SURFACE/STORM WATER MANAGEMENT STRATEGY:

1960 & 2040 Mickleham Road, Mickleham

Lindum Vale

Satterley Property Group

May 2018

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1 Introduction

Alluvium Consulting Australia Pty Ltd (Alluvium) has been engaged by Satterley Pty Ltd (Satterley) to prepare a Surface/Storm Water Management Strategy (SWMS), in support of its permit application for the 1960 & 2040 Mickleham Road, Mickleham site.

The purpose of this SWMS is to propose management strategies for:

- Stormwater quantity
- Stormwater quality
- Passive irrigation
- Interim conditions

Through meeting these objectives, this SWMS acts as a critical component of the development servicing strategy and ensures stormwater is managed in accordance with Melbourne Water's and Council's requirements. Information with respect to scheme assets are provided at a concept design level.

Following an ecological assessment of tree moisture needs, the site specific functional design response for the subdivisional layout and drainage should be guided by the following principles (where practical):

- that the drainage system maximises passive irrigation opportunities;
- that water remains as close to the surface as possible in areas identified for passive irrigation;
- that the subdivision is designed to delineate small catchments to minimise pipe sizes;
- that internal and external stormwater are considered as a means to passively irrigate retained native vegetation;
- that open spaces areas are designed to act as overland flow paths where practical;
- that the alignment of road reserves assist with local passive irrigation opportunities; and that drainage infrastructure does not impact on the health of retained trees.

1.1 Reference material

- Melbourne Water's Aitken Creek Developer Services Scheme
- Lindum Vale (Mt Ridley West) Precinct Structure Plan (MPA)
- Preliminary development layout (Spiire Consulting)
- Site visit and inspection
- Site survey
- Australian Rainfall & Runoff (1987) – Engineers Australia
- Australian Rainfall & Runoff (2016) – Engineers Australia
- Urban Stormwater Best Practice Environmental Management Guidelines (1999)
- Stormwater Strategy – Lindum Vale (Aug 2015), prepared by Dalton Consulting Engineers
- Lindum Vale PSP 1202: Biodiversity Assessment Draft Report (Apr 2015), prepared by Biosis

2 Site overview

Satterley's 1960 & 2040 Mickleham Road 145 hectare landholding sits approximately 9 kilometres north of Craigieburn. The site is generally bound by the, the powerline transmission easement to the north, Mickleham Road to the west, Mt Ridley Road to the south and existing rural living zone to the east (refer to Figure 1).

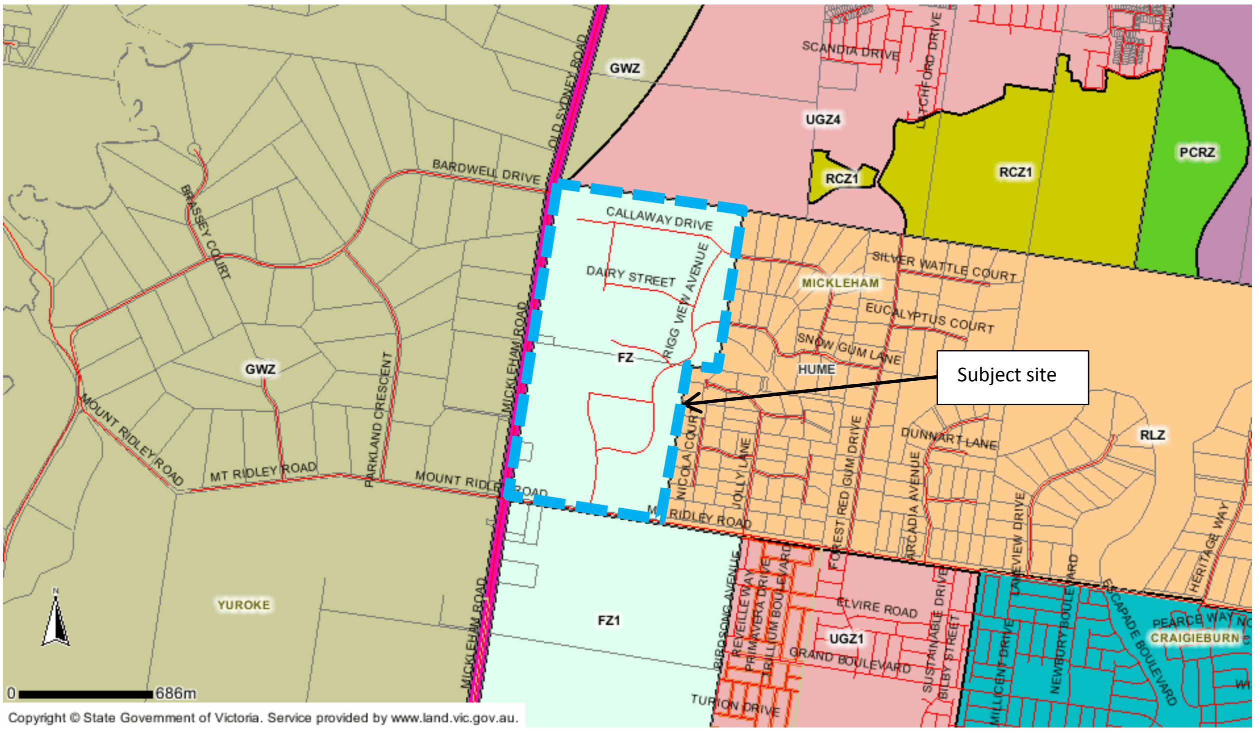


Figure 1. *Site location*

Satterley's Mickleham Road site is located in the Lindum Vale (Mt Ridley West) Precinct Structure Plan, currently in preparation by the VPA. Figure 2 shows the most currently available Future Urban Structure. The PSP went on formal exhibition on 31 August 2017.

The site occupies the periphery of the Urban Growth Boundary, bound to the north-west by the Outer Metropolitan Ring Road (OMR) corridor. There is a significant stand of remnant native vegetation within the site, predominantly River Red Gum and Grey Box Gum, covered by environmental significance overlays (ESO) 5 and 11. This presents a constraint on the total developable area as most of these trees are to be retained subject to Council approval. Additionally, a large section of conservation zoned land exists in the south-eastern corner.

The site is located within the Malcolm Creek catchment, part of the greater Merri Creek catchment. The topography of the subject site varies with grades typically ranging from 0.5 to 2% and the land generally falls in an easterly direction.

Figure 2. *Lindum Vale Precinct Structure Plan (PSP)*

A small section (approximately 12 hectares) of the southern part of the site is included in the Aitken Creek Development Services Scheme (see Appendix A). The remainder of the site is not covered by a currently active DSS.

2.1 Site photos

An aerial photograph is shown in Figure 3, which covers the subject site and its surrounds. The remnant native vegetation is clearly visible within the site boundary.

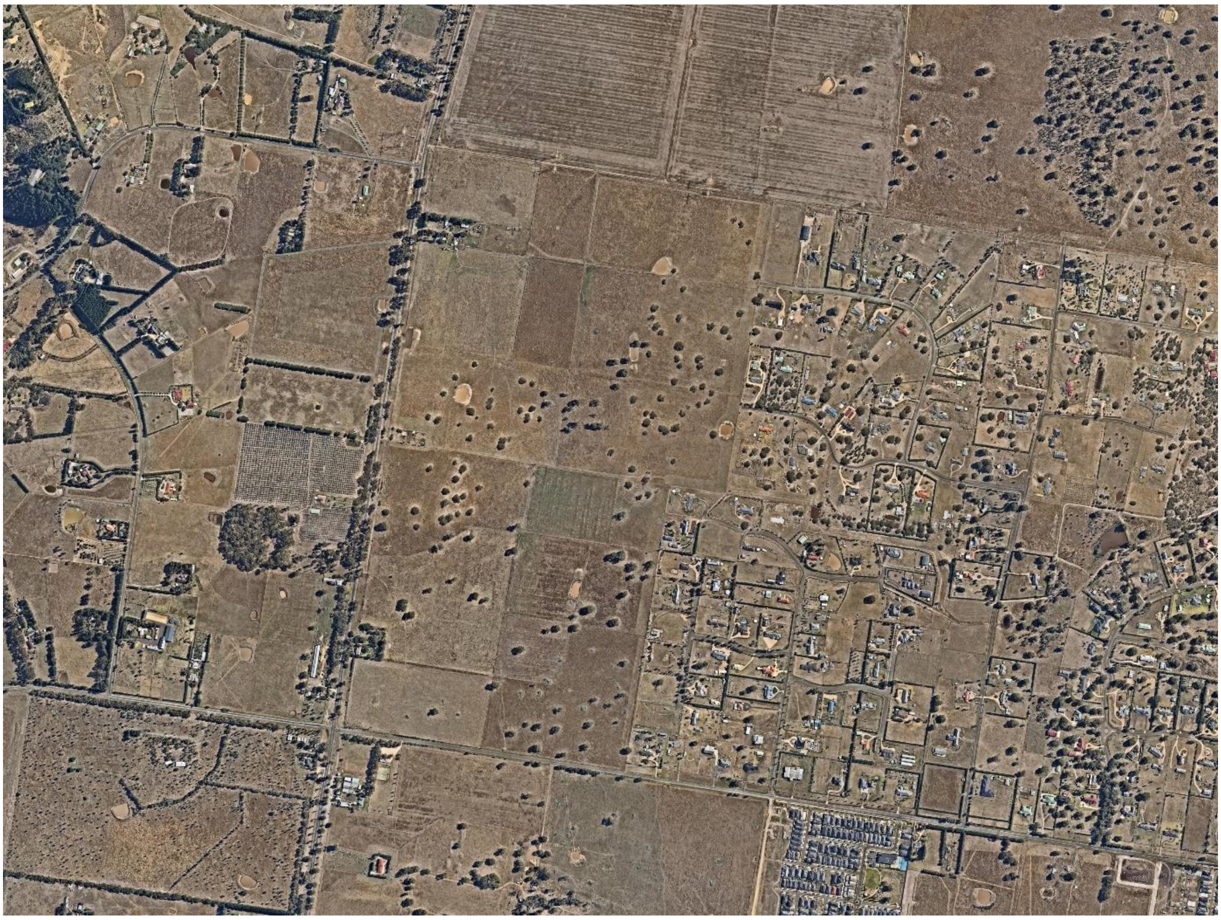


Figure 3. *Aerial photograph of the site*

3 Catchments

There are two major catchment types considered in this report; these are referred to as the "External Catchment" and the "Internal Catchment." For the purposes of this report, the term "external catchment" refers to any land outside the Lindum Value site boundary. Broadly, the site includes two distinct catchments. A large northern catchment forms part of the local Malcolm Creek catchment. Malcolm Creek drains to Merri Creek approximately 8 kilometres to the south-east. A ridgeline separates a smaller southern catchment which drains south to Aitken Creek. Aitken Creek eventually joins Merri Creek a little over 1 kilometre south of its confluence with Malcolm Creek.

A large, approximately 80 hectare external catchment enters the site from the west and joining the internal northern catchment. Figure 4 gives the catchment context and extent. The size and description of these catchments are provided in Table 1. The total catchment area is approximately 221.8 hectares. These are the base catchments, which will be altered slightly when the major and minor flows are considered in detail.

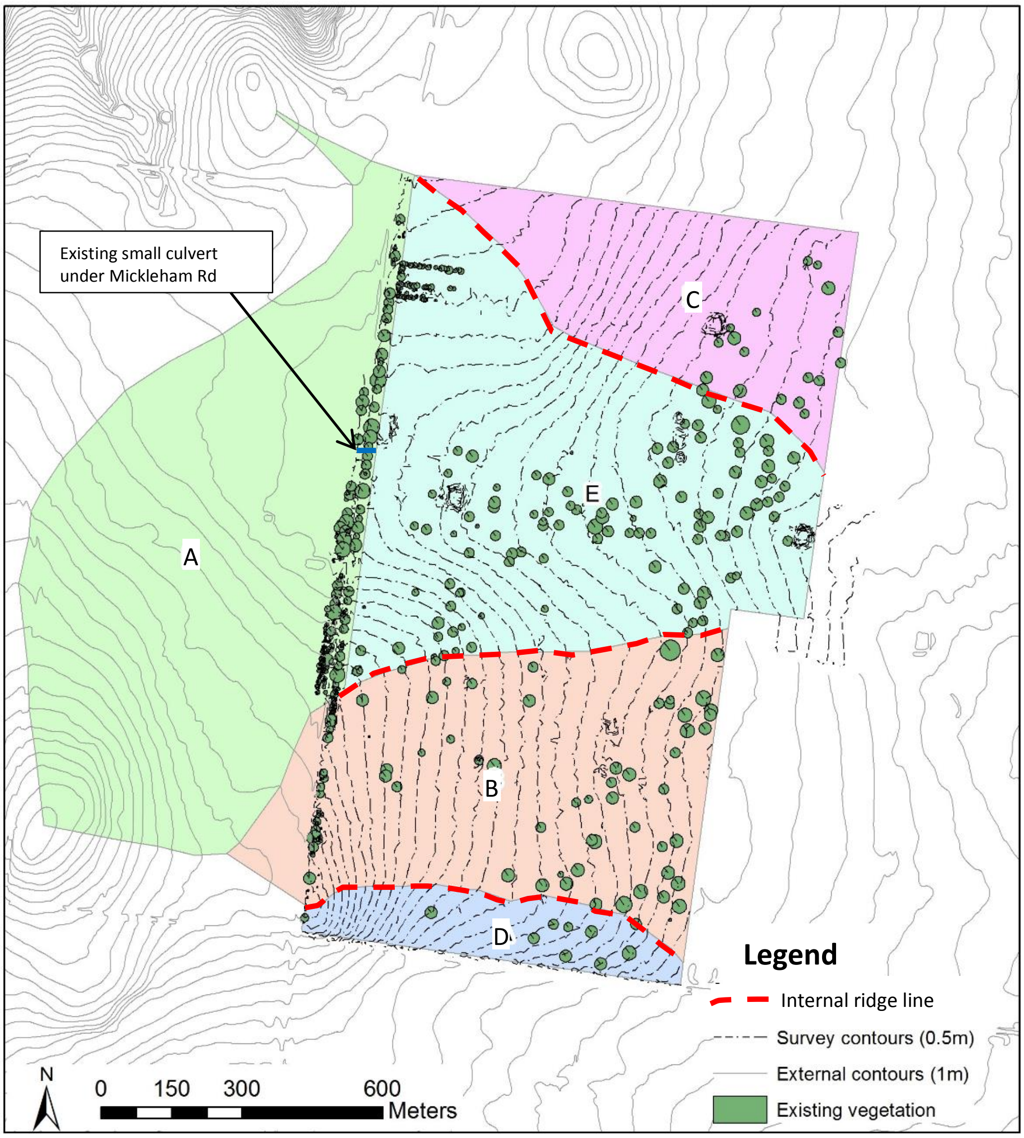


Figure 4. *Total catchment extent for water quality treatment*

Table 1. Catchment areas contributing to the water quality treatment system

Catchment type	Sub-catchment label	Area (ha)	Notes
External	A	79.7	External catchment in green-wedge zone. Flows under Mickleham Road through existing culverts at the natural surface low point and enters the subject site through the western boundary. Not required to be treated for water quality standards.
Internal	B	42.5	Drains east to Malcolm Creek, exiting the site toward the south-eastern boundary. Forms a confluence with catchment E approximately 1.5 kilometres to the east of the subject site.
Internal	C	26.6	Drains east to Malcolm Creek, exits the subject site at the north-eastern boundary. Forms a confluence with catchments B and E approximately 2 kilometres to the east of the subject site.
Internal	D	9.9	Drains south to Aitken Creek. Forms part of the Aitken Creek DSS and is not considered for this study.
Internal	E	64.0	Exits the subject site at the central eastern boundary through an existing open drainage cut. Eventually drains to Malcolm Creek, meeting with the natural outlet to catchment B and C to the east at 1.5 and 2 kilometres, respectively.

4 Existing conditions - site analysis

The drainage and hydrologic analysis of the existing site has been informed from site inspections and hydrologic modelling. The kinematic wave equation and rational method was used to estimate the peak design flows from the subject site under existing (i.e. pre-development) conditions.

Recent research on the estimation of peak flood flows for rural catchments for Engineers Australia has been published in Australian Rainfall and Runoff (ARR) Project 5, Stage 2 Report, dated June 2012. This report recommends that ARR move to a regional regression analysis approach for calculating pre-development peak flood flows. The report also considered the accuracy of the current ARR method (the Adams Rural Rational Method) and found that this method was appropriate, but suggested adjustment of the results for very small catchments as per the relation shown on Figure 5.3.6 of the ARR 2012 report (see Figure 5 below). The latest (2016) edition of ARR provides guidance on how to use the Regional Flood Frequency Estimate (RFFE) for design flood estimation in ungauged catchments. However, the RFFE model has several constraints which limit its applicability to this particular site.

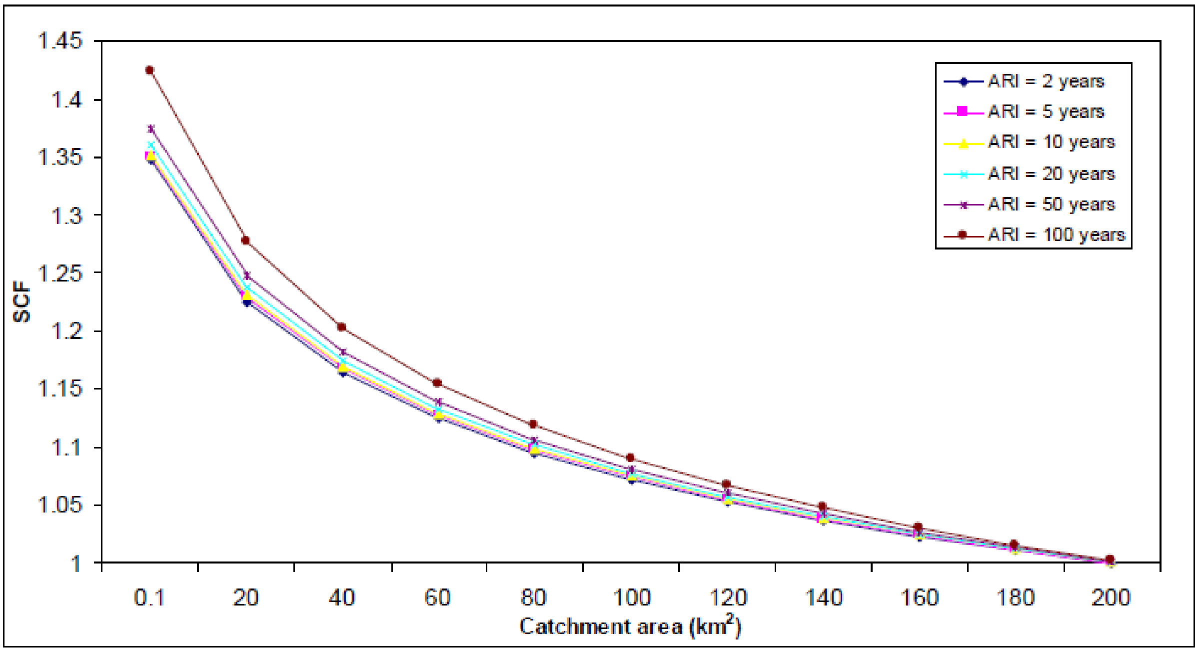


Figure 5. *Relationship between scale correction factor (SCF) and catchment area.*

Peak flows for existing rural conditions are therefore to be derived using the current ARR Method with Adams equation for estimation of time of concentration with matched runoff coefficients, all in accordance with the recommendations set out in ARR. The correction factors are then to be applied to calculated discharges. This will be compared for consistency to the estimate from the RFFE model, noting there will be high uncertainty in the latter result.

The following design rainfall parameters were adopted for Cloverton based upon the Bureau of Meteorology's "Intensity Frequency Duration (IFD) Tool – AR&R 87).

Table 2. AR&R Design Rainfall parameters

Parameter	Value
1hr 2yr	19.1
12hr 2yr	3.95
72hr 2yr	1.05
1hr 50yr	43.0
12hr 50yr	7.86
72hr 50yr	2.41
Skew	0.33
F2	4.3
F50	14.97
Zone	1

4.1 Catchment outfall

Within the northern catchment, from sub-catchments B, C and E (refer Figure 4 above), the current overland drainage results in three distinct flow path outlets (see Figure 6). These eventually form a confluence downstream to the east and connect to Malcolm Creek. Two of these converge a short distance east of the site boundary. The third converges approximately 1.5 kilometres east.

Under existing conditions the major drainage line exiting the site is shown as the central blue dashed line in Figure 6. This drainage line is contained within a Melbourne Water drainage reserve through the low-density residential area to the east.

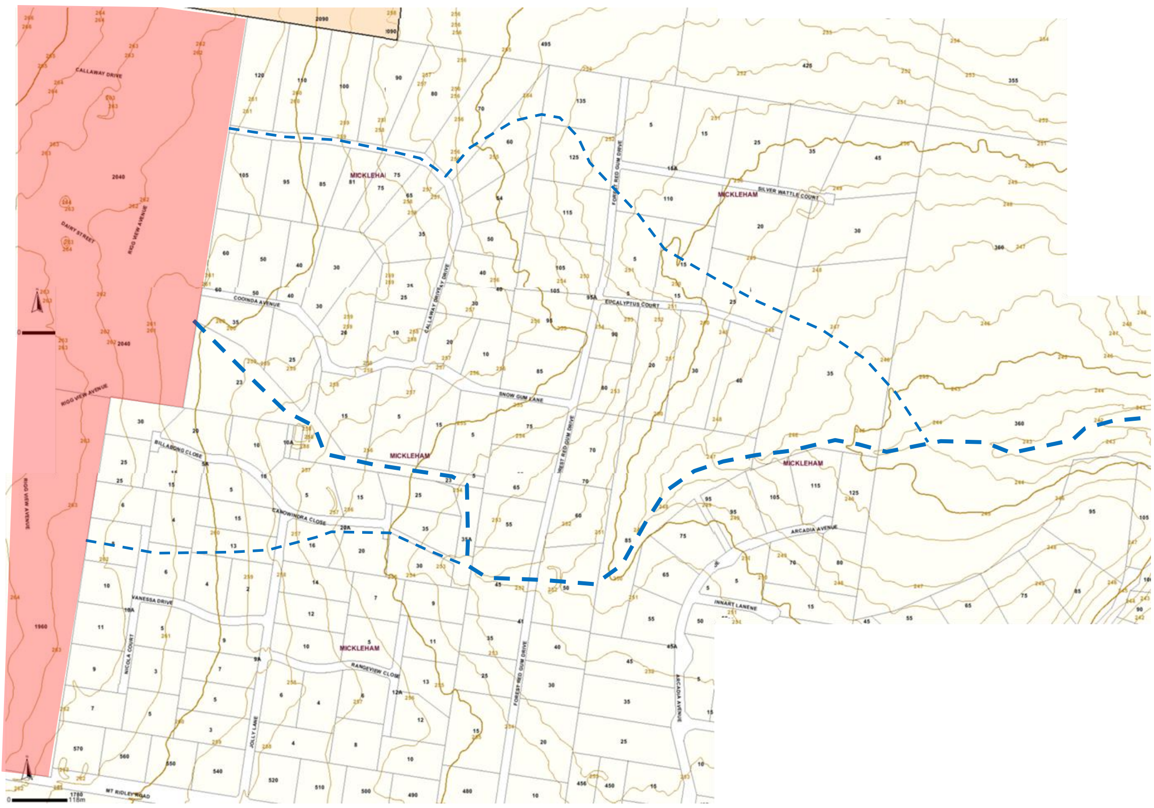


Figure 6. *Overland flow paths and natural drainage outfalls*

In contrast two other minor drainage lines exit the site with no drainage reserve or easement. Under existing conditions the discharge characteristics would be that of “sheet flow” across the boundary. For the southern depression, flows would currently discharge from the subject site directly into a private allotment. For the northern depression, surface flows can initially be conveyed within the adjoining road reserve. However the current road reserve (Callaway Drive) has a low point about 400 metres, where it then flows through a low-density residential allotment.

Based on the above, the existing outfall constraints and characteristics need to inform the future surface water management strategy for the development of the Lindum Vale PSP. That is the concentrated outflows from the developed catchment should not be allowed to discharge into adjoining residential properties. As a result the proposed surface water management strategy will need to collect, retard and convey all surface flows up to the 100 year ARI event to the existing drainage reserve that interfaces with the development.

Table 3 shows the results from the rational method and the RFFE model. Note the RFFE result is not used directly in this study, but was useful in providing confidence in the estimate from the Rational Method. RFFE flow estimates for catchments B and C were not provided as the catchment area is smaller than the recommended range for this method.

Table 3. Estimated pre-development 100 year ARI peak flows

Catchment	**100 year ARI peak flow** *(m^3/s)*	
	Rational Method	RFFE model (median estimate)
C	1.53	n/a
A, E	5.88	4.5
B	2.26	n/a

4.2 Hydrologic Modelling

RORB software (v6.18) is used to model the effect of development in the study area. RORB is a rainfall-runoff routing model that simulates catchment influences on runoff through translation and attenuation of rainfall inputs. RORB is used to estimate the changes in 100 year ARI peak flow and required storage volumes; and the effectiveness of retarding basin design on reducing flow rates to similar levels at existing conditions.

The RORB model was initially developed using sub-catchment characteristics of the undeveloped (existing) site. Existing conditions were informed by aerial photography, previous site visits and professional judgement. Figure 7 shows the RORB model of the catchment including subareas and reaches.

The model was “calibrated” to existing conditions using an estimate of peak flow from the Adams Rural Rational Method. The RORB model was used to estimate key design flows throughout the catchment and size retarding basin storages. At least 4 subareas exist upstream from the point of interest.

The hydrologic modelling considered a range of design storms, from 10 minutes duration through to 72 hours, to determine the critical duration event with respect to reach and other major storage.

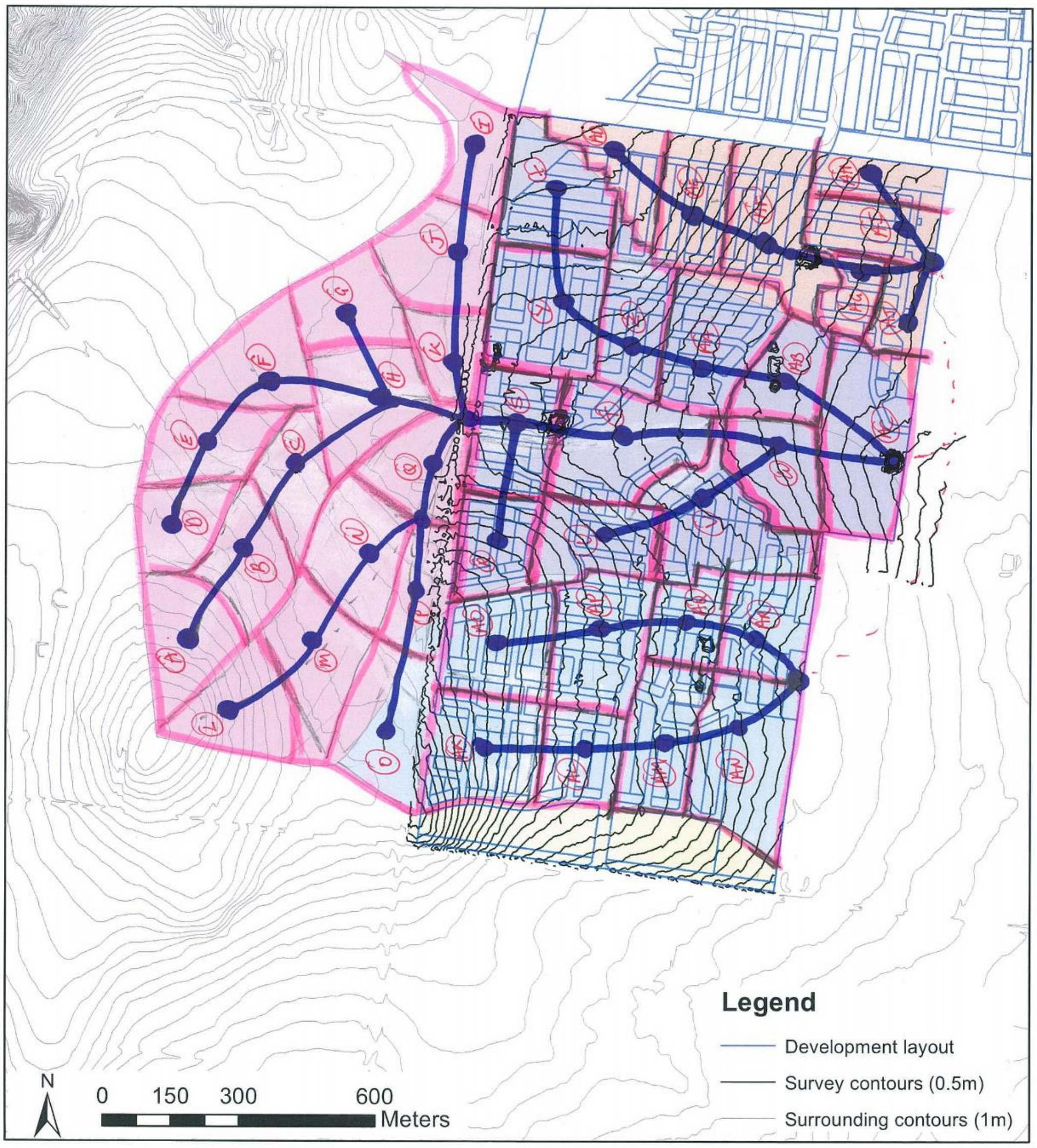


Figure 7. *RORB model of the total catchment contributing to the treatment system.*

Rainfall inputs in the form of Intensity Frequency Duration (IFD) data were taken for Mickleham. Table 4 shows the results for the Rational Method and RFFE, and the peak flow from the calibrated RORB model. Table 5 shows the calibrated catchment parameters, rainfall inputs, aerial reduction factors and loss rates. An initial loss of 10mm and continuing loss model of 2.5mm/hr were assumed.

Table 4. Comparison of 100 year ARI peak flow estimates.

Estimation method		**100 year ARI peak flow *(m3/s)***	
-	*Outlet AJ (north)*	*Outlet AC (central)*	*Outlet AR (south)*
Rational Method	1.53	5.88	2.26
RORB*	1.62	5.33	2.44

**RORB model calibrated to match Rational Method estimate*

Table 5. RORB model parameters and calibrated values for existing conditions.

Model parameter	Value
Kc	2.15
IL	10 mm
CL	2.5 mm/h
IFD location	Mickleham
Aerial reduction factors	Siriwardena and Weinmann

Developed conditions

Development in the catchment is simulated primarily by varying fraction impervious data, changing reach types to match road and pipe design, and varying the loss model. Fully developed residential sub-catchments adopted a fraction impervious of 0.75, whilst those with drainage reserves and open space were modified accordingly. Open space and conservation areas used a fraction impervious of 0.1. The green wedge external catchment to the west was assumed to remain undeveloped and adopted a fraction impervious of 0.05. Catchment boundaries and reach lengths are as in Figure 7.

An initial loss of 10mm and runoff coefficient (proportional loss) model of 0.6 were assumed for developed conditions.

5 Criteria for SWMS

Based upon the findings in Section 4.1, retardation storage will be required to control the peak flowrates generated by future development of the Lindum Vale PSP area. For flows up to the 100 year ARI event, the only available point of discharge will be the existing Melbourne Water drainage reserve. This will require the use of three retarding basins to collect and mitigate flows. The outlet from the upper and lower retarding basins will be a pipeline that outfalls to the drainage reserve immediately downstream of the central retarding basin. In order to provide an outfall to the development, the existing drainage line will be re-formed into a constructed waterway from the eastern site boundary to the drainage line confluence located about 400 metres upstream of Forest Redgum Drive (refer to Section 8 for further details)

Therefore in summary the criteria for the proposed Lindum Vale strategy, based on the analysis of existing conditions and drainage authority requirements are as follows:

- Meet best practice pollutant removal targets
- Convey major flows through the site along road reserves and drainage reserve network
- Convey minor flows through local catchments in a piped network
- Fully developed stormwater runoff rates to be retarded to the equivalent pre-development peak flow rates, up to the 100 year ARI event, in order to protect downstream and adjacent properties. This requires:
    - No discharge of flows (ie catchment C) from the site along the northern existing drainage line
    - No discharge of flows from (ie catchment B) the site along the southern existing drainage line
    - The only discharge point from the site is along the central drainage line to the existing Melbourne Water drainage reserve. Flows to be retarded to the equivalent peak 100 year pre-development flow from catchments A,B and E.
- Consider how the drainage system can continue to supply runoff/watering of the retained native vegetation that exists throughout the site in open space.

6 Stormwater Quantity – Proposed Strategy

6.1 Drainage system

The proposed internal drainage system should be designed and constructed in accordance with the minor / major drainage system philosophy. For drainage assets within a catchment area of 60 hectares, Council design standards are expected to apply. For drainage assets greater than 60 hectares, Melbourne Water design standards are expected to apply.

Sub-catchment areas and runoff behaviour are described in Table 6. The internal sub-catchments and the location of flows at key points of interest are shown in Figure 8.

Table 6. Sub-catchment areas and descriptions

Name	Area (ha)	Fraction impervious	Notes
A	79.72	0.05	External. Flows through culvert under Mickleham Road and enters site on western boundary. Higher flows expected to overtop Mickleham Road and enter the subject site at multiple points.
b	7.33	0.55	Internal. Flows east to southern outlet
c1	2.14	0.75	Internal. Generally flows east to catchment Z
D	12.15	0.52	Internal. Flows south across southern boundary into Aitken Creek DSS. Not considered as part of this study
e	11.09	0.2	Internal. Flows east to central outlet
F	2.30	0.75	Internal. Flows north-east to catchment G
G	3.55	0.63	Internal. Flows east to catchment W
H	2.35	0.55	Internal. Flows east to northern outlet
I	4.22	0.75	Internal. Generally flows east, modified to converge with catchment H at northern outlet
J	7.84	0.54	Internal. Generally flows east, modified to converge with catchment H at northern outlet
K	5.76	0.64	Internal. Flows south-east to catchment H
L	5.75	0.66	Internal. Flows south-east to catchment K
M	8.20	0.72	Internal. Flows south to catchment N
N	6.92	0.75	Internal. Flows south-east to catchment O
O	4.06	0.75	Internal. Generally flows south-east to catchment R
P	6.55	0.73	Internal. Generally flows east. Low flows join catchments O, higher flows diverted to catchment S
Q	3.26	0.75	Internal. Generally flows north-east. Flows diverted east to catchment Y
R	4.89	0.75	Internal. Flows east to catchment E
S	5.20	0.15	Internal. Flows east to catchment E
T	2.59	0.75	Internal. Generally flows north-east to catchment Q
U	3.92	0.55	Internal. Flows east to catchment B
V	6.78	0.71	Internal. Flows east to catchment B
W	5.03	0.75	Internal. Flows east to catchment X
X	5.68	0.1	Internal. Generally flows east to southern outlet
Y	7.82	0.61	Internal. Generally flows north-east to catchment C
Z	8.92	0.59	Internal. Generally flows north-east to central catchment outlet

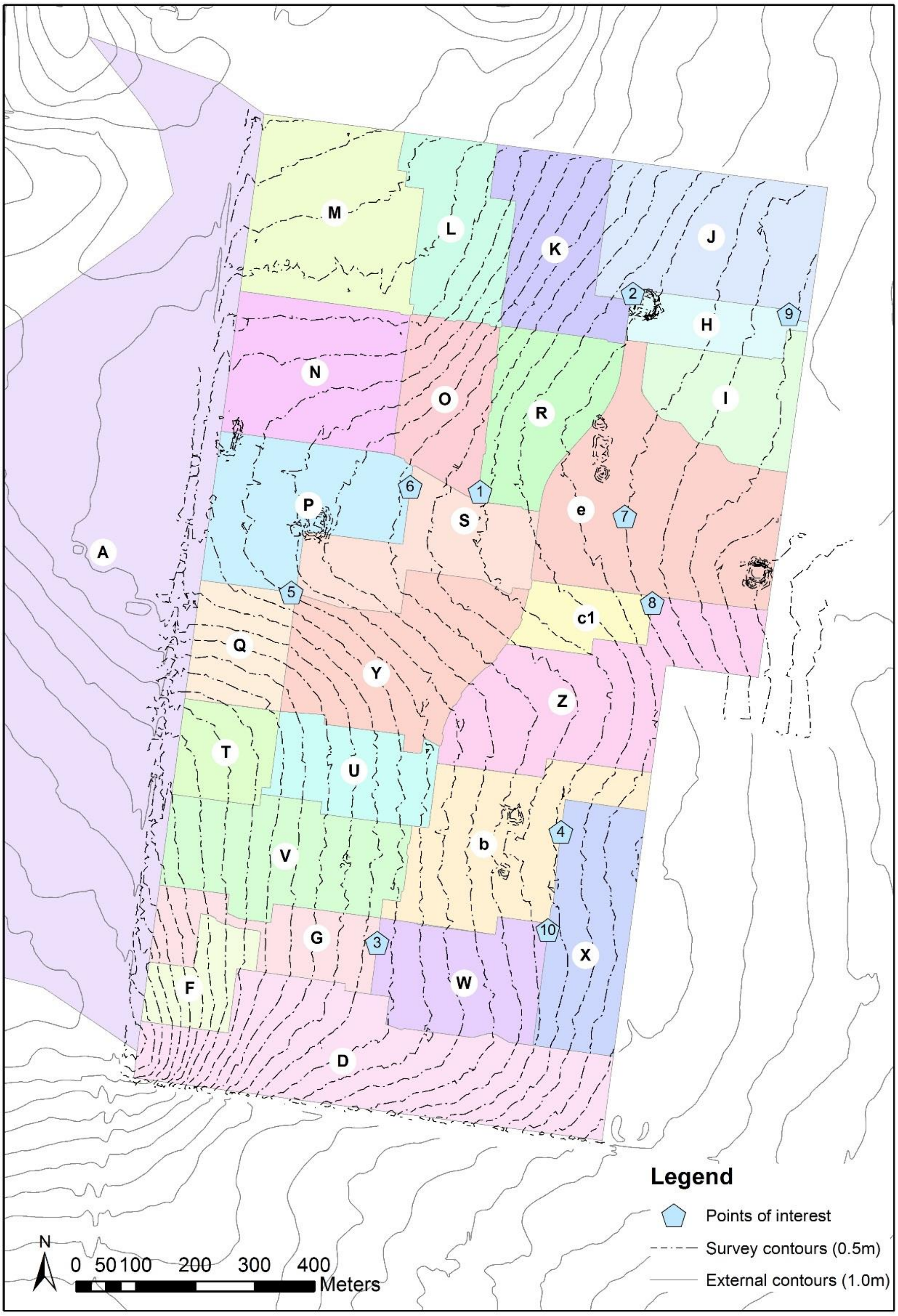


Figure 8. *Drainage sub-catchments and key points of interest in the subject site*

6.2 Minor drainage system

The minor drainage system would consist essentially of an underground piped network and should be designed to accommodate a 1 in 5 year average recurrence interval event (ARI). The calculations adopted a 5-year ARI runoff coefficient of 0.68 for residential area, based on a fraction impervious of 0.75. Table 7 gives the minor flows at flow locations shown in Figure 8.

Table 7. Ultimate minor flows

Location	Contributing catchment	Area (ha)	tc (min)	I (mm/h)	Minor flows (5 year ARI)	Maximum pipe size required (mm diameter)
0	A	79.5	42	31.57	1.73	-
1	A*,M, N, O	98.68 (19.18)	14.0	57.47	2.08	1050
2	K, L	11.5	13.6	60.4	1.1	750
3	F, G	5.9	10.8	65.8	0.6	600
4	b, U, V	18.0	13.3	61.1	1.8	900
5	T, Q	5.9	11.7	64.2	0.7	675
6	P	6.55	9.0	70.46	0.87	750
7	A*, M, N, O, P, R, S,T,Q,Y	128.17 (49.49)	16	53.80	5.44	1350
8	c1, Y	9.33	12.0	61.86	1.1	750
9	H, I, K, L	18.1	16.3	55.2	1.6	1050
10	F, G, W	10.9	13.6	60.5	0.9	825

‘ - partial area controls. Overall contributing area is shown in brackets*

Based on the catchment areas, all the pipe network within the subject site is expected to become the responsibility of Council, with the exception of the minor drainage pipe from location 0 to location 7. This entire length of pipe will be a Melbourne Water asset, as the external catchment entering the western boundary exceeds 60 hectares in area.

Stormwater quantity criteria:

- ✓ Convey minor flows (Q5 year) through residential catchments in a piped network
  - ✓ Maximum flow is 5.44 m^3/s, with pipe size of 1350 mm
  - ✓ All pipes are Council assets, except for minor drainage pipe that extends from Location 0 to the proposed wetland within the central corridor

6.3 Major drainage system

The major drainage system will convey the 100 year ARI flows through the study area. This consists of the road reserves throughout the development and retarding basins at each treatment asset location.

As explained earlier, an external catchment west of Mickleham Road flows through the central portion of the subject site. This catchment is outside of the urban growth zone. There is a currently a small culvert under the road to accommodate surface flows. In larger events flows would overtop the road as “broad sheet flow”, with an inundation width of over 150 metres. This SWMS recommends that the culvert under Mickleham Road be upgraded to convey the 100 year flows under the road. The peak 100 year ARI flow is 4.60 cumecs (refer to Table 8), which would require twin culverts each 2.1 metres wide and 1.2 metres high to minimise the hydraulic head loss to around 100mm. An inlet and outlet structure at either end of the road reserve, combined with a low flow bypass pipe (to ensure the culverts are not permanently full of water), will enable road cover over the culverts and surcharge to a shallow depth overland flow path (see Figure 9). The downstream overland flow path will be the east-west “Boulevard Connector Street” with a 6 metre central median swale. Hydraulic analysis using HEC-RAS has determined that the proposed PSP 31 metre road reserve has an overland flow capacity of 7.5 cumecs, therefore the maximum 100 year flows can easily be contained. The 6 metre central swale provides an appropriate “land-form” to initially transfer the surcharge flows from the Mickleham Road culverts into the Boulevard road reservation.

This SWMS recommends that overland flows will generally flow across the natural topography and open space tree reservations. Given the desire to retain as many trees as possible, any significant earthwork cut to channelise the system should be avoided. Road reserves will be slighted elevated and localised landscape mounding will be utilised to direct any overland flows.

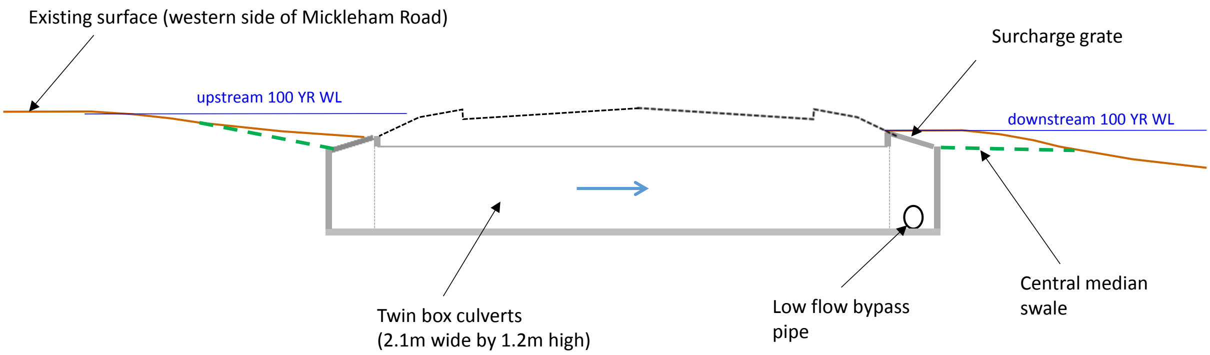


Figure 9. *Conceptual culvert arrangement at Mickleham Road*

Generally, the flows required to be conveyed in road reserves will be the 100 year ARI flow minus the 5 year ARI flow which will be contained within the minor piped drainage system. Major flow descriptions are given in Table 8 below.

Table 8. Ultimate major flows

Location	Contributing catchment	Area (ha)	tc (min)	I (mm/h)	Major flows (100 year ARI)	Q gap (Q100 - Q_{pipe})
0	A	79.5	42	61.93	4.60	-
1	A*, M, N, O	98.68 (19.18)	14	115.91	5.30	3.42
2	K, L	11.5	13.6	122.3	2.8	1.7
3	F, G	5.9	10.8	133.5	1.6	0.9
4	b, U, V	18.0	13.3	123.6	4.5	2.7
5	T, Q	5.9	11.7	130.1	1.7	0.9
6	P	6.55	9	59.32	4.56	2.46
7	A*, M, N, O, P, R, S,T,Q,Y	128.17 (48.49)	16	108.09	11.64	6.2
8	c1, Y	9.33	12.0	122.4	2.6	1.5
9	H, I, K, L	18.1	16.3	111.1	4.0	1.8
10	F, G, W	10.9	13.6	122.4	1.9	0.5

* Partial area effect controls (see contributing area in brackets)

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 9. This capacity has been determined using HEC-RAS based on the Melbourne Water floodway safety criteria for residential streets used as floodways and Council's requirement that 100 year flows must be contained within the road reserve and must not enter any part of private allotments:

- 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

Table 9. Road capacity flows.

Road width	Slope	Road capacity (m^3/s)
16 m	0.5 %	4.5
16 m	1.0 %	4.25
16 m	1.5 %	4.0
20 m	0.5 %	5.50
31 m	0.63 %	7.5

Based upon the above information all overland flows can be safely contained within the proposed road reserves. There are several locations where the overland flows are proposed to side-cast from the road into open space reserves. Where this occurs, flows are distributed along the length of the road and not concentrated in defined grassed floodways. The resulting flow depth across these sections is very small. Figure 10 shows the overland flow paths through the subject site.

Downstream of the north-south connector street, the drainage reserve/tree reserve for overland flows should be at least 60 metres wide. The culvert arrangement under the north-south collector road is likely to be similar to Figure 9, except that the size of the twin culverts may increase to 2.7 metres wide by 1.2 metres high.

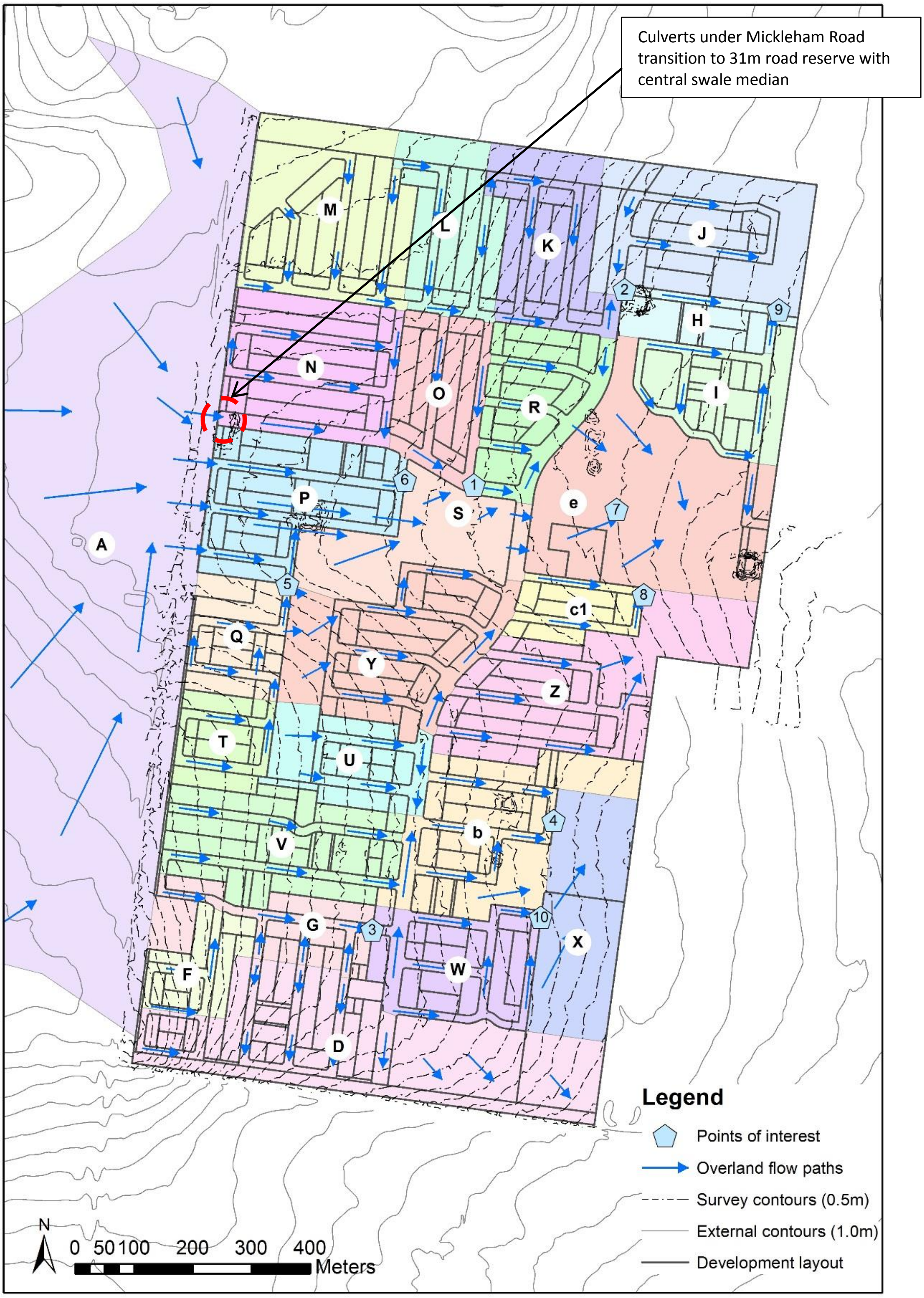


Figure 10. *Overland flow paths (based on indicative/preliminary development layout).*

Stormwater quantity criteria:

- ✓ Convey internal major flows through road reserves and pipe system
  - Maximum gap flow = 6.1 m^3/s distributed across open space at sub-catchment E
- ✓ Open space corridor provides conveyance for flows entering from large external sub-catchment A
- ✓ Retarding basins provide storage for flood attenuation of 100 year ARI peak flows to pre-development levels (see Section 6.4)

6.4 Retarding basin design

Developed stormwater runoff rates need to be controlled to the equivalent pre-development peak flow rates, up to the 100 year ARI event, in order to protect downstream and adjacent properties. This requires:

Catchment C – Northern Basin (refer to Figure 4)

- No discharge of flows from the site along the northern existing drainage line
- The collection, storage and reduction in peak flow rates via a local wetland/retarding basin asset
- All outflows from the basin, up to the 100 year ARI event, are conveyed in a pipe which traverses the eastern boundary of the site. The pipe outfalls to the existing Melbourne Water drainage reserve to the south. A constructed waterway will need to be formed within the 40 metre drainage corridor to provide outfall depth.

Catchment B – Southern Basin (refer to Figure 4)

- No discharge of flows from the site along the southern existing drainage line
- The collection, storage and reduction in peak flow rates via a local wetland/retarding basin asset
- All outflows from the basin, up to the 100 year ARI event, are conveyed in a pipe which traverses the eastern boundary of the site. The pipe outfalls to the existing Melbourne Water drainage reserve to the north. A constructed waterway will need to be formed within the 40 metre drainage corridor to provide outfall depth.

Catchment E – Central Basin (refer to Figure 4)

- The outlet downstream of Catchment E is the only discharge point from the site, where it connects to the existing Melbourne Water drainage reserve. The combined overall flows discharged to the Melbourne Water drainage reserve is to be retarded to the equivalent peak 100 year pre-development flow from catchments A,B and E (ie 6.9 cumecs).

The three proposed wetlands (see section 7 below) are located within the footprint of retarding basins designed to reduce peak flow rates to a level similar to pre-developed conditions. The initial retarding basin design was dictated by the wetland design, where the retarding basin formed the storage area "gained" by cut from the existing surface to the wetland normal water level.

The adequacy of this storage volume was assessed using the RORB model. Spillway parameters and pipe connections from the site outlet at the central wetland were initially assumed based on existing site contours. An iterative method was applied to size the pipe outlet connections such that the design peak outflow was similar to the estimate of existing conditions. The initial storage options provided by the cut from the existing surface to the wetland proved adequate to accommodate the 100 year ARI flow from the catchment (i.e. the combined treatment asset design is constrained by the wetland area). Table 10 shows the storage parameters of the retarding basins, and the design criteria for the outlets (that is, the 100 year ARI peak flow to be conveyed). The outlets at the northern and southern wetlands connect to the central wetland outlet to provide an overall site discharge to the existing drainage corridor east of the site boundary.

Table 10. Retarding basin RORB results (9 hour critical storm duration)

Wetland/RB	Catchment area *(ha)*	Peak outflow *(m^3/s)*	Normal Water Level *(m AHD)*	Peak 100 year Flood Level *(m AHD)*	Peak storage *(m^3)*
North	*26.6*	*0.98*	*259.4*	*260.5*	*8310*
Central	143.7	4.51	258.2	259.8	25600
South	42.5	1.54	260.2	261.7	14400
Combined	-	6.91	-	-	-

7 Proposed stormwater quality treatment system

7.1 Water quality treatment assets

The Lindum Vale PSP includes provision for a drainage reserve including water quality treatment assets within the significant stand of native trees toward the centre-east site boundary (refer Figure 2 above). The PSP shows large treatment assets intended to “centrally” treat the entire catchment. This arrangement is likely unfeasible based on the need to provide flood protection to adjoining allotments and the protection of existing trees. This has been informed by Alluvium’s review and analysis of existing site grades and the anticipated development layout. It also does not consider the diverging and converging alternate catchment outlets toward the north and south (refer section 4.1 above). Alluvium’s recommendation is that treatment assets be distributed at these natural catchment outlets accomplishing a dual function of nutrient removal and flood attenuation. However, treated (and attenuated) flows will be re-distributed to the central catchment outlet via a piped network, as the north and south natural drainage outlets are restricted by existing property development.

There are benefits to locating the wetlands/basins along the eastern edge to provide a buffer/green edge to the adjoining low density residential.

A MUSIC (Model for Urban Stormwater Improvement Conceptualisation) modelling approach has been used to establish the proposed treatment train strategy. The model estimates the amount of pollutants the catchment produces, the performance of treatment measures and the pollutant load generated once the catchment is treated. The Melbourne *Water Draft Design Construction and Establishment of Constructed Wetlands: Design Manual* has been followed.

Based on discussions with Melbourne Water, the expectation for the PSP is that stormwater quality meets Best Practice for Environmental Management (BPEM) targets, including:

- 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)

In accordance with Melbourne Water's MUSIC Guidelines, Melbourne Airport rainfall station was used with a standard 10-year template from 1971-1980.

Sub-catchment fraction impervious values were similar to the RORB model, with fully developed residential areas adopting 0.75, and public and open space contributing proportionately at a representative fraction of 0.1. The required treatment train areas to meet best practice are provided in Table 11. Note that there is no requirement to treat flows entering from the external catchment to the west, nor the smaller southern internal catchment contributing to the Aitken Creek DSS. The latter assumes payment of the stormwater quality component of the DSS contribution rate.

Table 11. Treatment asset design parameters to meet BPEM requirements

	North wetland	Central wetland	South wetland
Catchment area (ha)	25.92	71.65	34.59
Treatment area at NWL (m^2)	5,700	12,000	7,000
Extended detention depth	0.35	0.35	0.35
Sediment basin treatment area at NWL (m^2)	350	850	450

The performance of the three wetlands as modelled in MUSIC is given in Table 12.

Table 12. MUSIC model pollutant removal performance

	Percent removed (%)		
Pollutant	**North wetland**	**Central wetland***	**South wetland**
Flow (ML/yr)	10	8	10
Total Suspended Solids (kg/yr)	80	80	80
Total Phosphorus (kg/yr)	69	72	69
Total Nitrogen (kg/yr)	49	51	50
Gross Pollutants (kg/yr)	100	106	100

*Note: performance may exceed 100% due to external catchment not requiring treatment.

Concept designs for all treatment assets are provided in Appendix B. Assets consist of a sediment basin in line with a wetland for water quality treatment. These assets will utilise the "air space" created by battering to the existing surface for flood attenuation (refer to 6.4 above).

The space available for wetlands at the natural catchment outfalls is constrained by desired residential allotment yield, native vegetation under the ESO, and the natural surface grading that optimises drainage function and positioning. These designs include provision for a 4-metre access path around the periphery of the treatment area and sediment dewatering areas. The overall land budget footprint required has been informed by preliminary 12d earthworks modelling of the treatment asset, with batters generally no steeper than 1 in 6.

8 Constructed Waterway

The main considerations for waterways are the waterway corridor, constructed waterway design (including waterway crossings), and flood levels. This SWMS demonstrates that the proposed waterway corridor will be sufficient term of flow conveyance and considers the river health objectives and amenity opportunities in a future urbanised landscape.

Waterway corridor

Waterways, whether natural or constructed, need to have an appropriate waterway corridor or reserve provided adjacent to development 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
- the core riparian zone

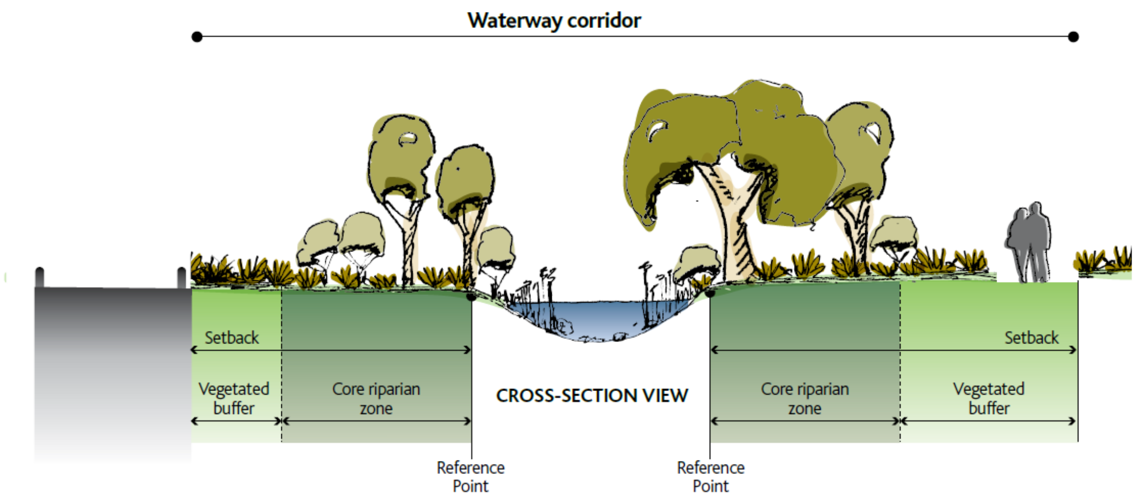


Figure 11. Waterway corridor (Melbourne Water's Waterway Corridor Guidelines)

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, and provide space for recreational infrastructure and activities (e.g. shared paths and (in some cases) stormwater treatment systems)".

A fundamental principle is to provide continuity along the core riparian zone, therefore the strong preference is to locate shared paths and other infrastructure outside of the core riparian zone.

The Existing Drainage Reserve

A drainage reserve, from the eastern boundary of the subject site to Forest Red Gum Drive was created many years ago during the development of the rural living subdivision. The drainage reserve was created along the main depression / open drain, with a width that varies between 25 metres to in excess of 40 metres. This reserve width was established well before Melbourne Water's "Waterway Corridor Guidelines" were developed.

At the western end of this corridor the drainage reserve supports on open cover of mature River Red-gum Eucalyptus camaldulensis, mainly in the northern half of the reserve. The open section of this drainage reserve supports an artifical shallow channel to convey surface runoff along the southern side of this section of the drainage reserve. Just east of this first triangular section of the drainage reserve is a well established farm dam with a spillway which discharges east into the downstream extension of the drainage reserve. This central portion of the drainage reserve has been artificially formed into a broad swale drain.

Just west of Forest Red Gum Drive the swale drain converts to a narrower artificial channel leading to a series of culverts which pass under the road. The broader expanse of this section of the drainage reserve appears to have been graded but still supports a high proportion of indigenous Wallaby-grasses as well as a range of exotic grasses and herbs.

In 2014 Biosis undertook a field inspection and assessment of the drainage reserve to determine the presence of any biodiversity constraints within this drainage reserve which would impact on the development of this corridor to receive additional flows from the proposed residential development of Lindum Vale. In summary, Biosis found that "*the biodiversity values of this drainage reserve are mainly limited to the remnant mature trees. Any development of drainage and retarding infrastructure that retains these trees and avoids the tree protection zones for them would otherwise have a relatively low biodiversity impact because only scattered occurrences of indigenous plants, rather than patches of native vegetation, would be impacted*."

Constructed waterway

As mentioned above the reformation of the existing drainage reserve into a constructed waterway would not be able to meet with Melbourne Water's current "Waterway Corridor Guidelines". That is a hydraulic width of 15 metres would require an overall waterway corridor width of 45 metres, under the current "waterway Corridor Guidelines", without active edges on either side of the corridor (refer to Figure 11). This is not possible for the existing reserve downstream of Lindum Vale as the available corridor reduces to only 25 metres wide.

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

As a result the constructed waterway was assessed using the general principles within the Melbourne Water Draft Constructed Waterway Guidelines. Hydraulic analysis along with site investigations, has been used to establish appropriate conditions for the. HEC-RAS have been used to design the waterway and model the major flows through the waterways to determine flood levels and to check shear stress values are appropriate to avoid erosion.

The alignment of the constructed waterway generally follows the alignment of the existing drainage line. Based on existing contours and proposed design invert levels, there is an existing drop of around 5.3 metres over 800 metres, creating an average grade of 1V: 150H (see Figure 12). This is an ideal grade for a compound channel, which will not require any grade control structures.

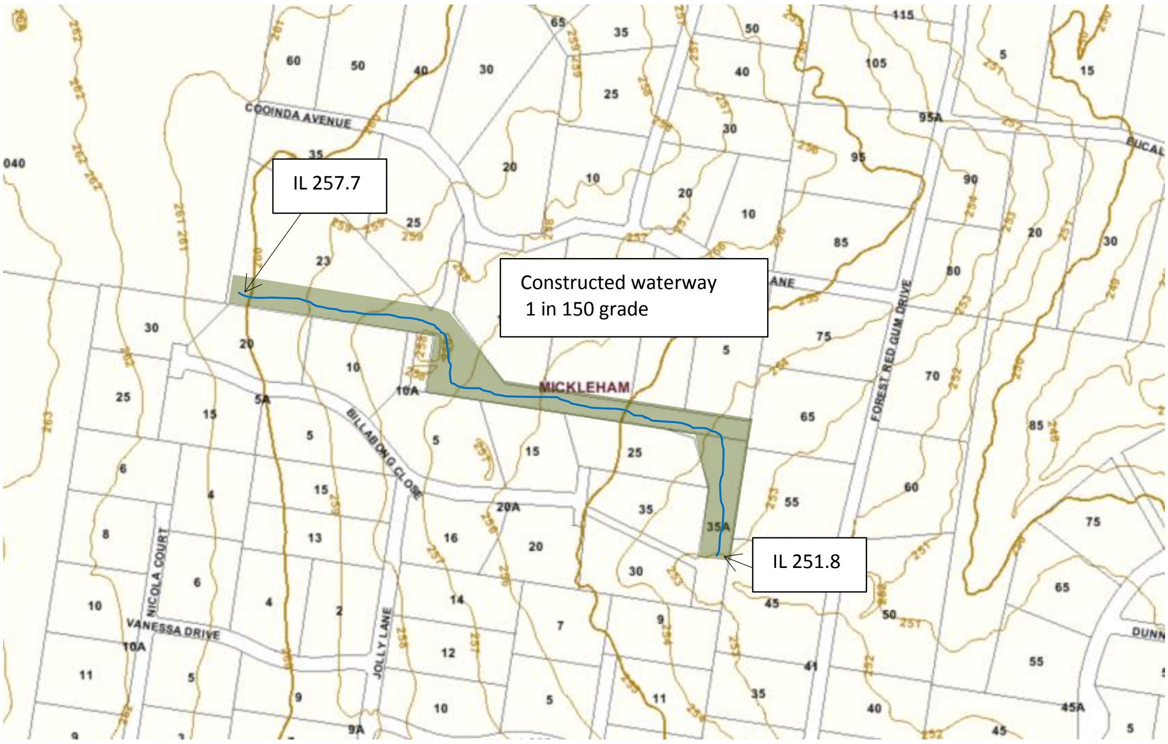


Figure 13. *Constructed Waterway corridor*

The low flow meandering channel is 0.4 m deep, with a base of 1 metre and slopes of 1 (V) : 5 (H). The low flow channel is to meander across the 11 metre base. It has a capacity of around 0.7 m^3/s, which is approximately a 6 month ARI design flow. The high flow channel has the capacity of the 100 year ARI event (ie 6.91 cumecs at Hogans Road). In order to convey these flows and remain within the waterway corridor, a typical cross-section depicted in Figure 13 will be used.

The shear stress within the waterway corridor does not exceed 45 N/m^2 – the shear resistance of short native grass (Draft Constructed Waterway Manual Part B2). This is a conservative value, and with vegetation establishment, the channel could be designed to tolerate greater shear stresses.

The maximum depth of flow in the constructed waterway for the 100 year ARI event is 0.92 metres. A minimum of 300mm freeboard will be provided to the existing low density residential allotments.

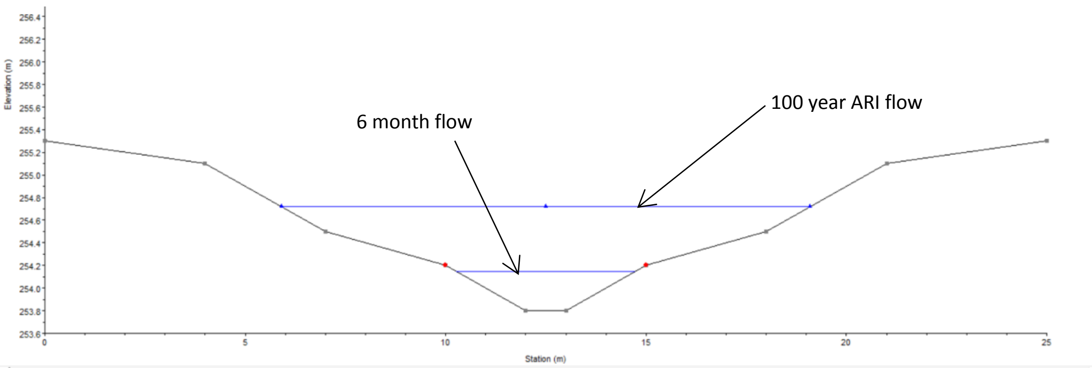


Figure 14. *Typical-section for the constructed waterway*

Waterway criteria:

- ✓ Flooding
  - ✓ Q100 Flows contained within waterway corridor
  - ✓ 300 mm freeboard to lots
- ✓ Design a constructed waterway to convey flows through the study area
  - ✓ Compound channel
    - ▪ High-flow channel capacity: Q100 year
    - ▪ Low flow meander channel: 6month
  - ✓ Shear stress less than 45 N/ms
  - ✓ Batter slopes no steeper than 1:5
  - ✓ Access Paths provided

9 Existing vegetation watering

The Lindum Vale PSP includes a significant number of existing trees through the precinct and the future urban structure plan has responded by allocating reserves to retain a relatively large population. In addition to the preservation of land that surrounds the trees it is important to consider the water needs of the vegetation to support a healthy and sustainable landscape.

Urban stormwater runoff provides a potential source of supply for future irrigation of the native vegetation. The configuration and design for the subdivisional drainage system should consider the potential for alternative and innovative approaches to integrate water and passive irrigation into the landscape. However a “one size fits all approach” is not possible at the Lindum Vale site. The various groups of trees are spread across diverse topographic and subsequently varying hydrologic regimes. For example some trees are currently located on “high ground” with very little surface runoff contributing to its moisture profile, whereas others are located within the low point and depression that meanders through the landscape.

It is therefore essential that any consideration to integrate any stormwater runoff into the reserve is informed by the eco-hydrology needs of the existing tree communities. As a result it would be necessary to identify the key tree locations that may require additional moisture based upon an ecological assessment of the species key hydrologic needs and characteristics. This would then enable options to be considered for the supply of water to meet those ecological needs. Some possible ways that the drainage infrastructure could integrate with the landscape is as follows:

- Passive irrigation by “shedding” surface runoff from roads into the open space reserves. This could potentially be enhanced by providing a “gravel trench” as a storage reservoir for specific trees.

- Passive irrigation via a drainage mechanism where flow “bubbles up” out of the pits in most storm events and is distributed as sheet flow into the reserves to water the trees. Such an approach is likely to require a low flow drain to ensure upstream pipelines are dry between storm events. Refer to figure 15 for a possible conceptual layout.

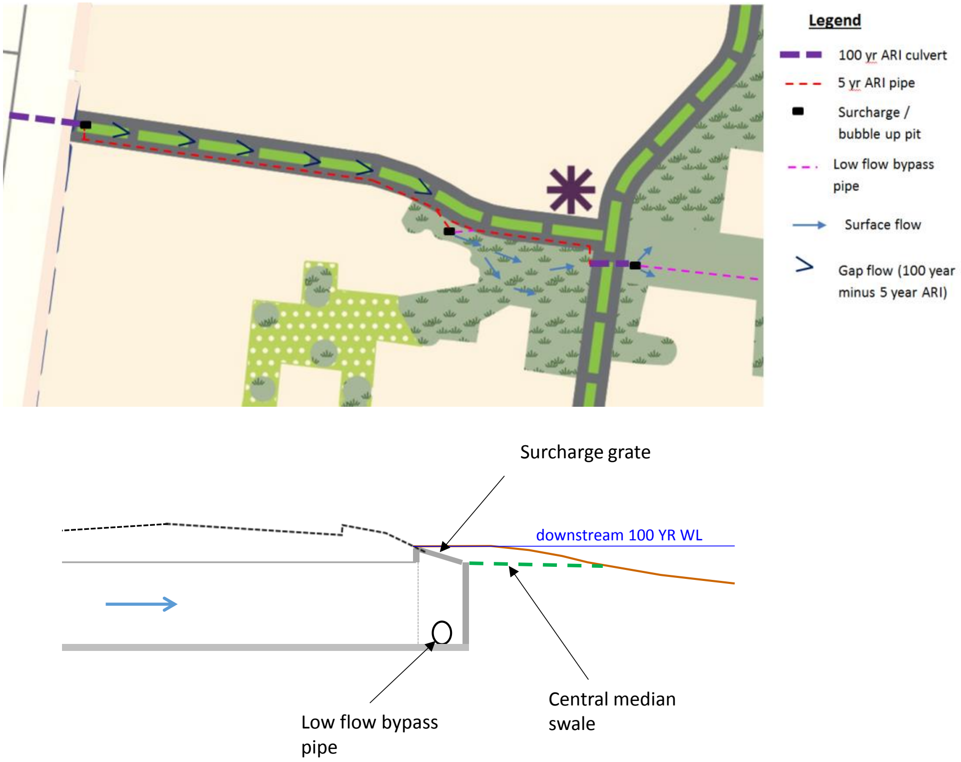


Figure 15. *Possible “bubble up” conceptual layout*

- Utilise a trickle feed from the constructed stormwater treatment wetland to supply a deep “banking” of water via a linear gravel trench that meanders through a tree community (refer to Figure 16).

Figure 16. Possible trickle feed from the constructed wetland

Based upon the above principles it is recommended that Council and the developer work together during the functional and detail design of the stormwater system to consider and evaluate the benefits and costs (capital and maintenance).

10 Proposed drainage strategy layout

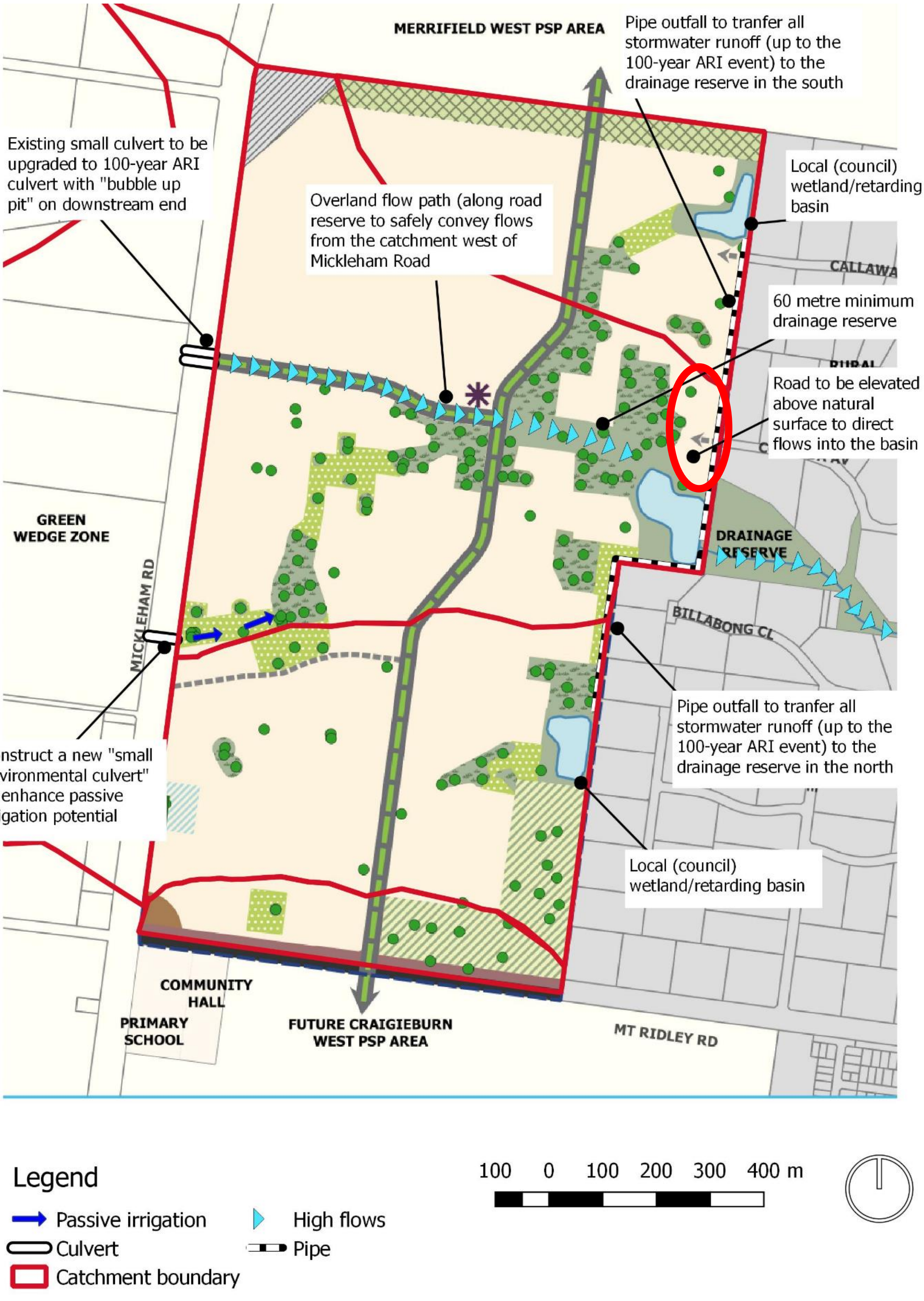


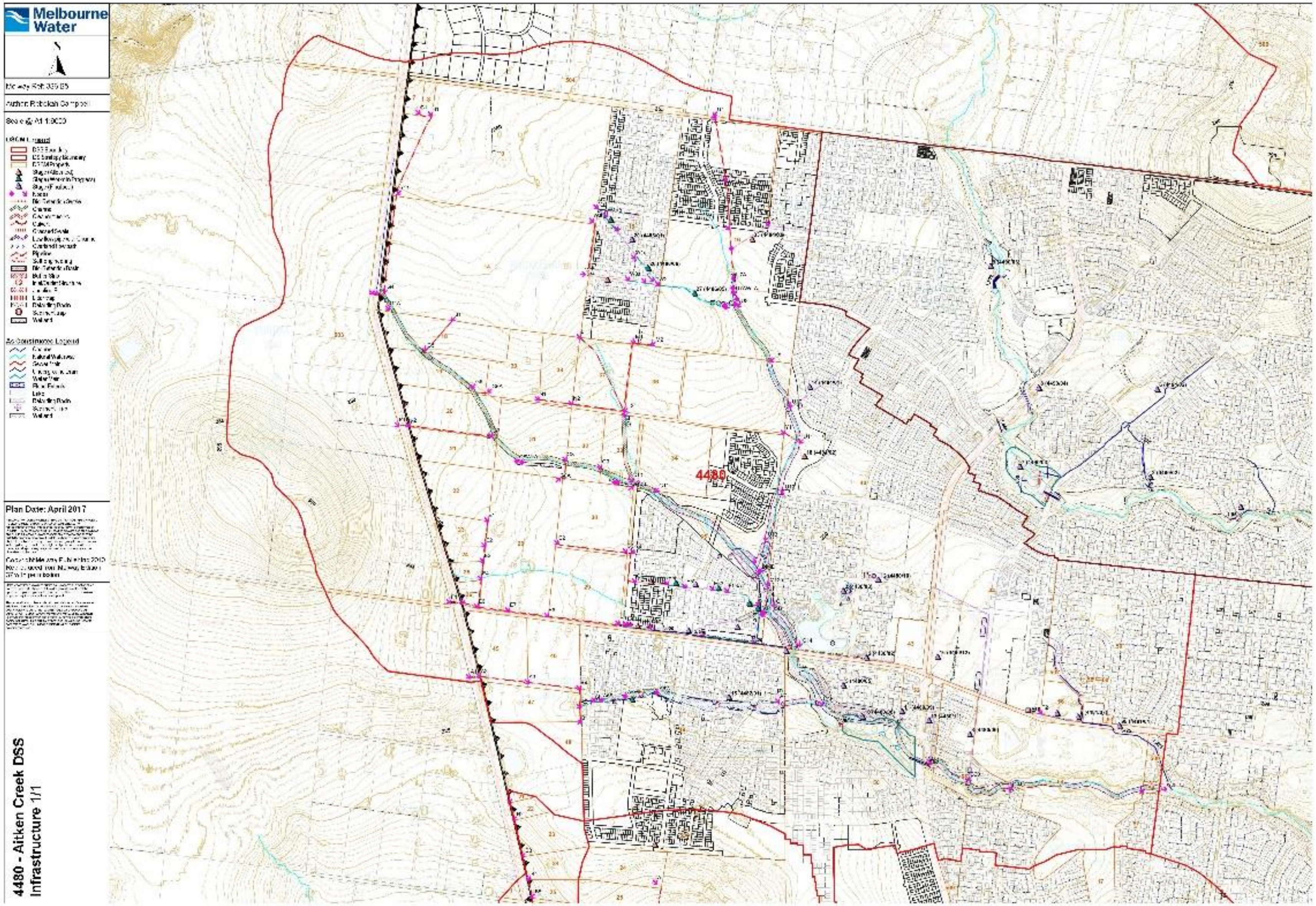
Figure 17. Proposed drainage strategy layout

11 Conclusion

This SWMS has proposed management strategies for stormwater quantity, stormwater quality and interim development. Through meeting these objectives, this SWMS acts as a critical component of the development servicing strategy and ensures storm water is managed in accordance with Melbourne Water's and Council's requirements.

The SWMS has considered both the interim and ultimate infrastructure requirements associated with the development of the Lindum Vale site, as well as opportunities for providing watering to high value remnant native vegetation.

Appendix A
Aitken Creek DSS


Melbourne Water
Plan Date: April 2017
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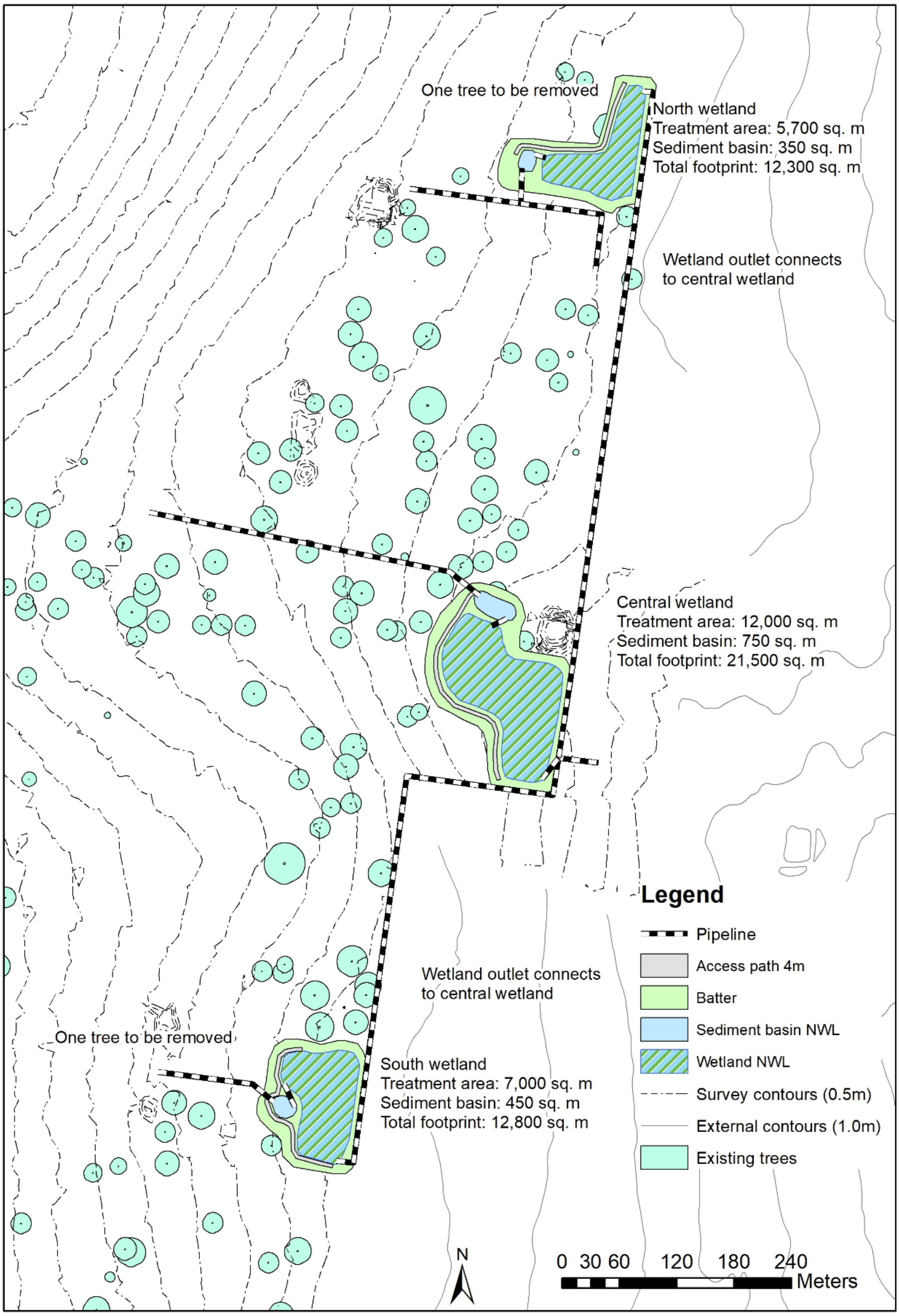
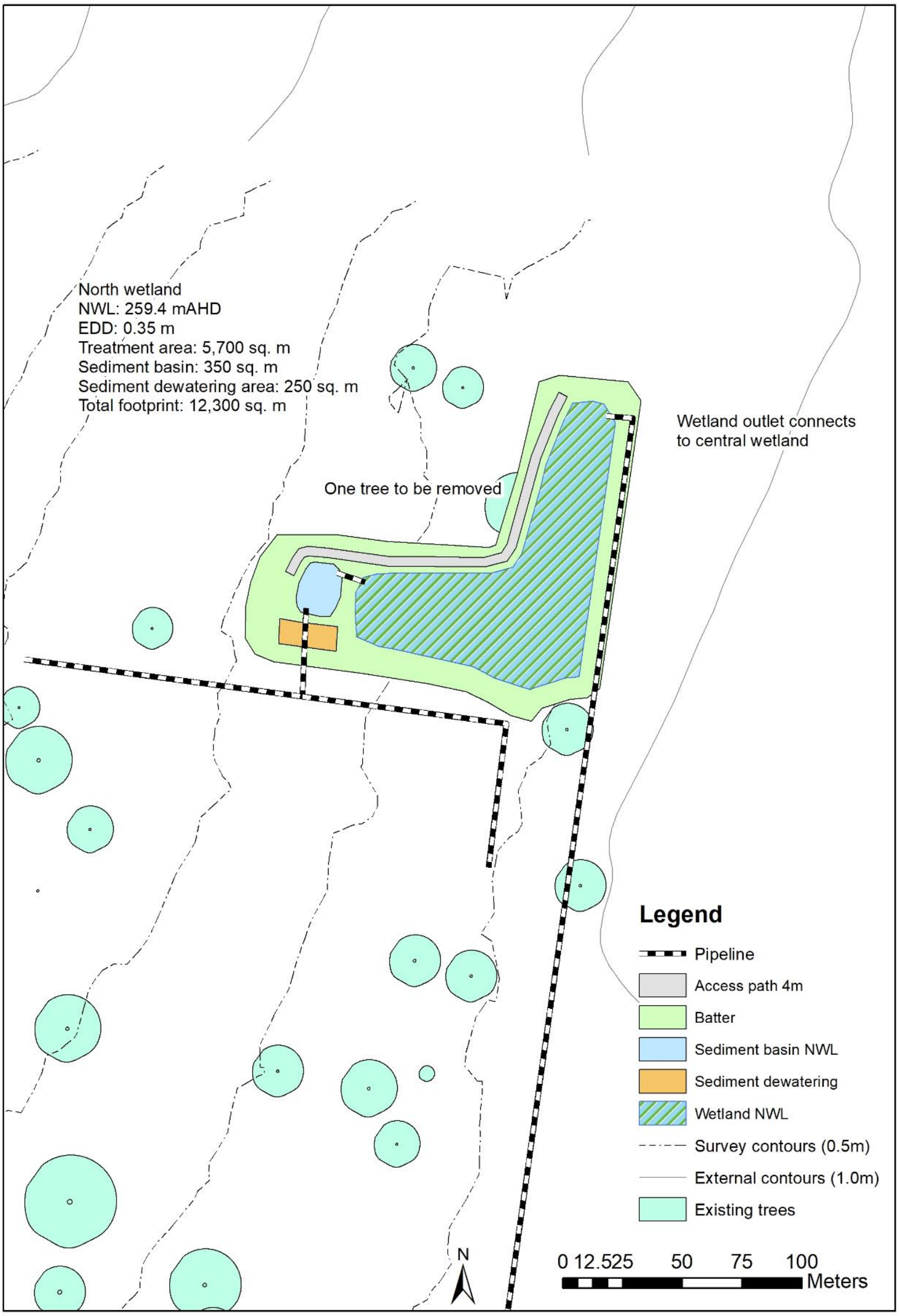
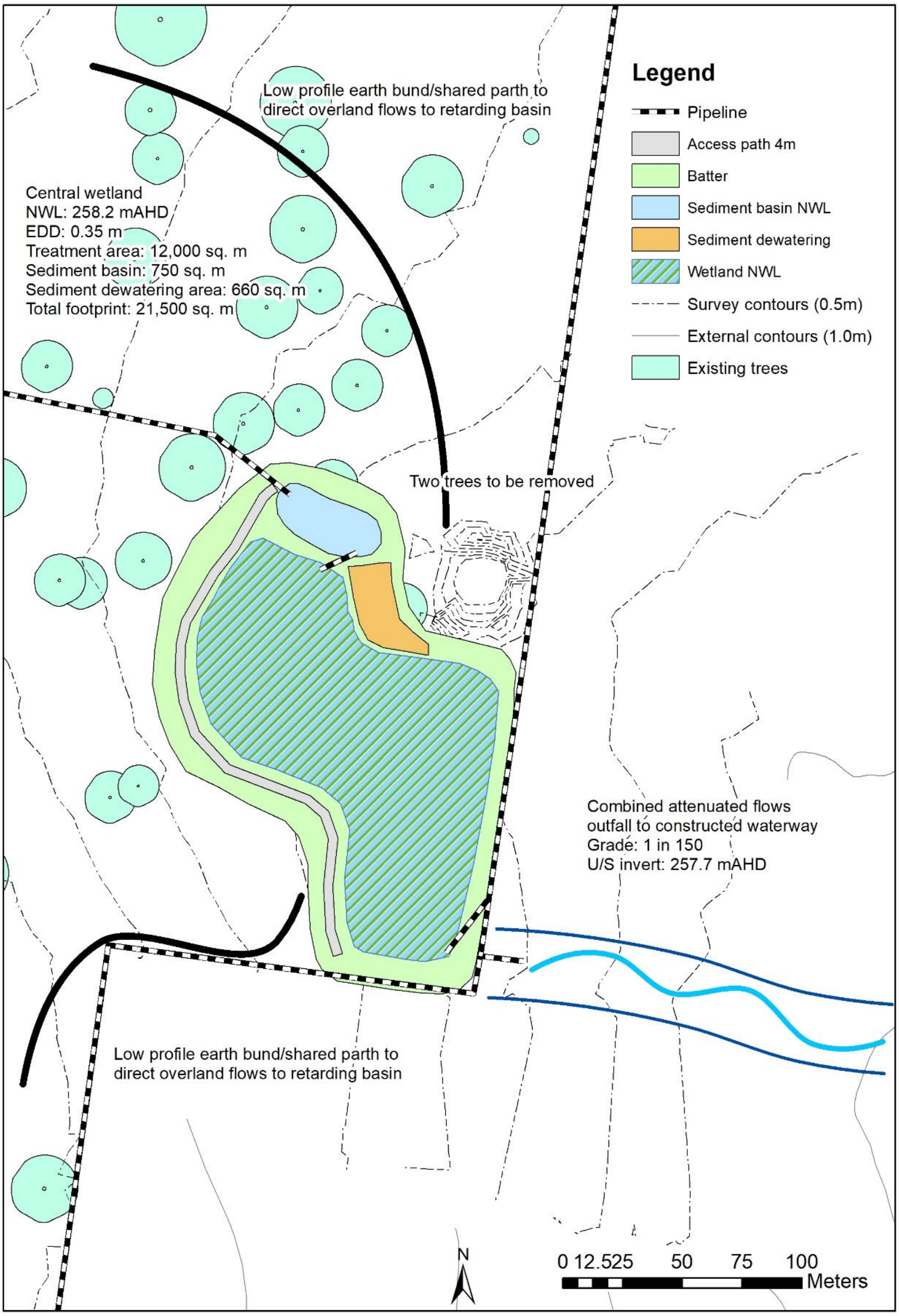
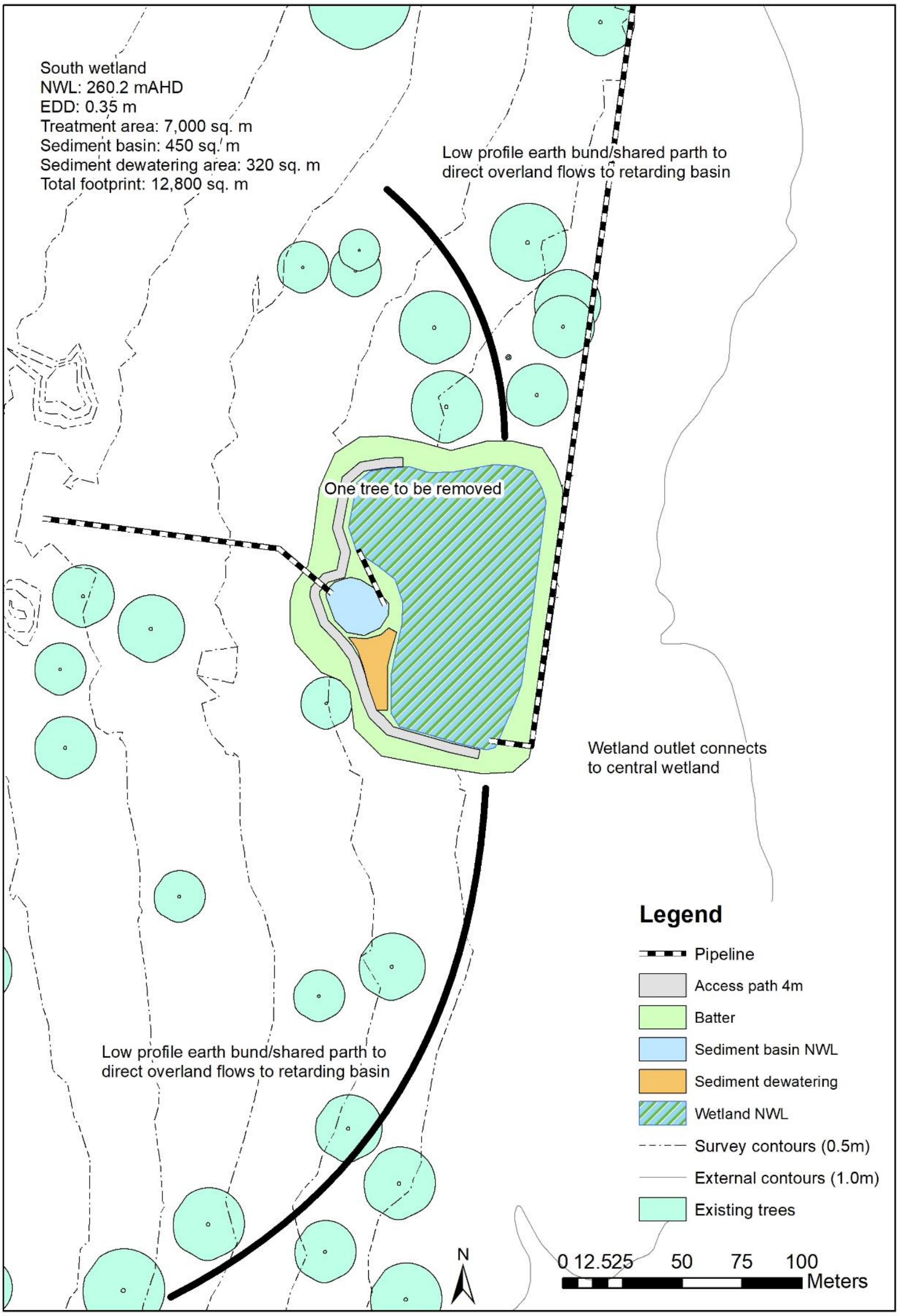
4480 - Aitken Creek DSS
Infrastructure 1/1

Appendix B
Water Quality Treatment Asset Concept Design


One tree to be removed
North wetland
Treatment area: 5,700 sq. m
Sediment basin: 350 sq. m
Total footprint: 12,300 sq. m
Wetland outlet connects
to central wetland
Central wetland
Treatment area: 12,000 sq. m
Sediment basin: 750 sq. m
Total footprint: 21,500 sq. m
Wetland outlet connects
to central wetland
One tree to be removed
South wetland
Treatment area: 7,000 sq. m
Sediment basin: 450 sq. m
Total footprint: 12,800 sq. m
Legend
Pipeline
Access path 4m
Batter
Sediment basin NWL
Wetland NWL
Survey contours (0.5m)
External contours (1.0m)
Existing trees
N
0 30 60 120 180 240
Meters


North wetland
NWL: 259.4 mAHD
EDD: 0.35 m
Treatment area: 5,700 sq. m
Sediment basin: 350 sq. m
Sediment dewatering area: 250 sq. m
Total footprint: 12,300 sq. m
Wetland outlet connects
to central wetland
One tree to be removed
Legend
Pipeline
Access path 4m
Batter
Sediment basin NWL
Sediment dewatering
Wetland NWL
Survey contours (0.5m)
External contours (1.0m)
Existing trees
N
0 12.525 50 75 100
Meters


Legend
Pipeline
Access path 4m
Batter
Sediment basin NWL
Sediment dewatering
Wetland NWL
Survey contours (0.5m)
External contours (1.0m)
Existing trees
Low profile earth bund/shared parth to direct overland flows to retarding basin
Central wetland
NWL: 258.2 mAHD
EDD: 0.35 m
Treatment area: 12,000 sq. m
Sediment basin: 750 sq. m
Sediment dewatering area: 660 sq. m
Total footprint: 21,500 sq. m
Two trees to be removed
Combined attenuated flows outfall to constructed waterway
Grade: 1 in 150
U/S invert: 257.7 mAHD
Low profile earth bund/shared parth to direct overland flows to retarding basin
N
0 12.525 50 75 100
Meters


South wetland
NWL: 260.2 mAHD
EDD: 0.35 m
Treatment area: 7,000 sq. m
Sediment basin: 450 sq. m
Sediment dewatering area: 320 sq. m
Total footprint: 12,800 sq. m
Low profile earth bund/shared parth to direct overland flows to retarding basin
One tree to be removed
Wetland outlet connects to central wetland
Low profile earth bund/shared parth to direct overland flows to retarding basin
Legend
Pipeline
Access path 4m
Batter
Sediment basin NWL
Sediment dewatering
Wetland NWL
Survey contours (0.5m)
External contours (1.0m)
Existing trees
N
0 12.525 50 75 100
Meters