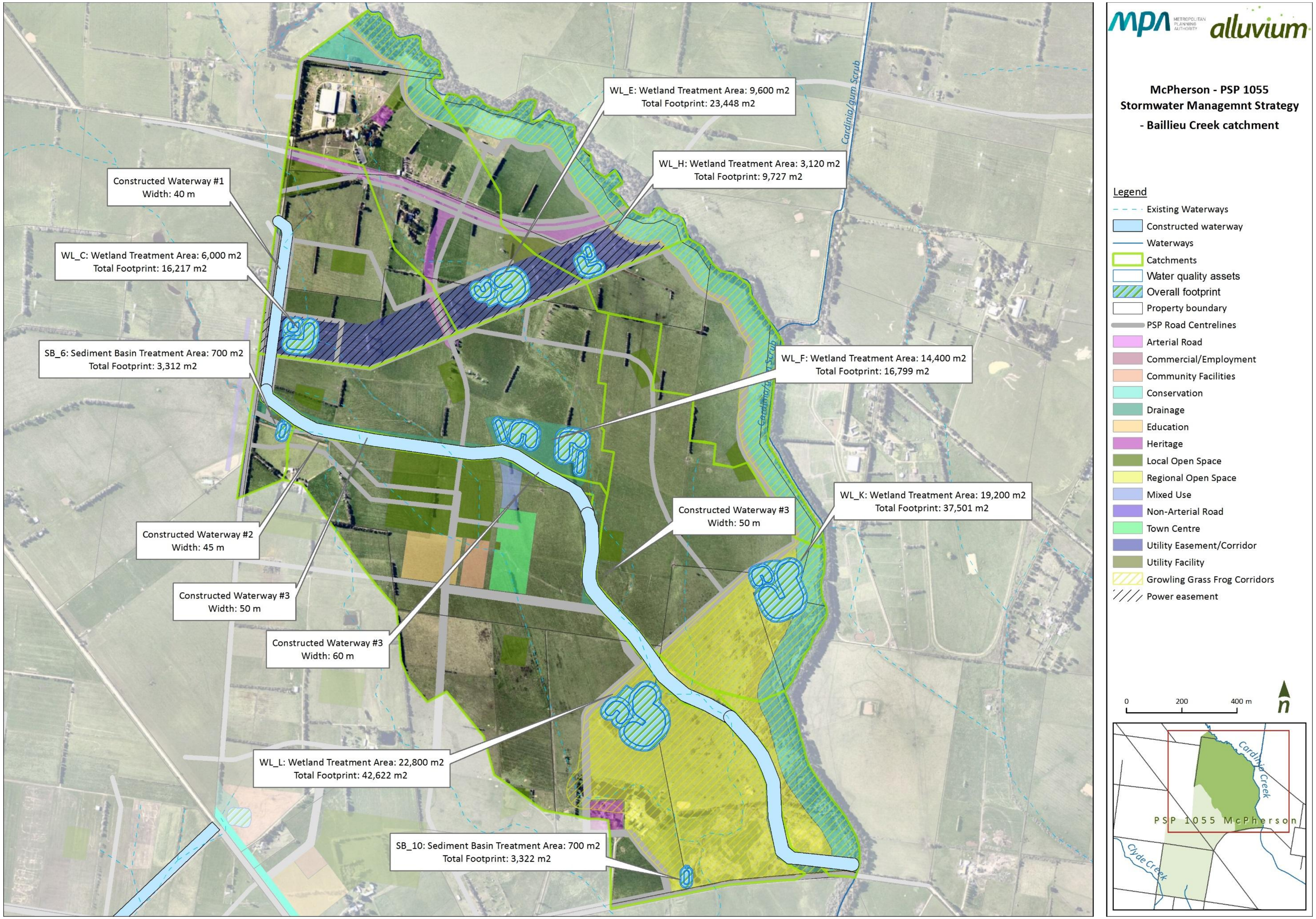


Figure 17. *Recommended layout of McPherson PSP (northern section) surface water management strategy*

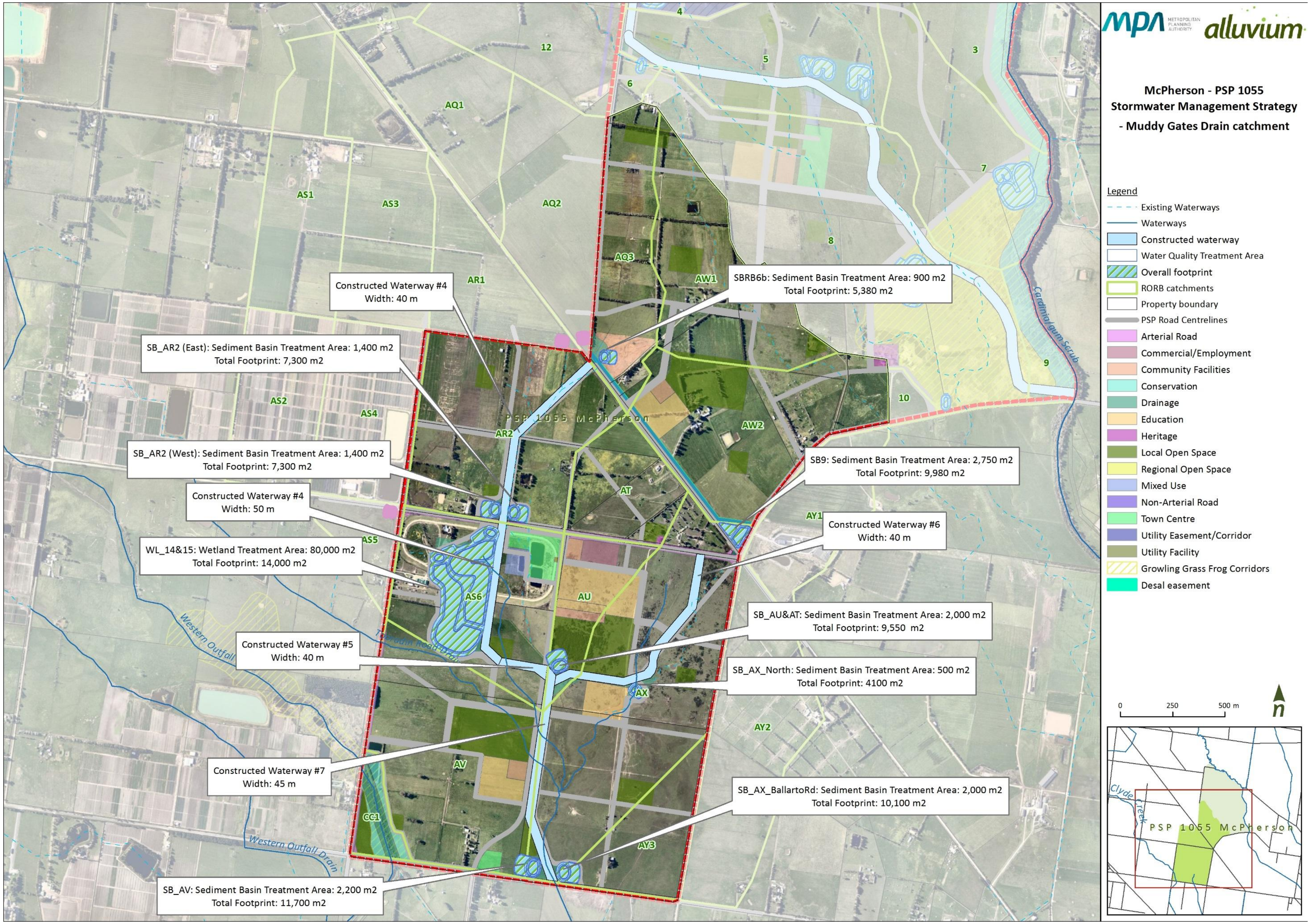


Figure 18. *Recommended layout of McPherson PSP (southern section) surface water management strategy*

9 SWMS assets required

The above strategies have outlined the assets required to deal with the quality and quantity issues associated with stormwater within McPherson PSP. A summary of the SWMS assets that are required are shown in Table 23. Please be aware if the asset contributing catchment is greater than 60 ha then Melbourne Water has the responsibility of the asset – otherwise the responsibility lies with the local council.

Table 23. Summary of Development Services Scheme assets

Asset type	Region	Description	Size	Total Footprint	Asset contributing catchment (ha)	Responsibility
Constructed Waterway	Baillieu Creek	1	40 m (width)	3.0 ha	> 60	Melbourne Water
		2	45 m (width)	2.8 ha	> 60	Melbourne Water
		3	50 m (width)	9.3 ha	> 60	Melbourne Water
		3a	60 m (width)	2.3 ha	> 60	Melbourne Water
	Muddy Gates Drain	4	40 m (width)	4.1 ha	> 60	Melbourne Water
		4a	50 m (width)	3.0 ha	> 60	Melbourne Water
		5	40 m (width)	1.1 ha	> 60	Melbourne Water
		6	40 m (width)	4.5 ha	> 60	Melbourne Water
		7	45 m (width)	4.4 ha	> 60	Melbourne Water
Stormwater Treatment	Baillieu Creek	SB_6	SB: 700 m^2 (at NWL)	3,312 m^2	4.6	Council
		SB_10	SB: 700 m^2 (at NWL)	3,322 m^2	4.3	Council
		WL_C	WL: 5,000 m^2 (at NWL) SB: 1,000 m^2 (at NWL)	16,217 m^2	20.7	Council
		WL_E	WL: 8,000 m^2 (at NWL) SB: 1,600 m^2 (at NWL)	23,448 m^2	33.9	Council
		WL_H	WL: 2,600 m^2 (at NWL) SB: 520 m^2 (at NWL)	9,727 m^2	10.4	Council
		WL_F	WL: 12,000 m^2 (at NWL) SB: 2,400 m^2 (at NWL)	16,799 m^2	79.5*	Melbourne Water
		WL_K	WL: 16,000 m^2 (at NWL) SB: 3,200 m^2 (at NWL)	37,501 m^2	64.4	Melbourne Water

	WL_L	WL: 19,000 m^2 (at NWL) SB: 3,800 m^2 (at NWL)	42,622 m^2	77.3	Melbourne Water
Muddy Gates Drain	WL_14&15	WL: 80,000 m^2 (at NWL) SB: 2,000 m^2 (at NWL)	140,000 m^2	455	Melbourne Water
	SBRB6b	SB: 900 m^2 (at NWL)	5,380 m^2	37	Council (potential to be consolidated with SBRB6a)
	SB9	SB: 2,750 m^2 (at NWL)	9,980 m^2	116	Melbourne Water
	SB_AR2 (east)	SB: 1,400 m^2 (at NWL)	7,300 m^2	45	Council
	SB_AR2 (west)	SB: 1,400 m^2 (at NWL)	7,300 m^2	46	Council
	SB_AX_North	SB: 500 m^2 (at NWL)	4,100 m^2	16	Council
	SB_AU&AT	SB: 2,000 m^2 (at NWL)	9,550 m^2	62	Melbourne Water
	SB_AX_BallartoRd	SB: 2,000 m^2 (at NWL)	10,100 m^2	68	Melbourne Water
	SB_AV	SB: 2,200 m^2 (at NWL)	11,700 m^2	72	Melbourne Water
20 Assets (9 sections of constructed waterways)		TOTAL	80.41 ha		

Table 24. Development Services Scheme assets rationale for placement

Asset No.	Topography Considerations	Environmental/Cultural Heritage Considerations	Drainage Level/Flow/Quality Control Considerations	PSP/Development Layout Considerations	Any other option?
Baillieu Creek Constructed Waterway	No well defined waterways except for cut farm drains. Waterway corridors generally follow broad flat valley floor with alignments developed to integrate with the proposed structure plan. Outfalls to Cardinia Creek through Regional Park.	No significant remnant values. Alignment runs through the GGF corridor so values are potentially higher in future.	Designed to provide minimum 100 year flood capacity with corridor widths based on the MW Corridor Guidelines.	Suits current layout. Aligned with Mirvac Masterplan Setout (Beveridge Williams, November 2016).	Potential to make slight adjustments to suit PSP 1055 structure plan.
Muddy Gates Drain Constructed Waterway	No well defined waterways except for cut farm drains. Waterway corridors generally follow broad flat valley floor with alignments developed to integrate with the proposed structure plan. Drainage line downstream of Ballarto Rd may require deepening to obtain outfall.	No significant remnant values.	Designed to provide minimum 100 year flood capacity with corridor widths based on the MW Corridor Guidelines.	Suits current layout.	Potential to make slight adjustments to suit PSP 1055 structure plan.
SB_6	Located on “land-locked” low point to collect and treat surface runoff to the south of the proposed waterway. Created by excavation with no embankments.	No significant remnant values.	Designed to provide minimum TSS removal prior to discharging to constructed waterway.	Suits current layout. Aligned with Mirvac Masterplan Setout such that the SB sits within the designated drainage and open space block (Beveridge Williams, November 2016).	None available due to topographic constraints and proposed waterway alignment. SB required to comply with water quality treatment protocol.
SB_10	Located on “land-locked” low point to collect and treat surface at south-eastern boundary of PSP. Created by excavation with no embankments.	No significant remnant values.	Designed to provide minimum TSS removal prior to discharging to constructed waterway	Located within proposed Regional Park. Final reserve layout may be varied to better suit future development in PSP 1055.	None available due to topographic constraints. SB required to comply with water quality treatment protocol.
WL_C	Located within existing valley drainage line and utilises encumbered land within the electricity easement. Created by excavation with no embankments.	No significant remnant values.	Sizing sufficient to achieve 85% TSS removal within electricity easement.	Suits current layout.	None available due to topographic constraints and proposed waterway alignment.

Asset No.	Topography Considerations	Environmental/Cultural Heritage Considerations	Drainage Level/Flow/Quality Control Considerations	PSP/Development Layout Considerations	Any other option?
WL_E	Located within existing valley drainage line and utilises encumbered land within the electricity easement. Space limited by transmission towers and proposed road corridors. Created by excavation with no embankments.	No significant remnant values.	Sizing sufficient to achieve 85% TSS removal within electricity easement.	Suits current layout. Aligned with Mirvac Masterplan Setout (Beveridge Williams, November 2016).	Potential to merge with WL_C or WL_H is limited due to flat topography between catchments. Any merge would result in need to lower WL_C or WL_H by approx 2-3 m which would have ripple effect of lowering the entire drainage system downstream.
WL_H	Located within existing valley drainage line and utilises encumbered land within the electricity easement. Created by excavation with no embankments.	No significant remnant values.	Sizing sufficient to achieve 85% TSS removal within electricity easement.	Suits current layout.	Potential to merge with WL_E is limited due to flat topography between catchments. Any merge would result in need to lower WL_E by approx. 3 m which would have ripple effect of lowering the entire drainage system downstream.
WL_F	Located on low point adjacent to constructed waterway. Created by excavation with no embankments.	No significant remnant values.	Sizing sufficient to achieve 85% TSS removal from upper catchment including WL_E contributing catchment.	Suits current layout. Aligned with Mirvac Masterplan Setout, such that the assets sit within the designated drainage reserve (Beveridge Williams, November 2016).	Limited potential to move due to topographic and constructed waterway site constraints.
WL_K	Located within existing valley drainage line and utilises encumbered land within the Regional Park and Cardinia Creek buffer. Created by excavation with no embankments.	Directly abuts the GGF corridor so values are potentially higher in future.	Positioned to collect and treat Cardinia Creek catchment and developable area to the west. Sizing just sufficient to achieve 85% TSS removal outcomes.	Located within proposed Regional Park and Cardinia Creek buffer as directed by MPA. Situated at a distance from the creek, and with an equitable split between the three parcels as directed by the MPA.	Potential to move southwest within Regional Park.

Asset No.	Topography Considerations	Environmental/Cultural Heritage Considerations	Drainage Level/Flow/Quality Control Considerations	PSP/Development Layout Considerations	Any other option?
				Final layout may be varied depending on internal spaces within Regional Park.	
WL_L	Located within existing valley drainage line and utilises encumbered land within the Regional Park. Created by excavation with no embankments.	Directly abuts the GGF corridor so values are potentially higher in future.	Sizing sufficient to achieve 85% TSS removal outcomes.	Located within proposed Regional Park. Final layout may be varied depending on internal spaces within Regional Park.	Potential to move linearly east and west within Regional Park.
WL_14&15	Utilises flat land that is partly subject to inundation and is currently very poorly drained. Created by excavation with no embankments.	No significant remnant values.	Combined to provide more efficient land use than two separate wetlands. Wetland designed to be offline with separate high flow channel. Additional treatment to SEPP F8 targets achieved in SE_WLRB.	Suits current layout.	Limited potential to move due to topographic site constraints.
SBRB6b	Utilises land that is otherwise at least partly developable if not for the constraints posed by the desalination pipe. Split into two segments (with SBRB6a) by the proposed east-west roadway. Created by excavation with no embankments.	No significant remnant values.	NTWL will be fixed by clearance to desalination pipe (no data available but likely about 1 m below existing surface).	Suits current layout.	Limited due to desalination pipe and road controls. SB required to comply with water quality treatment protocol.
SB9	Utilises land that is otherwise at least partly developable if not for the constraints posed by the desalination pipe. Created by excavation with no embankments.	No significant remnant values.	Located within confined space between desalination pipe and high voltage power easement. NTWL will be fixed by clearance to desalination pipe (no data available but likely about 1 m below existing surface).	Suits current layout.	Limited due to desalination pipe and road controls. Potential to move north. SB required to comply with water quality treatment protocol.
SB_AR2 (east)	Located on low point along the east west collector road to collect and treat surface runoff to the east of the proposed waterway. Created by excavation with no	No significant remnant values.	Designed to provide minimum TSS removal prior to discharging to waterway. Additional treatment to BPEM targets achieved in WL_14&15.	Suits current layout.	Limited due to topographic, constructed waterway and road controls. SB required to comply with water quality treatment

Asset No.	Topography Considerations	Environmental/Cultural Heritage Considerations	Drainage Level/Flow/Quality Control Considerations	PSP/Development Layout Considerations	Any other option?
	embankments.				protocol.
SB_AR2 (west)	Located on low point along the east west collector road to collect and treat surface runoff to the west of the proposed waterway. Created by excavation with no embankments.	No significant remnant values.	Designed to provide minimum TSS removal prior to discharging to waterway. Additional treatment to BPEM targets achieved in WL_14&15.	Suits current layout.	Limited due to topographic, constructed waterway and road controls. SB required to comply with water quality treatment protocol.
SB_AX_North	Located on low point to collect and treat surface runoff to the east of the proposed waterway. Created by excavation with no embankments.	No significant remnant values.	Designed to provide minimum TSS removal prior to discharging to waterway. Additional treatment to SEPP F8 targets achieved in SE_WLRB.	Suits current layout.	Limited due to topographic, constructed waterway and road controls.
SB_AU&AT	Located on low point to collect and treat surface runoff to the north of the proposed waterway. Created by excavation with no embankments.	No significant remnant values.	Designed to provide minimum TSS removal prior to discharging to waterway. Additional treatment to SEPP F8 targets achieved in SE_WLRB.	Suits current layout.	Limited due to topographic, constructed waterway and road controls.
SB_AX_BallartoRd	Located on lowest southern point of PSP to collect and treat surface runoff to east of proposed waterway. Created by excavation with no embankments other than Ballarto Road formation. Drainage line downstream of Ballarto Rd may require deepening to obtain outfall.	High remnant flora values identified in excavation area. Advised by MPA EPBC Act recorded but not considered large enough to require attention.	Designed to provide minimum TSS removal prior to discharging to waterway. Additional treatment to SEPP F8 targets achieved in SE_WLRB.	Suits current layout.	Limited due to topographic, constructed waterway and road controls. SB required to comply with water quality treatment protocol.
SB_AV	Located on lowest southern point of PSP to collect and treat surface runoff to west of proposed waterway. Created by excavation with no embankments other than Ballarto Road formation. Drainage line downstream of Ballarto Rd may require deepening to obtain outfall.	High remnant flora values recently identified in excavation area, which will need to be considered in final arrangement.	Designed to provide minimum TSS removal prior to discharging to waterway. Additional treatment to SEPP F8 targets achieved in SE_WLRB.	Suits current layout.	Limited due to topographic, constructed waterway and road controls. SB required to comply with water quality treatment protocol.

10 Default Deemed to Comply Solution for Temporary Drainage

The deemed to comply solution criteria for temporary drainage has been documented for the PSP 53 and 54 Stormwater Management Strategy (Craigie 2013). It is recommended that the Muddy Gates Drain catchment should follow that of the PSP 53 and 54 Stormwater Management Strategy. This will ensure consistency in approach between the PSPs.

Extract from the PSP 53 and 54 Stormwater Management Strategy (Craigie 2013):

> A temporary drainage solution has been developed in accordance with a modified version of MW's standard conditions for localised intensive development proposals in the KooWeeRup Flood Protection District (KWRFPD). This solution will be deemed to comply with all requirements without specific hydrologic and water quality design computations.
>
> By way of background, the drainage system in the KWRFPD cannot accept any increase in stormwater flows resulting from intensive development, such as poultry farms. All such developments must therefore incorporate an on-site stormwater retention dam that controls runoff from only the impervious surfaces within the development. The requirements of this detention are:
>
> - 900 m^3 of freeboard storage in a dam above full supply level per hectare of catchment area (and including the dam area in this);
> - Freeboard storage to be no more than 450 mm deep;
> - Outlet from the dam to be controlled to 3 1/s per hectare of catchment (including dam area again); and
> - The dam should be lined with an impervious lining and the freeboard provision should be above the natural surface to avoid possible groundwater problems.
>
> The Clyde Creek and Muddy Gates catchments drain via the Western Contour Drain and Muddy Gates Drain to Western Port and are outside the KWRFPD. Whilst the sloping lands in these catchments are mostly moderately to well-drained, lower lying areas around drainage lines still experience drainage problems under existing rural land use and waterlogging of lower lying flat lands is an issue in normal winter/spring seasons. This is especially the case in Muddy Gates Drain beyond the PSP 53 and 54 boundaries but is also of significance along Clyde Creek and tributaries. Drainage capacity in the outfall systems below Ballarto Road is also affected by tidal constraints.
>
> It follows therefore that while restrictions on development drainage should be less severe than in the KWRFPD, they should still be tighter than in areas where such downstream drainage restrictions do not apply.
>
> For application to urban developments in Clyde Creek and Muddy Gates Creek the default criteria for automatic compliance of a temporary drainage management asset will need to ensure best practice water quality treatment outcomes and a high degree of control over peak discharge rates. The criteria are developed assuming an excavated unplanted sediment pond with average pool depth of 0.5 m is used as the management asset, and are as follows:
>
> - 600 m^3 of freeboard storage in a dam (between normal top water level and spillway level) per hectare of fully developed inlet catchment area (and including the dam area in this);
> - Water surface area at NTWL to be not less than 4% of developed catchment area (excluding the dam area);
> - Extended detention depth to be not less than 0.5 m;
> - Outlet from the dam to be controlled to 9 1/s per hectare of catchment (including dam area) at spillway overflow level;

- No change to existing receiving drainage lines or flood levels at property boundary/ies.

Whilst the criteria above do not fully address the issue of extra volumetric runoff arising from urban development, this is offset as far as practicable by ensuring peak outlet discharges are significantly less than would occur under existing site conditions. Water is released from storage at very low rates over a much longer period of time. Computations show that the ratio of “post development” to “existing conditions” peak discharges will be as follows:

Deemed to comply standards for peak discharge from development (temporary works)	
ARI (yrs)	**Post development/Existing Conditions (%)**
1	70
10	45
100	30

For the Baillieu Creek catchment, which drains through the KooWeeRup Flood Protection District (KWRFPD), but is located outside of it, it drains to Cardinia Creek, which is largely incised has dose not suffer the issue of waterlogging of lower lying flat lands is an issue in normal winter/spring seasons that the Muddy gates Drain catchment is subject too. Therefore for application to urban developments in the Baillieu Creek catchment, where staging precedes that of the downstream stage, the default criteria for automatic compliance of a temporary drainage management asset will need to ensure:

- Sediment control of 95% of 125 micron, and
- Retardation of peak flows back to that of pre development peak flow rates.

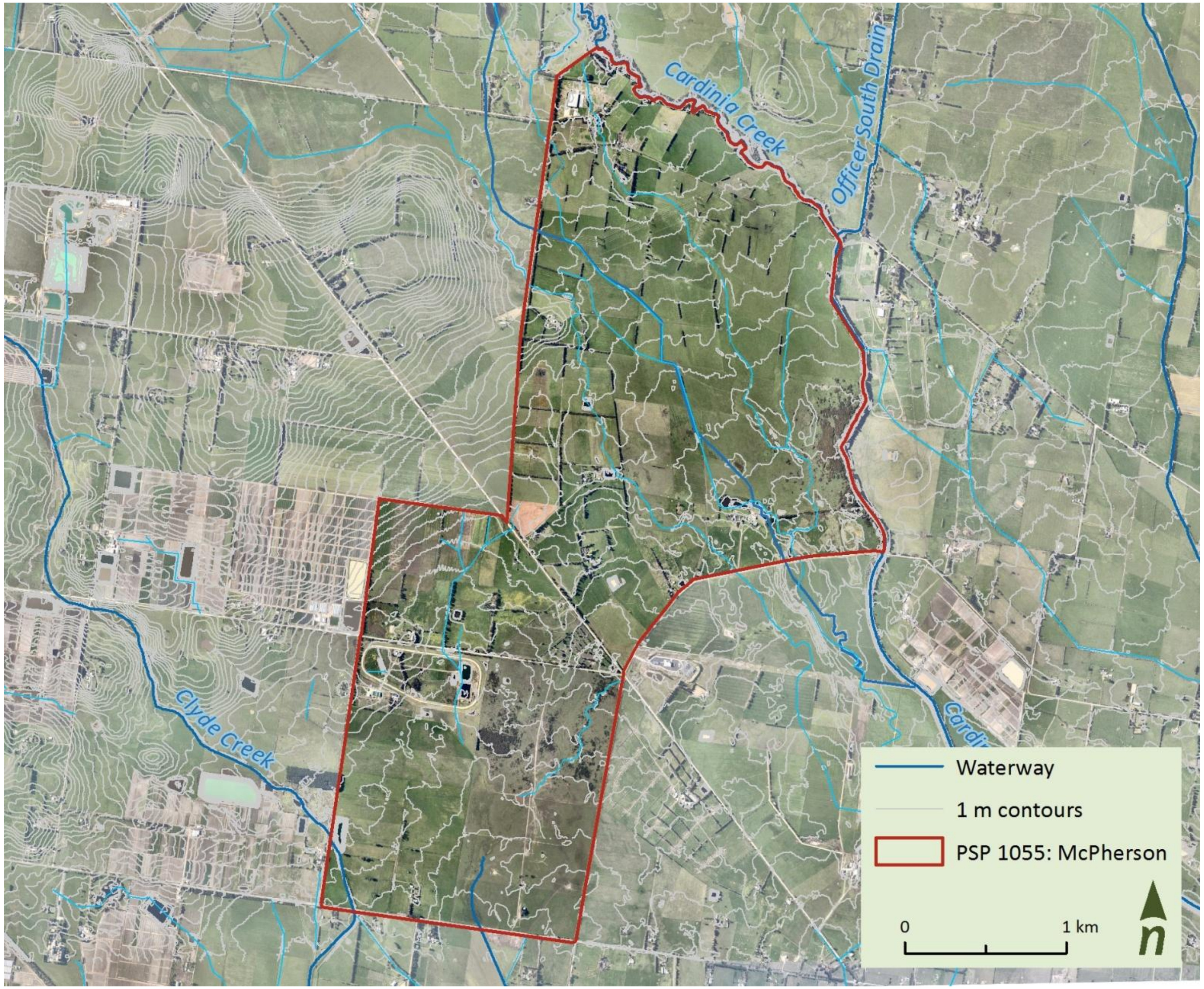
11 Conclusion

The SWMS contained within this report has proposed management strategies for stormwater quantity, stormwater quality, and existing and constructed waterways. Alluvium has attempted to strike a balance between waterway health and environmental objectives, whilst ensuring that safety and best practice standards are achieved and ensure efficient use of land. The strategy proposes 20 drainage assets to service the PSP, including seven wetlands, ten sediment basins and three constructed waterways (consisting of nine sections). Of these assets, eleven are proposed to be owned by Melbourne Water and nine by council.

The SWMS has been designed to provide the potential to facilitate water to the existing and future habitat. More specifically, the strategy will provide stormwater, treated to Best Practice Environmental Management Guidelines (BPEMG), which could be considered as a supply source for the GGF, Australian Grayling and Dwarf Galaxias within McPherson PSP, if required at some future time.

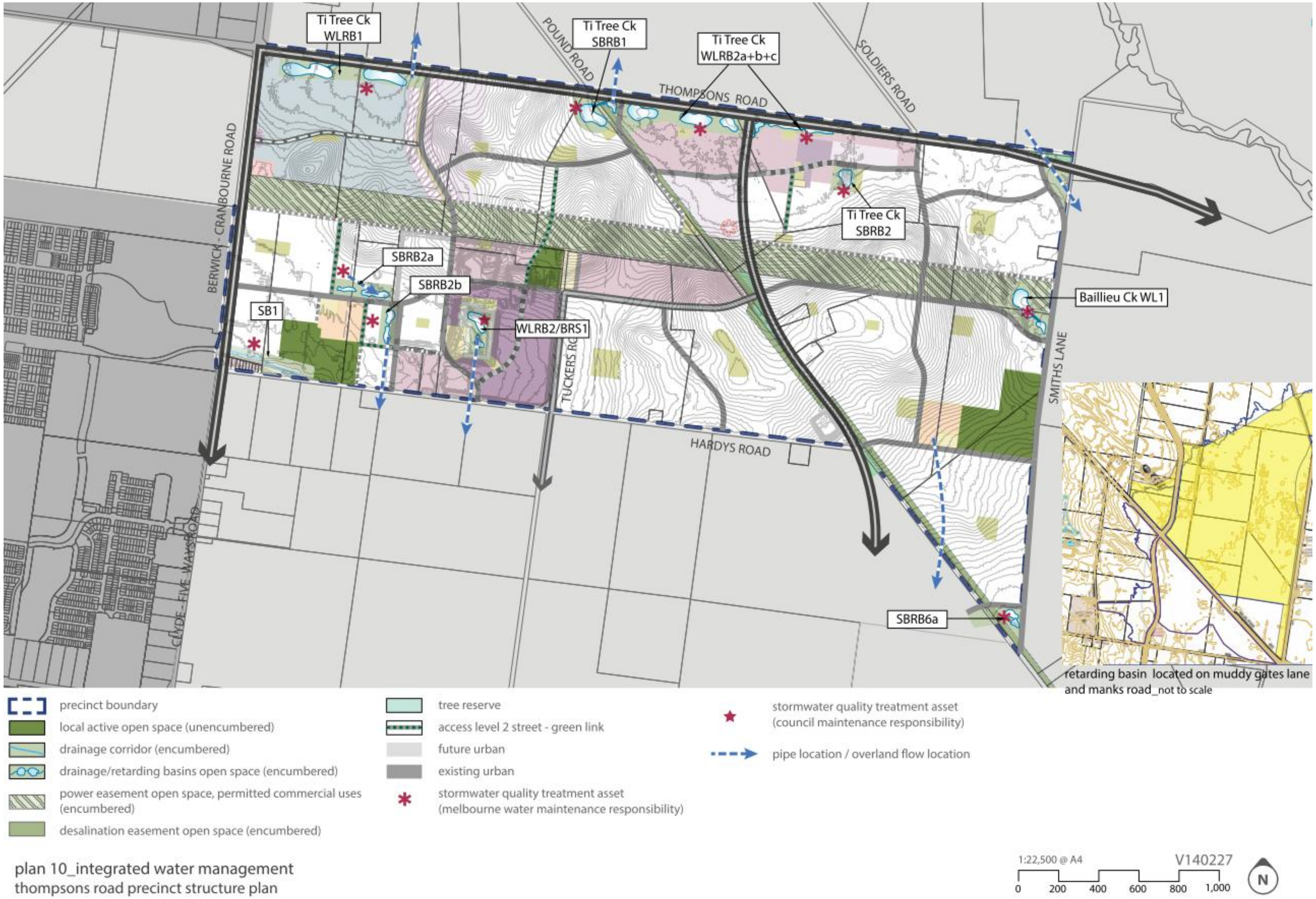
Appendix A
Site contour plan

Site contour plan

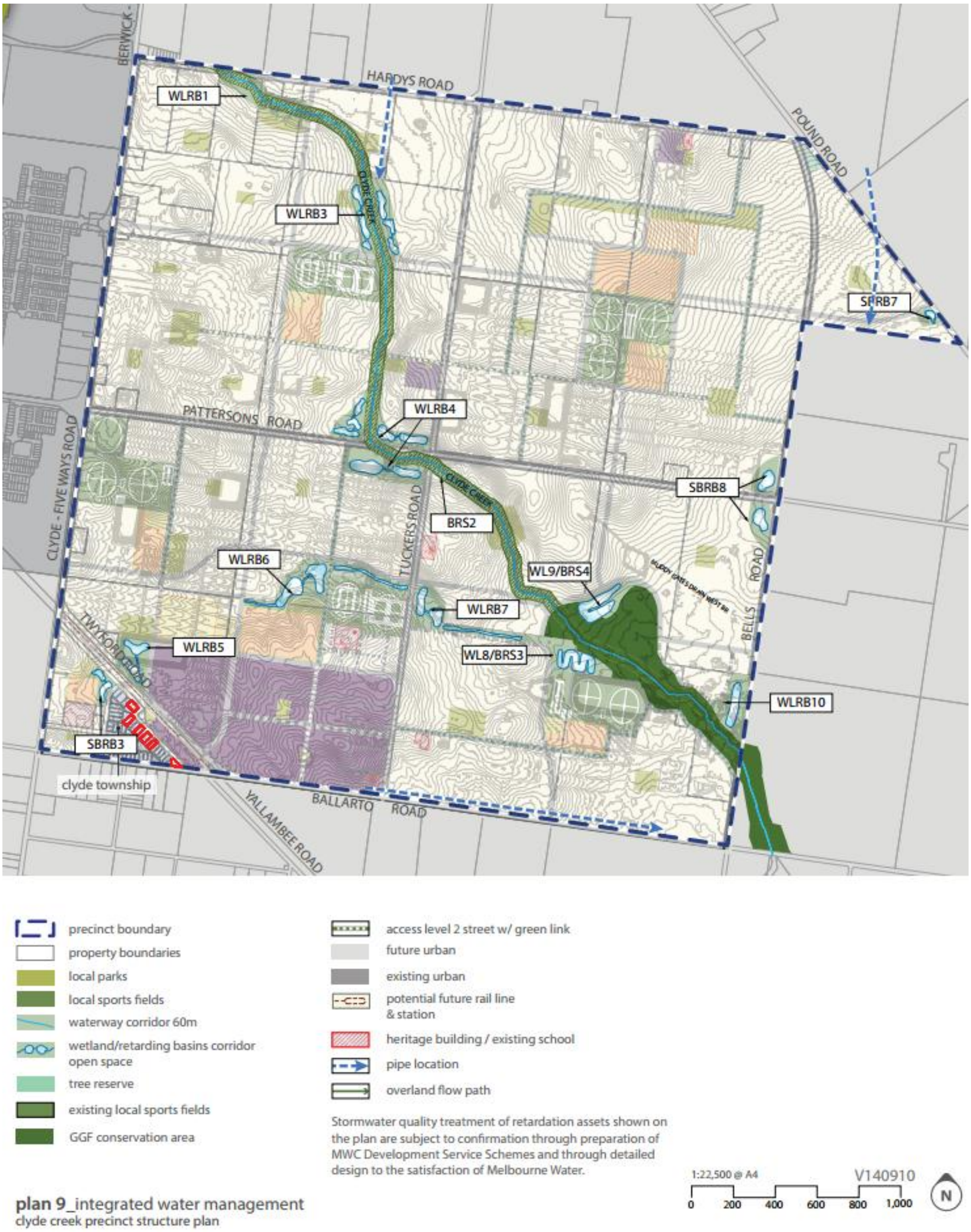


Appendix B
Surrounding precinct structure plans and Mirvac Masterplan

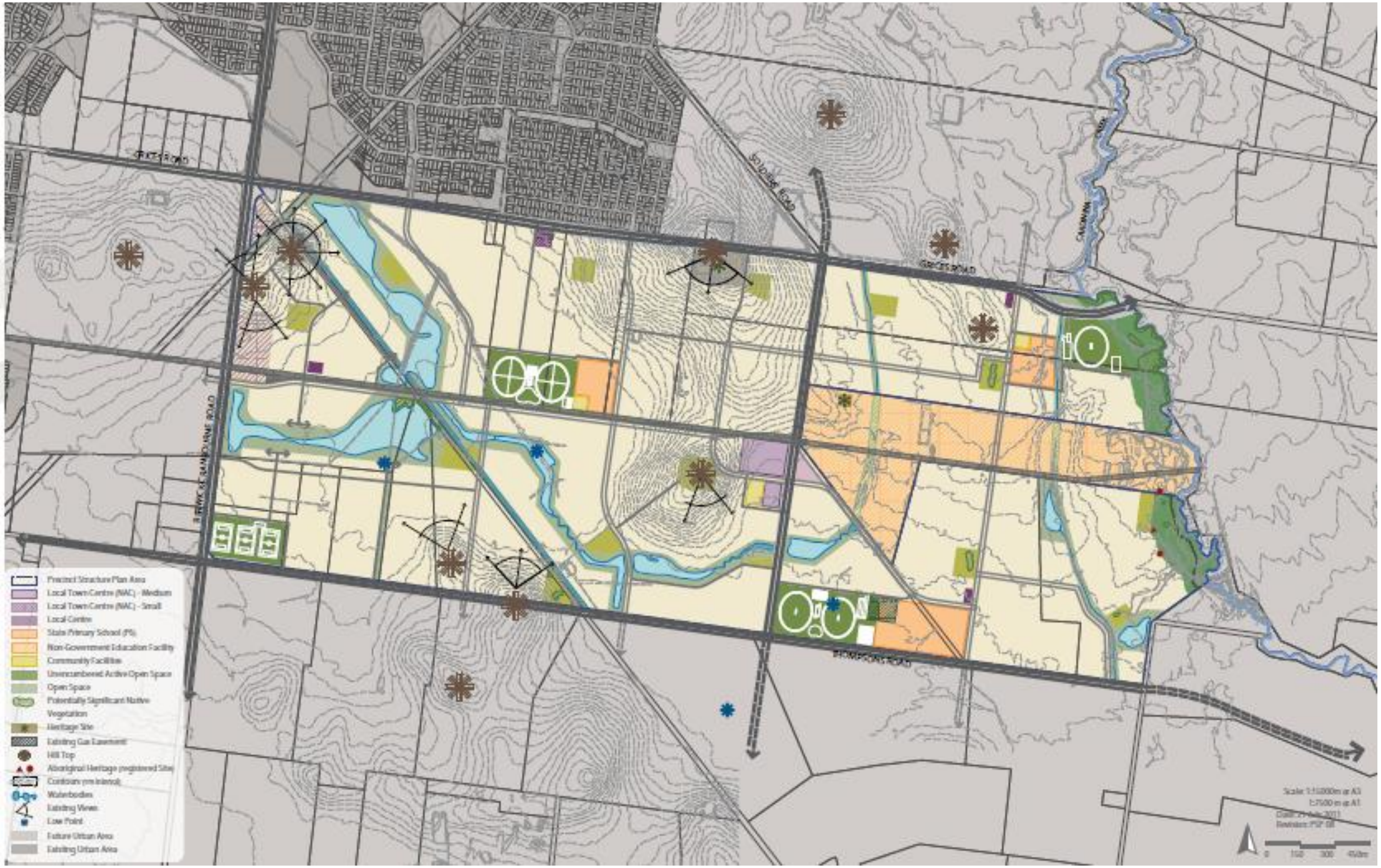
PSP 1053 Thompsons Road



Clyde Creek PSP 1054

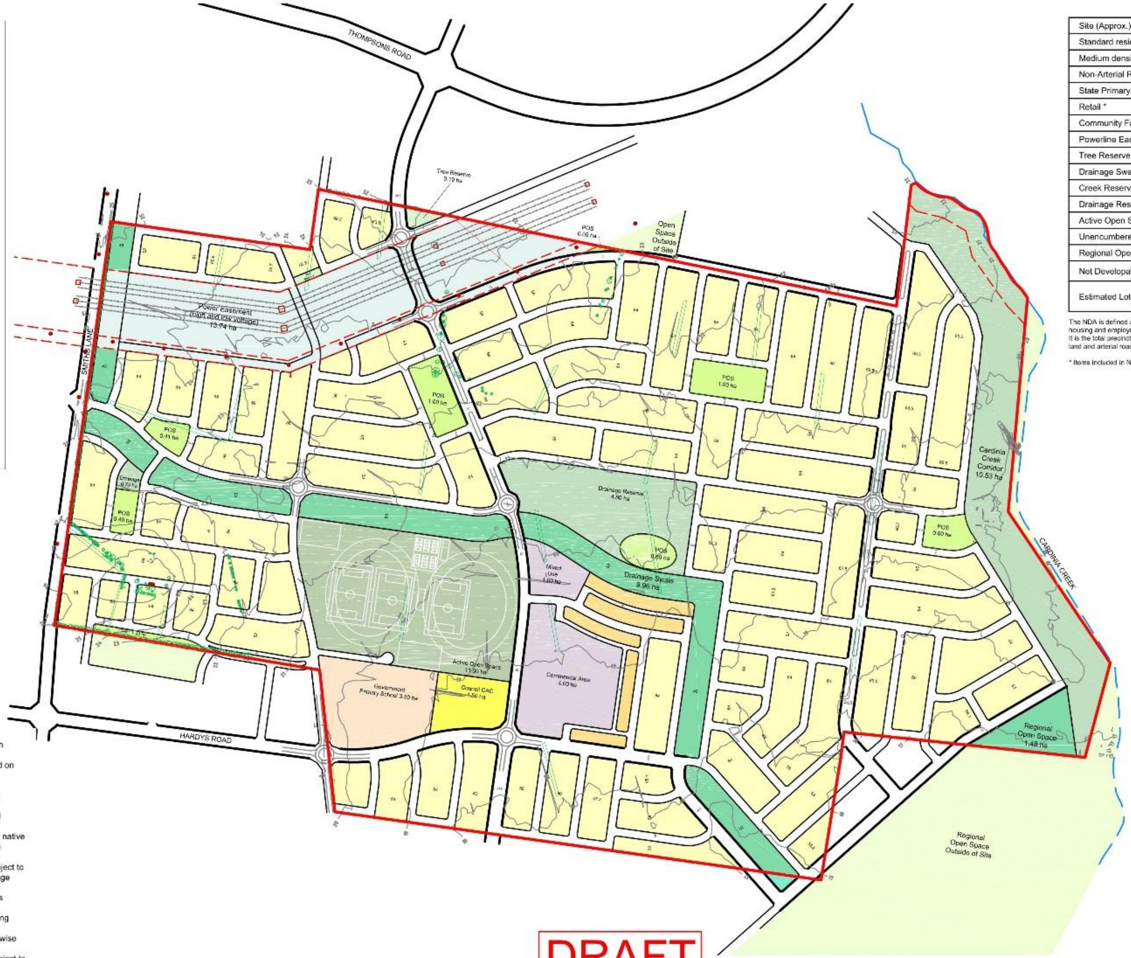


PSP 1013 Clyde North



LEGEND

- Title boundary (approx.)
- Existing easement
- Existing contours (1m interval)
- Standard residential lots
- Medium density residential lots
- State school
- Council Community Activity Centre (CAC)
- Retail/Supermarket/Speciality area
- Creek reserve
- Drainage swale (45-50m width)
- Drainage reserve
- Local open space
- Active open space
- Tree reserve
- Connector street - 28.5m (20m adjacent to commercial uses and reserves)
- Local access street level 1 - 16m (14.5m adjacent to reserves)
- Existing tree
- Existing dead tree
- Existing planted tree stand
- Regional open space



Site (Approx.)	199.452 ha
Standard residential lots *	85.852 ha
Medium density residential lots *	2.211 ha
Non-Arterial Roads *	44.617 ha
State Primary School	3.504 ha
Retail *	4.999 ha
Community Facilities	1.503 ha
Powerline Easement	13.742 ha
Tree Reserve *	0.434 ha
Drainage Swale	10.143 ha
Creek Reserve	10.529 ha
Drainage Reserve	5.033 ha
Active Open Space	10.999 ha
Unencumbered Passive Open Space	4.405 ha
Regional Open Space	1.483 ha
Net Developable Area	138.113 ha
Estimated Lot yield	approx 1965 lots @ 448m² average lot size

The NDA is defined as the total amount of land within the site that is made available for development of housing and employment buildings, including lots, all connector and local streets.
It is the total precinct area minus community facilities, educational facilities, open space, encumbered land and arterial roads.

* Items included in NDA

Notes

- This plan is indicative only and is intended for discussion purposes only
- This plan has been drafted by Beveridge Williams based on the design sketch provided by Justin Ray of Co-Make, February 2015
- This plan is subject to change during the Council - MPA precinct structure plan preparation process
- All dimensions and areas are subject to survey and final computations
- This plan has yet to take into consideration native flora, native fauna or Aboriginal cultural heritage, which may require further investigation
- Wetland / Drainage areas are approximate only and subject to detailed engineering design and may be subject to change during the precinct structure plan preparation process
- Access/egress to the site is subject to Council / Vicroads approval
- Road widths are indicative only and subject to engineering design
- Road widths are 16m (Local Access Road) unless otherwise noted
- All public open space areas are conceptual only and subject to change during the precinct structure plan preparation process
- The future road classification of Smiths Lane has yet to be confirmed. The design, NDA and estimated lot yield will change subject to the final classification.

DRAFT

FOR DISCUSSION PURPOSES ONLY

80 0 80 160 240 320 400 480m

Indicative Masterplan Setout

110 Smiths Lane, Clyde

Mirvac

Beveridge Williams
development & environment consultants
Melbourne ph : 03 9524 8888
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Version	Date	Description
20	[illegible]	Amended as per JR of Comake instructions
19	[illegible]	Assumed average Lot Size Reduced
18	[illegible]	Amended as per AC of Mirvac instructions
17	[illegible]	Amended as per AC of Mirvac instructions
16	[illegible]	Amended as per AC of Mirvac instructions

Drafted By: L. NICKELS
Checked By: C. KIRKCALDY (L.NICKELS)
Drawing Ref: 1101438_IMS
Version No: 20
Date: 06.11.2015
Initial Issue: 10.12.2014
Scale (A1): 1:4000
(A3): 1:8000

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Appendix C
Wetland velocity check

Wetland velocity check

A manual calculation has been used to check the flow velocities through the assets for the concept design. This calculates the flow area from the flow depth (between the extended detention depth and normal water level) and the average width in that area. The average width is determined from the narrowest part of the macrophyte zone and- sediment basin.

Table 25. Wetland velocity calculations for WL_C

	Parameter	Q 3 month	Q 1 year	Q 5 year
Flow conditions	Design Flow (m3/s)	0.50	1.12	2.48
	Flow depth (m) – sed basin	0.35	0.35	0.35
	Flow depth (m) – wetland	0.35	0.35	0.35
Sediment pond	Width at NWL (m)	15	15	15
	Width at EDD (m)	19.2	19.2	19.2
	Average width (m)	17.1	17.1	17.1
	Flow Area (m2)	6.0	6.0	6.0
	Flow Velocity (m/s)	0.08	0.19	0.41
	Check	Ok	Ok	OK
Macrophyte zone	Width at NWL (m)	35	35	35
	Width at EDD (m)	39.2	39.2	39.2
	Average width (m)	37	37.1	37.1
	Flow Area (m2)	13	13	13
	Flow Velocity (m/s)	0.04	0.09	0.19
	Check	Ok	Ok	Ok

Table 26. Wetland velocity calculations for WL_E

	Parameter	Q 3 month	Q 1 year	Q 5 year
Flow conditions	Design Flow (m3/s)	0.68	1.55	3.40
	Flow depth (m) – sed basin	0.35	0.35	0.35
	Flow depth (m) – wetland	0.35	0.35	0.35
Sediment pond	Width at NWL (m)	20	20	20
	Width at EDD (m)	24.2	24.2	24.2
	Average width (m)	22.1	22.1	22.1
	Flow Area (m2)	7.7	7.7	7.7
	Flow Velocity (m/s)	0.09	0.20	0.44
	Check	Ok	Ok	OK
Macrophyte zone	Width at NWL (m)	44	44	44
	Width at EDD (m)	48.2	48.2	48.2
	Average width (m)	46	46.1	46.1
	Flow Area (m2)	16	16	16
	Flow Velocity (m/s)	0.04	0.10	0.21
	Check	Ok	Ok	Ok

Table 27. Wetland velocity calculations for WL_H

	Parameter	Q 3 month	Q 1 year	Q 5 year
Flow conditions	Design Flow (m3/s)	0.40	0.90	2
	Flow depth (m) – sed basin	0.35	0.35	0.35
	Flow depth (m) – wetland	0.35	0.35	0.35
Sediment pond	Width at NWL (m)	15	15	15
	Width at EDD (m)	19.2	19.2	19.2
	Average width (m)	17.1	17.1	17.1
	Flow Area (m2)	6.0	6.0	6.0
	Flow Velocity (m/s)	0.07	0.15	0.33
	Check	Ok	Ok	OK
Macrophyte zone	Width at NWL (m)	25	25	25
	Width at EDD (m)	29.2	29.2	29.2
	Average width (m)	27	27.1	27.1
	Flow Area (m2)	9	9	9
	Flow Velocity (m/s)	0.04	0.09	0.21
	Check	Ok	Ok	Ok

Table 28. Wetland velocity calculations for WL_F

	Parameter	Q 3 month	Q 1 year	Q 5 year
Flow conditions	Design Flow (m3/s) *(flow halved)	0.29	1.32	2.88
	Flow depth (m) – sed basin	0.35	0.35	0.35
	Flow depth (m) – wetland	0.35	0.35	0.35
Sediment pond	Width at NWL (m)	17	17	17
	Width at EDD (m)	21.2	21.2	21.2
	Average width (m)	19.1	19.1	19.1
	Flow Area (m2)	6.7	6.7	6.7
	Flow Velocity (m/s)	0.04	0.20	0.43
	Check	Ok	Ok	OK
Macrophyte zone	Width at NWL (m)	38	38	38
	Width at EDD (m)	42.2	42.2	42.2
	Average width (m)	40	40.1	40.1
	Flow Area (m2)	14	14	14
	Flow Velocity (m/s)	0.02	0.09	0.20
	Check	Ok	Ok	Ok

*Flow split into a dual fed system to lower width requirement

Table 29. Wetland velocity calculations for WL_K

	Parameter	Q 3 month	Q 1 year	Q 5 year
Flow conditions	Design Flow (m3/s)	0.79	1.8	3.93
	Flow depth (m) – sed basin	0.35	0.35	0.35
	Flow depth (m) – wetland	0.35	0.35	0.35
Sediment pond	Width at NWL (m)	28	28	28
	Width at EDD (m)	32.2	32.2	32.2
	Average width (m)	30.1	30.1	30.1
	Flow Area (m2)	10.5	10.5	10.5
	Flow Velocity (m/s)	0.07	0.17	0.37
	Check	Ok	Ok	OK
Macrophyte zone	Width at NWL (m)	63	63	63
	Width at EDD (m)	67.2	67.2	67.2
	Average width (m)	65	65.1	65.1
	Flow Area (m2)	23	23	23
	Flow Velocity (m/s)	0.03	0.08	0.17
	Check	Ok	Ok	Ok

Table 30. Wetland velocity calculations for WL_L

	Parameter	Q 3 month	Q 1 year	Q 5 year
Flow conditions	Design Flow (m3/s)	1.09	2.49	5.43
	Flow depth (m) – sed basin	0.35	0.35	0.35
	Flow depth (m) – wetland	0.35	0.35	0.35
Sediment pond	Width at NWL (m)	30	30	30
	Width at EDD (m)	34.2	34.2	34.2
	Average width (m)	32.1	32.1	32.1
	Flow Area (m2)	11.2	11.2	11.2
	Flow Velocity (m/s)	0.10	0.22	0.48
	Check	Ok	Ok	OK
Macrophyte zone	Width at NWL (m)	68	68	68
	Width at EDD (m)	72.2	72.2	72.2
	Average width (m)	70	70.1	70.1
	Flow Area (m2)	25	25	25
	Flow Velocity (m/s)	0.04	0.10	0.22
	Check	Ok	Ok	Ok

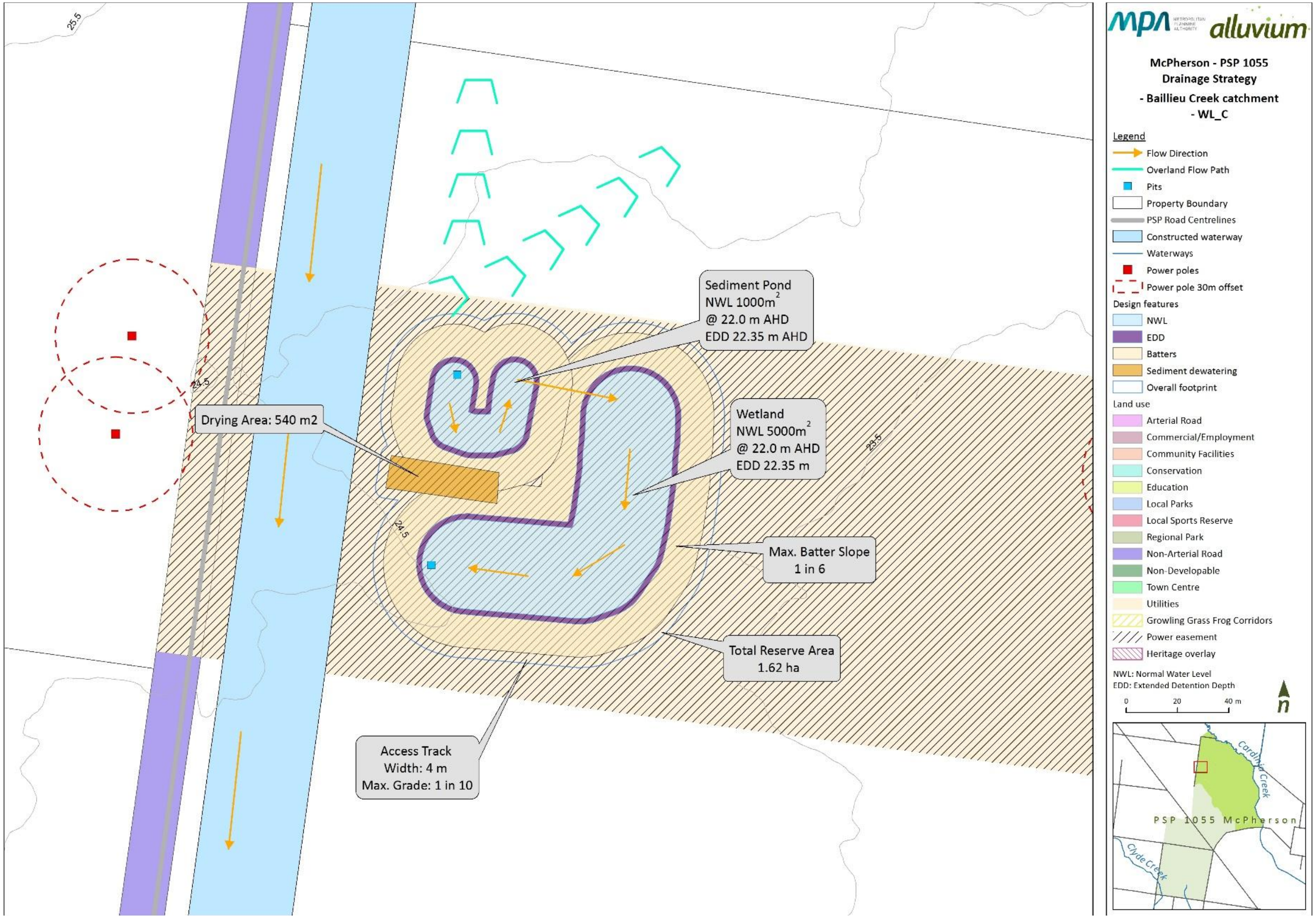
Table 31. Wetland velocity calculations for WL_14&15 Ext

	Parameter	Q 3 month	Q 1 year	Q 5 year
Flow conditions	Design Flow (m3/s)	1.87	4.99	9.37
	Design Flow (dual fed system)	0.94	2.49	4.68
	Flow depth (m) – sed basin	0.5	0.5	0.50
	Flow depth (m) – wetland	0.35	0.35	0.35

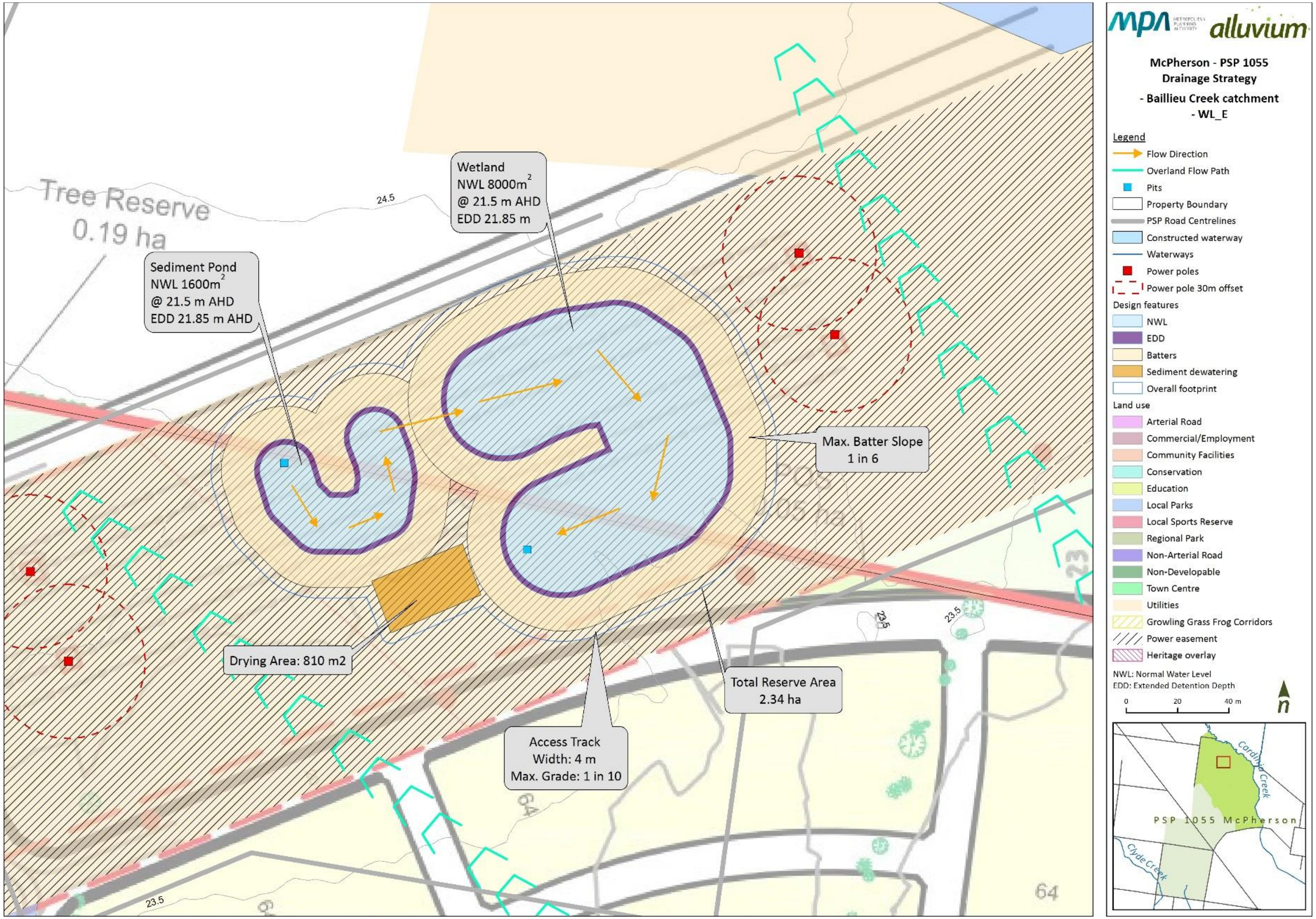
Sediment pond	Width at NWL (m)	12	12	-
	Width at EDD (m)	18	18	-
	Average width (m)	15.0	15.0	-
	Flow Area (m2)	5.3	5.3	-
	Flow Velocity (m/s)	0.18	0.47	-
	Check	Ok	Ok	-
Macrophyte zone	Width at NWL (m)	52	52	52
	Width at EDD (m)	56.2	56.2	56.2
	Average width (m)	54	54.1	54.1
	Flow Area (m2)	19	19	19
	Flow Velocity (m/s)	0.05	0.13	0.25
	Check	Ok	Ok	Ok

Appendix D
Wetland concept designs

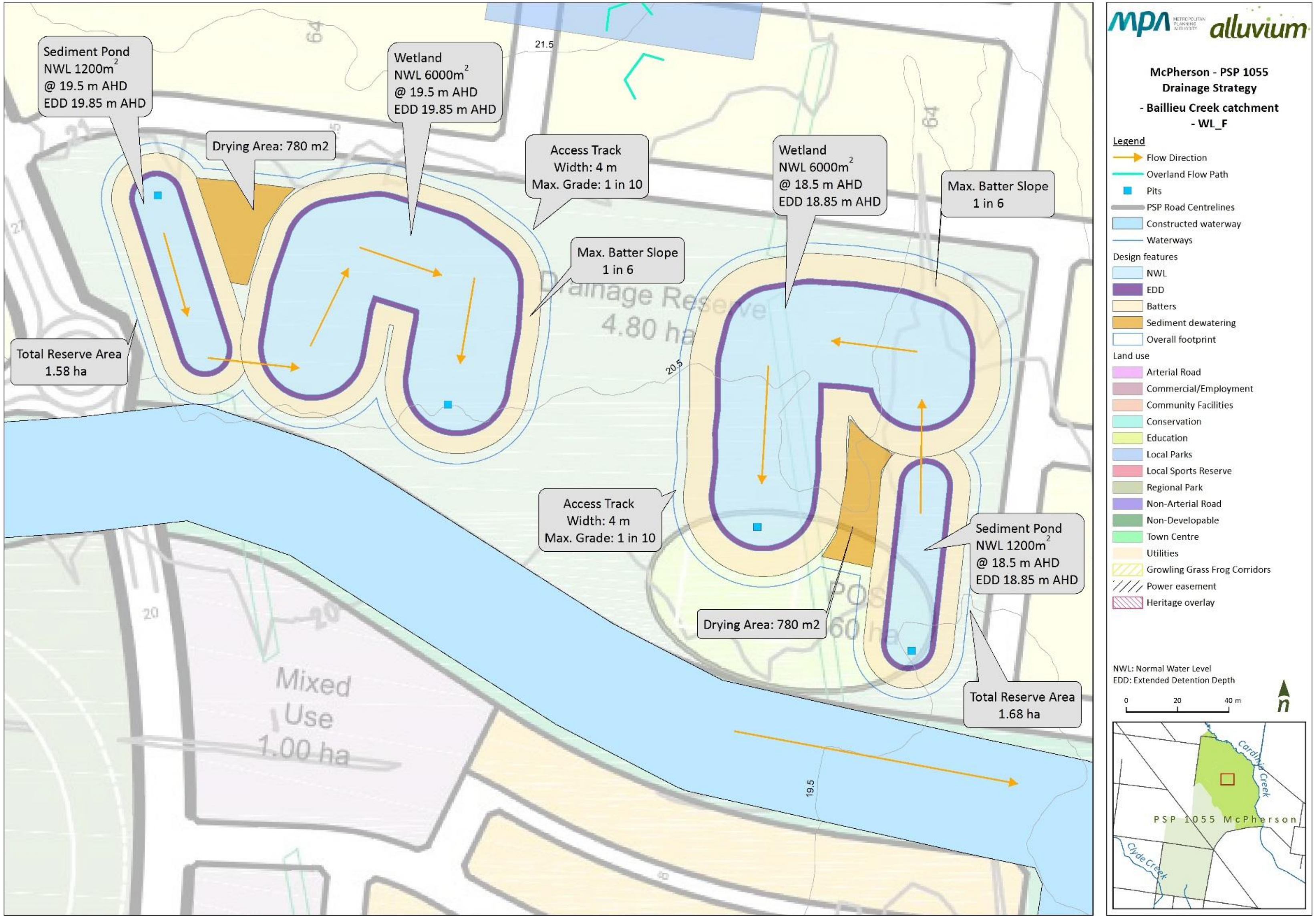
Baillieu Creek – WL_C



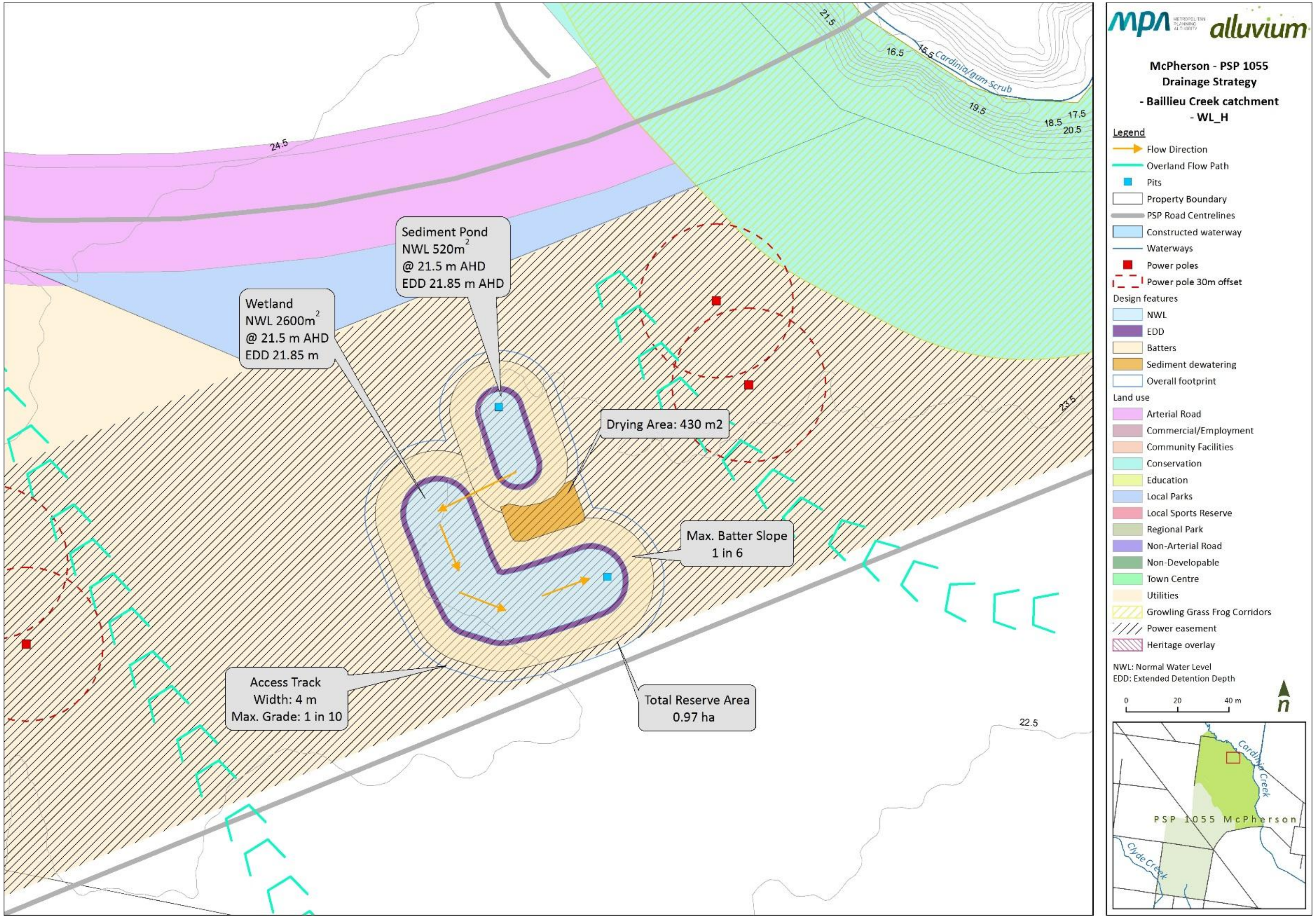
Baillieu Creek – WL_E



Baillieu Creek – WL_F

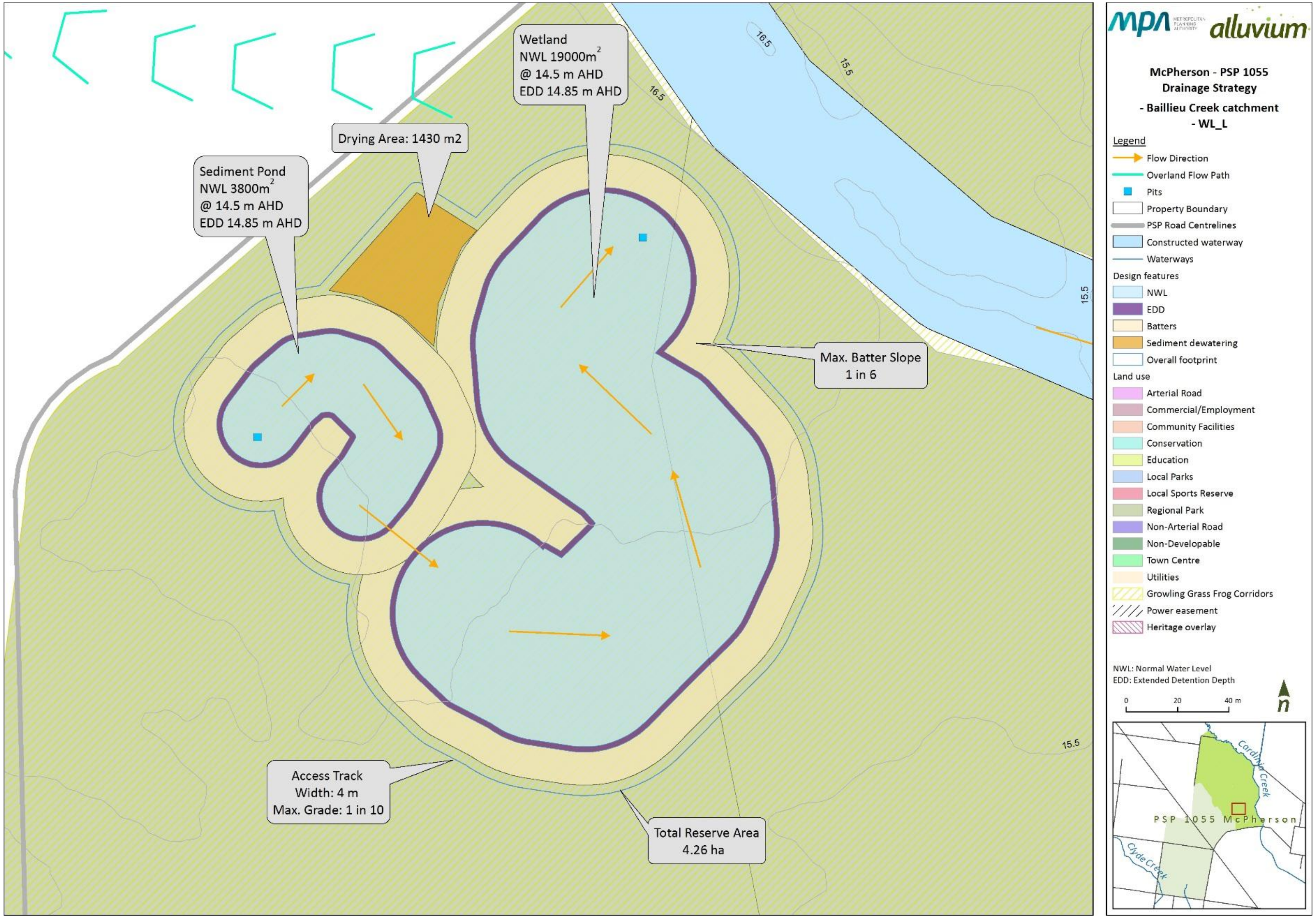


Baillieu Creek – WL_H



Baillieu Creek – WL_K

Baillieu Creek – WL_L



Muddy Gates Drain – WLRB_14&15