Officer South DSS Options Assessment

Revision: C

Melbourne Water

6 September 2022

Officer South DSS Options Assessment

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Executive summary

Introduction

Jacobs together with Spiire has been engaged by Melbourne Water (MWC) to assess Development Service Scheme (DSS) large drainage asset layout options for the Officer South Employment Precinct Structure Plan (PSP) and progress the preferred option to Functional Design. There are currently two Interim status, DSS's (Officer South DSS 1304 and Lower Gum Scrub Creek 1402) proposed in this Precinct making provision for drainage, flood mitigation and stormwater quality treatment assets to enable development. Several 'treatment train' options, comprising of retarding basins, sediment basins, wetlands and waterways, have been assessed against a range of criteria with the aim of minimising the impacts of development.

This report represents all of the design work that has informed the Options Assessment undertaken in September 2022. Based on the analysis presented in this report a preferred concept option will be selected and progressed from concept to functional design of DSS assets to inform DSS footprint requirements and costs effects more accurately for the DSS and PSP.

The purpose of this document is to summarise the background, constraints, calculations, modelling, and development of the options to arrive at the preferred option.

Background

The Officer South Employment PSP is located approximately 65 km from Melbourne's CBD within the south-eastern growth corridor. The site is approximately 1,069 ha, bounded by the Princes Freeway to the north, and features three major watercourses, Gum Scrub Creek to the east, Cardinia Creek to the south-west and Officer South Rd Drain through the middle of the site.

The Officer South area has several challenges due to the site location, topography of the land, waterways, and ecological considerations. Challenges are summarised briefly as follows:

- Flat terrain - the region is characterised by flat flood prone areas (frequent flooding is an issue for downstream landowners) and maintaining drainage outfalls into the Koo Wee Rup Flood Protection District (KWRFPD),
- Upstream development - Large upstream catchments are already currently being partly developed. Meeting best practice stormwater quality treatment and flood mitigation requirements are a challenge for this area.
- Existing services – particularly the major gas main (the Dandenong to Morwell main) traverses the site east-west and will affect the design and constructability of drainage outlets, waterways and crossings.,
- Ground conditions – shallow likely saline groundwater and sodic- acid sulphate soils are known to be present in the area, soil testing is required for all assets to inform design and construction.
- Areas of cultural sensitivity – affect a large proportion of area adjacent the creeks and the location of potential constructed assets.
- Significant or threatened biodiversity and habitat areas – a large Area of Strategic Importance is mapped across the Creek corridors and adjacent land; and Cardinia Creek provides habitat for nationally listed threatened fish species and Growling Grass Frog (GGF).

These challenges were considered in the development of options.

Melbourne Water Objectives for Officer South and Lower Gum Scrub Creek DSS

The following DSS objectives were developed for the DSSs to guide the drainage investigation and Options analysis:

- Meet Melbourne Water legislation requirements and other strategic directions: Water Act 1989, EPBC Act 1999, Environment Protection Act (General Environment Duty), Healthy Waterways Strategy, cultural heritage, etc.

- Meet DSS principles as prescribed in the *Principles for Provision of Waterway & Drainage Services for Urban Growth*.
- Ensure appropriate flood protection for new development within the PSP.
- Not further exacerbate existing flooding on downstream properties including the State significant Koo Wee Rup Flood Protection District (KWRFPD)
- Meet Predevelopment flow targets at key points in Officer South Employment catchment. This has been set to 2010 datum time since this time is before the development had commenced in the Officer PSP catchment and these flows and volumes effect the Officer South Employment (OSE) PSP and downstream landowners south of the OSE PSP who are effected by both PSPs .
- Protect/minimise impact on environmental and waterway values.
- Meet critical drainage and other agency asset operational requirements to ensure constructability (i.e. gas main crossings)
- Apply the EPA's GED, General Environmental Duty principles in the design of the Development Services Scheme works.

Options Assessment

A total of 3 main options, comprising of 11 overall sub-options, were investigated. Each option includes up to 10 different retarding basin/ wetlands distributed throughout the PSP and features different diversion scenarios of the Officer DSS development flow (incoming from north of the Precinct). The main options include:

1. Conveying flows of Officer DSS flows into Gum Scrub Creek (including 6 sub-options). The intent of Option 1 is to mimic the predevelopment conditions and to provide distributed stormwater quality and retarding treatment, aimed at targeting the local catchments within the PSP as well as the upstream catchments.
2. Officer DSS flows to continue in Officer South Road Drain to Cardinia Creek (including 3 sub-options). This option was based on earlier work by Stormy Water Solutions (2020). The intent of Option 2 is to reduce flooding in Gum Scrub Creek by diverting flows down a reconstructed Officer South Road Drain and discharging into Cardinia Creek
3. Officer South Road Drain flows conveyed at southern end to Gum Scrub Creek (including 2 sub-options). The intent of this option is to convey flows out of the environmentally sensitive Cardinia Creek and into Gum Scrub Creek.

The options were analysed using RORB, 12D, MUSIC models and other analysis. Options that met predevelopment 2010 flows (for a range of AEP's from 50 % to 1 %) at critical points in the PSP were shortlisted for further assessment using a Multi Criteria Assessment (MCA) framework.

The options that were shortlisted included Option 1D, 1E, 1F, 2C and 3B, based on their ability to achieve the peak flow target and nitrogen reduction in Cardinia Creek and Gum Scrub Creek. Table 1 shows the assessment of the long list of options.

Table 1 Assessment of Options Long List

Option	Reserve Area (Ha)	Peak Flow Target	Cardinia Ck TN Reduction (%)	GSC TN Reduction (%)	COMMENTS
1A	N/A	N/A	N/A	N/A	Initial assessment showed this to be less effective than1B and therefore not assessed in detail.
1B	85.8	✗	✓	✗	Option dismissed due to not meeting predeveloped 2010 flow criteria at Patterson Rd for all events.

Option	Reserve Area (Ha)	Peak Flow Target	Cardinia Ck TN Reduction (%)	GSC TN Reduction (%)	COMMENTS
1C	N/A	N/A	N/A	N/A	Option dismissed due to not being acceptable to the VPA.
1D	102.2	✓	✓	✗	Highest level of SWQT. However, only a 42% reduction in TN is achieved in Gum Scrub Creek.
1E	102.2	✓	✓	✗	Poorer SWQT for GSC in comparison to 1D. Only a 31% reduction in TN is achieved.
1F	117.9	✓	✓	✗	Largest reserve area. A 41% reduction in TN is achieved in Gum Scrub Creek.
2A	N/A	N/A	N/A	N/A	Initial assessment showed this to be less effective than 2C and therefore not assessed in detail.
2B	N/A	N/A	N/A	N/A	Initial assessment showed this to be less effective than 2C and therefore not assessed in detail.
2C	108.2	✗	✗	✗	Flood criteria for 10% AEP event and above at OSR outlet not met. And only 37% reduction in TN.
3A	N/A	N/A	N/A	N/A	Initial assessment showed this to be less effective than 3B and therefore not assessed in detail.
3B	108.2	✗	✓	✗	Treatment much higher for Cardinia Ck than 2C as low flows are being diverted conveyed to GSC.

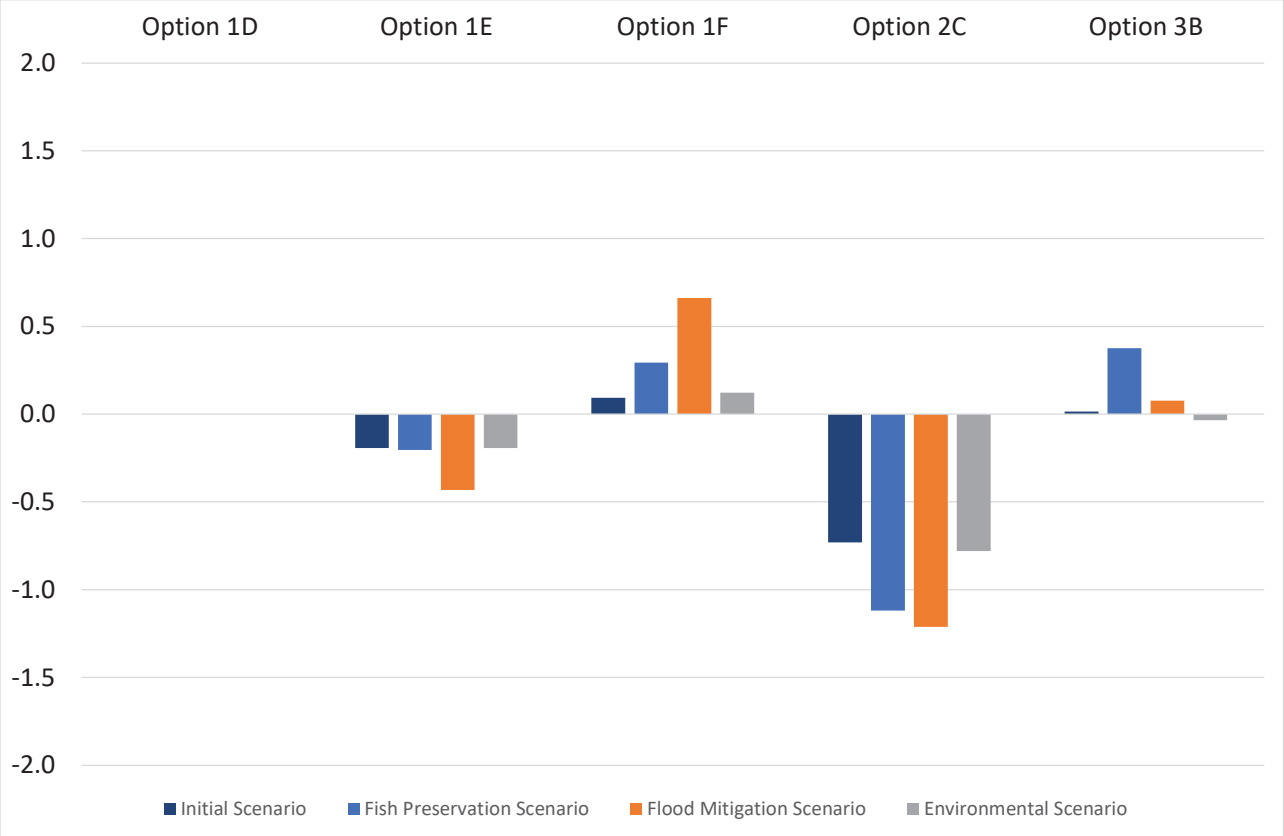
Multi-Criteria Analysis (MCA)

The MCA considered the following 6 criteria (initial weightings shown in brackets):

1. Peak Flows downstream of the PSP (20%) – a comparison of RORB modelled peak flows and volumes leaving the PSP and flowing into Cardinia Creek and Gum Scrub creek.
2. Stormwater Quality (10%) – a MUSIC model assessment of nitrogen, phosphorus and suspended solids removal provided by each option.
3. Fish Preservation (10%) – a preliminary assessment of 50% AEP and annual flows from RORB and MUSIC models as an indication of whether post development flows will impact the Australian Grayling.
4. Liveability (10%) – analysing data from a 12D model and using metrics recently developed by Melbourne Water, including the wetland reserve area open to the public for recreation.
5. Cost (40%) – a comparison of the capital cost of each option, including land acquisition costs which contribute up to 45 percent of the scheme cost.
6. Environment & Heritage Impacts (10%) – using a 12D model to assess the impact on very high value retention trees, high value retention trees and growling grass frog habitat.

In line with Melbourne Waters Triple Bottom Line (TBL) Guidelines all criteria were scored between -4 to +4 which corresponds to 'much worse' than the base case (-4) to 'much better' than the base case (4). Option 1D was set as the base and was given a score of 0 for all criteria. Option 1D was adopted as the base case because it meets the predeveloped 2010 flow targets at all outlets, storm water quality treatment (SWQT) targets for Cardinia Creek and comes closest to meeting the SWQT targets for Gum Scrub Creek. As shown in Figure 1 the option that had the highest weighted MCA score under a range of different weighting scenarios was Option 1F.

Figure 1 Total Weighted MCA Scores by Option (comparison with 1D)



The weightings were adjusted to test the sensitivity of each option under different weighting scenarios. The fish preservation scenarios increased the fish preservation weighting to 30 percent and reduced the cost to 20 percent. The flood mitigation scenario increased the peak flow weighting to 40 percent and reduced cost to 20 percent. The environmental scenario increases the environment and heritage weighting to 30 percent and reduced cost to 20 percent.

The MCA scores are very similar, i.e. all within a range between -1.5 and +1.0. This is partly because only options that could meet predevelopment flow targets were shortlisted for assessment. Furthermore, the difference between the least expensive option and the most expensive option was only about 15 percent.

The table below uses Melbourne Water's qualitative MCA rating scale to show how each option performs against each criterion. It helps explain the advantages and disadvantages of each option. Option 1E and Option 2C have no real advantages over the base case. Option 1F retards peak flows more than the base case and Option 3B provides better outcomes for fish preservation.

Table 2 Multi Criteria Assessment Qualitative Scores (comparison with 1D)

Criteria	1D	1E	1F	2C	3B
1. Peak Flows downstream of the PSP	The Same	Slightly Worse	Better	Worse	The Same
2. Stormwater Quality	The Same	The Same	The Same	The Same	The Same
3. Fish Preservation	The Same	The Same	The Same	Worse	Slightly Better
4. Liveability	The Same	The Same	Slightly Better	The Same	The Same
5. Cost	The Same	The Same	Slightly Worse	The Same	The Same
6. Environment & Heritage	The Same	The Same	The Same	Slightly Worse	Slightly Worse

Option 1F and Option 1D are very similar, with the primary difference being that Option 1F has 220,000 cubic metres more total flood storage capacity than Option 1D. Under Option 1F there is more storage capacity at the lower end of the PSP catchment in retarding basins I and J. These larger retarding basins cost more but provide greater flow retardation. During the functional design process the retarding basins will be optimised.

Option 3B is slightly better than Option 1D (the base case) and Option 1F in relation to fish preservation. The Australian Grayling is a threatened species of fish that inhabits Cardinia Creek. It has become threatened for a variety of reasons including increased sedimentation and erosion due to riparian vegetation removal. Property development without appropriate waterway infrastructure, typically results in increased flows and increased sedimentation and erosion. Jacobs (2020) recommends that any increase in the frequency of channel forming flows in Cardinia Creek is undesirable. The study recommends that there should be no more than 1 event per month greater than 370 ML/d that last longer than 31 hours, no more than 1 event every 6 months greater than 370 ML/d that lasts longer than 70 hours and no more than 1 event per year that lasts longer than 89 hours. Further work investigating the impact of post development storm water flows on the Australian Grayling is being undertaken by Melbourne Water as part of a separate project. The results of this separate project will be used to confirm (or otherwise) that Option 1F provides adequate fish protection. It will be used to influence the functional design of the preferred Option.

The land required for each option is incorporated into the Multi-Criteria Assessment (MCA) through the cost criterion. Nevertheless, the amount of land needed is of interest to numerous stakeholders and is presented in the table below.

Table 3 Land Requirements

Description	1D (ha)	1E (ha)	1F (ha)	2C (ha)	3B (ha)
Total Land Requirement	135	135	164	124	124

Preferred Option Summary

Option 1F is the preferred Option based on the Options Assessment undertaken in September 2022. It is expected that as further investigations occur and more information is gathered that Option 1F will be refined. The intent of Option 1F was to attenuate flows as much as possible, via large assets along Gum Scrub Creek, to mitigate the impact to downstream properties south of the PSP. An overview of the key design aspects for Option 1F are as follows:

- Officer DSS flows that drain under the Pakenham Bypass are to be conveyed in a constructed waterway following the natural contours to Gum Scrub Creek and discharge into the proposed Lecky Road Retarding Basin.
- Lecky Rd RB is online (approximately 21ha). This is in accordance with previous agreements between the landowner and MW and contributes to the flood storage requirements of GSC.
- RB I is online to Gum Scrub Creek with proposed wetland treatment online with a shallow marsh design treating the total upper catchment.
- A diversion of $3m^3/s$ low flow diversion from Gum Scrub Creek to Cardinia Road Drain at the electricity easement is to occur. The flows will then be conveyed to Toomuc Creek and onwards to the leveed outfall system which discharges into Western Port Bay. The purpose of this diversion is to reduce regular volumes in the Gum Scrub Creek catchment south of the PSP which is likely to cause regular inundation of properties if not diverted.
- All RBWL west off Officer South Rd are to be offline and service local catchments.
- No augmentation of the Cardinia Creek Levee system is required in this option.

Figure 2 illustrates the concept of Option 1F and Table 4 provides a breakdown of the parameters of each asset within the option.

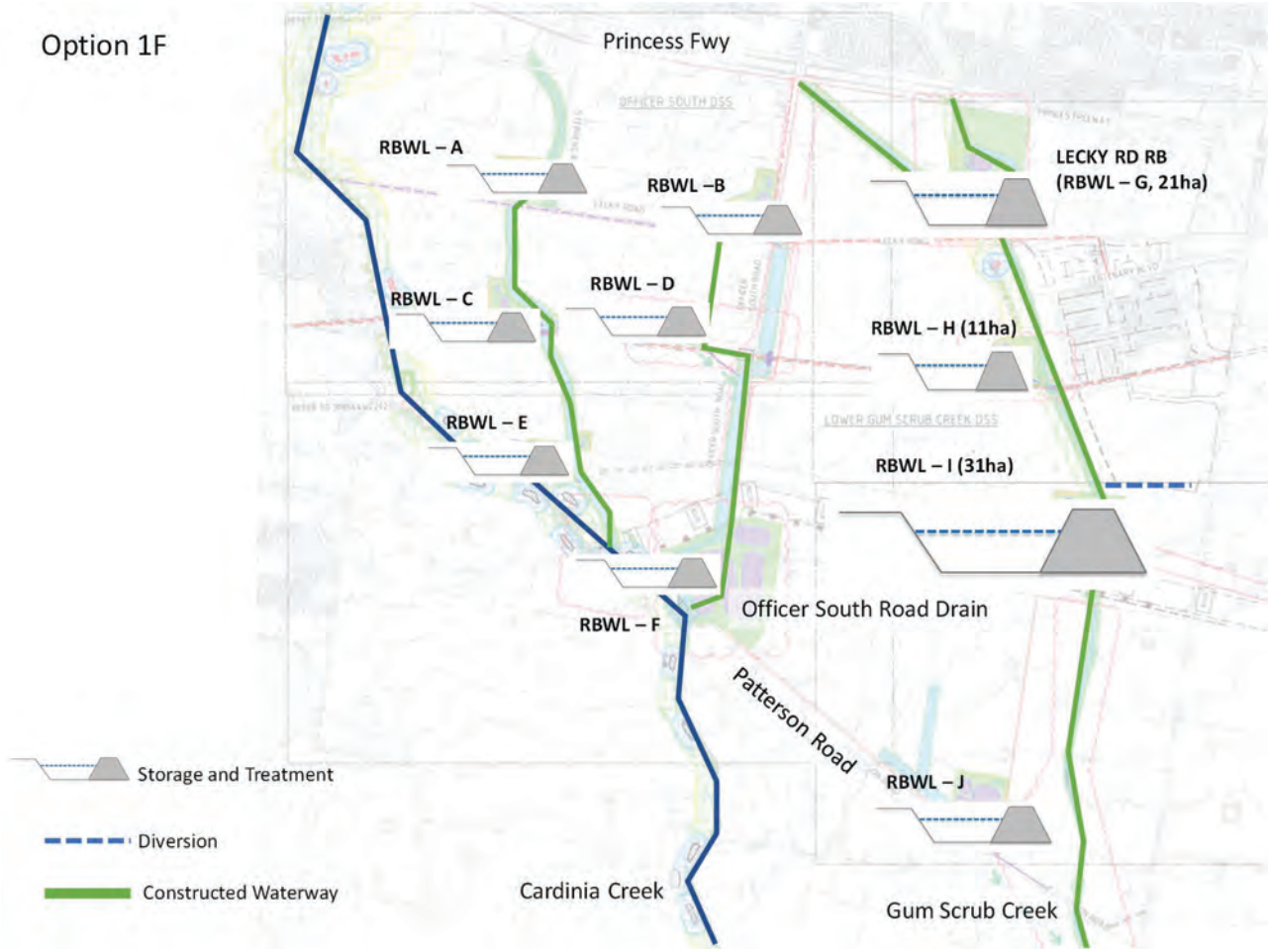


Figure 2 Option 1F Schematic

Table 4 Option 1F Asset Summary

Name	Reserve Area (ha)	Wetland Area (ha)	Storage (m^3)
RBWL A	21.0	3.6	60,365
RBWL B	10.3	4.4	152,650
RBWL C	5.5	2.3	22,162
RBWL D	7.4	3.4	41,854
RBWL E	5.4	2.0	49,550
RBWL F	3.9	1.8	57,158
RBWL G	21.2	12.3	321,320
RBWL H	10.9	5.4	68,354
RBWL I	31.2	10.7	596,380
RBWL J	14.3	7.4	178,630
Total	131.1	53.3	1,548,423

Table 5 provides a summary of the results of Option 1F with respect to peak flow and stormwater quality treatment as well as more details on the general configuration around the gas main crossings.

Table 5 Summary of Option 1F

ITEM	FINDING/OUTCOME
PEAK FLOWS	Predeveloped 2010 flows met at the Stephen Rd Waterway.
	Predeveloped 2010 flows at the Officer South Rd outlet to Cardinia Creek are met up to the 1% AEP event.
	Predeveloped 2010 flows are met at the Patterson Rd outlet of Gum Scrub Creek.
	Predeveloped 2010 flows at the Patterson Rd outlet are met for the 1% AEP CC event factoring for future predevelopment climate change conditions.
	Predevelopment flow conditions in Cardinia Creek south of the PSP are not increased.
SWQT	BPEM is met for the Cardinia Creek Catchment
	BPEM is not being met for the Gum Scrub Creek Catchment, 41% total nitrogen removal. The under treatment of the catchment is due to the lack of treatment north of the Princes Freeway
WATER BALANCE	Cardinia Creek is receiving less volume in the developed scenario than predeveloped scenario.
	Gum Scrub Creek is receiving approximately 14% more volume in the developed scenario than predeveloped scenario.
GAS MAIN CROSSINGS	Stephens Rd Waterway 2x1350mm RCP including a 50% blockage factor. To be refined during the functional design.
	Officer South Rd - 2x1500mm RCP including a 50% blockage factor. To be refined during the functional design.

ITEM	FINDING/OUTCOME
	Gum Scrub Creek – 60m weir crossing over the top of 450mm T1 main. Still to be designed based on survey.
LEVEES	No upgrades to the downstream levees are proposed.

Risks and Limitations

The options analysis has identified a preferred option. Further work is required to optimise the preferred option and address a variety of risks. Some of the risks that need to be addressed are:

- The peak flows associated with the preferred option are less than predevelopment 2010 peak flows, but TUFLOW modelling of the preferred option will be required to confirm that post development flooding will be equal to or less than predevelopment flooding.
- Some retarding basins and wetlands are relatively deep and will need to be optimised during the functional design phase.
- The services proving of the gas main at critical locations, such as the crossing of Gum Scrub Creek, did not access the low point of the creek. An estimate of the gas level has been made at these crossings based on adjacent 'nearest' data and APA's cover level requirements for crossing waterways.
- Many of the options rely on a diversion to Cardinia Road Drain as proposed by Melbourne Water, to meet the predevelopment and volume objectives, however, the impact on the adjacent DSS and footprint sizes has not been investigated.
- Other services that have not been proved that may impact on the design are the Telstra optic cable and other gas mains.
- Aboriginal heritage areas of significance are located adjacent Cardinia Creek, Gum Scrub Creek, and the headwaters of the Stephens Road waterway line (and DELWP mapped wetland). Some assets are located within these areas and cultural heritage management plans will be required.
- Further geotechnical testing is required to confirm ground conditions to inform the constructability of proposed waterway and drainage flood management assets.
- Further sodic soils also dispersive, acid sulfate testing should be undertaken. Sodic soils are particularly relevant to the design of waterway infrastructure.
- Further hydrogeological testing is required to confirm the depth of groundwater and salinity to inform future asset design.
- Further due diligence testing for land contamination should be undertaken opportunistically with the above ground testing.
- Flood modelling needs to be undertaken for the preferred option to confirm flood impacts within the PSP and for properties downstream of the PSP.
- At this stage costing is only comparative. A more detailed cost estimate of the preferred option will need to be prepared.

Next Steps

The next steps are to confirm with Melbourne Water that the preferred Option is Option 1F and then commence the functional design process. The functional design process will involve refining the preferred option, including addressing some of the above risks and limitations.

Important note about your report

Melbourne Water (MW) engaged Jacobs Group (Australia) Pty Ltd (Jacobs) to complete this options assessment report as part of the Officer South DSS project.

This report is limited to the scope of services set out in the agreement between Jacobs and Melbourne Water (MW). The findings in the report are based on industry accepted runoff routing and flood modelling. Such models only provide estimates of potential future conditions. The actual storm events will vary in size, intensity, and temporal pattern. The catchment will also be changed, by the development industry, in ways that cannot be predicted. The findings in this report do not represent a prediction of the future. The information should be used a guide only.

The findings presented in this report are professional opinions based solely upon information and data gathered by Jacobs, provided, or made available by MW, or has been otherwise made available to Jacobs in the public domain, as of September 2022. Jacobs has relied upon and presumed that this data is accurate and representative of the environmental conditions at the site. Except as otherwise stated in the report, Jacobs has not attempted to verify the accuracy or completeness of data collected by others. If the information presented by others is subsequently determined to be false, inaccurate, or incomplete, or if site conditions change beyond September 2022, then it is possible that our conclusions as expressed in this report may change.

Jacobs has prepared this report in accordance with the usual care and thoroughness of the consulting profession, for the sole purpose described above and by reference to applicable standards, guidelines procedures and practices at the date of issue of this report. For the reasons outlined above, however, no other warranty or guarantee, whether expressed or implied, is made as to the data, observations and findings expressed in this report, to the extent permitted by law.

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This report should be read in full, and no excerpts are to be taken as representative of the findings. No responsibility is accepted by Jacobs for use of any part of this report in any other context. This report has been prepared on behalf of, and for the exclusive use of Melbourne Water, and is subject to and issued in accordance with, the provisions of the agreement between Jacobs and Melbourne Water. Jacobs accepts no liability or responsibility whatsoever for, or in respect of, any use of, or reliance upon, this report by any third party.

Contents

Appendices

Acronyms and abbreviations

AEP	Annual Exceedance Probability
ARR	Australian Rainfall & Runoff
ASI	Area of Strategic Importance
BPEMG	Best Practice Environmental Management Guidelines
CK	Creek
CREP	Cardinia Road Employment Precinct
D/S	Downstream
DSS	Development Services Scheme
DTFV	Department Treasury & Finance Victoria
EPA	Environment Protection Authority
GED	General Environmental Duty
GSC	Gum Scrub Creek
HWS	Healthy Waterways Strategy
IWM	Integrated Water Management
KWRFP	Koo Wee Rup Flood Protection District
MCA	Multi Criteria Assessment
MNES	Matters of National Environmental Significance
MSA	Melbourne Strategic Assessment
MWC	Melbourne Water
OSR	Officer South Road
OSRD	Officer South Road Drain
PSP	Officer South Employment Precinct Structure Plan
RB	Retarding Basin
RBWL	Retarding Basin Wetland
RORB	Runoff Routing Model
SWQT	Stormwater Quality Treatment
U/S	Upstream
VPA	Victorian Planning Authority

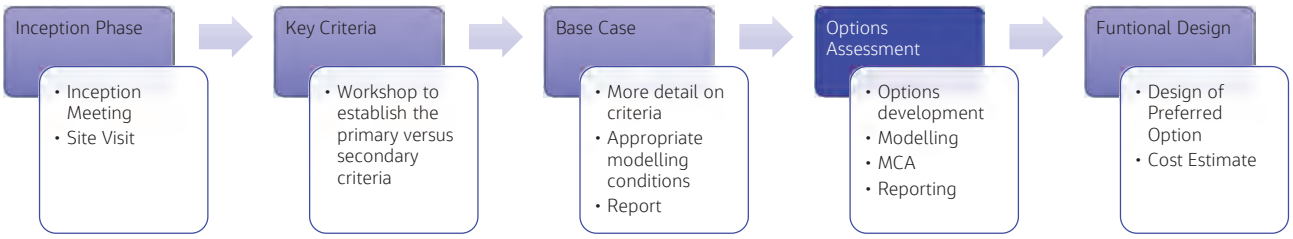
1. Introduction

Jacobs together with Spiire has been engaged by Melbourne Water (MWC) to assess Development Service Scheme (DSS) options for the Officer South Employment Precinct Structure Plan (PSP).

The design of stormwater assets forming the DSS options has been guided by stormwater quality, and hydrological and hydraulic models to ensure that the schemes adequately address peak flow, stormwater quality, fish preservation, liveability, cost, environmental and heritage criteria.

1.1 Project Scope and Objectives

The approach to this assessment is illustrated below.



This report represents the work up to the Options Assessment. Based on the analysis presented in this report a preferred option will be selected and proceed to Functional Design to inform DSS costs more accurately.

The purpose of this document is to summarise the background, constraints, calculations, modelling, and development of the options to arrive at the preferred option. The specific scope is to:

- Review all background documents, data and constraints provided by MWC, the Victorian Planning Authority (VPA) and those developed during this assessment.
- Review and incorporate the implications of constraints associated with this region, which include (but not limited to):
    - Flat terrain and the downstream influence of the Koo Wee Rup Flood Protection District (KWRFPD).
    - Large upstream catchments, currently being developed.
    - Existing services, particularly the major gas mains.
    - Ground conditions (groundwater and sodic soils).
    - Areas of cultural significance.
    - Significant or threatened biodiversity and habitat areas.
- Develop primary and secondary criteria in collaboration with MWC to assess options for the future DSSs.
- Develop a long list of options in collaboration with MWC and the VPA and short list these to the most viable options.
- Develop concepts for each short-listed option, incorporating waterways, wetlands, retarding basins, outlet configurations and downstream levees.
- Assess and model each option with respect to peak flow and stormwater quality performance.

- Undertake a Multi Criteria Analysis (MCA) incorporating the above results, cost, constructability, and environmental criteria.
- Select the preferred option to proceed to Functional Design of proposed DSS assets.
- Assess the preferred option with respect to downstream flood impacts in and south of the PSP.

Melbourne Water Objectives for Officer South and Lower Gum Scrub Ck Development Services Schemes

The following DSS objectives were developed for the DSSs to guide the drainage investigation and Options analysis:

- Meet Melbourne Water legislation requirements and other strategic directions: Water Act 1989, EPBC Act 1999, Environment Protection Act (General Environment Duty), Healthy Waterways Strategy, cultural heritage, etc.
- Meet DSS principles as prescribed in the *Principles for Provision of Waterway & Drainage Services for Urban Growth*.
- Ensure appropriate flood protection for new development within the PSP.
- Not further exacerbate existing flooding on downstream properties including the State significant Koo Wee Rup Flood Protection District (KWRFPD)
- Protect/minimise impact on environmental and waterway values.
- Meet critical drainage and other agency asset operational requirements to ensure constructability (i.e. gas main crossings)
- Apply the EPA's GED, General Environmental Duty principles in the design of the Development Services Scheme works.

1.2 Existing Catchment

The Officer South Employment Precinct Structure Plan (PSP) is in the south-eastern growth corridor approximately 45km south-east of Melbourne. The PSP covers approximately 1,069 hectares and is bound by Princes Freeway to the north, Gums Scrub Creek to the east and Cardinia Creek to the south and west as shown on Figure 3. The site is influenced by three catchments upstream of the Princes Freeway, including Cardinia Creek, Officer South Drain and Gum Scrubs Creek.

The Officer South area is characterised by flat terrain with the land generally sloping from the north-west to south-east towards Western Port Bay. The upstream catchment north of Princes Freeway consists of a combination of urbanised areas including the suburbs of Beaconsfield and Officer and hilly rural areas in the upper Cardinia catchment. These catchment areas are outlined in Table 1 and shown in Figure 4. The upstream area has experienced urban development from 2010 to 2021.

There are three primary waterways/drains in the area which defines the PSP. Cardinia Creek to the west, Officer South Drain in the centre and Gum Scrub Creek to the east, as shown on Figure 3. Officer South Drain flows into Cardinia Creek and Lower Gum Scrub Creek flows in a southern direction into the Koo Wee Rup Flood Protection District outfall. Also illustrated on Figure 1 is the Cardinia Creek Outfall levee.

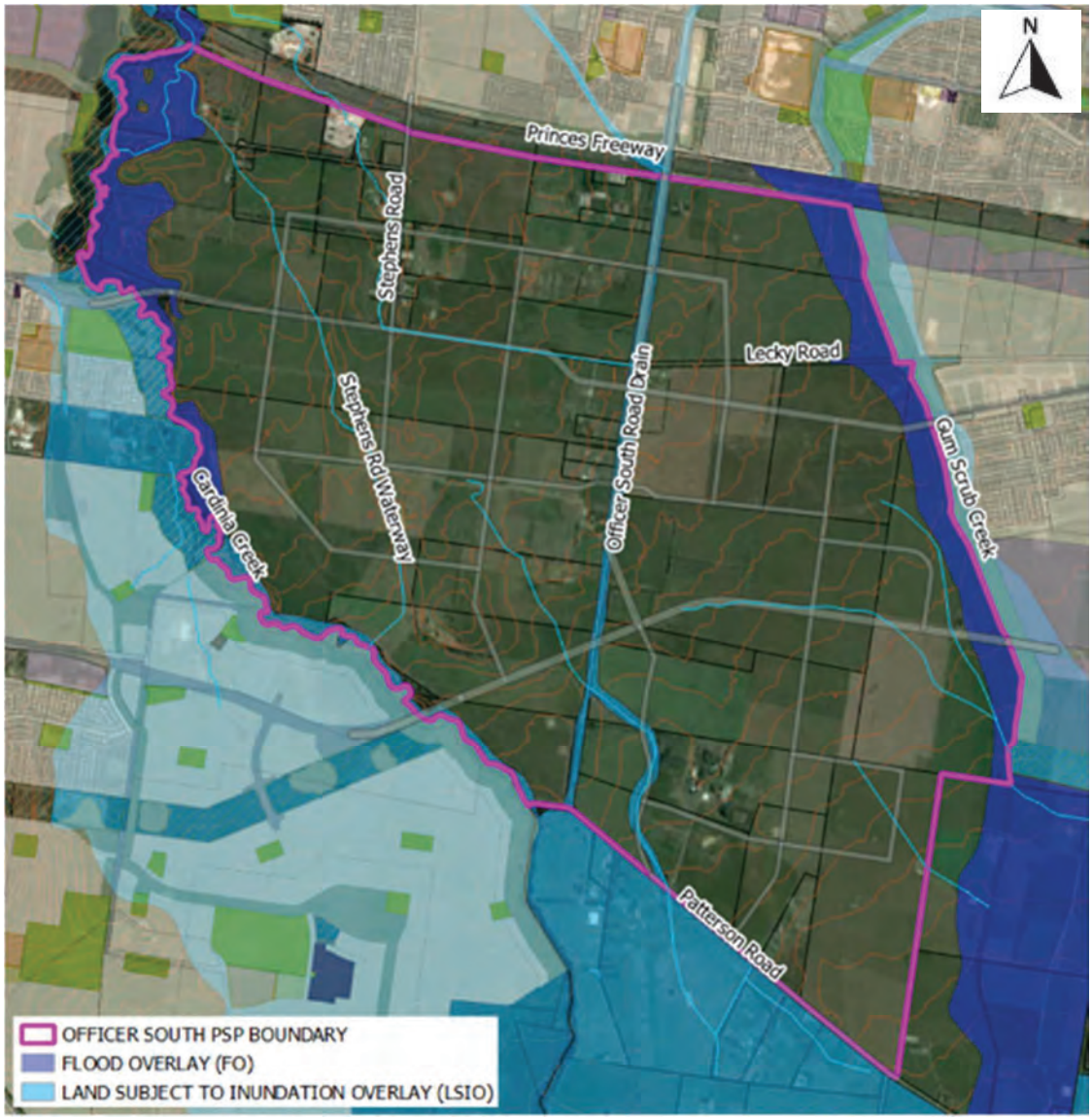


Figure 3 Existing Conditions - Officer South Employment PSP and major watercourses

Site Visit

A site visit was undertaken on the 24th March 2021 with MWC representatives to understand existing site features and constraints. James Hodgens from MWC led the visit. Key outcomes from the visit are described below:

- Gum Scrub Creek retained moderate flows at the time of the site visit and is considered quite shallow and undersized for its catchment.
- Officer Road Drain is a narrow drain with a depth of approximately 1 metre. It was dry at the time of the site visit (see point below regarding diversion of flows to Gum Scrub Creek). It appears to be very undersized for the upstream developing catchment. The existing Officer South Road Drain is a bypass drain built in the 1950s-60s to drain flows South to Cardinia Creek from the Officer Township.
- The Arcadia outfall (upstream of Officer Road Drain at the Princes Freeway) is quite deep and full of water. A temporary piped outfall has been provided to Gum Scrub Creek, and to Officer Road drain to accommodate particularly large events.
- No flow enters the PSP from north of the Princes Freeway near the service station.
- Outfall levee system is a complex hydraulic drainage system with 300 flood gates within the Koo Wee Rup area (refer to Figure 5 for an indicative indication of the overall system).
- A group of landowners have concerns about nuisance flooding (approximate location of the flooding issue is shown on Figure 4). A significant event occurred in May 2020 (MWC has engaged Engeny to undertake interim designs to provide a temporary outfall design before the ultimate drainage works are constructed through Officer South Employment PSP ..
- Vegetation prevents erosion and undercutting of levees however needs to be balanced with reducing conveyance capacity and can cause flooding issues.

Due to access constraints, it was not possible to observe the potential fish habitat along Stephen's Rd or the main outfall proposed for Cardinia Creek.

Summary of Existing Conditions

Flows from Cardinia Creek are likely to be primarily contained within the waterway; however, this assessment will aim to determine the level of interaction with the PSP and area downstream of the PSP. Officer South Drain and Gum Scrub Creek operate as large table drains, conveying frequent flows downstream. More infrequent events exceed the capacity of these drains and engage the floodplain.

A summary of the catchments, including the large upstream catchment areas, and key features of the waterways are shown in Table 6. These features and constraints are described in more detail in subsequent sections. A catchment plan is shown in Figure 4.

Table 6 Catchment Summary

Catchments	Total catchment area	Upstream catchment area	Key features
Cardinia Creek	9,188 ha	7,935 ha	▶ Large catchment, downstream of the Cardinia Creek Reservoir ▶ High priority reach within MWC's Healthy Waterways Strategy (2018). High ecological and biodiversity values e.g. Dwarf Galaxias, Australian Grayling, and Growling Grass Frog (Jacobs, 2020). Refer to Section 1.5.2 for more detail.
Officer Road Drain	1,529 ha	1,010 ha	▶ Rapidly developing upstream catchment. ▶ Highly constrained, small roadside drain to cater for low flows and a rural catchment. ▶ Remnant vegetation along the channel. Refer to Section 1.5.2 and Appendix A for more detail.

Gum Scrub Creek	3,397 ha	1,830 ha	▶ Rapidly developing upstream catchment. ▶ Small farmers cut drain that frequently spills. ▶ Areas of Strategic Importance mapped across and in adjacent land. Refer to Section 1.5.2 and Appendix A for more detail.

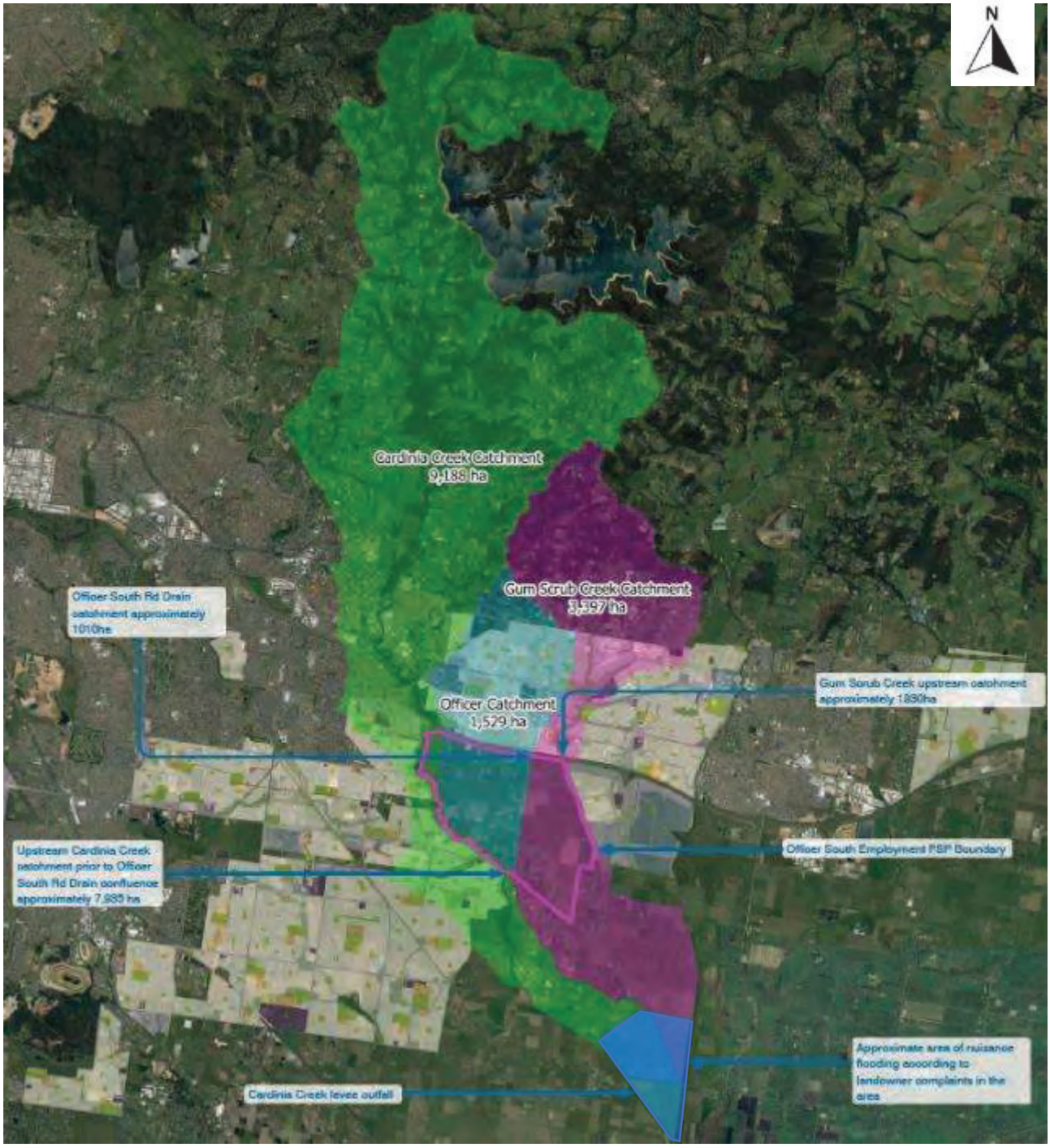


Figure 4 Upstream Catchment Map

1.3 Outfall Conditions

The two outfalls for the site, Cardinia Creek and Gum Scrub Creek, convey flows southwards through the KWRFPD (shown on Figure 5) via a system of levees, and ultimately to Western Port Bay. MWC has advised there have been a number of landowner complaints regarding nuisance flooding from residents downstream of the PSP (area of complaint is shown indicatively on Appendix A). This is due to development occurring in

the Officer area upstream of the Princes Freeway, however, it has also been a 'wetter' than average year and further analysis needs to be undertaken to determine the exact cause. In the design of stormwater infrastructure, MWC has stated consideration must be given to the flood impacts on downstream landowners. Consequently, this means the stormwater assets within the PSP need to service for the catchment upstream of the Princes Freeway as well as the PSP area.

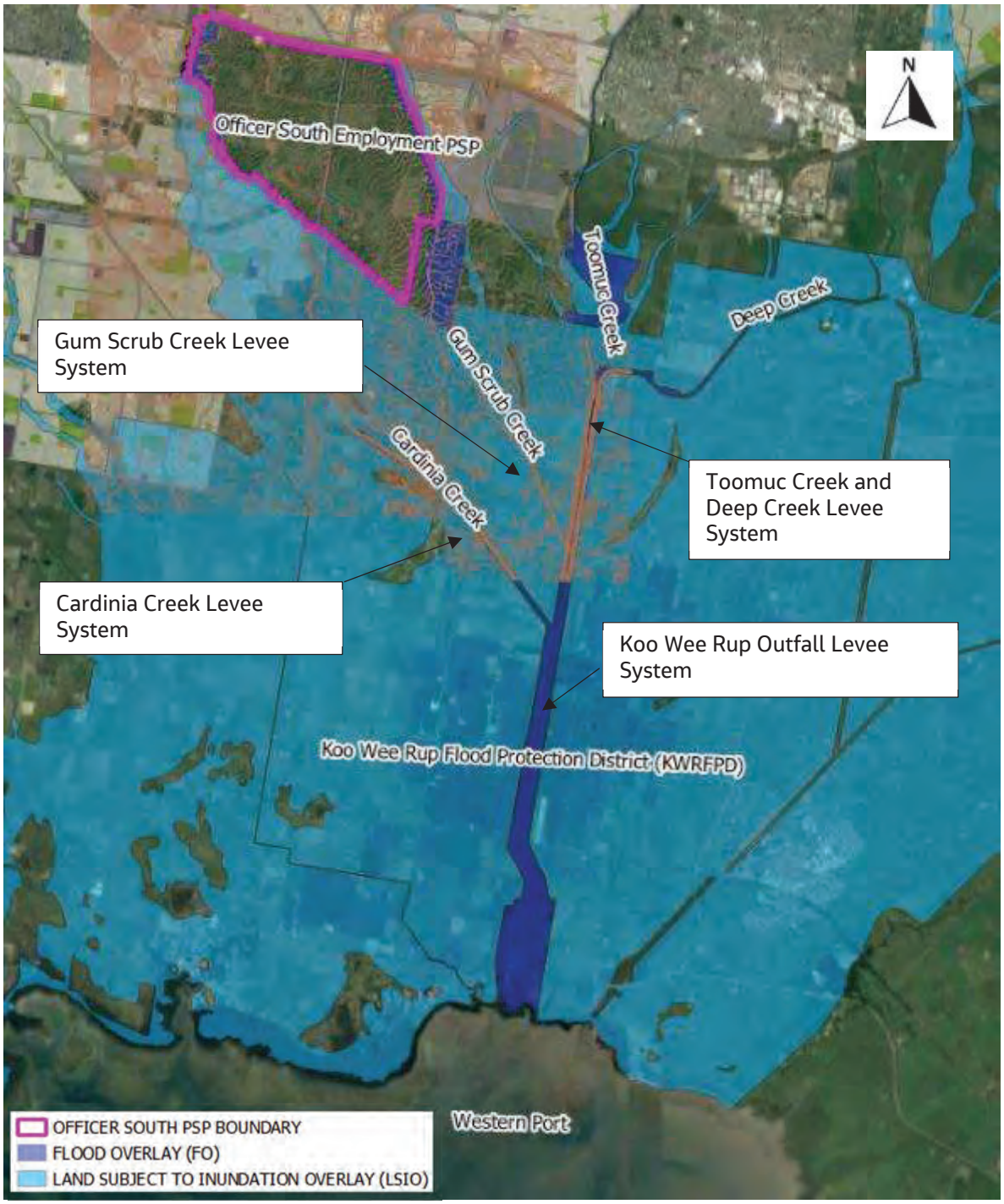


Figure 5 Existing Officer South Employment PSP Outfalls

1.4 Existing Values & Conditions

The land within the PSP currently consists of open paddocks and the major stormwater features described above, being the three waterways and minor tributaries. The following sections describe the background

studies and constraints that impact and inform the options development. Appendix A illustrates these constraints and considerations.

1.4.1 Aboriginal Heritage

There are 23 recorded Aboriginal cultural heritage places located within or near the PSP. Most of the recorded places are within or adjacent to Cardinia Creek (Tardis, 2021). The Gum Scrub Creek alignment was subject to development and is therefore, less likely to contain artefacts, however, some areas of sensitivity were still identified. Mandatory Cultural Heritage Management Plans will be required within a 100 m offset of Cardinia Creek and 50 metres of registered Aboriginal Places (Tardis, 2021). Typically, property owners developing in these areas would undertake these assessments, however, this poses a risk to some of the stormwater treatment asset locations (that are typical located near creek lines) and footprints, and MWC may wish to undertake more detailed studies to confirm the viability. Refer to Appendix A illustrating the cultural heritage sensitive areas.

1.4.2 Biodiversity and Ecology

Vegetation

Within the paddocks there are a total of 10,430 trees (Homeward Consulting, 2020). Most of the trees have been planted for windbreaks and screening purposes or are located along roadside verges. The trees have been assessed by the VPA and 16 are marked as very high retention value and 699 are marked as high retention value (VPA 2021A). There are also numerous scattered trees which are also of high retention value. The very high and high retention value trees are to be retained and incorporated into the new development. Several of the very high and high retention value trees are on or near potential drainage and waterway asset sites. Additional high value trees have been highlighted by Cardinia Shire Council to be retained in the PSP which need to be considered in the ultimate DSS design.

Growling Grass Frog

The Melbourne Strategic Assessment (MSA) has identified both Cardinia Creek and Gum Scrub creek as "Areas of Strategic Importance" (ASI). This means that there are areas within the region which are important for Growling Grass Frog (GGF) habitat under DELWP authority. The MSA identifies areas to be protected. The ASI can be seen on Appendix A and further information can be found on the DELWP website.

Protected Fish Species

The section of Cardinia Creek from the Princes Freeway to Chasemore Rd is listed as part of Conservation Area 36 in DELWP's Biodiversity Conservation Strategy (2013). Protected and threatened fish species have been identified within this reach, Dwarf Galaxias and Australian Graylings, and as a result Jacobs were commissioned to investigate the implications on the values with the DSS (Jacobs, June 2020). The Jacobs draft report identifies the reach between Officer South Road and Chasemore Road as a high-risk reach, as shown on Figure 6, and states that a critical risk to the fish species is the increase in peak hourly flow rates. Whilst the peak flows do not necessarily impact the fish directly, the flow rates can modify the fish habitat which ultimately affects the fish. The risk to the reaches identified in the report are based on the previous Officer South DSS concept plans. Through this options analysis and future functional design of DSS assets, the risk profiles may change. Jacobs recommended:

- The frequency of flows that result in bed mobilisation should be maintained at current levels
- Stormwater and IWM infrastructure should be designed to reduce the high hourly peaks and to maintain the current bed mobilisation regime.

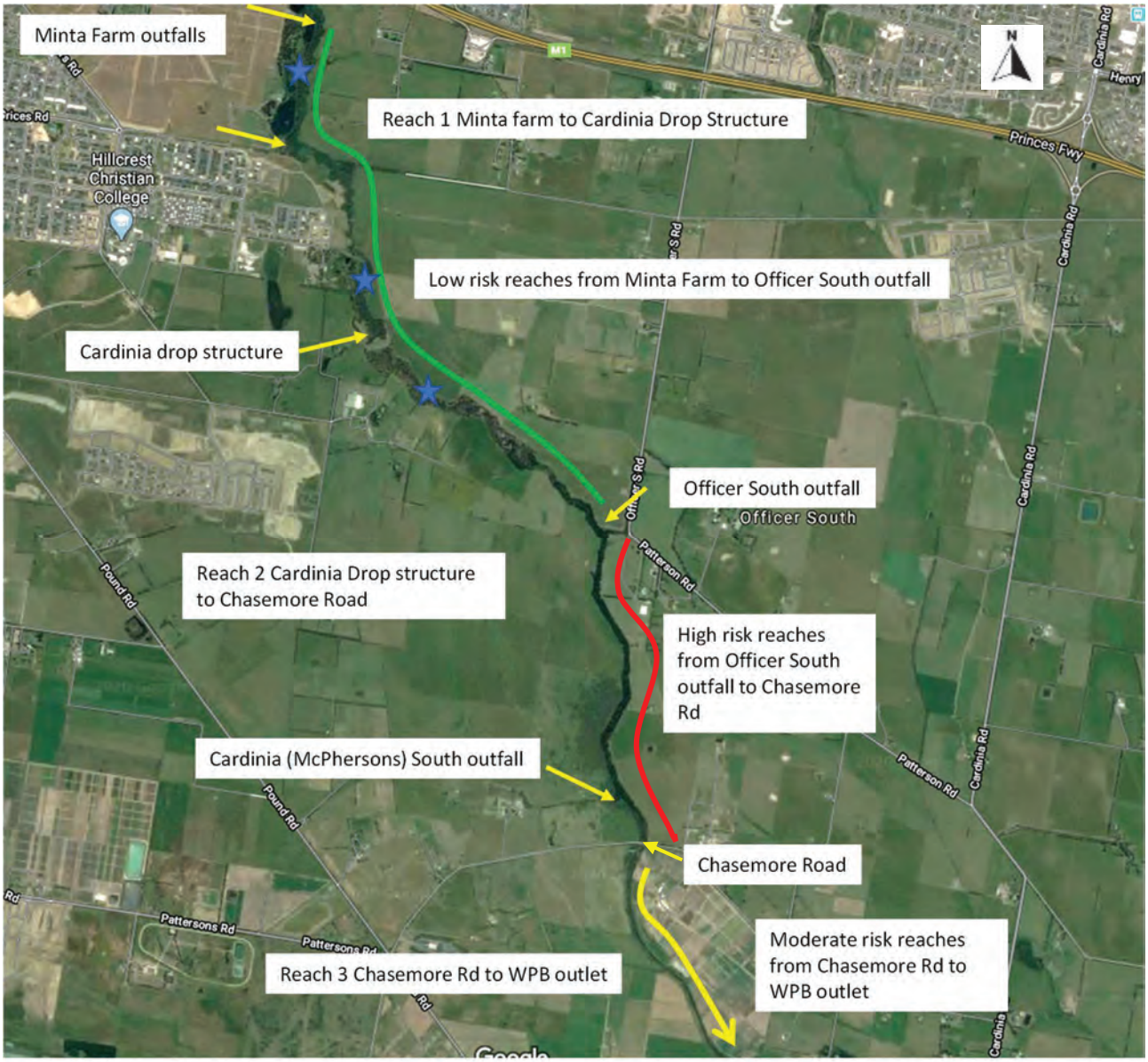


Figure 6 Jacobs Fish Study – Reach Risks based on development of the PSPs in the region (Source: Cardinia Creek Hydrological and Fish Risk Assessment (draft) by Jacobs (June 2020)).

1.4.3 Post-Contact Heritage

There are properties within the precinct that are heritage listed and three more potential sites that have been identified. Of the two properties, one is of significance to Cardinia Shire, Cardinia Park, and the other Jesmond Dene House, has a picket fence of significance to Cardinia Shire. It is unlikely that either of these properties will have a significant impact on scheme assets within the precinct. For further information refer to the Benchmark Heritage Management Report (September 2020).

1.4.4 Ground Conditions

Acid Sulfate Soils (ASS)

Potential acid sulphate soils (PASS) underlie large areas of Australia's coastline, riverine, lakeside and other inland environments. These soils are naturally occurring and can be found under low-lying areas like coastal plains, wetlands and mangroves. In an undisturbed and waterlogged state these soils are relatively harmless, but when disturbed and exposed to oxygen through drainage or excavation, these soils may produce sulphuric acid in volumes sufficient to degrade waterways, vegetation and infrastructure.

The Victorian Planning Authority commissioned a review of sodic/dispersive soils and acid sulfate soils to inform the precinct planning for Officer South Employment Precinct (WSP, 2021). The assessment involved a field investigation to collect information from 45 boreholes and three groundwater bores. The risk of acid sulphate soils is low. Further Melbourne Water testing is to be arranged to inform the constructability of waterway, drainage and flood protection assets. The risk of sodic soils is discussed below.

Sodic Soils

Based on the information available, soils across the Officer South precinct area are of a sodic and dispersive origin, in accordance with literature including Sargeant (1975), Howe et al. (1979) and Macmillan et al. (1997) and other more recent reports covering this site and local area. The WSP (2021) report provides insight and clarification that these conditions exist.

Jacobs have previously provided advice on the management and treatment of sodic soils for other precinct areas (Beveridge North West: Jacobs 2020, Shenstone Park: Jacobs 2020, Wallan East (Part 1): Jacobs 2021, Wallan South: Jacobs 2021). Treatment and management options are expected to be similar in Officer South to those outlined for these areas. The treatment and management options are generally tailored to each investigation area where there is an explicit level of understanding of sodic soil results within specific areas. General options to manage sodic soils include:

- Soil compaction, as it reduces dispersion potential.
- Chemical amelioration with additives such as gypsum.
- Minimising the extent and depth of cut, particularly on graded surfaces.
- Minimising exposure periods of exposed soils.
- Using non-sodic topsoil and vegetation to protect sodic soils.
- Construction management plans in place to identify hazards related to sodic soils.

There are high exchangeable sodium percentage (ESP) values that are encountered across the Officer South project site. There is also a significantly more annual rainfall which puts greater risk on erosion for earthworks in this region compared to the north of Melbourne (Wallan South 646 mm, Officer South 807 mm). In addition the PSP is located near the bottom of large catchments which increase the erosion risk, due to large flows passing through the area.

Whilst the sodic soils are undesirable due to the potential to increase erosion and sediment transport during construction, they are generally able to be managed through proper design and construction protocols. These are to be considered during functional design. It is recommended that further sodic/dispersive soil investigations are undertaken in the Officer South Precinct Area to support the design of DSS assets. It is also recommended that a formal vulnerability assessment is undertaken to assess the implications of sodic soils for future planned development and design of DSS assets.

Groundwater

A review of publicly available water table mapping suggests that the groundwater levels at the site are shallow, less than 5 meters below ground level as shown in Figure 7. The water table could be deeper (5-10 meters) in some isolated areas along Cardinia Creek.

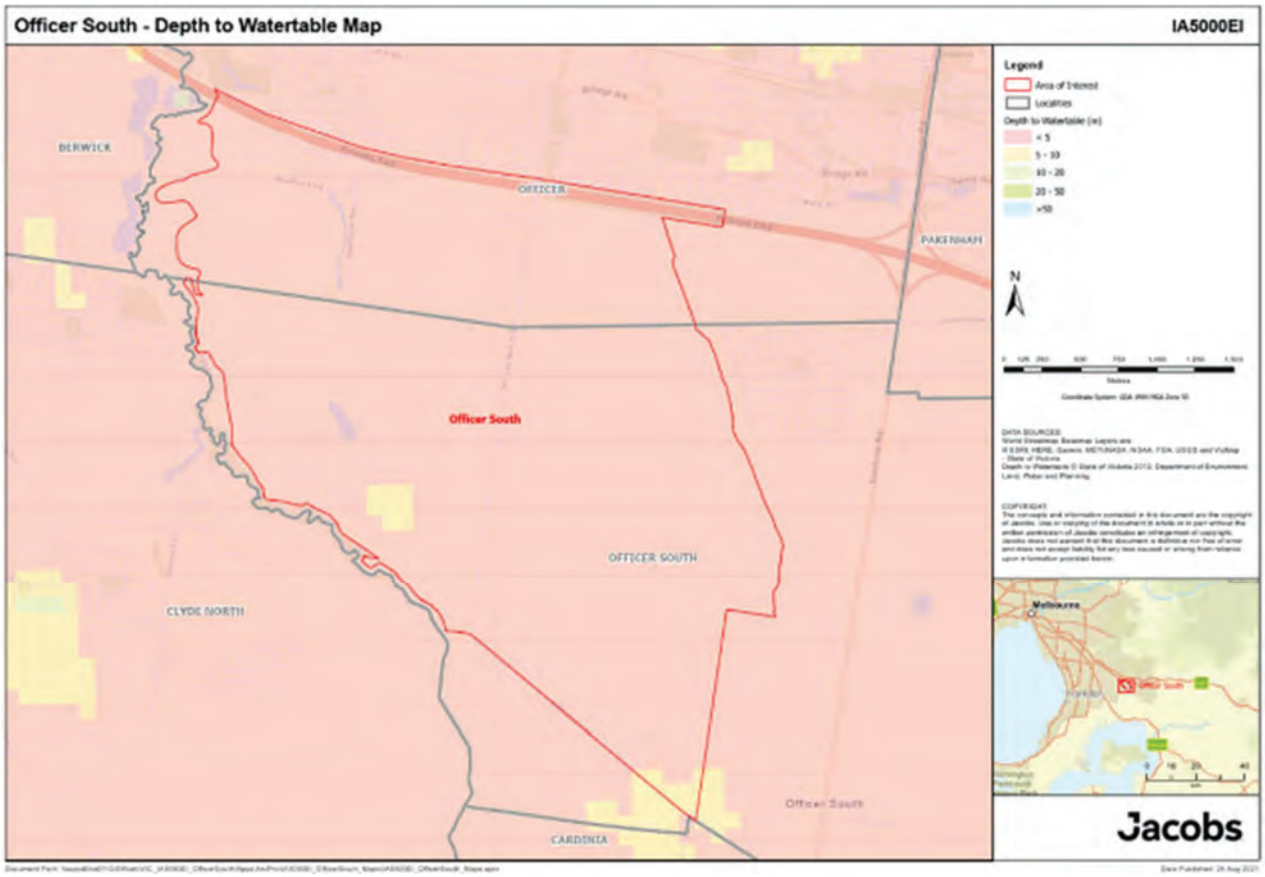


Figure 7 Depth to Groundwater

Groundwater salinity in the Officer South region is expected to range between 3,500 – 7,000 mg/L total dissolved solids (TDS). Groundwater in the regional aquifer is typically less saline to the west, north and east of Officer South.

WSP installed three groundwater monitoring bores along Cardinia Creek. The depth to water table was 3.3m in the northern two bores and more than 7 m deep in the southern bore. The southern bore was installed at 7.1m depth and was dry. Groundwater conditions encountered in these three bores is largely consistent with the expected conditions. Based on the available data, it was considered that groundwater could be encountered during construction and further investigations were recommended. No aquifer testing was completed to confirm aquifer properties and potential groundwater inflow rates.

In terms of its impact on stormwater infrastructure, groundwater is generally considered problematic. For drainage infrastructure, such as pipes, if the groundwater is saline it can affect the structural integrity and lifespan of the pipes due to saline concentrations reacting with the cement in the pipes. For stormwater treatment infrastructure, such as wetlands, which require clay lined bases to prevent water infiltrating into the ground, the upward pressure on the clay from the groundwater can damage the liner and therefore require costly repairs. Saline groundwater can also impact plants within stormwater treatment assets if the salt levels are too high.

Melbourne Water is considering undertaking further targeted groundwater assessments at retarding basin sites after the preferred servicing option has been identified.

Contaminated Land

Available aerial photographs from 2004 to 2021 were reviewed by Jacobs to identify the historical land uses within the study area. Aerial photographs for the Officer South Employment Precinct were provided and observations are summarised below in Table 7.

Table 7 Officer South, Employment Precinct Site History

Year	Description	Photo	Source
2004	Agricultural land use. Between 1974-1985 a racetrack and associated buildings were constructed in the north of the precinct. A gas pipeline easement was added in an east-west direction between 1991-2004.		Google Earth
2014	Agricultural land use. Development of residential area north-east from the precinct. BP service station built in 2013 on-site in the north-west corner of the study area.		Google Earth
2021	The current site use is predominantly agricultural land, with some residential properties throughout the site. BP service station still operational.		Google Earth

An online search using Victoria Unearthed was conducted on 6 September 2021 to identify any contaminated sites throughout the study area. The search included EPA environmental audit sites, EPA priority sites, EPA licenced sites, EPA landfills, and Groundwater Quality Restricted Use Zones (GQRUZ). The search identified no past or current contaminated sites throughout the study area, some sites were noted in surrounding areas.

Generally, there is a low to medium level of potential contamination of land, with potential contamination arising from historical agricultural activities. Land contamination has the potential to impact construction costs, e.g. costs associated with disposal. Melbourne Water is considering undertaking further targeted assessment of land contamination at retarding basin sites after the preferred servicing option has been identified.

1.4.5 Existing Services

Gas Mains

A major 450 mm diameter APA gas main traverses the precinct from east to west and is located approximately 1 m below natural surface (refer to Appendix A for alignment). The main has an associated 20.1 m wide easement. This forms a significant constraint to stormwater assets as drainage will need to cross it. The level is not accurately known at the cross over of some sections, as services provers could not access the low point. This will need to be approximated based on the closest available information. This gas main and its restrictions will need to be taken into consideration when designing assets adjacent to the gas main as it needs to be crossed. This may occur either via crossing beneath the main, above the main or alternatively relocating the main if neither of the previous two options can be achieved.

In addition, there are two significant APA distribution mains of 150 mm and 180 mm diameters which encumber the PSP. The 180 mm diameter main runs along Lecky Rd, from Officer South Rd to Gum Scrub Creek in the east and the 150 mm diameter pipeline is located adjacent to Officer South Rd from Lecky Rd into the Officer PSP (refer to Appendix A). The depths of these mains are currently unknown and will require service proving. Further information regarding the gas mains can be found in the GHD Site Situational Analysis report (GHD, 2020).

Electricity Easement

There is an electrical transmission easement which traverses the southern portion of the site (refer to Appendix A). The easement is ~146 m wide and caters for two 500 kV overhead lines. Electrical easements are typically seen as an opportunity for co-location of stormwater assets subject to consultation with Ausnet. Powerlines form a constraint to these designs due to vertical and horizontal clearance requirements. Further information regarding the electrical infrastructure can be found in the GHD Site Situational Analysis report (GHD, 2020).

Communications

The primary communications infrastructure in the precinct is the major Telstra fibre optic cable, located within the Lecky Road reserve, from Cardinia Creek to Officer South Rd (refer to Appendix A). This depth below natural surface and size of the infrastructure is currently unknown and will require service proving. This asset could be a constraint to stormwater infrastructure depending on its depth.

1.5 Predevelopment Flow Conditions 2010

Predevelopment flows are shown in the figure below for critical points in the PSP. The predevelopment 2010 flows are based on RORB modelling described in section 2.2.4 and supporting reports listed in section 6. This includes the predevelopment of the greater Officer and Gum Scrub Creek catchments set at a time datum of 2010 before the Officer Township PSP was approved and significant development had commenced in the catchments. This is necessary because the existing Officer PSP and Officer South Employment PSP must have their flows and volumes mitigated to prevent adverse effects on properties south of these PSPs, both under current and future development conditions.

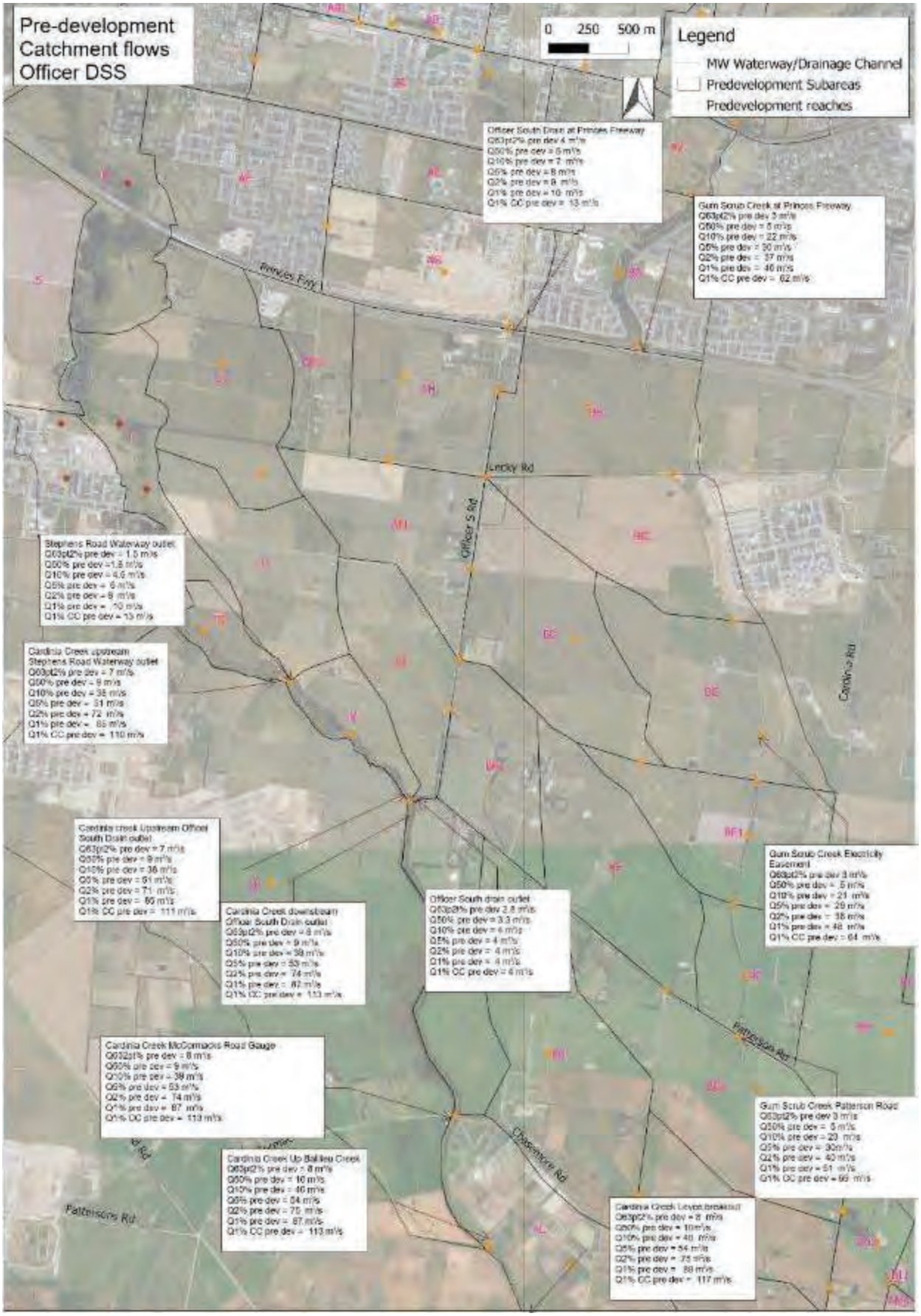


Figure 8 Predevelopment Flows 2010

1.6 Future Developed Conditions

Planning for the PSP is being undertaken by the Victorian Planning Authority (VPA). The VPA is leading a planning process that involves the Cardinia Shire Council, State government agencies and servicing authorities, including Melbourne Water, and landowners.

The PSP will primarily include commercial land with residential precincts (about 2,200 dwellings) north of Lecky Road and industrial land south of Lecky Road (VPA 2020A). The current draft structure plan is shown in Figure 9.

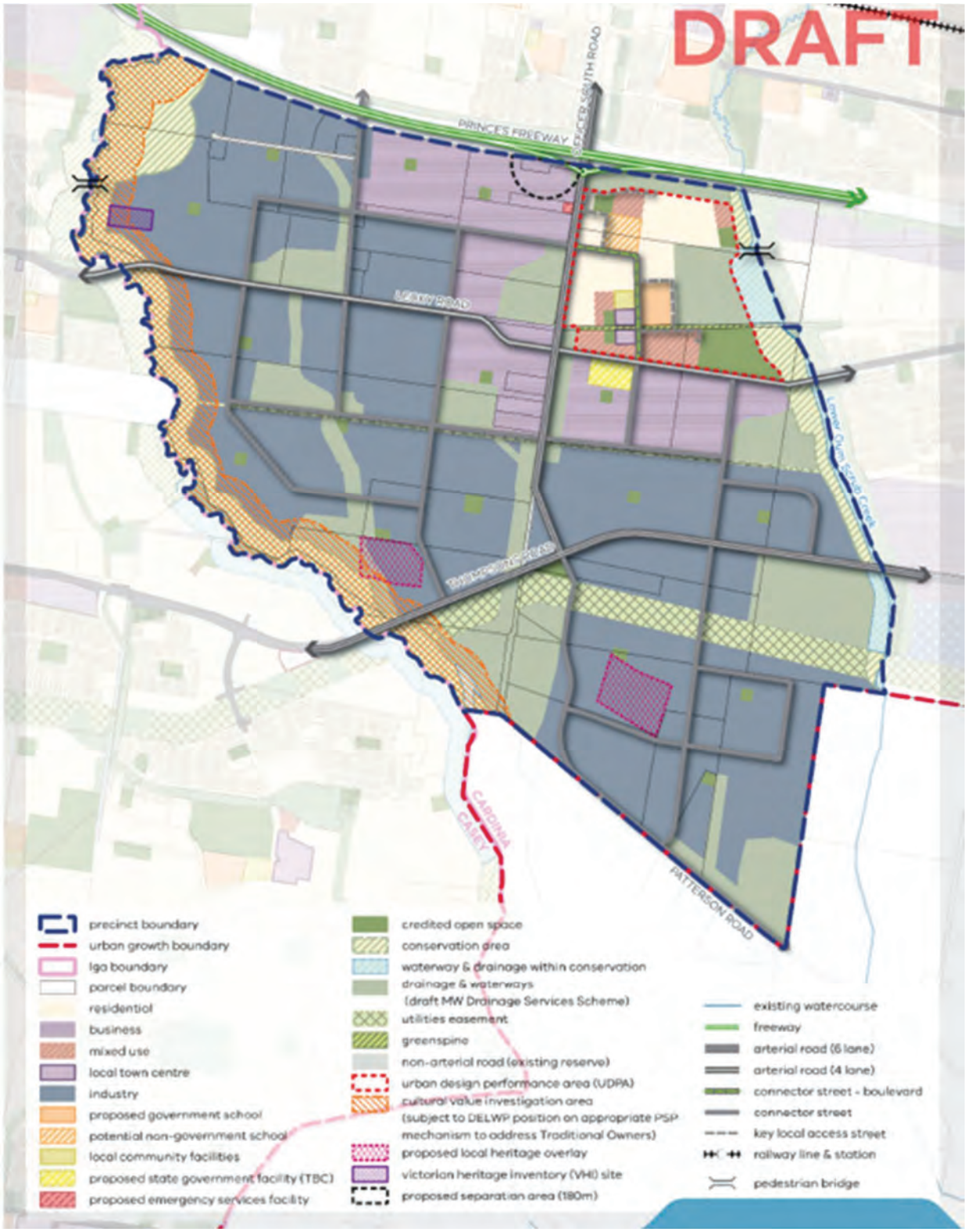


Figure 9 VPA's Draft Future Urban Structure (July, 2022)

1.7 Proposed Drainage & Waterway Assets

As identified by MWC and based on the previous (superseded) Strategy (SWS, 2020), the site is defined by two schemes as shown in Figure 10, and described as follows:

- Officer South DS (1304) – Is the area west of Officer South Road Drain to Cardinia Creek. It includes multiple waterways, as well as multiple offline stormwater quality treatment assets (wetlands / retarding basins). This Scheme ultimately drains to Cardinia Creek, which is a high priority waterway under Melbourne Water's Healthy Waterway Strategy (HWS).
- Lower Gum Scrub Creek DS (1402) - Primarily includes the preservation of the Gum Scrub Creek corridor and features several stormwater assets, retarding basin/wetlands, to be placed in several locations adjacent the Creek.

These schemes for the Officer South PSP will include up to 10 retarding basins. These retarding basins are referred to with letter identifiers (i.e., A, B, C, etc) and common names, e.g., Lecky Road. Figure 11 illustrates the location of these assets conceptually.

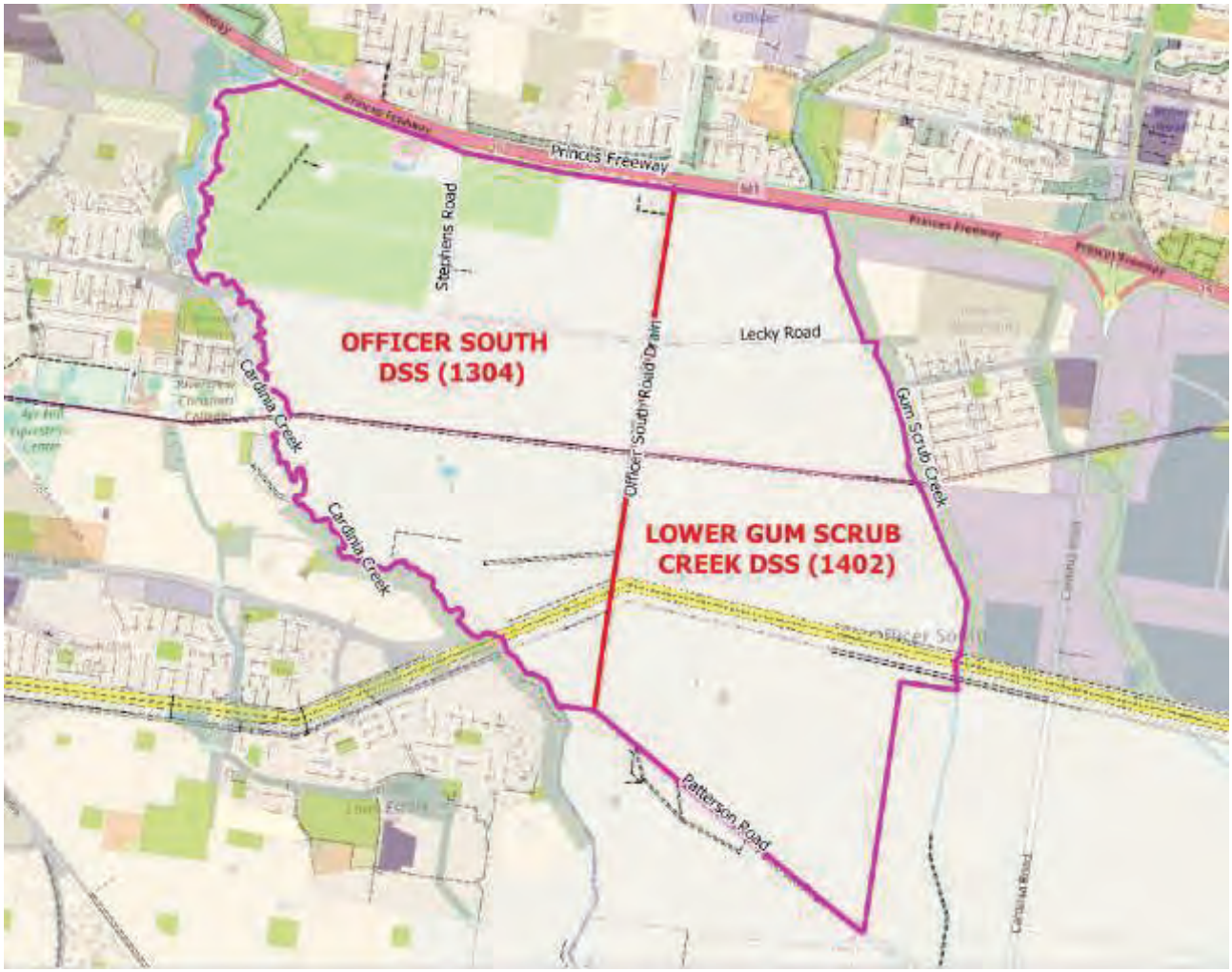


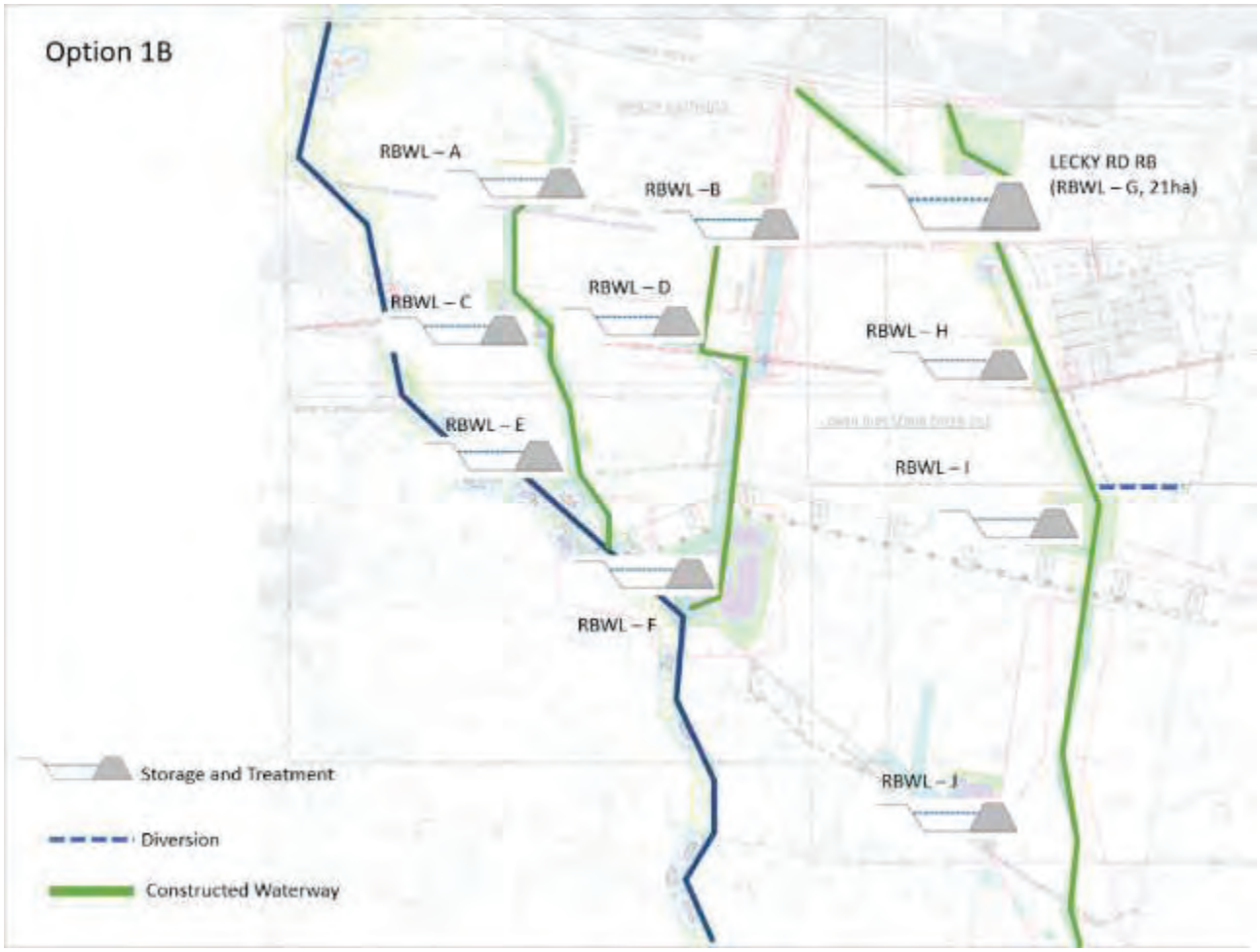
Figure 10 MWC Proposed Development Services Schemes

These proposed Development Services Schemes for the Officer South PSP will include up to 10 retarding basins. These retarding basins are referred to with letter identifiers (i.e., A, B, C, etc.) and common names, e.g., Lecky Road. The table below cross references the letter identifiers with the common names and provides the street address for each retarding basin. Figure 11 illustrates the location of these assets conceptually.

Table 8 Retarding Basin ID, Names & Locations

Retarding Basin	Common Name	Location
A		North of Lecky Rd and west of Stephens Rd
B		North of Lecky Rd and west of Officer South Rd
C		North of the gas main and between Cardinia Creek and Stephens Rd Waterway
D		North of the gas main and between Stephens Rd Waterway and Officer South Rd
E		South of the gas main and between Cardinia Creek and Stephens Rd Waterway
F		At the southern end of Officer South Rd adjacent to Cardinia Creek.
G	Lecky Road	Along Gum Scrub Creek North of Lecky Rd.
H		North of the gas main and adjacent to Gum Scrub Creek
I		South of the gas main and adjacent to Gum Scrub Creek,
J		North of Patterson Rd and west of Gum Scrub Creek

Figure 11 Asset Identifiers (example option)



2. Options Investigation and Modelling

2.1 Options Overview

Eleven (11) options were investigated at the request of Melbourne Water, options 1A, 1B, 1C, 1D, 1E, 1F, 2A, 2B, 2C, 3A and 3B. The options were broadly:

- Option 1 - Conveyance of Officer DSS flows into Gum Scrub Creek.
- Option 2 - Officer DSS flows to continue in Officer South Road Drain to Cardinia Creek
- Option 3 - Officer South Road Drain fully diverted at southern end to Gum Scrub Creek.

More details on sub options are provided in Table 9. Layout Plans of each of the options are shown in Appendix C. The sub options involved combinations of retarding basin sizes, diversions from various catchments, e.g. diversion of Gum Scrub Creek flows to Cardinia Road Drain, and different sizes for the Lecky Road Retarding Basin. The purpose of conveying waterway flow from Officer South Road Drain to Gum Scrub Creek is to minimise the flow to Cardinia Creek (replicating the conditions under predevelopment flow, refer Jacobs (2022a)). All options have proposed stormwater treatment wetlands located in them of various designs for the treatment of the nominated catchments.

The options can be described follows:

Table 9 Options Summary

Option	GSC Diversion	Description
1A		Flows are routed and retarding basins /wetlands are sized and located based on MWC normal practice.
1B	✓	Flows are routed and retarding basins /wetlands are sized and located based on MWC normal practice. There is diversion of flows from GSC to Cardinia Road Drain
1C		As per Option 1A, but Retarding Bain G at Lecky Road is increased in size to maximise stormwater treatment and retardation opportunity.
1D	✓	As per Option 1B, but Retarding Basin G is decreased in size (to reduce impact on the residential land) and Retarding Basin H is increased in size to balance where storm water treatment occurs.
1E		As per Option 1B, but Retarding Basin G is decreased in size and Retarding Basin H and I are increased in size to maximise the potential stormwater treatment.
1F	✓	As per Option 1B, but Retarding Basin H is offline with a diversion from GSC and Retarding Basin I is significantly increased in size and is online to GSC.. There is diversion of flows from GSC to Cardinia Road Drain
2A		Officer South DSS Flows continue down Officer South Road via a constructed waterway. There is no diversion of flows in the catchment. .
2B	✓	Officer South DSS Flows continue down Officer South Road via a constructed waterway. There is a diversion of flows from Gum Scrub Creek to Cardinia Road Drain.,.
2C	✓	Officer South DSS Flows predominantly continue down Officer South Road via a constructed waterway. There is a minor diversion. There is diversion of flows from Gum Scrub Creek to Cardinia Road Drain
3A		Same as Option 2A, however, flows are diverted from the southern end of Officer South Road into Gum Scrub Creek. There is no diversion of flows from GSC to Cardinia Road Drain. .
3B	✓	Same as 2B , flows are conveyed from the southern end of Officer South Road into Gum Scrub Creek . There is a diversion of flows from Gum Scrub Creek to Cardinia Road Drain.

The options are discussed and assessed with respect to hydrological and stormwater quality treatment performance from Section 2.3 to Section 2.9.

2.2 Model Set Up and Assumptions

This section describes the models that were used to size the assets required within each of the options and ensure that the options best meet the objectives. The analysis described in this section underpins the multi-criteria assessment. It also includes key information and assumptions that influence the options.

2.2.1 MUSIC Modelling

MWC's MUSIC Guidelines (2018) were used to prepare MUSIC Models for each of the proposed retarding basin wetlands. MUSIC software can be used to simulate pollution production from catchments and pollution reduction through constructed wetlands.

The stormwater management levels set by MWC for the project are consistent with Best Practice Environmental Management (BPEM) objectives set under Victoria's Planning Provisions and the EPA's General Environmental Duty GED 2021 which sets out general principles and guidance for protection of people and the environment. Compared to typical urban annual loads the target levels reductions are as follows:

- Total Suspended Solids: 80 per cent
- Total Phosphorus and Nitrogen: 45 per cent
- Litter: 70 per cent.

Key inputs and model set up data are as follows:

- MWC's Koo Wee Rup 10 year rainfall template was used for all simulations. Timesteps for all models were 6 minutes.
- Source nodes were inputs are based on MWC (2018). The two main fraction impervious values used were:
    - 0.9 - Industrial Area
    - 0.75 - Residential Area
    - All other parameters for the Source Nodes, such as Field Capacity, Soil Storage and probability curves, are in accordance with MWC's MUSIC Guidelines (2018).
- Treatment nodes were generally setup in accordance with MWC (2018) for conceptual designs. Key design parameters are listed in Table 10.

Table 10 Treatment Node Parameters

Parameter	Value
EDD (m)	0.35
EDD – LARGE ONLINE WETLANDS (m)	0.15*
DETENTION TIME – SEDIMENT BASINS (hrs)	12
DETENTION TIME – WETALNDS (hrs)	72
EXFILTRATION RATE (mm/hr)	0

*Not in accordance with general guidance, discussed below.

The one instance where the guidelines were not followed was in relation to the large online wetlands where it's proposed that the EDD is 0.15m rather than 0.35m as agreed with MWC. The rationale for the reduction in EDD is because of the large catchments – the normal water level (NWL) will be exceeded for long periods of time, which is a risk to the plant's survival within the wetland.

The stormwater quality treatment (SWQT) results are based on catchment wide treatment (i.e. including the catchment north of the Princes Freeway) rather than just the PSP area. RBWL G (Lecky Road Retarding Basin

Wetland), RBWL, F and I are online, in some options these are treating upper external catchments as well as local catchments. Local catchments are being treated to Best Practice and the regional retarding basins wetlands are treating upper catchment of Officer Township PSP. It is not preferred to have retarding basins online to waterways due to the potential impacts to the migration of aquatic species. However, in this instance the flood protection function necessitates the basins being online.

Further assumptions on the MUSIC models are detailed in Appendix G.

2.2.2 Water Balances

In addition to assessing the SWQT of the PSP area, the MUSIC models were used to assess volumes of water being generated and conveyed through the site. Water balance modelling is a conceptual representation of the hydrological cycle, with the particular focus on the inflows equalling the outflows. Water balances focus on the regular flows, as opposed to the peak flows. For this project, the regular flows were derived from Melbourne Water's Koo Wee Rup MUSIC Rainfall template, which provides the 10 years of average rainfall data. Water balances are useful to gain an understanding of the regular flows and the annual volumes of water likely to occur within a catchment. Given that volume was a risk to the fish within Cardinia Creek (Jacobs, 2020) and the farmland downstream of Gum Scrub Creek, water balances were undertaken for each option to better understand the risk to these two entities. Results of the Water Balances can be found in the options summaries in Section 2.3.

2.2.3 12d Design

12d is a terrain modelling software commonly used within the civil engineering and surveying industries. 12d was utilised in the concept design phase for the following purposes:

- To design assets (concept design level),
- Determine asset footprints, with appropriate batters,
- Determine retarding basin volumes,
- Ensure that vertical geometry of assets is feasible, and
- Extracting cut/fill quantities to inform cost estimates.

2.2.4 RORB Modelling

All RORB modelling work has been completed to inform the MCA options analysis. This work is intended solely as a guide, and the refined preferred option will be subject to further modelling for the purposes of functional design.

RORB (version 6.45) existing conditions and future conditions models for the project area developed by Stormy Water Solution (SWS, 2020) were provided by Melbourne Water and used as a starting point for the assessment.

Based on discussions with Melbourne Water it was decided that the existing conditions would be reclassified as "predevelopment" conditions and set to represent a period during 2010. This would also align with a Cardinia Creek fish study completed by Jacobs in 2020. By adopting this approach, it would enable MW to appropriately understand the predevelopment conditions and specifically the nature of the downstream flooding in frequent events to a specific datum in time from which to measure from.

The previously adopted RORB parameter are summarised in Table 11. The proposed changes are provided in Table 12. The proposed change include:

- Adding the interstation area at Officer South Drain at the Princes Freeway – k_c/d_{av} ratio applied as the same as the Remainder of the model (GCS).
- Changing the Gauge Cardinia Creek McCormack Road kc value to fix the k_c/d_{av} value as per the previous model.

Table 11: Previously adopted RORB parameters

	k_c	d_{av}	K_c/d_{av}	Initial loss	Continuous loss
Gauge Cardinia Creek McCormacks Road	20.5	22.04	0.93	25	2.5
Gum Scrub Creek at Highway	5.5	4.05	1.36	25	3
Remainder of model (GSC) /primary DSS area	8.5	6.80	1.25	25	3

Table 12: Proposed changes to the RORB parameters

	k_c	d_{av}	K_c/d_{av}	Initial loss	Continuous loss
Officer South Drain at Princes Freeway	3.39	2.71	1.25	25	3
Gauge Cardinia Creek McCormacks Road	22.0	23.7	0.93	25	2.5
Gum Scrub Creek at Highway	5.5	4.05	1.36	25	3
Remainder of model (GSC) /primary DSS area	8.5	6.80	1.25	25	3

Predevelopment 2010 conditions were modelled in RORB. Refer to Jacobs (2021) and Jacobs (2022a) for a further description of the predevelopment model set up, including calibration to gauge data. Refer to Appendix B for the predevelopment flow map, derived under Jacobs (2022a).

RORB modelling was used to size the retarding basins in the drainage scheme and to assess peak flows leaving the PSP. Retarding basins in this precinct are designed to attenuate from the 50 % AEP to 1 % AEP developed flow to predevelopment levels.

The predevelopment models were converted to post-development models by adjusting the fraction impervious values and inputting the diversions at the appropriate locations depending on the option being modelled.

2.2.5 TUFLOW Modelling

TUFLOW modelling will be used to test that the adopted option adequately protected downstream areas from flooding. TUFLOW was only used to model predevelopment flood conditions and the preferred option.

Cardinia Road Drain Diversion

All options, with the exception of Option 1E (refer to Section 3 for a description of the options), reference a diversion from Gum Scrub Creek to Cardinia Road Drain. The purpose of the diversion is to reduce the impact of the increased volume of water due to development on downstream farmland south of the PSP, along Gum Scrub Creek and to reduce the peak of the low flow storm events. The diversion is proposed to occur after RB H and prior to RB I and follow the Gum Scrub Creek alignment until the electricity easement. The diversion would then veer to the east and be located either within or along the major electrical transmission line easement north of Watsons Road and outfall to the online wetland system in the Cardinia Industrial DSS, which would ultimately flow through to Cardinia Road Drain and Toomuc Creek and the major Koo Wee Rup outfall system. An indicative alignment is shown in in Figure 12Figure 12 Gum Scrub Creek – Cardinia Rd Drain diversion and Cardinia Industrial DSS. Figure 12 below and will be refined at a later stage.

The reasons that a diversion is proposed at this location include:

- Reduction of regular development flows and volumes from entering the Gum Scrub Creek system which is volume sensitive south of the PSP.
- Minimal interference to developable land.

- The diversion rate of approximately 3 m^3/s of low flow was assessed as the likely maximum that could be diverted based on a reasonable pipe size that could meet standards and achieve a free draining outfall.
- The PSP south of the electrical easement and east of Gum Scrub Creek as not been finalised, therefore allowing for flexibility of the reserve width downstream of this diversion.
- Being downstream of two retarding basins allows for longer duration of regular flows and volumes to be diverted from the Gum Scrub Creek Catchment
- Being upstream of RB I allows for more efficient use of storage for RB I.

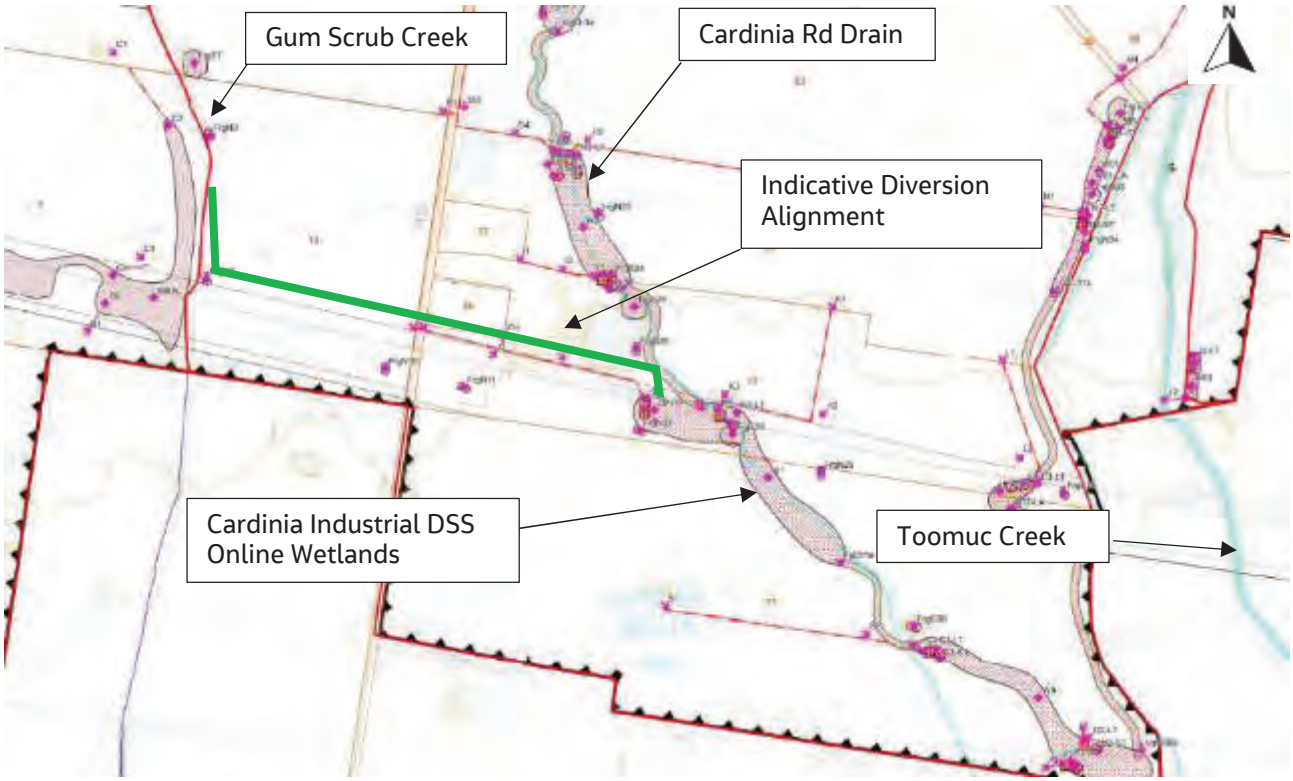


Figure 12 Gum Scrub Creek – Cardinia Rd Drain diversion and Cardinia Industrial DSS.

2.2.6 Gas Main Crossings

A major, APA owned, 450mm gas transmission main traverses the PSP site from east to west. The gas main is located roughly in the centre of the PSP as shown in Figure 13 below.

Figure 13 APA Transmission Main

The gas main is installed approximately 1.1m below natural surface for the majority of the site, however, increases in depths at waterway and road crossings. Survey has been undertaken to understand depths of the main and the key crossing points which include Stephen Rd Waterway, Officer South Rd and surrounds, and Gum Scrub Creek. Indicative plans of the crossings can be found in Appendix D, with the plans to be further refined based on the preferred option.

A summary of how it is proposed to cross the gas main crossing for the options is shown in Table 12 below.

Table 13 – Indicative Sizing for Gas Crossing Locations

CROSSING LOCATION	Option 1	Option 2 and 3
STEPHENS RD WATERWAY	2x1350mm RCP pipes below the main which take into account a 50% blockage factor	2x1350mm RCP pipes below the main which take into account a 50% blockage factor
OFFICER SOUTH RD	2x1500mm RCP pipes below the main which take into account a 50% blockage factor.	14x1500mm RCP pipes which take into account a 50% blockage factor.
GUM SCRUB CREEK	Crossing would occur over the main via a waterway crossing with a concrete weir. Indicative sizing is a 60m weir.	Current indicative sizing is approximately 50m.

The rational for the above. The general intent for the crossings is that since the gas main is approximately 1m below the natural surface at the Stephen Rd Waterway and Officer South Rd crossing, it would be easier and more cost effective to construct beneath crossings than to construct over or lower the gas main. Initial advice from APA is that if the clearance between the gas main and drainage asset is between 500mm-750mm, then recoating of the gas main is required. They also advise that pipes must be installed with their standard drawing 530-DWG-L 1001 and have provided conditional acceptance of the crossings.

For the Gum Scrub Creek crossing, a different approach has been taken. Flows are proposed to be conveyed over the main. This is because it is believed the gas main has been lowered to align beneath the creek. Therefore, to cross under the main in this location would require deep waterways downstream. It would also require numerous pipes to convey the large flows beneath the main. Further survey is required to confirm the levels of the gas main at Gum Scrub Creek and confirm that crossing over the main is possible. This will be addressed in the functional design phase. For the purpose of this Options Analysis, it is assumed that since large flows are being conveyed at present, so long as the cover on the gas main is not reduced, conveying flows above the main is acceptable.

2.2.7 Levee Augmentation

In options where flows greater than the predeveloped scenario are directed to Cardinia Creek (i.e. Options 2 and 3, refer Sections 2.8 and 2.9), the downstream levee system may overtop more frequently than at present. To mitigate against this increase in overtopping it is proposed that 1.2km of levees, between Chasemore Rd and Cardinia Rd, would be augmented to service for the 10% AEP developed flows. The cost estimate for these options includes an allowance for these augmentations (refer to Table 61). A desktop assessment determined that the capacity of the levees downstream of Cardinia Rd were adequate to convey the 10% AEP and therefore were not required to be upgraded.

The scope of the upgrade is to widen the levee system by approximately 60m by removing the existing northern levee and relocating it to the north as shown in Appendix D.

2.3 Option 1A and 1B

2.3.1 Design Intent

Flows are conveyed from the Officer South Road Waterway at southern side of the Princes Freeway to Gum Scrub Creek. There is diversion of flows from Gum Scrub Creek to Cardinia Road Drain. The intent of Option 1 is to provide distributed stormwater quality and retarding treatment, aimed at targeting the local catchments within the PSP. The one exception is RBWL G (Lecky Rd retarding basin), which is online to both the Officer South DSS and Gum Scrub Creek. This RB WL has been designed to service the upstream Officer Township PSP and Gum Scrub Creek catchment due to historical agreements that MWC has with the landowner.

An overview of the key design aspects for Option 1A and 1B are as follows:

- Officer DSS is diverted to Gum Scrub Creek.
- Lecky Rd RB is online (approximately 21.1ha. In accordance with previous agreements between the landowner and MWC).
- RB's H and I are offline to GSC and service the local catchments.
- All RB's ultimately draining to Cardinia Creek are to be offline and service local catchments.
- Option 1B is the same as 1A but also has the addition of $3m^3/s$ diversion of flow from Gum Scrub Creek to Cardinia Road Drain at the electricity easement.
- No Downstream levees south of the PSP require augmentation i for any of the 'Option 1' options.

2.3.2 Overview of Option

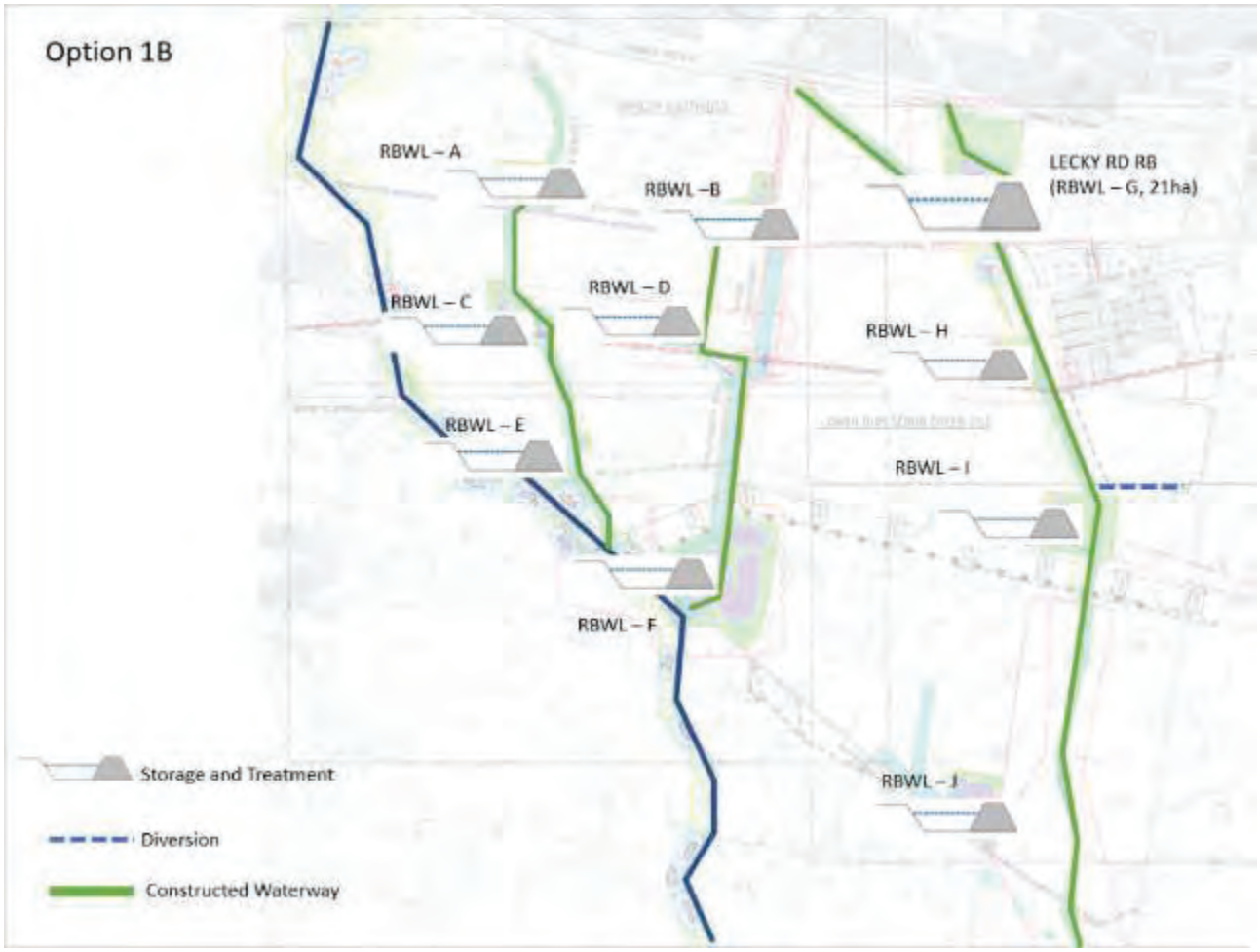
Option 1A was discounted from the assessment as it was found that Option 1B, which is effectively the same but with a diversion from Gum Scrub Creek to Toomuc Creek was not meeting serviceability or flood protection requirements and therefore this option would not either.

Figure 14 illustrates the concept of Option 1B and Table 14 provides a breakdown of the parameters of each asset within the option. Refer to Appendix E for more details on the configuration of each of the assets, including outlet and spillway sizing.

Table 14 Option 1B Asset Summary

Name	Reserve Area (ha)	Wetland Area (ha)	Flood Storage (m^3)
RBWL A	7.81	3.3	60,365
RBWL B	10.3	4.2	152,650
RBWL C	5.54	2.2	22,162
RBWL D	7.42	3.2	41,854
RBWL E	5.37	1.9	49,550
RBWL F	3.91	1.6	57,158
RBWL G	21.19	11.7	321,320
RBWL H	5.29	2.2	32,013
RBWL I	9.24	3.3	191,900
RBWL J	9.68	4.6	136,020
Total	**85.8**	**38.2**	**1,064,992**

Figure 14 Option 1B Schematic



2.3.3 RORB Results

Peak flow results from RORB for the range of AEP's relevant to the design of the retarding basins for Option 1B are provided in Table 15. Flood volume results for the 50 % AEP and 1 % AEP are provided in Table 16.

Refer to Section 2.2 for a description of the assumptions and model set up and Appendix F for further details on the associated durations and temporal patterns.

Table 15 Option 1B Peak Flows

LOCATIONS*	50% AEP (m^3/s)	10 % AEP (m^3/s)	1% AEP (m^3/s)	1% AEP Climate Change (m^3/s)
STEPHENS RD WW U/S CARD CK	1.2 (1.8)	2.2 (4.6)	3.9 (10.0)	5.3 (13.0)
OSR U/S CARD CREEK	1.7 (3.3)	2.9 (4.0)	5.6 (4.0)	6.6 (4.0)
GSC PATTERSON RD	10.6 (5.0)	31.1 (23.0)	58.0 (51.0)	67.9 (69.0)

*Brackets indicate predeveloped flows

Table 16 Option 1B Flood Volumes

FLOOD VOLUMES	50% AEP (pre-dev) (m^3)	50% AEP (m^3)	Difference (%)	1% AEP (pre-dev) (m^3	1% AEP (m^3)	Difference (%)
OSR PRINCES FWY	79,800	119,000	49%	137,000	334,000	144%
STEPHENS RD WW U/S CARD CK	17,600	58,500	232%	61,500	249,000	305%
OSR U/S CARDINIA CREEK	69,300	83,700	21%	214,000	244,000	14%
GSC PRINCES FWY	159,000	234,000	47%	1,320,000	1,840,000	39%
GSC PATTERSON RD	218,000	358,000	64%	1,610,000	1,960,000	22%
DIVERSION	N/A	217,000	100%	N/A	374,000	100%

RORB Results Discussion

With respect to peak flows the following findings were obtained (refer to Appendix B for the predevelopment flow map and Appendix C illustrating these results):

- Peak predevelopment flows are being met at the Stephens Rd waterway outlet to Cardinia Creek.
- Peak predevelopment flows are being met for the frequent events at the Officer South Rd Drain, however not for the 1% AEP and 1% AEP Climate Change (CC) events, where flows were approximately 1.5m^3/s and 2.5 m^3/s higher than predeveloped flows respectively.
- Flows along Gum Scrub Creek are exceeding the predevelopment flows for all events. Of most importance is that the 50% AEP is double the predeveloped flows for this option. Therefore there would be a significant impact to farming downstream.
- Predevelopment flow conditions in Cardinia Creek South of the PSP are not increased..

In addition to establishing peak flows, RORB was also used to determine the impact of volume from the 50% AEP and 1% AEP flood events. Key findings around volume for the flood events were as follows:

- The volumes increase by 64% in the 50% AEP developed scenario along Gum Scrub Creek at Patterson Rd compared the predeveloped scenario.
- The volumes increase by 22% in the 1% AEP developed scenario along Gum Scrub Creek at Patterson Rd compared the predeveloped scenario.
- The diversion to Cardinia Road Drain is reducing the 50% AEP peak developed flow by 38%.

2.3.4 MUSIC Results

The performance of the assets with respect to stormwater quality treatment based on MUSIC modelling is shown in Table 17 for the Cardinia Creek and Gum Scrub Creek catchments. Whilst Table 18 illustrates the results of the water balance to understand the impact of developed volumes on the creeks.

Table 17 Option 1B Catchment Stormwater Quality Treatment

TREATMENT PARAMETER	CARDINA CREEK	GUM SCRUB CREEK
TSS Reduction (%)	89.6	79.3
TSS Reduction (Kg/yr)	428,500	876,000
TP Reduction (%)	78.1	64.5
TP Reduction (Kg/yr)	760	1,500
TN Reduction (%)	55.1	36.9
TN Reduction (Kg/yr)	3,750	6,000

Table 18 Option 1B Water Balance Volumes

LOCATION	Pre-dev (GL/yr)	Developed (GL/yr)
OSR - PRINCES FWY	2.5	4.7
WEST OSR - CARDINIA CREEK	3.5	2.2
PRINCES FWY – GSC	4.6	8.7
PATTERSON RD-GSC	6.3	7.6 (without diversion 10.7)
DIVERSION	N/A	3.1

MUSIC Results Discussion

Key findings from MUSIC for Option 1B were as follows:

- The Gum Scrub Creek catchment is not meeting BPEM standards for the catchment, with only a 37% reduction in Total Nitrogen. However, this is primarily due to the shortfall in treatment within the catchment upstream of the Princes Freeway (this Precinct's assets are not able to compensate for a lack of treatment in the upstream Precinct).
- The Officer South Road catchment is achieving higher than BPEM standards, suggesting that that wetlands within this catchment will be able to be refined at the functional design stage and closer to construction. The reason for the higher than BPEM treatment was that areas for the wetlands were increased to optimise usage of the base of the retarding basin.
- The key learning from the higher than BPEM treatment in the Cardinia Creek catchment, is that the drainage reserve areas are adequate accommodate wetland assets sized to be meet BPEM targets.
- The volume of flows entering Cardinia Creek are 1.3GL/yr lower in the developed cased scenario compared to the predeveloped scenario. This is due to the significant diversion to Gum Scrub Creek.
- The volume of flows entering Gum Scrub Creek are ~4.1 GL/yr higher in the developed scenario compared to the predeveloped scenario, the increase in volume at the Gum Scrub Creek outlet is 1.3 GL/yr.
- The diversion from Gum Scrub Creek to Cardinia Road Drain, which diverts flows in the range of 0.5m3/s-3.5m3/s to Cardinia Road Drain, is diverting 3.1 GL/yr from the downstream farmers. This volume can be refined based on adjusting the flow ranges, however, at present it is diverting approximately 29% of the developed upstream flows to Cardinia Road Drain, resulting in an increase of 21 % compared to the predeveloped scenario at Patterson Rd.

2.3.5 Summary of Option 1B

Key takeaways from this option are as follows:

Table 19 Summary of Option 1B

Item	Finding/Outcome
PEAK FLOWS	Predeveloped flows are met at the Stephen Rd Waterway.
	Predeveloped flows at the Officer South Rd outlet are met up to the 10% AEP event.
	Predevelopment flow conditions in Cardinia Creek south of the PSP are not increased.
	Predeveloped flows are not met at the Patterson Rd along Gum Scrub Creek.
SWQT	BPEM is met for the Cardinia Creek Catchment
	BPEM is not met for the Gum Scrub Creek Catchment, 37% total nitrogen removal. The undertreatment of the catchment is due to the lack of treatment north of the Princes Freeway
WATER BALANCE	Cardinia Creek is receiving less volume in the developed scenario than predeveloped scenario.
	Gum Scrub Creek is receiving approximately 21% more volume in the developed scenario than predeveloped scenario.
GAS MAIN CROSSINGS	Stephens Rd Waterway- 2x1350mm RCP (inc. 50% blockage factor. To be refined during the functional design.)
	Officer South Rd - 2x1500mm RCP (inc. 50% blockage factor. To be refined during the functional design.)
	Gum Scrub Creek – 60m weir crossing over the top of 450mm T1 main. Still to be designed based on survey.
LEVEES	No upgrade to the downstream levees are proposed.

2.4 Option 1C

2.4.1 Design Intent

This option was the same as Option 1A except that the Lecky Rd RB was to be increased in size to approximately 30ha. This option was opposed by the VPA and as a result was not investigated further due to the fact that the land take of the Lecky Rd RB would not be acceptable to stakeholders.

2.5 Option 1D

2.5.1 Design Intent

This option was assessed at the request of the VPA. The intent was to minimise the land required by the Lecky Road Retarding Basin. The Lecky Road Retarding Basin is located on land that the VPA regard as being particularly valuable and required for residential development. To compensate for the smaller RB on land north of Lecky Rd, RB's I and H have been increased in size.

An overview of the key design aspects for Option 1D are as follows:

- Officer DSS flows are conveyed following contours into the proposed Lecky Rd Retarding basin.
- Lecky Rd RB Is online with same footprint as the SWS concept approximately 11.12ha.
- RB's H and I are online to GSC with wetland treatments.
- All RB's west of Officer South Rd are to be offline and service local catchments.
- $3m^3/s$ diversion from GS Creek to Cardinia Road Drain at the electricity easement is to occur.
- No levee augmentation is required for any of the 'Option 1' options.

Figure 15 Illustrates the concept of Option 1D and Table 20 provides a breakdown of the parameters of each asset within the option. Refer to Appendix E for more details on the configuration of each of the assets, including outlet and spillway sizing.

Figure 15 Option 1D Schematic

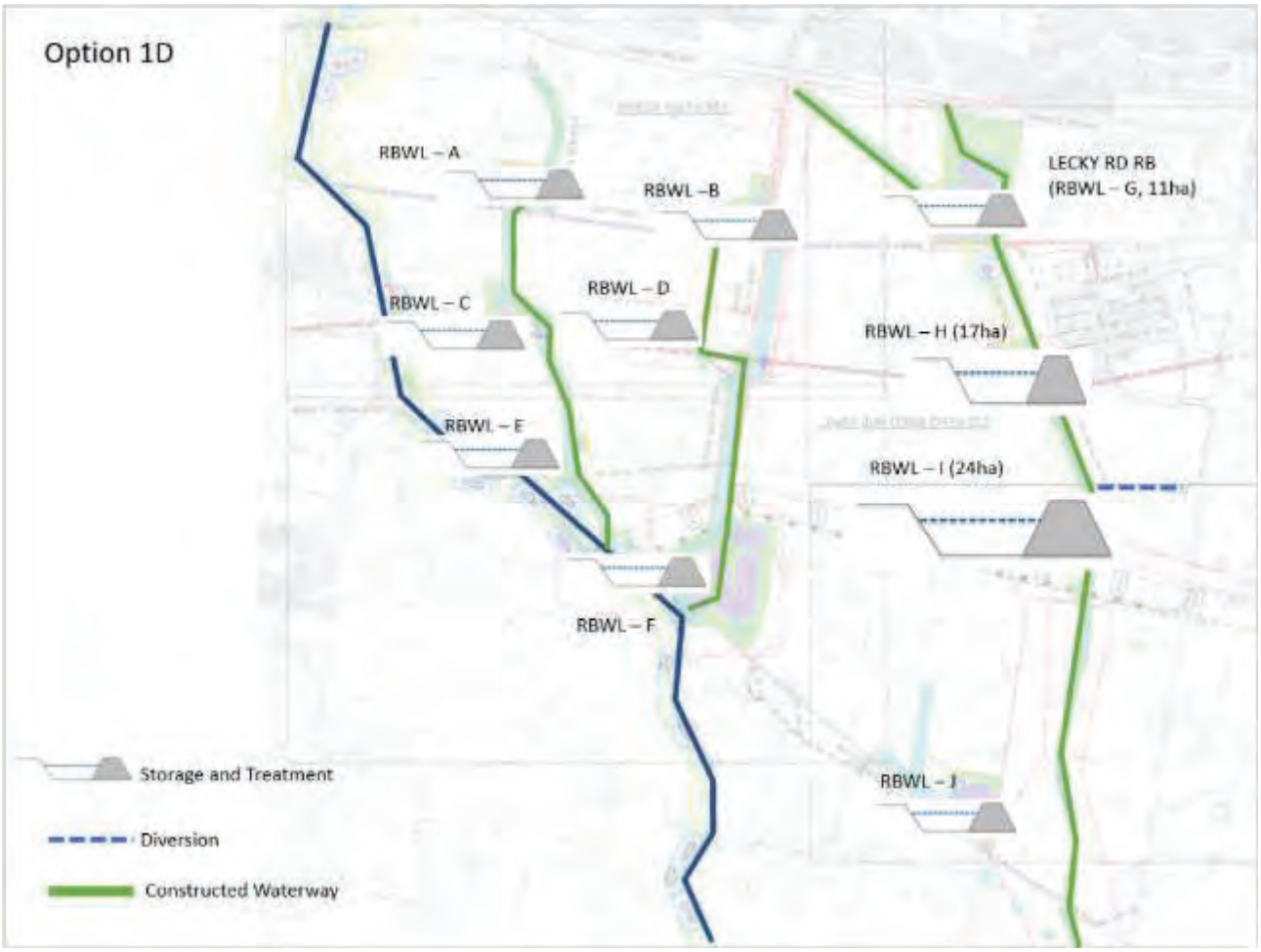


Table 20 Option 1D Asset Summary

Name	Reserve Area (ha)	Wetland Area (ha)	Flood Storage (m^3)
RBWL A	7.8	3.6	60,365
RBWL B	10.3	4.4	152,650
RBWL C	5.5	2.3	22,162
RBWL D	7.4	3.4	41,854
RBWL E	5.4	2.0	49,550
RBWL F	3.9	1.8	57,158
RBWL G	11.1	6.3	172,450
RBWL H	16.9	10.8	127,640
RBWL I	24.4	10.6	511,080
RBWL J	9.4	4.9	136,020
Total	**102.2**	**50.2**	**1,330,929**

2.5.2 RORB Results

Peak flow results from RORB for the range of AEP's relevant to the design of the retarding basins for Option 1D are provided in Table 21. Flood volume results for the 50 % AEP and 1 % AEP are provided in Table 22.

Refer to Section 2.2 for a description of the assumptions and model set up and Appendix F for further details on the associated durations and temporal patterns.

Table 21 Option 1D Peak Flows (brackets indicate predevelopment flow)

LOCATIONS*	50% AEP (m^3/s)	10 % AEP (m^3/s)	1% AEP (m^3/s)	1% AEP CC (m^3/s)
STEPHENS RD WW U/S CARD CK	1.1 (1.8)	2.0 (4.6)	3.5 (10.0)	5.3 (13.0)
OSR U/S CARD CREEK	1.6 (3.3)	2.7 (4.0)	5.1 (4.0)	6.6 (4.0)
GSC PATTERSON RD	3.1 (5.0)	17.3 (23.0)	41.0 (51.0)	62.2 (69.0)

Table 22 Option 1D Flood Volumes

FLOOD VOLUMES	50% AEP (pre-dev) (m^3)	50% AEP (m^3)	Difference (%)	1% AEP (pre-dev) (m^3	1% AEP (m^3)	Difference (%)
OSR PRINCES FWY	79,800	119,000	49%	137,000	334,000	144%
STEPHENS RD WW U/S CARD CK	17,600	54,400	209%	61,500	153,000	149%
OSR U/S CARDINIA CREEK	69,300	78,200	13%	214,000	220,000	3%
GSC PRINCES FWY	159,000	171,000	8%	1,320,000	673,000	-49%
GSC PATTERSON RD	218,000	305,000	40%	1,610,000	1,750,000	9%
DIVERSION	N/A	213,000	100%	N/A	369,000	100%

RORB Results Discussion

With respect to peak flows, the following findings were obtained (refer to Appendix B for the predevelopment references and Appendix C illustrating these results):

- Peak predevelopment flows are being met at the Stephens Rd waterway outlet to Cardinia Creek.
- Peak predevelopment flows are being met for the frequent events at the Officer South Rd Drain, however not for the 1% AEP and 1% AEP CC events, where flows are approximately 1.1 m3/s and 2.6 m3/s higher than predeveloped flows respectively.
- Peak predevelopment flows are being met for the 50% AEP, 10% AEP, 1% AEP storm events along Gum Scrub Creek at Patterson Rd, with the 50% AEP being approximately 40% lower than predeveloped levels and the 1% AEP being approximately 20% lower than predeveloped levels.
- The 1% CC AEP storm event along Gum Scrub Creek at Patterson Rd is meeting the 1% AEP predevelopment peak flow rates factoring for future climate change conditions.

- Predevelopment flow conditions in Cardinia Creek south of the PSP are not increased. In addition to peak flows, RORB was also used to determine the impact of volume from the 50% AEP and 1% AEP flood events. Key findings around volume for the flood events were as follows:

- The volumes increase by 40% in the 50% AEP developed scenario along Gum Scrub Creek at Patterson Rd compared the predeveloped 2010 scenario.
- The volumes increase by 9% in the 1% AEP developed scenario along Gum Scrub Creek at Patterson Rd compared to the predeveloped 2010 scenario.

The diversion to Cardinia Road Drain is reducing the 50% AEP peak developed flow by 41%.

2.5.3 MUSIC Results

The performance of the assets with respect to stormwater quality treatment based on MUSIC modelling is shown in Table 23 for the Cardinia Creek and Gum Scrub Creek catchments. Whilst Table 24 illustrates the results of the water balance to understand the impact of developed volumes on the creeks.

Table 23 Option 1D Catchment Stormwater Quality Treatment

TREATMENT PARAMETER	CARDINA CREEK	GUM SCRUB CREEK
TSS REDUCTION (%)	89.6	88.3
TSS REDUCTION (Kg/yr)	428,500	1,317,000
TP REDUCTION (%)	78.1	71.8
TP REDUCTION (Kg/yr)	760	2,230
TN REDUCTION (%)	55.1	42.2
TN REDUCTION (Kg/yr)	3,750	9,000

Table 24 Option 1D Water Balance Volumes

LOCATION	Pre-dev (GL/yr)	Developed (GL/yr)
OSR - PRINCES FWY	2.5	4.7
WEST OSR - CARDINIA CREEK	3.5	2.2
PRINCES FWY – GSC	4.6	8.7
PATTERSON RD-GSC	6.3	7.2 (without diversion 10.6)
DIVERSION	N/A	3.4

MUSIC Results Discussion

Key findings from MUSIC for Option 1D were as follows:

- Gum Scrub Creek Catchment is not meeting BPEM standards for the catchment, with 40% reduction in Total Nitrogen. However, this is primarily due to the shortfall in treatment within catchment upstream of the Princes Freeway.
- The Officer South Road Catchment is achieving higher than BPEM standards, suggesting that wetlands within this catchment may be able to be refined closer to construction. The reason for the

higher than BPEM treatment is that areas for the wetlands were increased to optimise usage of the base of the retarding basin.

- The volume of flows entering Cardinia Creek is 1.3GL/yr lower in the developed cased scenario compared to the predeveloped 2010 scenario.
- The volume of flows entering Gum Scrub Creek is ~4.3L/yr higher in the developed scenario compared to the predeveloped 2010 scenario and 0.9GL/yr higher at the Patterson Road outlet in the developed scenario compared to the predeveloped 2010 scenario.
- The diversion from Gum Scrub Creek to Cardinia Road Drain, which diverts flows in the range of $0.5m^3/s$-$3.5m^3/s$ into Toomuc Creek system is diverting 3.4GL/yr from the downstream Gum Scrub Creek Catchment farmers. This volume can be refined by adjusting the modelled diversion rules. Currently, it diverts approximately 32% of developed upstream flows to Toomuc Creek, resulting in a 14% increase compared to the predeveloped 2010 scenario at Patterson Rd.

2.5.4 Summary of Option 1D

Key takeaways from this option are as follows.

Table 25 Summary of Option 1D

Item	Finding/Outcome
PEAK FLOWS	Predeveloped flows met at the Stephen Rd Waterway.
	Predeveloped flows at the Officer South Rd outlet are met up to the 1% AEP event.
	Predeveloped flows are met at the Patterson Rd outlet.
	Predeveloped flows at the Patterson Rd outlet are met for the 1% AEP CC event factoring for future predevelopment climate change conditions.
	Predevelopment flow conditions in Cardinia Creek south of the PSP are not increased.
SWQT	BPEM is met for the Cardinia Creek Catchment
	BPEM is not met for the Gum Scrub Creek Catchment, 40% total nitrogen removal. The undertreatment of the catchment is due to the lack of treatment north of the Princes Freeway
WATER BALANCE	Cardinia Creek is receiving less volume in the developed scenario than predeveloped 2010 scenario.
	Gum Scrub Creek is receiving approximately 14% more volume in the developed scenario than predeveloped scenario.
GAS MAIN CROSSINGS	Stephens Rd Waterway- 2x1350mm RCP (inc. 50% blockage factor. To be refined during the functional design.)
	Officer South Rd - 2x1500mm RCP (inc. 50% blockage factor. To be refined during the functional design.)
	Gum Scrub Creek – 60m weir crossing over the top of 450mm T1 main. Still to be designed based on survey.
LEVEES	No upgrade to the downstream levees is proposed.

2.6 Option 1E

2.6.1 Design Intent

Same as Option 1D but with the exclusion of a diversion of 3m^3/s from GSC to Cardinia Rd Drain at the electricity easement.

Figure 16 Illustrates the concept of Option 1E and Table 26 provides a breakdown of the parameters of each asset within the option. Refer to Appendix E for more details on the configuration of each of the assets, including outlet and spillway sizing.

Figure 16 Option 1E Schematic

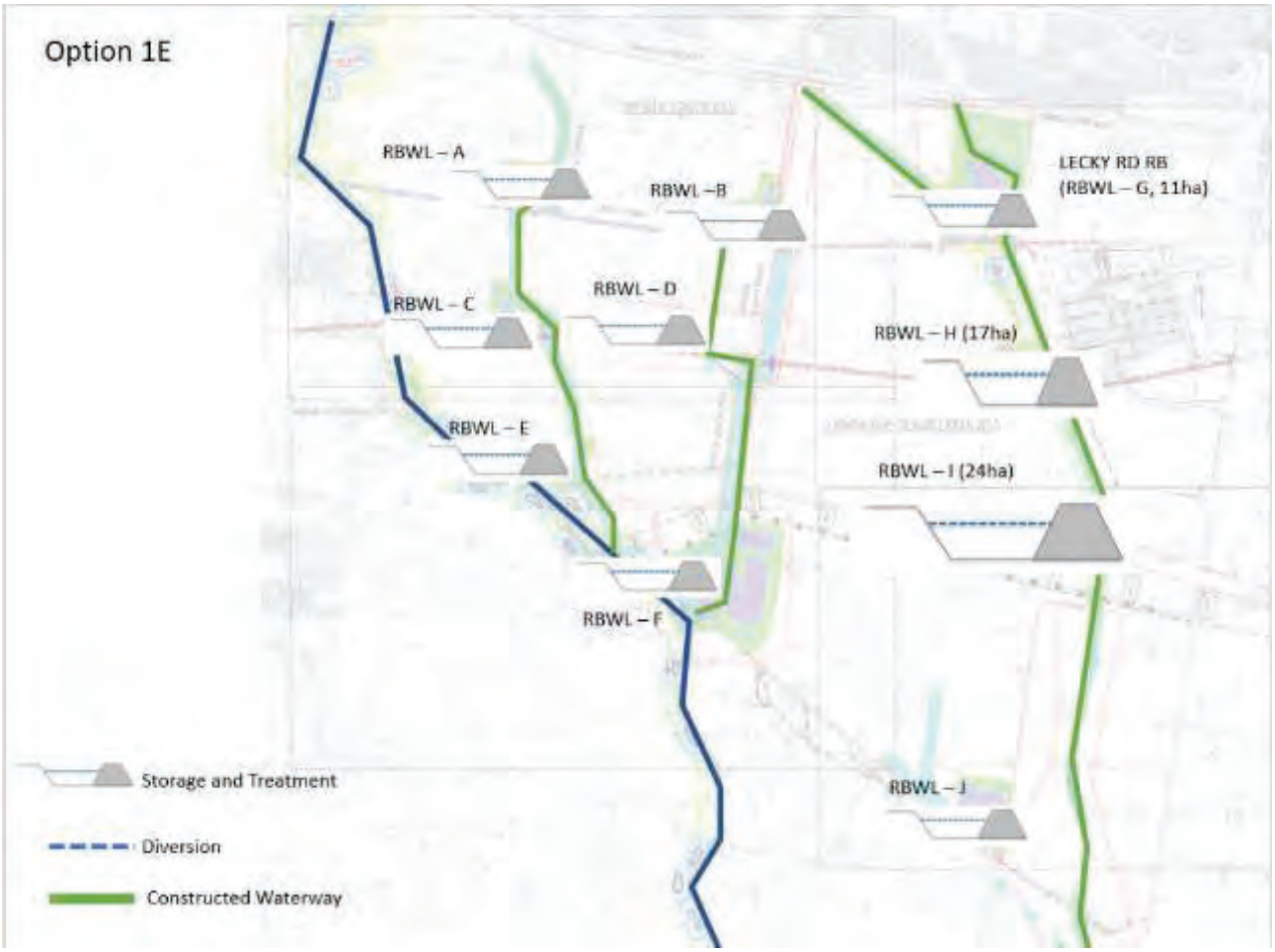


Table 26 Option 1E Asset Summary

Name	Reserve Area (ha)	Wetland Area (ha)	Flood Storage (m^3)
RBWL A	7.8	3.6	60,365
RBWL B	10.3	4.4	152,650
RBWL C	5.5	2.3	22,162
RBWL D	7.4	3.4	41,854
RBWL E	5.4	2.0	49,550
RBWL F	3.9	1.8	57,158

Name	Reserve Area (ha)	Wetland Area (ha)	Flood Storage (m^3)
RBWL G	11.1	6.3	172,450
RBWL H	16.9	10.8	127,640
RBWL I	24.4	10.6	511,080
RBWL J	9.4	4.9	136,020
Total	102.2	50.2	1,330,929

2.6.2 RORB Modelling Results

Peak flow results from RORB for the range of AEP's relevant to the design of the retarding basins for Option 1E are provided in Table 27. Flood volume results for the 50 % and 1 % AEP are provided in Table 28.

Refer to Section 2.2 for a description of the assumptions and model set up and Appendix F for further details on the associated durations and temporal patterns.

Table 27 Option 1E Peak Flows

LOCATIONS*	50% AEP (m^3/s)	10 % AEP (m^3/s)	1% AEP (m^3/s)	1% AEP CC (m^3/s)
STEPHENS RD WW U/S CARD CK	1.1 (1.8)	2.0 (4.6)	3.5(10.0)	5.3 (13.0)
OSR U/S CARD CREEK	1.6 (3.3)	2.7 (4.0)	5.1 (4.1)	6.6 (4.0)
GSC PATTERSON RD	3.7 (5.0)	19.0 (23.0)	43.6 (51.0)	62.2 (69.0)

*Brackets indicate predeveloped flows

Table 28 Flood Volume changes from pre-developed to developed condition

FLOOD VOLUMES	50% AEP (pre-dev) (m^3)	50% AEP (m^3)	Difference (%)	1% AEP (pre-dev) (m^3)	1% AEP (m^3)	Difference (%)
OSR PRINCES FWY	79,800	119,000	49%	137,000	334,000	144%
STEPHENS RD WW U/S CARD CK	17,600	54,400	209%	61,500	153,000	149%
OSR U/S CARDINIA CREEK	69,300	78,200	13%	214,000	228,000	7%
GSC PRINCES FWY	159,000	171,000	8%	1,320,000	1,120,000	-15%
GSC PATTERSON RD	218,000	519,000	138%	1,610,000	2,100,000	30%
DIVERSION	N/A	N/A	N/A	N/A	N/A	N/A

RORB Results Discussion option 1E

The main findings based on the peak flow data presented in Table 27 are as follows:

- Peak predevelopment flows are being met at the Stephens Rd waterway outlet to Cardinia Creek.
- Peak predevelopment flows are being met for the frequent events at the Officer South Rd Drain, however not for the 1% AEP and 1% AEP CC events, where flows are approximately 1.1m^3/s and 2.6 m^3/s higher than predeveloped 2010 flows respectively.
- Peak predevelopment flows are being met for the 50% AEP, 10% AEP, 1% AEP storm events along Gum Scrub Creek at Patterson Rd, with the 50% AEP being approximately 25% lower than predeveloped 2010 levels and the 1% AEP being approximately 15% lower than predeveloped 2010 levels.
- There is no low- medium flow diversion to Cardinia Road Drain in this option.
- Predevelopment flow conditions in Cardinia Creek south of the PSP are not increased.
- The 1% CC AEP post development peak flow rate along Gum Scrub Creek at Patterson Rd (62 m^3/s) is lower than the 1% CC AEP predevelopment peak flow rate (69 m^3/s) factoring for future climate change conditions.

In addition to establishing peak flows, RORB was also used to determine the impact of volume from the 50% AEP and 1% AEP flood events. Key findings around volume for the flood events were as follows:

- The volumes increase by 138% in the 50% AEP developed scenario along Gum Scrub Creek at Patterson Rd compared to the predeveloped 2010 scenario.
- The volumes increase by 30% in the 1% AEP developed scenario along Gum Scrub Creek at Patterson Rd compared to the predeveloped 2010 scenario.

Further information is available in Appendix B and Appendix C.

2.6.3 MUSIC Results

The performance of the assets with respect to stormwater quality treatment based on MUSIC modelling is shown in Table 29 for the Cardinia Creek and Gum Scrub Creek catchments. Whilst Table 30 illustrates the results of the water balance to understand the impact of developed volumes on the creeks.

Table 29 Option 1E Catchment Stormwater Quality Treatment

TREATMENT PARAMETER	CARDINA CREEK	GUM SCRUB CREEK
TSS Reduction (%)	89.6	80.8
TSS Reduction (Kg/yr)	428,500	1,414,000
TP Reduction (%)	78.1	62.0
TP Reduction (Kg/yr)	760	2,400
TN Reduction (%)	55.1	30.8
TN Reduction (Kg/yr)	3,750	9,000

Table 30 Option 1E Water Balance Volumes

LOCATION	Pre-dev (GL/yr)	Developed (GL/yr)
OSR - PRINCES FWY	2.5	4.7
WEST OSR - CARDINIA CREEK	3.5	2.2
PRINCES FWY – GSC	4.6	8.7
PATTERSON RD-GSC	6.3	10.5
DIVERSION	N/A	N/A

MUSIC Results Discussion

Key findings from MUSIC for Option 1E were as follows:

- Gum Scrub Creek Catchment is not meeting BPEM standards for the catchment, with only a 31% reduction in Total Nitrogen. However, this is primarily due to the shortfall in treatment within catchment upstream of the Princes Freeway.
- The Officer South Road Catchment is achieving higher that BPEM standards, suggesting that that wetlands within this catchment may be able to be refined closer to construction.
- The principle reason for the large discrepancy in nitrogen reduction along Gum Scrub Creek at Patterson Rd in Option 1D and 1E is that 1D is diverting 3.4GL/yr of waterway away from Gum Scrub Creek. The quality of the water being diverted is unknown, but it will have passed through several treatment assets upstream of the diversion (Lecky Rd RBWL and RBH and will likely be re-treated within the Cardinia Industrial DSS online wetlands).
- The volume of flows entering Cardinia Creek are 1.3GL/yr lower in the developed cased scenario compared to the predeveloped 2010 scenario.
- The volume of flows entering Gum Scrub Creek at Patterson Rd are 4.2GL/yr higher in the developed scenario compared to the predeveloped 2010 scenario (a 67 % increase).

- An increase of 4.21GL/yr to farmers on Gum Scrub Creek downstream of the PSP may detrimental to the viability of some farmland.

2.6.4 Summary of Option 1E

Key takeaways from this option are as follows:

Table 31 Summary of Option 1E

Item	Finding/Outcome
PEAK FLOWS	Predeveloped 2010 flows met at the Stephen Rd Waterway.
	Predeveloped 2010 flows at the Officer South Rd outlet are met up to the 1% AEP event.
	Predeveloped 2010 flows are met at the Patterson Rd outlet.
	Predeveloped 2010 flows at the Patterson Rd outlet are met for the 1% AEP CC event factoring for future predevelopment climate change conditions.
	Predevelopment flow 2010 conditions in Cardinia Creek South of the PSP are not increased.
SWQT	BPEM is met for the Cardinia Creek Catchment
	BPEM is not met for the Gum Scrub Creek Catchment, 31% total nitrogen removal. The undertreatment of the catchment is due to the lack of treatment north of the Princes Freeway
WATER BALANCE	Cardinia Creek is receiving less volume in the developed scenario than predeveloped 2010 scenario.
	Gum Scrub Creek is receiving approximately 67% more volume in the developed scenario than predeveloped 2010 scenario.
GAS MAIN CROSSINGS	Stephens Rd Waterway- 2x1350mm RCP (inc. 50% blockage factor. To be refined during the functional design.)
	Officer South Rd - 2x1500mm RCP (inc. 50% blockage factor. To be refined during the functional design.)
	Gum Scrub Creek – 60m weir crossing over the top of 450mm T1 main. Still to be designed based on survey.
LEVEES	No upgrade to the downstream levees are proposed.
COMMENTS	The main difference between Option 1D and 1E, is the level of stormwater quality treatment along Gum Scrub Creek at Patterson's Rd is significantly higher in Option 1D. This is due to water being taken out the Gum Scrub Creek system and diverted to Cardinia Road Drain. When the treatment is assessed at the confluence of Gum Scrub Creek and Toomuc Creek, the results in pollutant reduction are much similar. Although it should be noted that, additional treatment of the diverted flow will occur through the Cardinia Industrial DSS.
	An increase of 4.21GL/yr to farmers properties on Gum Scrub Creek downstream of the PSP may be detrimental to the viability of some farmland. due to inundation and other poor drainage effects

2.7 Option 1F

2.7.1 Design Intent

Option 1F is the preferred Option based on this Options assessment. It is expected that as further investigations occur, Option 1F will be revised as more information is gathered. The intent of Option 1F was to investigate attenuating flows as much as possible, via large assets along Gum Scrub Creek, to mitigate the development flow and volume impact to downstream properties south of the PSP.

An overview of the key design aspects for Option 1F are as follows:

- Officer DSS flows are directed via a waterway to Gum Scrub Creek following the natural contours where overland flows always drained.
- Lecky Rd RB is online (sized approximately 21ha). In accordance with previous agreements between the landowner and MWC.
- RB H offline RB wetland servicing local catchment has flows of up to $3m^3/s$ diverted from Gum Scrub Creek to minimise the low flows in Gum Scrub Creek and provide SWQT for the upstream catchment.
- RB I is online to Gum Scrub Creek with online wetland treatment maximised for total upper catchment flow. Wetland can be constructed as a shallow marsh with shallow Normal Water Level (NWL) and EDD of 0.15m
- A diversion of $3m^3/s$ from Gum Scrub Creek to Cardinia Road Drain at the electricity easement is to occur.
- All RB's west of Officer South Rd are to be offline and service local catchments.
- RB Wetland J is to heavily retard local catchment flows up to the 1% AEP+CC to mitigate flow effects on Gum Scrub Creek and downstream properties.
- No levee augmentation is required for any of the 'Option 1' options.

Figure 17 illustrates the concept of Option 1F and Table 32 provides a breakdown of the parameters of each asset within the option. Refer to Appendix E for more details on the configuration of each of the assets, including outlet and spillway sizing.

Figure 17 Option 1F Schematic

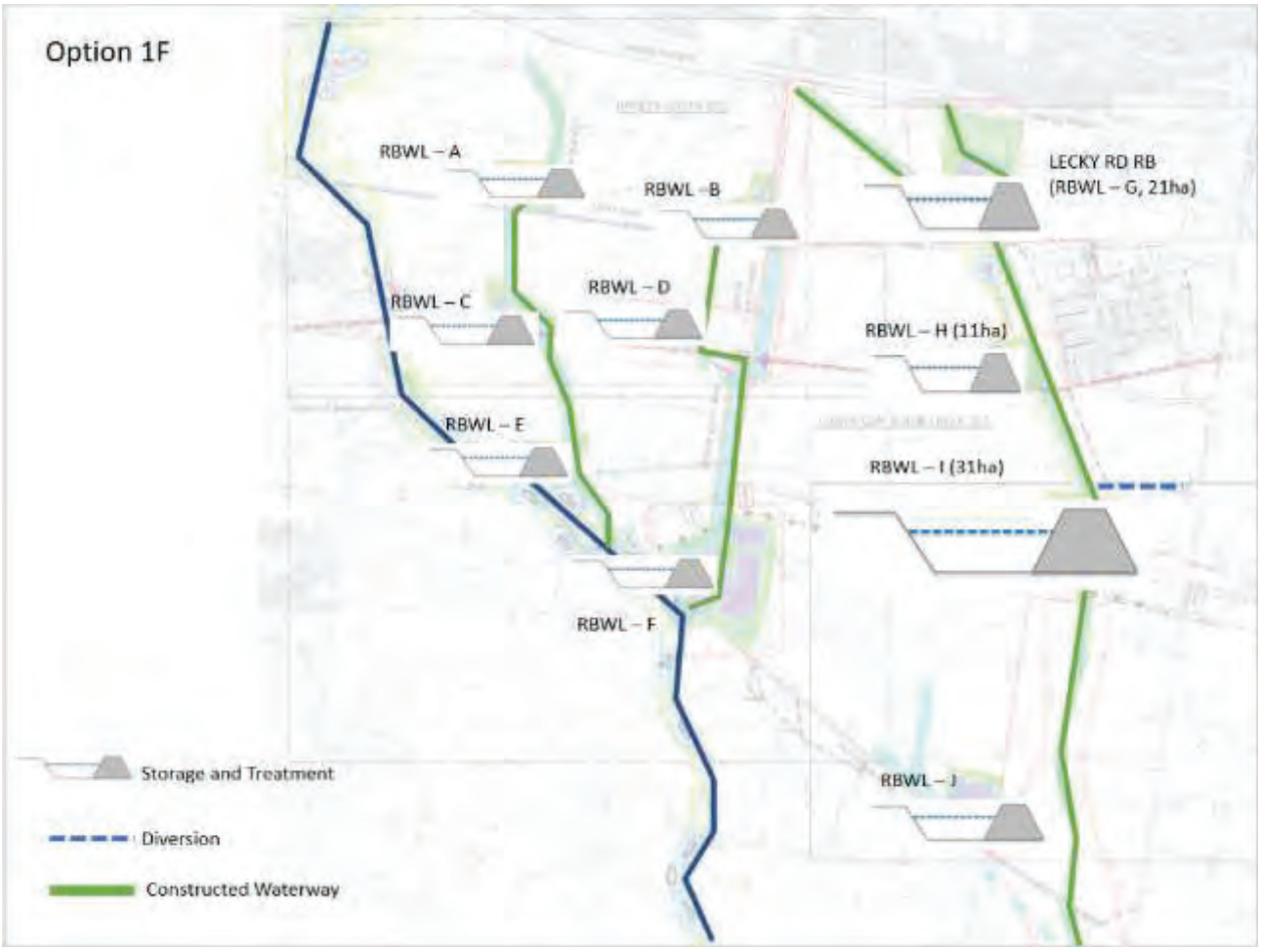


Table 32 Option 1F Asset Summary

Name	Reserve Area (ha)	Wetland Area (ha)	Flood Storage (m^3)
RBWL A	21.0	3.6	60,365
RBWL B	10.3	4.4	152,650
RBWL C	5.5	2.3	22,162
RBWL D	7.4	3.4	41,854
RBWL E	5.4	2.0	49,550
RBWL F	3.9	1.8	57,158
RBWL G	21.2	12.3	321,320
RBWL H	10.9	5.4	68,354
RBWL I	31.2	10.7	596,380
RBWL J	14.3	7.4	178,630
Total	**131.1**	**53.3**	**1,548,423**

2.7.2 RORB Modelling Results

Peak flow results from RORB for the range of AEP's relevant to the design of the retarding basins for Option 1F are provided in Table 33. Flood volume results for the 50 % and 1 % AEP are provided in Table 34.

Refer to Section 2.2 for a description of the assumptions and model set up and Appendix F for further details on the associated durations and temporal patterns.

Table 33 Option 1F Peak Flows

LOCATIONS*	1F 50% AEP (m^3/s))	1F 10 % AEP (m^3/s)	1% AEP (m^3/s))	1% AEP CC (m^3/s)
STEPHENS RD WW U/S CARD CK	1.1 (1.8)	2.0 (4.6)	3.5 (10.0)	5.4 (13.0)
OSR U/S CARD CREEK	1.6 (3.3)	2.7 (4.0)	5.1 (4.0)	6.6 (4.0)
GSC PATTERSON RD	2.0 (5.0)	15.1 (23.0)	38.4 (51.0)	53.6 (69.0)

*Brackets indicate predeveloped 2010 flows

Table 34 Option 1F Flood Volumes

FLOOD VOLUMES	50% AEP (pre-dev) (m^3)	50% AEP (m^3)	Difference (%)	1% AEP (pre-dev) (m^3)	1% AEP (m^3)	Difference (%)
OSR PRINCES FWY	79,800	119 ,000	49%	137,000	335,000	145%
STEPHENS RD WW U/S CARD CK	17,600	54,400	209%	61,500	153,000	149%
OSR U/S CARDINIA CREEK	69,300	78,200	13%	214,000	228,000	7%
GSC PRINCES FWY	159,000	171,000	8%	1,320,000	673,000	-49%
GSC PATTERSON RD	218,000	256,000	17%	1,610,000	1,660,000	3%
DIVERSION	N/A	283,000	100%	N/A	409,000	100%

RORB Results Discussion

With respect to peak flows, the following findings were obtained (refer to Appendix B for the predevelopment references and Appendix C illustrating these results):

- Peak predevelopment flows 2010 are being met at the Stephens Rd waterway outlet to Cardinia Creek.
- Predevelopment flow 2010 conditions in Cardinia Creek South of the PSP are not increased.
- Peak predevelopment flows 2010 are being met for the frequent events at the Officer South Rd Drain, however not for the 1% AEP and 1% AEP CC events, where flows are approximately 1.1m^3/s and 2.6 m^3/s higher than predeveloped 2010 flows respectively.
- Peak predevelopment flows 2010 are being met for the 50% AEP, 10% AEP, 1% AEP storm events along Gum Scrub Creek at Patterson Rd, with the 50% AEP being approximately 60% lower than

predeveloped levels and the 1% AEP being approximately 25% lower than predeveloped 2010 levels.

- The 1% CC AEP storm event along Gum Scrub Creek at Patterson Rd is meeting the 1% AEP predevelopment 2010 peak flow rates factoring for future climate change conditions.
- An interesting result from this option is that the 1% AEP CC flows along GSC at Patterson Rd is almost equivalent to the 1% AEP pre-development flow at this location. This means that even if climate change occurs as predicted, there will be minimal impact to the downstream landowners in terms of the 1% AEP peak flow.

In addition to establishing peak flows, RORB was also used to determine the impact of volume from the 50% AEP and 1% AEP flood events. Key findings around volume for the flood events were as follows.

- The estimated volumes increase by 17% in the 50% AEP developed scenario along Gum Scrub Creek at Patterson Rd compared the predeveloped 2010 scenario.
- The estimated volumes increase by 3% in the 1% AEP developed scenario along Gum Scrub Creek at Patterson Rd compared the predeveloped 2010 scenario.
- The diversion to Cardinia Road Drain is reducing the 50% AEP peak developed flow volume by 53%.

2.7.3 MUSIC Results

The performance of the assets with respect to stormwater quality treatment based on MUSIC modelling is shown in Table 35Table 29Table 23 for the Cardinia Creek and Gum Scrub Creek catchments. Whilst Table 36Table 24 illustrates the results of the water balance to understand the impact of developed volumes on the creeks.

Table 35 Option 1F Catchment Stormwater Quality Treatment

TREATMENT PARAMETER	CARDINA CREEK	GUM SCRUB CREEK
TSS Reduction (%)	89.6	88.8
TSS Reduction (Kg/yr)	428,500	1,317,000
TP Reduction (%)	78.1	71.9
TP Reduction (Kg/yr)	760	2,230
TN Reduction (%)	55.1	40.7
TN Reduction (Kg/yr)	3,750	8,600

Table 36 Option 1F Water Balance Volumes

LOCATION	Pre-dev (GL/yr)	Developed (GL/yr)
OSR - PRINCES FWY	2.5	4.7
WEST OSR - CARDINIA CREEK	3.5	2.2
PRINCES FWY – GSC	4.6	8.7
PATTERSON RD-GSC	6.3	7.2 (without diversion 10.5)
DIVERSION	N/A	3.3

MUSIC Results Discussion

Key findings from MUSIC for Option 1F were as follows:

- Gum Scrub Creek Catchment is not meeting BPEM standards for the catchment, with only a 41% reduction in Nitrogen. However, this is primarily due to the shortfall in treatment within Officer and Gum Scrub Creek catchments upstream of the Princes Freeway.
- The Officer South Road Catchment is achieving higher that BPEM standards, suggesting that that wetlands within this catchment may be able to be refined closer to construction.
- The volume of flows entering Cardinia Creek are 1.3GL/yr lower in the developed cased scenario compared to the predeveloped 2010 scenario.
- The volume of flows entering Gum Scrub Creek are 4.2GL/yr higher and 0.9GL/yr higher at Patterson Rd in the developed scenario compared to the predeveloped 2010 scenario.
- The diversion from Gum Scrub Creek to Cardinia Road Drain, which diverts flows in the range of $0.5m^3/s$-$3.5m^3/s$ to Cardinia Road Drain, is diverting 3.3GL/yr of future urban developed flow from the downstream farmland immediately south of the PSP. This volume can be refined based on adjusting the flow ranges, however, at present the option is diverting approximately 31% of the ultimate development upstream flows to Cardinia Road Drain. This, results in a 14% volume increase at Patterson Road in the Gum Scrub Creek Catchment.[1]

2.7.4 Summary of Option 1F

Key learnings from this option are as follows.

Table 37 Summary of Option 1F

Item	Finding/Outcome
PEAK FLOWS	Predeveloped 2010 flows met at the Stephens Rd Waterway.
	Predeveloped 2010 flows at the Officer South Rd outlet are met up to the 1% AEP event.
	Predeveloped 2010 flows are met at the Patterson Rd outlet.
	Predeveloped 2010 flows at the Patterson Rd outlet are met for the 1% AEP CC event factoring for future predevelopment climate change conditions.
	Predevelopment flow conditions in Cardinia Creek south of the PSP are not increased.
SWQT	BPEM is met for the Cardinia Creek Catchment
	BPEM is not being met for the Gum Scrub Creek Catchment, 41% total nitrogen removal. The under treatment of the catchment is due to the lack of treatment north of the Princes Freeway
WATER BALANCE	Cardinia Creek is receiving less volume in the developed scenario than predeveloped 2010 scenario.
	Gum Scrub Creek is receiving approximately 14% more volume in the developed scenario than predeveloped 2010 scenario.
GAS MAIN CROSSINGS	Stephens Rd Waterway- 2x1350mm RCP (inc. 50% blockage factor. To be refined during the functional design.)

[1] Option 1F was ultimately adopted as the preferred option. It was refined to ensure that there was a negligible volume increase at Patterson Road in the Gum Scrub Creek catchment by refining the modelled diversion rules.

Item	Finding/Outcome
	Officer South Rd - 2x1500mm RCP (inc. 50% blockage factor. To be refined during the functional design.)
	Gum Scrub Creek – 60m weir crossing over the top of 450mm T1 main. Still to be designed based on survey.
LEVEES	No upgrade to the levees downstream of the PSP are proposed.
COMMENTS	An interesting result from this option is that the 1% AEP CC along GSC at Patterson Rd is almost equivalent to the 1% AEP predevelopment flow at this location. This means that even if climate change occurs as predicted, there should be minimal impact to the downstream landowners in terms of the 1% AEP peak flow.. ..

2.8 Option 2A, 2B and 2C

2.8.1 Design Intent

Option2A, 2B and 2C are based on the Stormy Water Solutions SWS (2020) concept design intent, with the intent of directing flows from the Officer DSS catchment down a proposed enlarged waterway/wetland along Officer South Rd to reduce the flows and flooding from entering Gum Scrub Creek. It varies from the SWS design with distributed treatment and retardation west of Officer South Road and an enlarged RB F located just upstream of Cardinia Creek in order retard and treat flows from the Officer DSS. Options 2A, 2B and 2C are essentially the same. The differences between the options are that 2A does not include any diversions from GSC to Cardinia Road Drain or from Officer South Rd to GSC. Option 2B includes a diversion from GSC to Cardinia Road Drain but not a diversion from Officer South Rd to GSC. And Option 2C includes a diversion from both GSC to Cardinia Road Drain and from Officer South Rd to GSC. Since Option 2C, provides the highest level of peak flow attenuation and volume removal for Cardinia Creek and Gum Scrub Creeks, this option was investigated first. If it was not meeting all the key flood criteria, the other options were not investigated in detail. As discussed later, it was found that Option 2C did not meet the 10% AEP flood criteria at Cardinia Creek and therefore Option 2A and 2B were not investigated further.

An overview of the key design aspects for Option 2C are as follows:

- Officer DSS is directed to Officer South Rd.
- Lecky Rd RB is online (approximately 21.1ha). In accordance with previous agreements between the landowner and MWC.
- RB's H and I are offline to GSC.
- All RB's west of Officer South Rd are to be offline and service local catchments.
- RB F is online to Officer South Rd, has a 26ha footprint, and is intended to treat and retard the Officer DSS.
- A diversion of 3m^3/s low - medium flow from Gum Scrub Creek to Cardinia Road Drain at the electricity easement is to occur.
- Utilises the existing minor diversion of Officer South DSS to Gum Scrub Creek (600 mm diameter pipe, approximately 0.4 m^3/s)
- Approximately 1.2km of the Cardinia Creek levee system required to be augmented between Chasemore Rd and Cardinia Rd to control the up to 10% AEP flood,, Break out flows occur in existing conditions between the 20% AEP-10%AEP. Exact details will be reviewed in the functional design if this option is successful

Figure 19 Illustrates the concept of Option 2C and

Table 38 provides a breakdown of the parameters of each asset within the option. Refer to Appendix E for more details on the configuration of each of the assets, including outlet and spillway sizing.

Figure 18 Option 2C Schematic

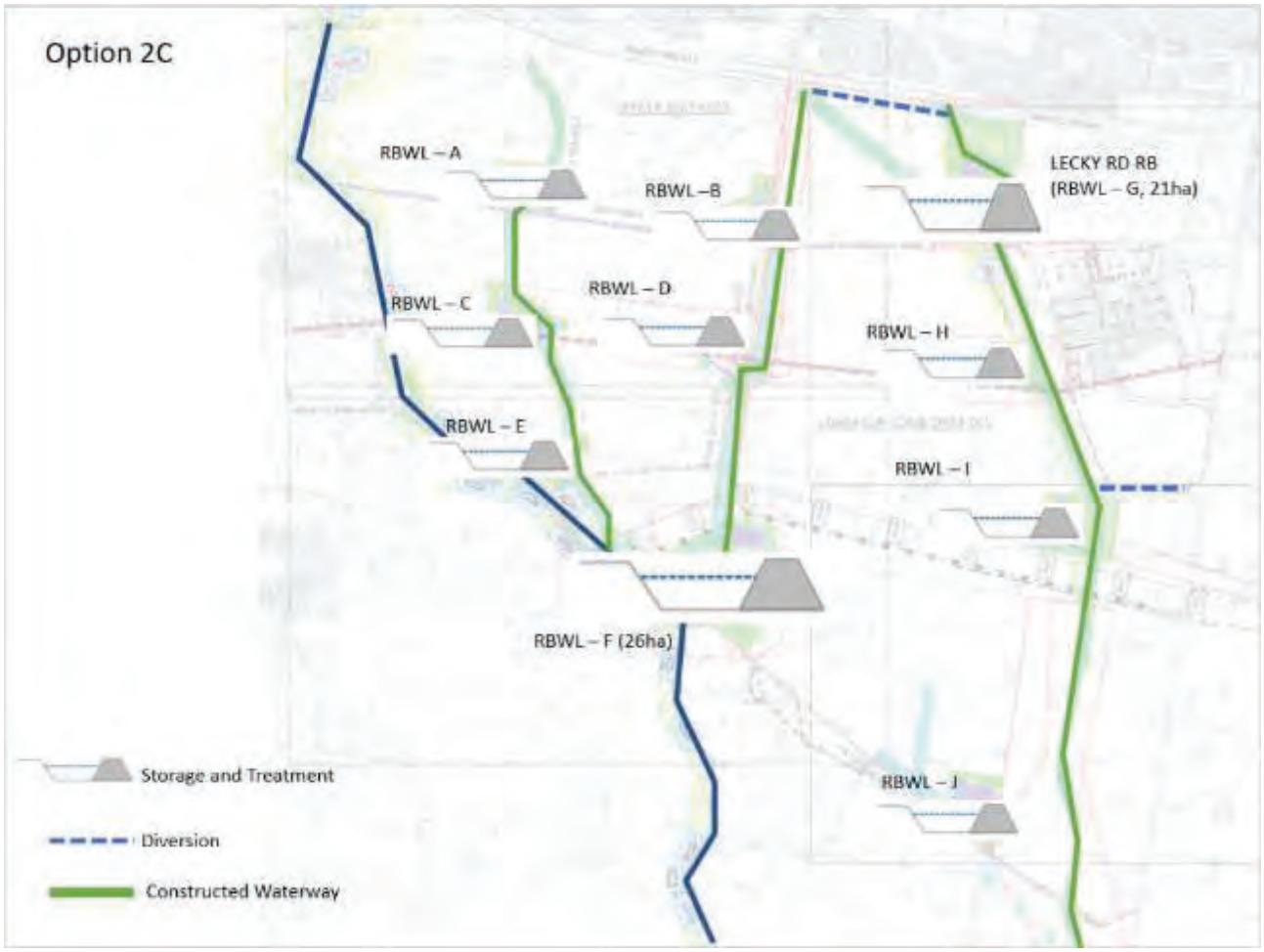


Table 38 Option 2C Asset Summary

Name	Reserve Area (ha)	Wetland Area (ha)	Flood Storage (m^3)
RBWL A	7.8	3.6	60,365
RBWL B	10.3	4.4	156,965
RBWL C	5.5	2.3	22,162
RBWL D	7.4	3.4	41,584
RBWL E	5.4	2.0	49,550
RBWL F	26.3	12.4	509,468
RBWL G	21.2	12.3	321,320
RBWL H	5.3	2.4	32,013
RBWL I	9.2	3.9	191,900
RBWL J	9.7	4.9	136,020
Total	108.2	51.6	1,521,347

2.8.2 RORB Modelling Results

Peak flow results from RORB for the range of AEP's relevant to the design of the retarding basins for Option 2C are provided in Table 39. Flood volume results for the 50 % AEP and 1 % AEP are provided in Table 40.

Refer to Section 2.2 for a description of the assumptions and model set up and Appendix F for further details on the associated durations and temporal patterns.

Table 39 Option 2C Peak Flows (brackets indicate predeveloped 2010 flows)

LOCATIONS *	50% AEP (m^3/s)	10 % AEP (m^3/s)	1% AEP (m^3/s)	1% AEP CC (m^3/s)
STEPHENS RD WW U/S CARD CK	1.2 (1.8)	2.2 (4.6)	3.9 (10.0)	5.3 (13.0)
OSR U/S CARD CREEK	2.6 (3.3)	10.3 (4.0)	25.4 (4.0)	28.8 (4.0)
GSC PATTERSON RD	2.8 (5.0)	12.1 (23.0)	33.0 (51.0)	38.7 (69.0)

Table 40 Option 2C Flood Volumes

FLOOD VOLUMES	50% AEP (pre-dev) (m^3)	50% AEP (m^3)	Difference (%)	1% AEP (pre-dev) (m^3	1% AEP (m^3)	Difference (%)
OSR PRINCES FWY	79,800	120,000	50%	137,000	319,000	133%
STEPHENS RD WW U/S CARD CK	17,600	58,500	232%	61,500	249,000	305%
OSR U/S CARDINIA CREEK	69,300	307,000	343%	214,000	1,350,000	531%

FLOOD VOLUMES	50% AEP (pre-dev) (m^3)	50% AEP (m^3)	Difference (%)	1% AEP (pre-dev) (m^3	1% AEP (m^3)	Difference (%)
GSC PRINCES FWY	159,000	122,000	-23%	1,320,000	1,130,000	-14%
GSC PATTERSON RD	218,000	208,000	-5%	1,610,000	1,240,000	-23%
DIVERSION	N/A	123,000	100%	N/A	144,000	100%

RORB Results Discussion

With respect to peak flows, the following findings were obtained (refer to Appendix B for the predevelopment references and Appendix C illustrating these results):

- Flows are lower than predeveloped 2010 for the 50% AEP events at all PSP outlets.
- All peak predevelopment flows are being met at the Stephens Rd waterway outlet to Cardinia Creek.
- Flows at Patterson Rd are well below predeveloped 2010 levels for all events.
- Flows are higher than predeveloped 2010 levels at the Officer South Road outlet for events above the 50% AEP.
- Flows are higher than predeveloped 2010 levels along Cardinia Creek at Chasemore Rd for all events.
- Since flows are higher than predeveloped 2010 levels in Cardinia Creek, works on the existing downstream levees are required. Refer to Section 2.2.7.
- Flows being conveyed along Officer South Road are significantly higher than predeveloped 2010 flows in the 1% AEP and 1% AEP CC events, approximately 6 -7 times higher.

In addition to establishing peak flows, RORB was also used to determine the impact of volume from the 50% AEP and 1% AEP flood events. Key findings around volume for the flood events were as follows.

- The flood volumes in the 50% AEP event increase to Cardinia Creek at the Stephens Rd Waterway Outlet by 232% and at the Officer South Rd outlet by 343%.
- The flood volumes in the 1% AEP event increase to Cardinia Creek at the Stephens Rd Waterway Outlet by 305% and at the Officer South Rd outlet by 531%.
- The volumes decrease by 5% in the 50% AEP developed scenario along Gum Scrub Creek at Patterson Rd compared the predeveloped 2010 scenario.
- The volumes decrease by 23% in the 1% AEP developed scenario along Gum Scrub Creek at Patterson Rd compared the predeveloped 2010 scenario.
- The proposed diversion to Cardinia Road Drain is reducing the 50% AEP peak developed volume in GSC by 37%.

2.8.3 MUSIC Results

The performance of the assets with respect to stormwater quality treatment based on MUSIC modelling is shown in Table 41 for the Cardinia Creek and Gum Scrub Creek catchments. Whilst Table 42illustrates the results of the water balance to understand the impact of developed volumes on the creeks.

Table 41 Option 2C Catchment Stormwater Quality Treatment

TREATMENT PARAMETER	CARDINA CREEK	GUM SCRUB CREEK
TSS REDUCTION (%)	79.1	83.6
TSS REDUCTION (Kg/yr)	983,000	747,700
TP REDUCTION (%)	64.7	64.4
TP REDUCTION (Kg/yr)	1,606	1,344
TN REDUCTION (%)	37.2	37.3
TN REDUCTION (Kg/yr)	6,170	6,200

Table 42 Option 2C Water Balance Volumes

WATER BALANCE VOLUMES	PRE-DEV (GL/yr)	DEVELOPED (GL/yr)
OSR - PRINCES FWY	2.5	4.7
WEST OSR - CARDINIA CREEK	3.5	5.1
PRINCES FWY – GSC	4.6	3.9
PATTERSON RD-GSC	6.3	6.1 (without diversion 7.6)
DIVERSION (OSRD – GSC (FWY))	N/A	1.7
DIVERSION (GSC -TOOMUC CK)	N/A	1.5

MUSIC Results Discussion

Key findings from MUSIC for Option 2C were as follows:

- There is a shortfall in total nitrogen across both the Cardinia Creek and Gum Scrub Creek catchments, with both catchments removing approximately 37% of total nitrogen.
- The volume of flows entering Cardinia Creek are 1.6GL/yr higher in the developed cased scenario compared to the predeveloped 2010 scenario.
- The volume of flows at Patterson Road on Gum Scrub Creek are 0.2GL/yr lower in the developed scenario compared to the predeveloped 2010 scenario.
- The diversion from Gum Scrub Creek to Cardinia Road Drain, which diverts flows in the range of 0.5m^3/s-3.5m^3/s to Toomuc Creek, is diverting1.5GL/yr from the downstream properties south of the PSP. This volume can be refined based on adjusting the flow ranges, however, at present it is diverting approximately 20% of the developed upstream flows to Toomuc Creek.
- The existing 600mm pipe installed along the south side of Officer South Road is diverting 1.7GL/yr of flow into Gum Scrub Creek.

2.8.4 Cardinia Creek Levee Upgrades

This option requires the upgrade of the downstream Cardinia Creek Levees due to increased flows within Cardinia Creek for the 10% AEP flows or greater. Refer to Section 2.2.7 for details on the proposed upgrades.

2.8.5 Summary of Option 2C

Key takeaways from this option are as follows:

Table 43 Summary of Option 2C

Item	Finding/Outcome
PEAK FLOWS	Flows are lower than predeveloped 2010 for the 50% AEP events at all PSP outlets.
	Predeveloped 2010 flows met at the Stephen Rd Waterway.
	Predeveloped 2010 flows are met at the Patterson Rd along GSC
	Flows are higher than predeveloped 2010 levels at the Officer South Road outlet for events above the 50% AEP.
	Predeveloped 2010 flows at the Patterson Rd outlet are met for the 1% AEP CC event factoring for future predevelopment climate change conditions.
	Flows are higher than predeveloped 2010 levels along Cardinia Creek at Chasemore Rd for all events.
SWQT	BPEM is not met for the Cardinia Creek Catchment, 37% total nitrogen removal.
	BPEM is not met for the Gum Scrub Creek Catchment, 37% total nitrogen removal.
WATER BALANCE	Cardinia Creek is receiving approximately 46% more volume in the developed scenario than predeveloped 2010 scenario.
	Gum Scrub Creek is receiving slightly less volume in the developed scenario than predeveloped 2010 scenario.
GAS MAIN CROSSINGS	Stephens Rd Waterway- 2x1350mm RCP. To be confirmed during functional design.
	Officer South Rd - 14x1500mm RCP To be confirmed during functional design.
	Gum Scrub Creek –50m weir crossing over the top.
LEVEES	1.2km of the Cardinia Creek levee system required to be augmented between Chasemore Rd and Cardinia Rd to contain the flows up to the 10% AEP developed flows.
COMMENTS	Flows being conveyed along Officer South Road to discharge into Cardinia Creek were significantly higher than predeveloped 2010 flows in the 1% AEP and 1% AEP CC events, approximately 6 -7 times higher. The large flows along Officer South Road will make the gas crossing difficult to construct. It is noted that this is a risk and further investigation is required to confirm that the gas main does not have be lowered.

2.9 Option 3A and 3B

2.9.1 Design Intent

Option 3 is very similar to Option 2. The main difference between the two options is that the low flows being conveyed along Officer South Road are diverted to GSC. The intent of this diversion is to protect the threatened species and their habitat within Cardinia Creek. Option 3A and 3B are the same, except Option 3A does not include a diversion from Gum Scrub Creek to Cardinia Road Drain Since Option 3B, which provides a higher level of flood protection, is not meeting all the key flood criteria, Option 3A was not investigated further.

An overview of the key design aspects for Option 3B are as follows:

- Officer DSS flows are directed to Officer South Rd
- Lecky Rd RB Is online (approximately 21.1ha. In accordance with previous agreements between the landowner and MWC).
- RB's H and I are offline to GSC.
- All RB's west of Officer South Rd are to be offline and service local catchments.
- RB F is online to Officer South Rd, has a 26ha footprint, and is intended to treat and retard the Officer DSS.
- There is a low flow diversion of $3m^3/s$ after RB F to divert flows to GSC.
- $3m^3/s$ diversion from GSC to Cardinia Road Drain..
- 1.2km of the Cardinia Creek levee system required to be augmented between Chasemore Rd and Cardinia Rd.

Figure 19 Illustrates the concept of Option 3B and Table 44 provides a breakdown of the parameters of each asset within the option. Refer to Appendix E for more details on the configuration of each of the assets, including outlet and spillway sizing.

Figure 19 Option 3B Schematic

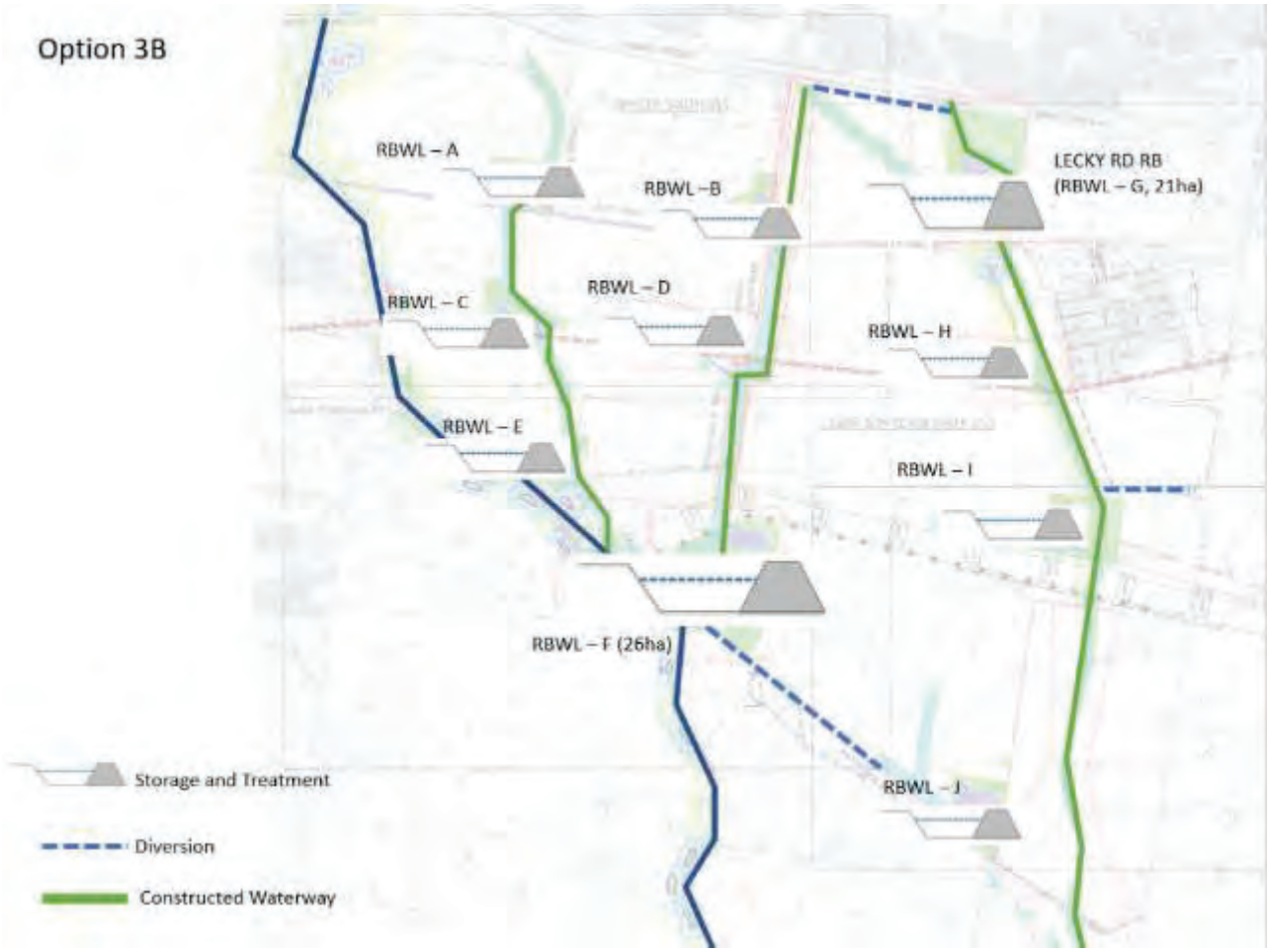


Table 44 Option 3B Asset Summary

Name	Reserve Area (ha)	Wetland Area (ha)	Storage (Flood m^3)
RBWL A	7.8	3.6	60,365
RBWL B	10.3	4.4	156,965
RBWL C	5.5	2.3	22,162
RBWL D	7.4	3.4	41,584
RBWL E	5.4	2.0	49,550
RBWL F	26.3	12.4	509,468
RBWL G	21.2	12.3	321,320
RBWL H	5.3	2.4	32,013
RBWL I	9.2	3.9	191,900
RBWL J	9.7	4.9	136,020
Total	**108**	**64**	**1,521,347**

2.9.2 RORB Modelling Results

Peak flow results from RORB for the range of AEP's relevant to the design of the retarding basins for Option 3B are provided in Table 45. Flood volume results for the 50 % and 1 % AEP are provided in Table 46.

Refer to Section 2.2 for a description of the assumptions and model set up and Appendix F for further details on the associated durations and temporal patterns.

Table 45 Option 3B Peak flows

LOCATIONS*	50% AEP (m^3/s)	10 % AEP (m^3/s)	1% AEP (m^3/s)	1% AEP CC (m^3/s)
STEPHENS RD WW U/S CARD CK	1.2 (1.8)	2.2 (4.6)	3.9 (10.0)	5.3 (13.0)
OSR U/S CARD CREEK	0.0 (3.3)	7.3 (4.0)	25.4 (4.0)	25.8 (4.0)
GSC PATTERSON RD	2.9 (5.0)	13.3 (23.0)	37.7 (51.0)	43.5 (69.0)

*Brackets indicate predeveloped flow

Table 46 Option 3B Flood Volumes

FLOOD VOLUMES	50% AEP (pre-dev) (m^3)	50% AEP (m^3)	Difference (%)	1% AEP (pre-dev) (m^3	1% AEP (m^3)	Difference (%)
OSR PRINCES FWY	79,800	120,000	50%	137,000	320,000	134%
STEPHENS RD WW U/S CARD CK	17,600	58,500	232%	61,500	256,000	305%
OSR U/S CARDINIA CREEK	69,300	-	-100%	214,000	1,350,000	531%
GSC PRINCES FWY	159,000	65,100	-59%	1,320,000	1,130,000	-14%
GSC PATTERSON RD	218,000	422,000	94%	1,610,000	1,530,000	-5%
DIVERSION	N/A	144,000	100%	N/A	367,000	100%

RORB Results Discussion

With respect to peak flows, the following findings were obtained (refer to Appendix B for the predevelopment references and Appendix C illustrating these results):

- Flows are lower than predeveloped 2010 levels for the 50% AEP events at the PSP outlets.
- All peak predevelopment flows are being met at the Stephens Rd waterway outlet to Cardinia Creek.
- Flows at Patterson Rd are well below predeveloped 2010 levels for all events.
- Flows are higher than predeveloped 2010 levels at the Officer South Road outlet for events above the 50% AEP.
- Flows are higher than predeveloped 2010 levels along Cardinia Creek at Chasemore Rd for the 10% AEP
- Since flows are higher than predeveloped 2010 levels in the 10% AEP Cardinia Creek, works on the existing downstream levees are required. Refer to Section 2.2.7.
- Flows being conveyed along Officer South Road are significantly higher than predeveloped 2010 flows in the 1% AEP and 1% AEP CC events, approximately 6 .5 times higher.

In addition to establishing peak flows, RORB was also used to determine the impact of volume from the 50% AEP and 1% AEP flood events. Key findings around volume for the flood events were as follows.

- The flood volumes in the 50% AEP event increase to Cardinia Creek at the Stephens Rd Waterway Outlet by 232% and decrease at the Officer South Rd outlet by 100%.
- The flood volumes in the 1% AEP event increase to Cardinia Creek at the Stephens Rd Waterway Outlet by 305% and at the Officer South Rd outlet by 531%.
- The volumes increase by 94% in the 50% AEP developed scenario along Gum Scrub Creek at Patterson Rd compared the predeveloped 2010 scenario.
- The volumes decrease by 5% in the 1% AEP developed scenario along Gum Scrub Creek at Patterson Rd compared the predeveloped 2010 scenario.
- The diversion to Cardinia Road Drain reduces the 50% AEP peak developed flow by 25%.

2.9.3 MUSIC Results

The performance of the assets with respect to stormwater quality treatment based on MUSIC modelling is shown in Table 47 for the Cardinia Creek and Gum Scrub Creek catchments. Whilst Table 48Table 24 illustrates the results of the water balance to understand the impact of developed volumes on the creeks

Table 47 Option 3B Catchment Stormwater Quality Treatment

TREATMENT PARAMETER	CARDINA CREEK	GUM SCRUB CREEK
TSS REDUCTION (%)	89.5	72.9
TSS REDUCTION (Kg/yr)	983,000	792,300
TP REDUCTION (%)	82.5	51.7
TP REDUCTION (Kg/yr)	1,606	1,390
TN REDUCTION (%)	62.8	24.9
TN REDUCTION (Kg/yr)	6,130	5,810

Table 48 Option 3B Water Balance Volumes

LOCATION	PRE-DEV (GL/yr)	DEVELOPED (GL/yr)
OSR - PRINCES FWY	2.5	4.7
WEST OSR - CARDINIA CREEK	3.5	1.7
PRINCES FWY – GSC	4.6	3.9
PATTERSON RD-GSC	6.3	9.5 (without diversion 11.0)
DIVERSION (OSRD@FWY– GSC)	N/A	1.7
DIVERSION (GSC -TOOMUC CK)	N/A	1.5
DIVERSION (OSRD@WLF – GSC)	N/A	3.4

MUSIC Results Discussion

Key findings from MUSIC for Option 3B were as follows:

- Cardinia Creek is exceeding best practice, with 36% of nitrogen removed.
- Gums Scrub Creek is well below best practice with 25% of nitrogen removed.
- The reason for Cardinia Creek's treatment being high and Gum Scrub Creek's low is due to the 50% flows from Officer South Road being diverted to Gum Scrub Creek.
- The developed flow volumes for Cardinia Creek are approximately 50% of the predeveloped 2010 flow volumes.
- There is a 50% increase of flow volume (3.2GL/yr) of at Patterson Rd on Gum Scrub Creek.
- The 600mm pipe installed along the south side of Officer South Road is diverting 1.7GL/yr of flow to Gum Scrub Creek.
- 1.5 GL/yr is being diverted from Gum Scrub Creek to Cardinia Road Drain

- 3.4 GL/yr is being diverted from Officer South Road, just upstream of Cardinia Creek, to Gum Scrub Creek.

2.9.4 Cardinia Creek Levee Upgrades

This option requires the upgrade of the downstream Cardinia Creek Levees due to increased flows within Cardinia Creek for the 10% AEP flows or greater. Refer to Section 2.2.7 for details on the proposed upgrades.

2.9.5 Summary of Option 3B

Key learnings from this option are as follows:

Table 49 Summary of Option 3B

Item	Finding/Outcome
PEAK FLOWS	Flows are lower than predeveloped 2010 for the 50% AEP events at all PSP outlets.
	Predeveloped 2010 flows are met at the Stephen Rd Waterway.
	Predeveloped 2010 flows are met at the Patterson Rd along Gum Scrub creek
	Flows were higher than predeveloped 2010 levels at the Officer South Road outlet for events above the 50% AEP.
	Flows measured along Cardinia Creek are higher than predevelopment conditions for the 10% AEP.
SWQT	BPEM is met for the Cardinia Creek Catchment, 63% total nitrogen removal.
	BPEM is not met for the Gum Scrub Creek Catchment, 25% nitrogen removal.
WATER BALANCE	Cardinia Creek is receiving approximately 50% less volume in the developed scenario than predeveloped 2010 scenario.
	Gum Scrub Creek is receiving 50% more volume in the developed scenario than predeveloped 2010 scenario.
GAS MAIN CROSSINGS	Stephens Rd Waterway- 2x1350mm RCP
	Officer South Rd - 14x1500mm RCP
	Gum Scrub Creek – 50m weir crossing over the top.
LEVEES	The levee system will need to be upgraded under this option. For the assessment of this option, it has been estimated that 1.2 km of the Cardinia Creek levee system needs augmentation between Chasemore Rd and Cardinia Rd to contain flows up to the 10% AEP developed flows. This will require further assessment if this option is adopted.
COMMENTS	Flows at the outlet of Officer South Road connection into Cardinia Creek are significantly higher than predeveloped 2010 flows in the 1% AEP and 1% AEP CC events, approximately 6.5 times higher. So this is not an ideal management of discharges and will require significant infrastructure to convey at high expense similar to some other options?
	The reason for Cardinia Creek's treatment being high and Gum Scrub Creek's low is due to the 50% AEP flows from Officer South Road being diverted to Gum Scrub Creek.
	There is 3.2GL/yr of additional volume being directed to Gum Scrub Creek, this could have a detrimental impact to downstream farmers.

The large flows along Officer South Road will make the gas crossing difficult to construct. It is noted that this is a risk and further investigation is required to confirm that the gas main does not have be lowered.

2.10 Summary of Options

A summary of all the options considering the reserve area, hydrological and stormwater quality treatment results are presented in Table 50. A tick indicates the requirement is being met, and a cross indicates it is not meeting the requirements.

Table 50 Options Summary Table

OPTION	TOTAL RESERVE AREA (ha)	PEAK FLOW ATTENUATION	SWQT (% REDUCTION OF TN)	VOLUME REDUCTION	COMMENTS
OPTION 1A	N/A	N/A	N/A	X	Less effective than1B and therefore not assessed in detail.
OPTION 1B	85.8	X	✓ (Card Ck) X 37% (GSC)	✓	Option dismissed due to not meeting predeveloped 2010 flow criteria at Patterson Rd for all events.
OPTION 1C	N/A	N/A	N/A	X	Option dismissed due to not being acceptable to the VPA.
OPTION 1D	102.2	✓	✓ (Card Ck) X 42% (GSC)	✓	Highest level of SWQT
OPTION 1E	102.2	✓	✓ (Card Ck) X 31% (GSC)	X	Poorer SWQT for GSC in comparison to 1D.
OPTION 1F	117.9	✓	✓ (Card Ck) X 41% (GSC)	✓	Largest reserve area. The under treatment of the GSC catchment is due to the lack of treatment north of the Princes Freeway.
OPTION 2A	N/A	N/A	N/A	X	Less effective than 2C and therefore not assessed in detail.
OPTION 2B	N/A	N/A	N/A	✓	Less effective than 2C and therefore not assessed in detail.
OPTION 2C	108.2	X	X 37% (Card Ck)	✓	Flood criteria for 10% AEP event and above at

			X 37% (GSC)		Officer South Rd outlet not met.
OPTION 3A	N/A	N/A	N/A	X	Less effective than 3B and therefore not assessed in detail.
OPTION 3B	108.2	X	X 63% (Card Ck) X 25% (GSC)	✓	Flood criteria for 10% AEP event and above at Officer South Rd outlet not met. Treatment much higher for Card Ck than 2C because low flows are being diverted to GSC.

Based on the results of the above assessment, Option 1D, 1E, 1F, 2C and 3B were considered in further detail in the MCA. Option 1D was selected as the base case because it meets the predeveloped 2010 flows at all outlets, meets SWQT for the flows discharging to Cardinia Creek and provides the highest level of treatment along Gum Scrub Creek.

3. Multi Criteria Analysis

A Multi Criteria Analysis (MCA) was used to assess the options. An MCA compares quantitative and qualitative costs and benefits of different options by using weighted scores. It is typically a less expensive method of comparing options than a Cost Benefit Analysis (CBA).

MCA is typically used for smaller projects or when the costs and benefits of a larger project cannot be valued (DTFV p4). MCA has been used for this project because some of the costs and benefits are hard to value such as ecological impacts and liveability benefits. However, the criteria have been developed collaboratively with MWC who have provided significant input and agreed to the criteria presented herein.

MCA is most effective when the costs, benefits, weights and scoring methodology are clear and transparent. The following sub-sections define the criteria and how each were weighted and scored.

However, an inherent limitation shared by all assessment tools, including MCA, is their reliance on available data. The effectiveness of these analytical methods in evaluating various options is heavily contingent upon the quality and comprehensiveness of the data at hand. In cases where data is incomplete, uncertain, or lacks granularity, MCA and other assessment tools may not provide a complete or accurate representation of the options under consideration. Furthermore, the development area, for which the options were being developed and assessed, was in a state of constant refinement, further complicating the assessment process.

3.1 Criterion 1 - Peak Flows Downstream of the PSP

Property development, without appropriate drainage infrastructure, typically results in higher peak flows and increased flooding. For simplicity, peak flows have been used as a proxy for flooding. It has been assumed that if peak flows are higher that flooding will be worse and flooding will be less severe if peak flows are lower.

Flood events will have an impact on properties within the PSP and downstream of the PSP. Drains and waterways can be constructed within the development to manage any in development flooding. This criterion is used to assess the impact of peak flows and flood events downstream of the PSP.

The empirical data used to calculate the scores for the peak flows downstream of the PSP, includes:

- 1% AEP Peak Flows at Gum Scrub Creek Patterson Road, Stephens Road waterway upstream of Cardinia Creek and Officer South Road waterway upstream of Cardinia Creek.
- 50% AEP Peak Flows at Gum Scrub Creek Patterson Road, Stephens Road waterway upstream of Cardinia Creek and Officer South Road waterway upstream of Cardinia Creek.

The empirical data used in the MCA scoring process was generated from the RORB model as described in Section 2.2.4. RORB is not a hydraulic flood modelling package but is used as a proxy for flood data in the absence of TUFLOW results. The flood impacts associated with the preferred option will be further assessed using a TUFLOW model to produce flood level maps. If required, the preferred option will be refined based on the results of the TUFLOW model.

3.2 Criterion 2 – Stormwater Quality

Property development, without appropriate waterway infrastructure, typically results in a reduction in stormwater quality, e.g., increases in total nitrogen loads. The stormwater quality has an impact on the local receiving waters such as Cardinia Creek and Gum Scrub Creek as well as downstream receiving waters such as Westernport Bay. The empirical data used to calculate the stormwater quality score includes:

- Total Nitrogen
- Phosphorus
- Suspended Solids

Litter management was not included in this criterion as it isn't distinguishable between options. MUSIC models will indicate that 100 percent of gross pollutants will be removed and collected in the sedimentation basins.

The empirical data used in the MCA scoring process was generated from the MUSIC model as described in Section 2.2.1.

3.3 Criterion 3 – Fish Preservation

The Australian Grayling is a threatened species of fish that inhabits Cardinia Creek. It has become threatened for a variety of reasons including increased sedimentation, damming and modification to stream flow and bank erosion due to riparian vegetation removal. Urban development, without appropriate waterway infrastructure, typically results in increased flows, pulses of flow, increased sedimentation and erosion.

Jacobs, Cardinia Creek Hydrological and Fish Assessment Report (2021) recommends that any increase in the frequency of channel forming flows from urban development in the Cardinia Creek is undesirable . The study recommends that there should be no more than 1 event per month greater than 370 ML/d that last longer than 31 hours, no more than 1 event every 6 months greater than 370 ML/d that lasts longer than 70 hours and no more than 1 event per year that lasts longer than 89 hours.

Further work investigating the impact of post development storm water flows on the Australian Grayling is being undertaken by Melbourne Water as part of a separate project. Whilst this study is waiting completion, 50% AEP pre and post development flows as well as the retardation of the three month – annual flows in the proposed wetland retarding basins will be used to measure impacts on the fish.

3.4 Criterion 4 – Liveability

Wetland and retarding basins have multi-functions including helping to minimise flooding impacts and improving stormwater quality. They can also often provide significant aesthetic and recreational value. The following metrics were considered:

- Number of assets to be created that will be open to the public, e.g., wetlands.
- Area of assets to be created that will be open to the public.

The number of assets to be created that will be open to the public and the length of new waterways to be created was not included in this assessment because they are common to all options. The total reserve area for each option was used in the MCA model to assess the liveability benefits.

3.5 Criterion 5 – Cost

This criterion assesses the financial cost associated with constructing the drainage and waterway assets, including the financial cost associated with the retarding basins, wetlands, constructed waterways and drainage pipes.

The empirical data used to calculate the cost scores was a comparative cost model. The comparative cost model is described in Section 5.6.

The criterion also includes the cost of land acquisition. The cost of land varies across the PSP as some land will be zoned residential and other land will be zoned industrial.

3.6 Criterion 6 – Environment & Heritage

The construction of retarding basins drains, and waterways can have impacts on environmental and cultural values. These impacts were measured by impacts to the:

- Number of Very High Retention Trees impacted by waterway and drainage assets.
- Number of High Retention Trees impacted by waterway and drainage assets.
- Area of BCS Conservation Area Frog Habitat impacted by waterway and drainage assets.

Aboriginal cultural heritage places have not been included in this assessment, as agreed with MWC, as there is limited information on what the impacts might be. Some assets are located within the regions of sensitivity identified by Tardis (2020), such as adjacent Cardinia Creek. This will require further investigation by MWC. Nonetheless, each option doesn't vary significantly in the impact on these areas, and therefore wasn't considered in the assessment.

DELWP were supplied plans for Option 1B. DELWP requested modifications to the layout of some retarding basins to minimise the impact on Growling Grass Frog habitat. This feedback will be used to inform the design of the Preferred Option (refer to Section 0).

3.7 Other Criterion Considered

The following criterion were also considered, but excluded from the MCA (as agreed with MWC) on the basis that they were not linked directly to the objectives of the project, were not complete or relevant, immaterial, or not mutually independent from other criteria (IA 2021, p27):

- Constructability: Construction costs associated with sodic soils, groundwater, other utilities (e.g., gas mains) can be costed and included in the cost criterion.
- Land Take: As noted in Section 3.4 the cost of land is included in the cost criterion, therefore the greater the land-take the more an option will cost. Therefore, land take has been excluded to avoid double counting. However, land take figures are provided separately as they are of significant interest to stakeholders.
- Public Reputation: Public reputation is considered not to be mutually independent from other criteria. Melbourne Water's reputation will suffer if it does not manage peak flows, stormwater quality, impact to Matters of National Environmental Significance (MNES), threatened species and other criteria.
- Climate Change Impacts: The impact of climate change is already included in Criterion 1. Climate change scenarios were modelled as part of the peak flow analysis.

3.8 Scoring

In line with Melbourne Waters TBL Guidelines all criteria were scored using between -4 to 4. The scores generally align to be the same as the base case (0), slightly better than the base case (1), better than the base case (2), much better than the base case (3) and very much better than the base case (4).

3.9 Base Case

As noted in Section 2.10, Option 1D was adopted as the base case for the MCA because it meets the predeveloped 2010 flows at all outlets, it meets SWQT for the flows discharging to Cardinia Creek and provides the highest level of treatment along Gum Scrub Creek and has a relatively small total reserve area footprint in comparison to the other options.

3.10 Weightings

Infrastructure Australia have prepared a technical guide to MCA which is referenced by DTFV. Infrastructure Australia recommends that MCA weighting should be kept simple and intuitive. It argues that other approaches generally add more complexity than is necessary or useful (IA 2021).

In line with the Infrastructure Australia guidance, the weighting of the criteria was divided equally between the benefits and the costs of the DSS. The benefits associated with peak flow management (as a proxy for flood management), the environmental benefits of wetland and retarding basins and liveability were all equally weighted. The costs of the DSS were split 40 percent towards financial cost and 10 percent associated with environmental and cultural impacts which do not vary significantly between the options. This approach resulted in the following weightings being adopted.

Table 51 MCA Weightings

Criterion	Weighting
1. Peak Flows - downstream of the PSP	20%
2. Stormwater Quality	10%
3. Fish Preservation	10%
4. Liveability	10%
5. Cost	40%
6. Environment & Heritage	10%

4. Multi Criteria Analysis Results

Based on the results of the assessment in Section 2.10, Option 1D, 1E, 1F, 2C and 3B were considered for assessment in the MCA. This section provides the assessment for each of these 5 shortlisted options (described in Section 2) against the 7 Criteria (described in Section 3). This section provides a justification for each assessment. The overall assessment is provided in Sections 4.7, 0 and 4.9. The MCA model has been provided with this report "Officer South DSS MCA & Cost Estimate v1.xlsx" and should be read in conjunction with the below analysis.

4.1 Peak Flows Downstream of the PSP

There are 3 points in the RORB model that estimate flow leaving the PSP. These are Gum Scrub Creek at Patterson Road, Stephens Rd upstream of Cardinia Creek and Officer South Road upstream of Cardinia Creek (refer to Figure 8 in Section 1.5). The table below shows the combined 1% AEP peak flow and 50% AEP peak flow at these outlets. The data has been derived from the projects RORB model and has been used as a proxy for flooding, i.e., the higher the peak flows and volumes the more likely is that there will be downstream flooding.

Table 52 MCA Peak Flows Downstream of the PSP - Supporting Data

Criteria	1D	1E	1F	2C	3B
1% AEP Peak Flows from PSP (m3/s)	50	52	47	62	67
50% AEP Peak Flows from PSP (m3/s)	6	6	5	7	4

Low to medium flows are also directed to the Cardinia Road Drain which outlets from the PSP to Toomuc Creek. The existing flows in Toomuc creek are considerably higher than the diverted low to medium flows. Consequently, the diversion only has a minor hydrological impact on the existing flows in Toomuc creek. Considering that the flood risks associated with low to medium discharges into Cardinia Road Drain and Toomuc Creek are not significant, the results for this diversion are not included in the table above.

Option 1F has the largest overall reduction in 1% AEP peak flows. This is primarily because it has 16 percent more storage than Option 1D and 1E and more low median flows are diverted to Cardinia Road Drain than under Option 2C and 3B.

Option 3B is considered very much worse than the base case for 1% AEP peak flow management and Option 2C is considered worse than the base case for 50% AEP peak flows. Scores for the other options have been scaled accordingly (a full break down of the calculations is shown in Appendix I MCA Calculations). The resulting raw MCA scores are shown in the table below.

Table 53 MCA Peak Flows Downstream of the PSP Raw Scores

Criteria	1D	1E	1F	2C	3B
Peak Flows Downstream of the PSP	0.0	-1.1	1.8	-2.5	0.0

4.2 Stormwater Quality

A MUSIC model was used to calculate the reduction in nitrogen, phosphorus and suspended solids in Cardinia Creek and Gum Scrub Creek. The reductions are shown in the table below.

Table 54 MCA Stormwater Quality - Supporting Data

Criteria	1D	1E	1F	2C	3B
Cardinia Total Nitrogen Reduction (kg/y)	3,750	3,750	3,750	6,170	6,130
Cardinia Phosphorus Reduction (kg/y)	760	760	760	1,606	1,606
Cardinia Suspended Solids Reduction (kg/y)	428,500	428,500	428,500	983,000	983,000
Gum Scrub Creek Total Nitrogen Reduction (kg/y)	9,000	9,000	8,600	6,200	5,810
Gum Scrub Creek Phosphorus Reduction (kg/y)	2,230	2,400	2,230	1,344	1,390
Gum Scrub Ck Suspended Solids Reduction (kg/y)	1,317,000	1,414,000	1,317,000	747,700	792,300

Option 1D, 1E and 1F provide the same levels of reduction in pollutant loads for Cardinia Creek because there is no difference in the wetland sizes for Cardinia Creek catchment under these options. Option 1F provides a slightly greater reduction in pollution loads for Gum Scrub Creek than Option 1D and 1E because of the larger wetland area under Option 1F.

Option 2C performs less well than the base case for both Cardinia Creek and Gum Scrub Creek. This due to two reasons:

1. Cardinia Creek catchment underperforms due to the Officer DSS area being included in the catchment
2. The wetlands in the Gum Scrub Creek catchment service PSP area and not the upstream catchments, like those in Option 1.

Option 3B performs slightly better than the base case for Cardinia Creek, but slightly worse than the base case for Gum Scrub Creek. This is because all the low flows from Officer South Rd are being diverted to Gum Scrub Creek, and as a result the treatment in the Cardinia Creek catchment increases at the expense of the Gum Scrub Creek catchment.

The metrics in the table above were converted into MCA scores the resulting raw MCA scores are shown in the table below.

Table 55 MCA Stormwater Quality Raw Scores

Criteria	1D	1E	1F	2C	3B
Stormwater Quality	0.0	0.1	0.0	0.2	0.2

Overall, there is only minimal difference between the options. Reducing pollutants in Cardinia Creek and Gum Scrub Creek were given equal weighting. The environmental values in Cardinia Creek are greater than in Gum Scrub Creek and Cardinia Creek could be given slightly greater weighting. However, all options achieve Best Practice Environmental Management targets for the Officer South Employment Precinct.

4.3 Fish Preservation

As noted in Section 4, further work will be undertaken by Melbourne Water as part of a separate project to assess the impact of proposed DSS on the Australian Grayling. When this work becomes available it will inform the functional design process for this project. In the interim, to assess which option is preferred, RORB and MUSIC data has been used. The 50% AEP Peak Flows obtained from RORB and annual volumes from

MUSIC model are likely to correlate with the flow regime required by the Australian Grayling and preferable to higher flows.

Table 56 MCA Fish Preservation - Supporting Data

Criteria	1D	1E	1F	2C	3B
50% AEP Flows in Cardinia Creek (m^3/s)	2.7	2.7	2.7	3.81	1.2
Annual flow at West OSR – Cardinia Creek (GL/Yr)	2.16	2.16	2.16	5.08	1.73

Option 2C is considered worse than the base case for both parameters. The scores for option 3B have been scaled accordingly. There is no difference between Option 1D, 1E and 1F. The resulting raw MCA scores are shown in the table below.

Table 57 MCA Fish Preservation Raw Scores

Criteria	1D	1E	1F	2C	3B
Fish Preservation	0.0	0.0	0.0	-2.0	1.5

Based on the MCA scores Option 3B is the best of the five options with respect to the fish preservation criterion. This is not surprising because Option 3B diverts flows out of Cardinia Creek into Gum Scrub Creek with the intention of minimising the impacts on Cardinia Creek. Option 2C is the worst of all the options because the inclusion of the Officer DSS catchment (approximately 1000ha) results in Cardinia Creek receiving higher flows and volumes.

4.4 Liveability

The total reserve area for each option (including the wetland area itself) was obtained from the projects 12D model. The results are shown in the table below.

Table 58 MCA Liveability - Supporting Data

Criteria	1D	1E	1F	2C	3B
Wetland Reserve Area (Ha)	102	102	118	108	108

Option 1F has the largest wetland area followed by Option 2C and Option 3B and then Option 1D and 1E. However, the difference in areas is relatively small.

Option 1F is considered slightly better than the base case. Scores for the other options have been scaled accordingly. The resulting raw MCA scores are shown in the table below.

Table 59 MCA Liveability Raw Scores

Criteria	1D	1E	1F	2C	3B
Liveability	0.0	0.0	1.0	0.2	0.2

Reserve areas were considered to be equal regardless of the location of the wetland. Wetlands that are closer to users (residential areas or business areas where workers may take advantage of an asset on their lunch break) are more valuable than wetlands that are further from users. The location of wetlands was determined by the VPA and other constraints and the wetlands were considered as assets for managing flooding and stormwater quality.

4.5 Cost

The cost of each option was estimated using a high-level master planning cost model. The cost estimates were prepared for use in the MCA to compare options. The cost model is appropriate for comparing options, but not to be used for determining budgets, in business cases, financial assessment purposes or proposals.

The rates in the cost model were based on development rates obtained by Spiire for recent developments in the west, north and southeast of Melbourne. Land acquisition rates were provided by Melbourne Water and checked against the rates provided below. The table below shows the rates that were used.

Table 60 Master Planning Cost Assumptions

Item	Rate	Unit
Wetlands (incl sediment basins)	$2,800,000	ha
Wetlands incl planting	$500,000	ha
Retarding Basins	$500,000	ha
Waterways (Small)	$2,500	m
Waterways (Large)	$3,000	m
Culvert Crossings (Single Barrel)	$10,000	m
Culvert Crossings (Multiple Barrel)	$30,000	m
Pipe Diversion to Cardinia Rd Drain	$1,650	m
Outfall/Levees (1.2 km upgrade)	$2,700,000	Item

Construction rates are highly variable and depend on a variety of factors including but not limited to ground conditions, procurement practices, market conditions, supply chain logistics, geographic location, economies of scale in the delivery of other infrastructure at the time of construction, regulatory changes, technological change, and weather conditions at the time of construction. Much of the infrastructure within the Officer South DSS will not be delivered for many years and the above rates are subject to considerable change. The rates in the above table are considered reasonable for a high-level master planning comparative cost model at the time the model was prepared.

The above rates were applied to quantities for each option derived from a 12D model. The resulting cost estimates for each option are shown in the table below.

Table 61 Comparative Cost Estimates

Item	1D ($M)	1E ($M)	1F ($M)	2C ($M)	3B ($M)
Wetlands (incl sediment basins)	141	141	149	145	145
Wetlands incl planting	25	25	27	26	26
Retarding Basins	26	26	39	28	28
Waterways (Small)	10	7	7	7	4
Waterways (Large)	15	15	15	21	21
Culvert Crossings (Single Barrel)	0.4	0.4	0.4	0.2	0.2
Culvert Crossings (Multiple Barrel)	0	0	0	1	1
Pipe Diversion to Cardinia Rd Drain	2	0	2	2	2
Land acquisition flood reserve	3	3	3	2	1
Land acquisition property reserve	213	213	271	205	228
Outfall/Levees	0	0	0	3	3
Design (10%)	43	43	51	44	46
Sub-Total	**478**	**473**	**564**	**483**	**504**
Contingency (30%)	143	142	169	145	151
Total	**622**	**615**	**734**	**628**	**656**

A contingency of 30 percent has been applied to all the options. The adopted rates are already conservative and therefore there may be an element of duplication. However, this does not have any impact on the MCA scores because all options are compared to the base case.

The cost model used is based on the area of each wetland and does not include the depth of the wetland. Checks of the volume of excavation required for each wetland were undertaken using data from the projects 12D model and the depth of the wetlands under each option are similar. The overall depth of each wetland will need to be considered in the functional design phase.

Option 1F was assessed and is being slightly worse than the base case. The scores for the other options have been scaled accordingly. The MCA results are shown in the table below.

Table 62 MCA Cost Raw Scores

Criteria	1D	1E	1F	2C	3B
Cost	0.0	0.1	-1.0	-0.1	-0.3

4.6 Environment & Heritage

A data set showing the location of very high retention trees and high retention trees was obtained from the VPA via Melbourne Water and overlain with the wetland areas. This was used to identify the number of very high retention and high retention trees that might be impacted by the construction of wetlands. A similar exercise was undertaken using for conservation areas provided by DELWP. The table below shows the potential impact on trees and frog habitat associated with wetland construction.

Table 63 MCA Environment & Heritage Supporting Data

Criteria	1D	1E	1F	2C	3B
Number of Very High Retention Trees impacted by waterway and drainage assets.	1	1	1	7	7
Number of High Retention Trees impacted by waterway and drainage assets.	11	11	15	65	65
Area (ha) of Frog Habitat in conservation areas impacted by waterway and drainage assets.	18	18	12	9	9

The cultural and European heritage impacts of the wetlands could not be differentiated between any of the options. Much of the wetland area is within areas of cultural sensitivity as the wetlands are naturally close to waterways and waterways are often areas of cultural sensitivity. None of the options results in the loss or disturbance of known heritage sites. However, cultural heritage sites within the footprints of wetlands, may be discovered as the VPA, Melbourne Water and other stakeholders working in the area undertake heritage investigations.

Option 2C and Option 3B were assessed as being worse than the base case for tree impacts and slightly better than the base case for frog habitat. The overall assessment was that they were slightly worse. Option 1E is the same as the base case. Option 1F was scaled using the rating for Option 2C and Option 2B. The resulting raw MCA scores are shown in the table below.

Construction of connected wetlands and other drainage assets will benefit habitat provisioning for key species such as GGF, migratory bird species and other species associated with riparian areas.

Table 64 MCA Environment & Heritage Raw Scores

Criteria	1D	1E	1F	2C	3B
Environment and Heritage Scores	0.0	0.0	0.3	-0.5	-0.5

Option 1F has the least impact on trees and frog habitat, followed by Option 1D and Option 1E. Option 2C and Option 3B have the greatest impact.

4.7 Results

A summary of the raw scores from the sections above is shown in the table below.

Table 65 Multi Criteria Assessment Raw Scores (comparison with 1D)

Criteria	1D	1E	1F	2C	3B
1. Peak Flows in and downstream of the PSP	0.0	-1.1	1.8	-2.5	0.0
2. Stormwater Quality	0.0	0.1	0.0	0.2	0.2
3. Fish Preservation	0.0	0.0	0.0	-2.0	1.5
4. Liveability	0.0	0.0	1.0	0.2	0.2
5. Cost	0.0	0.1	-1.0	-0.1	-0.3
6. Environment & Heritage	0.0	0.0	0.3	-0.5	-0.5

The above scores are shown using the qualitative MCA rating scales used by Melbourne Water. To determine the qualitative rating the scores are rounded to the nearest whole number.

Table 66 Multi Criteria Assessment Qualitative Scores (comparison with 1D)

Criteria	1D	1E	1F	2C	3B
1. Peak Flows in and downstream of the PSP	The Same	Slightly Worse	Better	Worse	The Same
2. Stormwater Quality	The Same	The Same	The Same	The Same	The Same
3. Fish Preservation	The Same	The Same	The Same	Worse	Slightly Better
4. Liveability	The Same	The Same	Slightly Better	The Same	The Same
5. Cost	The Same	The Same	Slightly Worse	The Same	The Same
6. Environment & Heritage	The Same	The Same	The Same	Slightly Worse	Slightly Worse

The weighted scores based on the weighting listed in section 3.8 and the raw scores in the table above and shown in the table below and the figures below.

Table 67 Multi Criteria Weighted Scores (comparison with 1D)

Criteria	1D	1E	1F	2C	3B
1. Peak Flows downstream of the PSP	0.0	-0.2	0.4	-0.5	0.0
2. Stormwater Quality	0.0	0.0	0.0	0.0	0.0
3. Fish Preservation	0.0	0.0	0.0	-0.2	0.1
4. Liveability	0.0	0.0	0.1	0.0	0.0
5. Cost	0.0	0.0	-0.4	0.0	-0.1
6. Environment & Heritage	0.0	0.0	0.0	-0.1	-0.1
Total	0.0	-0.2	0.1	-0.7	0.0

Figure 20 Components of the MCA Scores by Option (comparison with 1D)

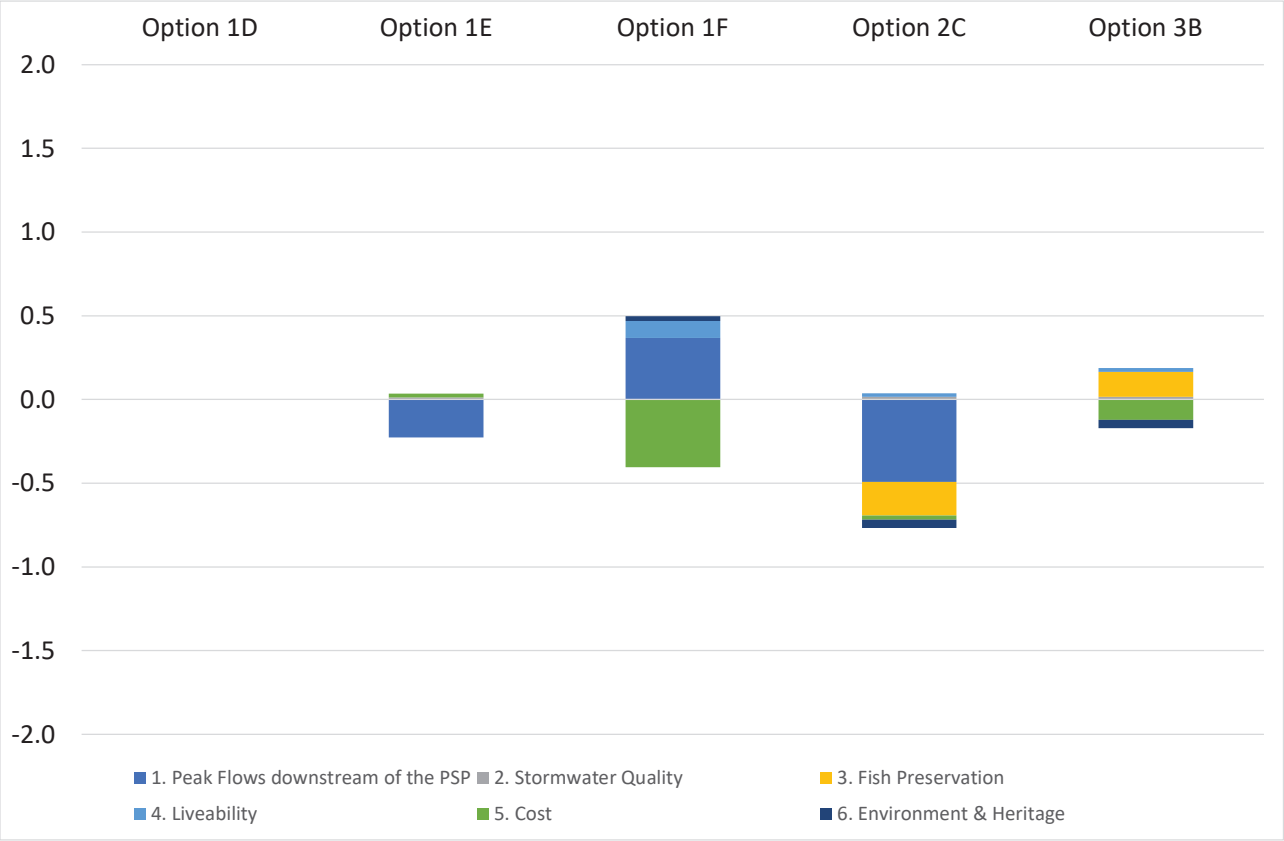
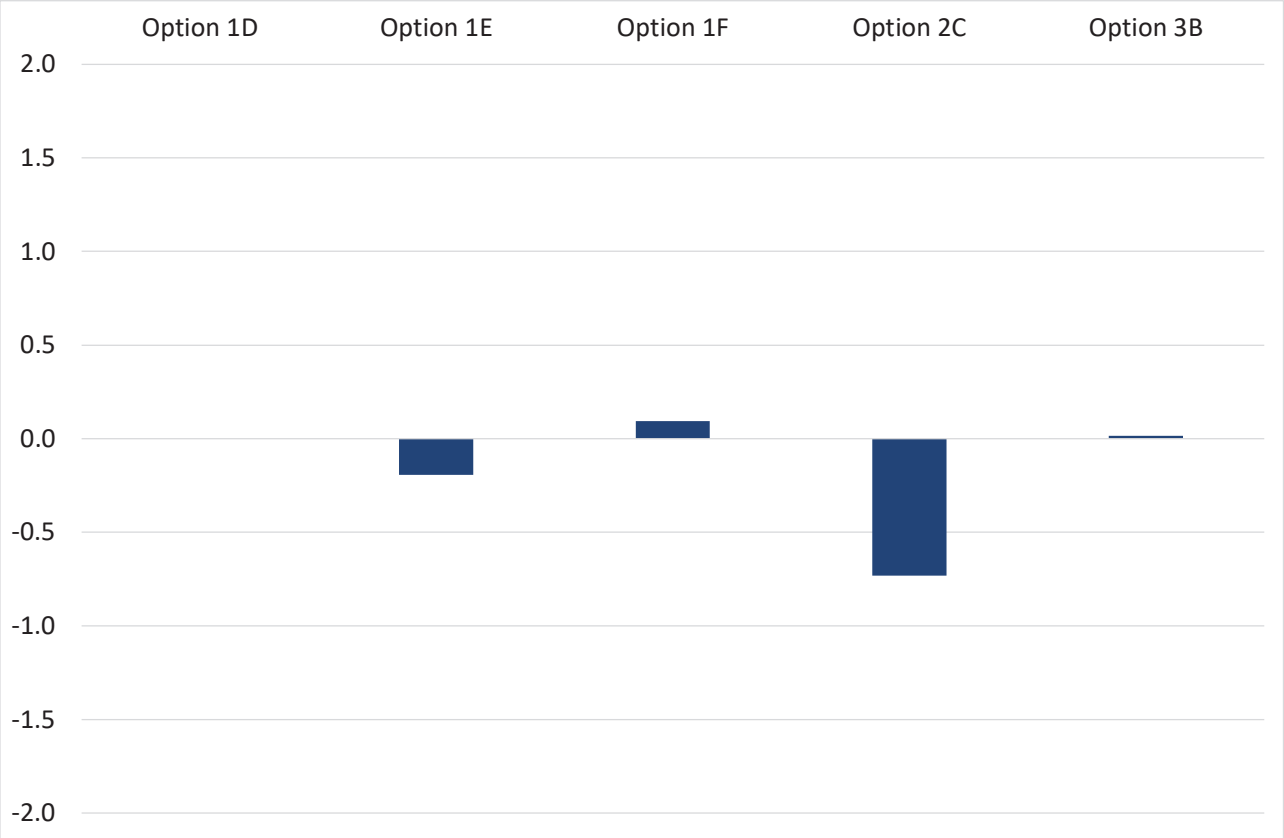


Figure 21 Total Weighted MCA Scores by Option (comparison with 1D)



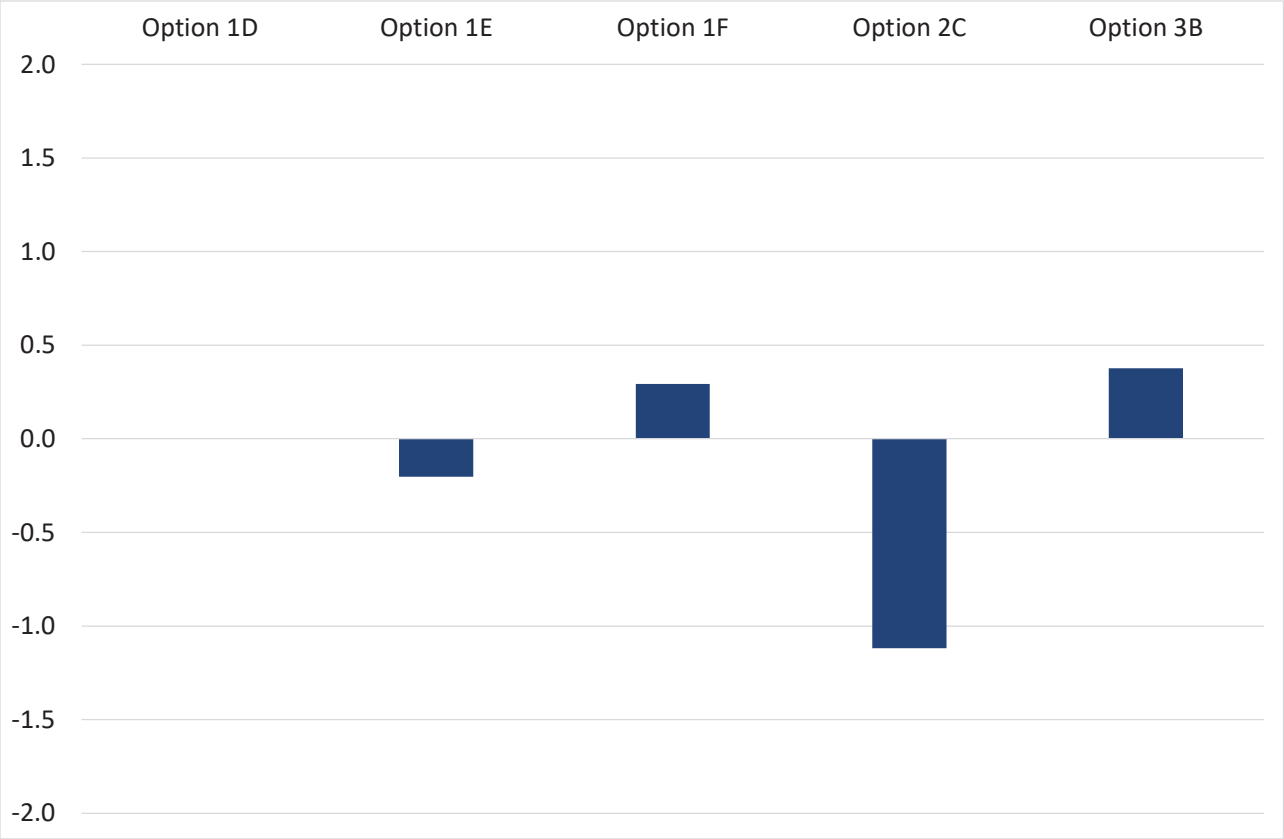
The options have very similar MCA scores. This is due to a variety of factors, including that there is only about a 13 percent difference in cost between the least expensive and most expensive option.

4.8 Sensitivity Analysis

Sensitivity analysis was undertaken by changing the criteria weightings. The sensitivity analysis indicates that Option 1F is the preferred option.

For the first sensitivity test, the weighting on cost was reduced to 20 percent and the weighting on fish preservation was increased to 30 percent. Option 3B is relatively better than Option 1D and Option 1F in relation to fish preservation. The weighting on cost was reduce to 20 percent and the weighting on fish preservation was increased to 30 percent. The resulting MCA scores are shown in the figure below.

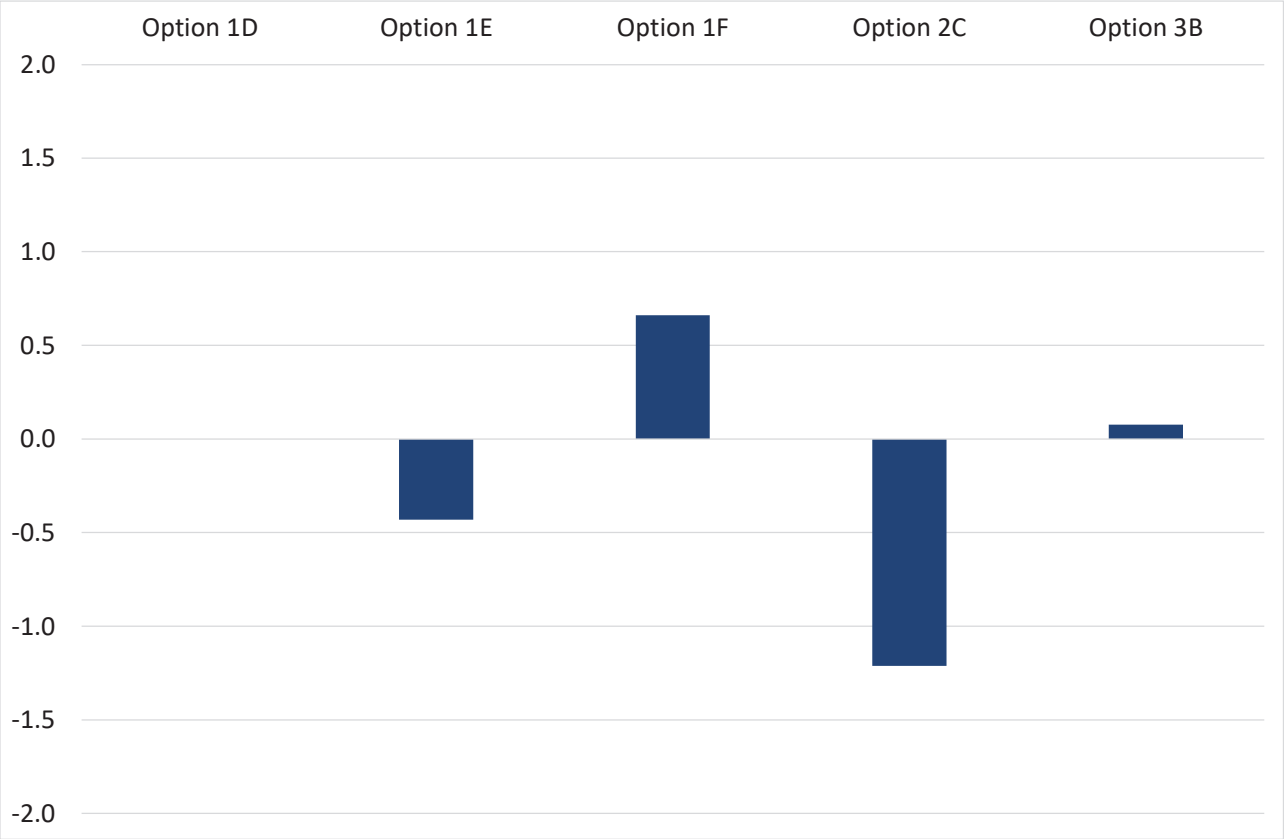
Figure 22 Total Weighted MCA Scores by Option (Fish Preservation Sensitivity)



The figure above indicates that Option 1F and Option 3B are only marginally better than Option 1D (the base case) in relation to fish preservation. Option 1E is slightly worse than the base case.

For a second sensitivity test, the weighting on cost was reduced to 20 percent and the weighting on peak flows downstream of the PSP was increase to 40 percent. The resulting MCA scores are shown in the figure below.

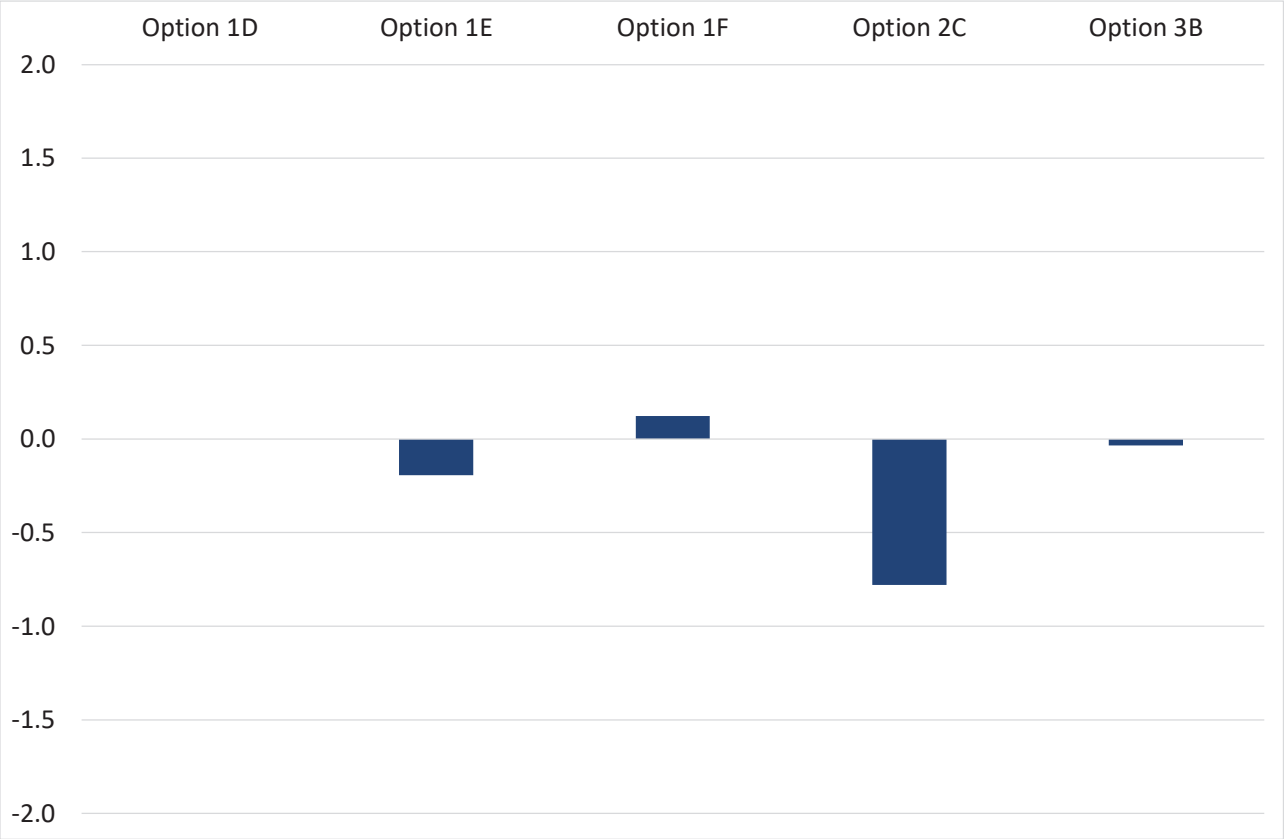
Figure 23 Total Weighted MCA Scores by Option (Peak Flow Downstream of PSP Sensitivity)



The figure above indicates that Option 1F is preferred over Option 1D (the base case) when the weighting of peak flows downstream of the PSP is increased. Option 1E, 2C and 3B are worse than Option (1D) the base case.

For a third sensitivity test, the weighting on cost was reduced to 20 percent and the weighting on environmental and heritage impacts was increases to 30 percent. The resulting MCA scores are shown in the figure below.

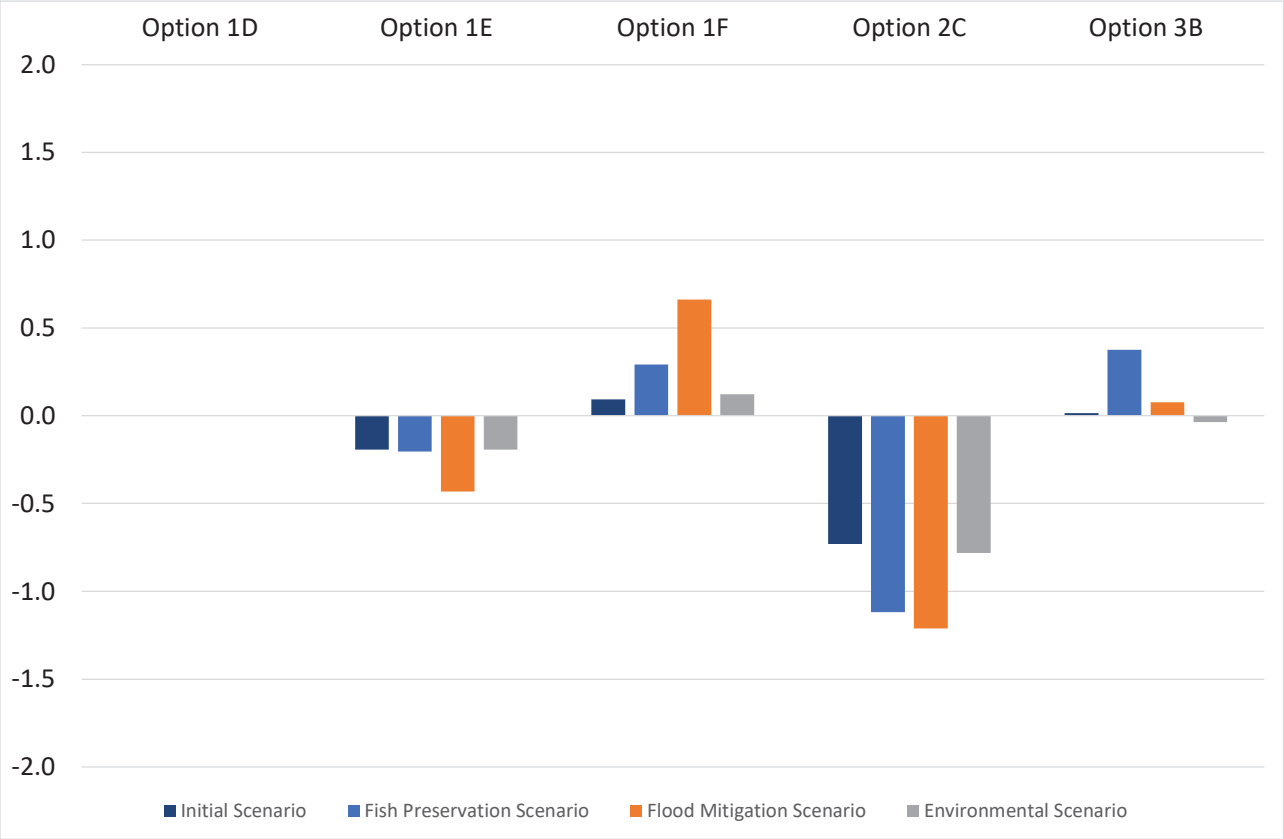
Figure 24 Total Weighted MCA Scores by Option (Environmental Sensitivity)



The figure above indicates that Option 1F is slightly better than the base case. Option 1E, 2C and 3B are slightly worse.

The results of all 4 sensitivity scenarios are shown in the figure below.

Figure 25 Total Weighted MCA Scores for all Weighting Scenarios



4.9 Summary

Key conclusions drawn from the MCA include:

- Options that did not meet benchmark predevelopment peak flows were not included in the MCA.
- All remaining options that were included in the MCA had similar peak flow, stormwater quality, fish preservation, cost and environmental impact results.
- There is not a large difference between the MCA scores of each of the options.
- There is only about a 15 percent difference between the least expensive and most expensive option.
- The MCA scores for all options range between 0.5 and minus 1.0 without sensitivity analysis.
- With sensitivity analysis the MCA scores range between minus 1.5 and positive 0.5.
- Option 1F is the same as the base case or slightly better than the base depending on the adopted weighting scenario, meeting the project objectives?
- Option 1F is slightly more expensive than the base case (Option 1D) but is more likely to robustly mitigate flood impacts in and downstream of the PSP.

Option 1F is the preferred option recommended for adoption based on it meeting the project objectives with the current background studies and information available to inform the assessment.

IWM Considerations

As part of Precinct planning, integrated water management (IWM) is increasingly important to stakeholders aiming to ensure all aspects of the water cycle are considered holistically. Integrated Water Management Plans are undertaken by the VPA during PSP development and are typically linked to the DSS as drainage is a large part of IWM. This section explores the potential options for IWM and assesses the applicability of

implementing performance objectives of the Healthy Waterways Strategy (HWS, Melbourne Water, 2018) and IWM within the DSS.

Two main documents are reviewed and referenced here:

- Jacobs (2022), Stormwater Investigations - Deep, Jacksons and Cardinia Creek Catchments, Draft Report prepared for Melbourne Water, 3 June 2022
- Spiire (2022), Integrated Water Management Plan – Officer South Precinct, prepared for the VPA, expected completion September 2022.

4.10 Stakeholders and Options Development

In developing Integrated Water Management Plans, its essential to consult with all Stakeholders to ensure an integrated, local and placed-based approach to the plans. The water sector in Victoria is made up of various service providers and authorities established to enable policy, regulation and service delivery. Historically these Stakeholders may have operated in silos, however, the modern approach with IWM integrate as much as possible all stakeholder objectives which vary by Precinct.

As documented in Spiire (2022), the key stakeholders who inform IWM policy in this region are listed in Table 68 along with their roles in IWM planning.

Table 68 – IWM Stakeholders for the Officer South Employment Precinct

Organisation / Stakeholder	Role and relevant documents
Department of Environment, Land, Water and Planning (DELWP)	DEWLP is responsible for aligning the strategic planning of all agencies relevant to both land use and water cycle planning in accordance with policy. Relevant documents to IWM: *Plan Melbourne (2016)* *Water for Victoria (2016)* *Western Port IWM Forum Strategic Directions Statement (2018)* *Improving Stormwater Management Advisory Committee (2018)* *Melbourne Strategic Assessment (2010)*
South East Water (SEW)	SEW is the retail water and sewerage service provider across the region. Relevant documents: *Urban Water Strategy (2019)* *GMUWSS (2022)*
Melbourne Water (MWC)	MWC is the caretaker for waterways in the Port Phillip and Westernport regions and responsible for regional drainage and flood plain management within this region. Relevant documents: *Development Service Scheme (DSS 1304 and 1402)* *Healthy Waterways Strategy (2018)*
Cardinia Shire Council (Council)	Local governing body. Council has set out the planning conditions for the site including the requirements for IWM planning. Relevant documents: *Cardinia Shire Council Sustainable Environment Policy 2018-28* *Cardinia Shire Council IWM Plan 2015-2025* *Cardinia Shire Council Liveability Plan (2017 – 29)* *Regional IWMS Cardinia and Casey Area* (not available).
Southern Rural Water (SRW)	Southern Rural Water is a water corporation responsible for managing supply of raw water such as for irrigation districts, as well as the regulation of surface water and groundwater licensing across a large portion of southern Victoria. Relevant documents: *Corporate Plan 2020 – 2021*
Port Phillip and Westernport CMA (PPWCMA)	The statutory authority protecting the region's catchment. The PPWCMA is one of 10 regional CMAs in Victoria, established in 2002 under the Catchment and Land Protection Act 1994. Relevant documents: *Corporate Plan 2020 - 2021*
Environmental Protection Authority (EPA)	State authority with respect to environmental protections. The regulator is independent statutory authority, established under the Environment Protection Act 1970 to prevent and reduce harmful effects to the environment. Relevant documents: *EPA Act 1970* *Environment Protection Amendment Act (2021)* *SEPP (WoV) 2018* *EPA Guidance Note (2021)* *EPA's Environmental Reference Standard*
Victorian Planning Authority (VPA)	The VPA is responsible for precinct structure planning in Victoria's Growth Areas and coordination of agencies to deliver integrated land use planning that aims to provide affordable housing, job creation and development. Relevant documents: *Future Urban Structure (FUS) of the OS PSP (2021)*

Organisation / Stakeholder	Role and relevant documents
	VPA Integrated Water Management PSP Note

These stakeholders have been consulted via the VPA's Integrated Water Management Plan for the precinct with the document currently being finalised (Spiire, 2022 – not yet available). The consultation occurred via workshops and interviews. This was to determine the vision for the precinct and the preferred options for IWM. A more detailed summary of the role each of these stakeholders play, and how each of these documents have informed the IWM Plan, can be found in Spiire (2021).

The Draft Stakeholder Vision for the Precinct based on Spiire (2022) builds on the Westernport Strategic Directions Statement (SDS) (2018) and has been customised by the Stakeholders for the Officer South Precinct:

Collaborating to deliver an innovative, affordable and sustainable, carbon neutral water cycle, that supports advanced industry; provides protection of waterway, biodiversity and Western Port values; and facilitates a more resilient, engaged, and prosperous community that connects to the broader region.

Also consistent with the Westernport SDS, the Stakeholders agreed to the following objectives:

Each of these objectives have a number of site specific, placed based outcomes. More details on each objective and the relevant outcomes to be achieved for IWM in this precinct, are outlined in Spiire (2022). The IWM options to deliver on these objectives were developed in collaboration with the Stakeholders and are described in subsequent sections.

4.11 IWM Context for Officer South

To inform the options, the greater precinct and regional scale water cycle influences need to be understood. In addition to the scheme information and options assessment provided herein, the following context applies to IWM in the Precinct (refer to Figure 26 for approximate locations for each item):

Item	Context
Cardinia Creek Catchment Priority Reach	The Cardinia Creek catchment is a stormwater priority area under MWC's Healthy Waterways Strategy (HWS). For a priority waterway in this region the volume targets dictated by the HWS with respect to development are 4.1 ML per impervious hectare of stormwater harvested and 0.8 ML per impervious hectare of stormwater infiltrated.
Cardinia Reservoir	Cardinia Reservoir is located ~12 km north of the Precinct. In addition to supplying customers, Cardinia Reservoir also has the capacity to transfer water to areas serviced by Westernport Water and South Gippsland Water and can transfer water back to Silvan Reservoir (Silvan) to the wider Melbourne network. Water is supplied to customers directly from Cardinia Reservoir through the Cardinia Treatment Plant. All water in Cardinia Reservoir is held as potable water entitlement, there are no environmental or Traditional Owners entitlements currently in place.
Pakenham Recycling Plan	The Pakenham Recycled Water Plant (RWP) is located to the east of Cardinia catchment. This RWP currently supplies Class A recycled water to agriculture in the Koo Wee Rup region. The capacity of the RWP is being upgraded to 12 ML/day in

Item	Context
	the near future, with plans to increase this to 40 ML/day by approximately 2030. Up to 25 ML/day of this water is being planned to supply Class A water to developments in the Cardinia catchment including this Precinct.
Desalination Plant	The desalination pipeline runs to the west of the Precinct. This is a ~2 m diameter pipe that delivers treated water to Cardinia Reservoir subject to a lease arrangement with MWC. This may be an opportunity for provision of harvested water to the reservoir when it is not in use.
Marine Outfall	With the upgrade to the Pakenham RWP, South East Water are also investigating a marine outfall via the South East Outfall (SEO) at the Eastern Treatment Plant (ETP). We have confirmed with South East Water that there is insufficient capacity in the existing network to direct this water from the Pakenham RWP to the SEO and a study is currently underway to investigate a new pipeline route to the SEO from ETP. There may be opportunity to leverage this marine outfall, however, a pipe duplication may be required to accommodate the different water supplies (stormwater versus recycled water).

Refer to Figure 26 for a general illustration of this context.

Figure 26 – Regional Water Infrastructure

All of this infrastructure, and the role it may play in IWM for the Precinct have been considered.

4.12 IWM Options

Firstly, two scenarios are being investigated to ensure that the Precinct can service long term needs. This is to allow flexibility in design such that future conditions can be accommodated. The two scenarios are:

"Future IWM Scenario" under current business as usual IWM framework	This scenario covers embedding good practice IWM (i.**e.,** not just the implementation of typical / regular drainage schemes) under the current frameworks that govern water cycle management in Victoria. 'Good Practice IWM' includes integrated assets that are generally accepted and utilised broadly in Victoria with plenty of case studies / examples.
"Future IWM Scenario" under a potential future IWM framework	This intends to cover a longer-term outlook on the IWM options that would be viable under a potential future framework and includes options that may seem aspirational now. This would be based on current predictions for what the future drivers might be (e.g., encompassing aspects like climate change and future policy changes) – that the PSP should be responding to in order to achieve future outcomes

In collaboration with the stakeholders, the following options were identified.

Table 69 – IWM Options Derived with the Stakeholders for the Officer South Employment Precinct (Spiire, 2022)

Scenario	Key Criteria	Proposed Key IWM Opportunities
Business as Usual IWM	○ Incorporates integrated assets that are generally accepted (with case studies available). ○ Criteria under current policy and framework conditions (e.g. current State Policy, BPEM, MWC and Council Standards, current Stakeholder Objectives) ○ Comparison against below 'Future IWM Framework' Criteria (ie how does 'Business as Usual' scenario stack up under future conditions?')	• Passive irrigation – on Boulevards or large landscaped roads only. Option: to incorporate infiltration along the creek corridors that would be owned and maintained under a shared agreement with Melbourne Water and Council. • Rainwater tanks – adopt a minimum on lot rainwater tank uptake. Option: to form this into regional scale rainwater tanks that can be owned and maintained under a shared Stakeholder agreement with SEW and Council. • Stormwater Harvesting – small scale servicing open space irrigation only facilities. Option: to extend the system to also service open space to the north of Princes Freeway and some nearby agricultural demand to support Water for Works.
Future IWM Framework	○ Incorporating climate change aspects ○ Incorporating predicted future policy changes and Stakeholder objectives, eg: - future flow reduction and stormwater quality targets (such as EPA BPEM changes and HWS objectives, CMA's more aspirational targets, Council and SEW's long term IWM plan objectives).	• Regional Rainwater Tanks - that can be owned and maintained under a shared Stakeholder agreement • Stormwater to Potable system – with a local storage and treatment facility that delivers water to Cardinia Reservoir. As an 'adaptive pathway' solution (ie to ensure the system in used until such time as 'stormwater to potable'

	- State Policy on 'stormwater to potable' change	is viable), the harvested water could be used for environmental flows.

A 'stormwater to potable' system is the only option that gets close to the HWS targets.

This is confirmed through the work undertaken by Jacobs (2022). The following options were explored.

Table 70 - IWM Options Derived with the Stakeholders for the Cardinia Creek Catchment (Jacobs, 2022)

Intervention	Description and Results
Leaky Rainwater Tanks and Raingardens	(2kL) with a controlled flowrate outlet to a raingarden (1m^2) at each lot. Rainwater is collected in the rainwater tank and released slowly to the raingarden at a rate to infiltrate the water into the groundwater system.
Kerb Cuts	Streets adjacent to public open space could be constructed with kerb cut outs to direct runoff to the open space, rather than the drainage system. This system would not deliver a significant volume of water harvested or infiltrated, but there is little increased cost for this infrastructure.
Passive Irrigation	Harvesting the road stormwater catchment to tree pits. One tree pit per lot was assumed.
Wetlands	The evapotranspiration from the wetlands under the DSS was considered in the modelling.
Storage	The remaining stormwater would be captured and stored in a regional storage facility to meet other regional demands. The modelling determined a 100 ML storage would be required. It is suggested this storage be located outside the urban growth boundary (downstream of the main end of line wetland treatment assets and would be filled from the wetland by gravity). A 10 ha land purchase has been factored into the storage assessment. Stormwater could also be pumped from the regional storage to the Cardinia Reservoir via a 22km pipeline to deliver environmental flows downstream of the reservoir. The stormwater would require further treatment (filtration and potentially nutrient removal) before being discharged to Cardinia Creek to meet environmental passing flows

It was identified this treatment train could absorb 6,700 ML/yr of the 8,674 ML/yr developed volume. It was found this will fall just short of the HWS targets. Jacobs also investigated alternative options including a marine outfall, via the Eastern Treatment Plant. This would achieve the flow reduction targets, however, would require a similar large footprint (10 ha factored in the assessment) and is at a larger cost. Ultimately, the assessment found Portfolio 1 had the best cost-benefit ratio. The costs associated with this infrastructure was found to be of the order of $160M – $200M.

In addition to the significant investment in infrastructure required to manage stormwater, there are two key barriers to implementation of the regional scale options in this area – integration with the recycled water network and indirect potable reuse restrictions. These barriers will need to be overcome to ensure the protection of urban waterways at risk of future stormwater generated from urban catchments. This is why an adaptive pathway has been investigated (to allow environmental flows).

4.13 Impact on the Scheme

In order to meet volume reduction targets for the GED, a regional harvesting scheme is required, which will require a larger land take. Jacobs (2022) has factored a 10 ha footprint into their assessment and Spiire (2022) has a preliminary footprint of the order of 5 ha. These are significant land takes. One option is to acquire land in the flood zone outside the urban growth boundary, and therefore not impact on Precinct and developable land.

The only other viable option is for Options 1B, 1D and 1F. These options do not require a larger land takes at RBWL F due to the upstream diversion to Gum Scrub Creek. Under Options 2 and 3, this land take is of the order of 26 ha. Some of this area could therefore be claimed for the large harvesting scheme that may be required.

Other impacts, such as to the wetland's inundation-frequency and provision of stormwater to future constructed GGF assets are still being investigated.

5. Next Steps

The options analysis has identified that Option 1F is the preferred option. However, further work is required to optimise this option and address various risks. Some of the risks and issues that need to be addressed include:

- The peak flows associated with the preferred option are less than predevelopment peak flows, but TUFLOW modelling of the preferred option will be required to confirm that post development flooding will be equal to or less than predevelopment flooding.
- Some retarding basins and wetlands are relatively deep and will need to be optimised during the functional design phase.
- The services proving of the gas main at critical locations, such as the crossing of Gum Scrub Creek, did not access the level of the gas main to inform the designs so far.. An estimate of the gas level has been made at these crossings based on adjacent 'nearest' data and APA's cover level requirements for crossing waterways. Where possible the design has tried to cross the mains without initiating lowerings.
- Many of the options rely on a diversion to Cardinia Road Drain as proposed by MWC to meet the predevelopment and volume objectives downstream of the PSP in the Gum Scrub Creek catchment, however, the impact on the adjacent DSS and footprint sizes is still to be investigated.
- The vertical clearances of the powerlines could not be obtained during this assessment. This may affect the location of some assets. Further consultation with Ausnet required.
- Other services that have not been proved that may impact on the design are the Telstra optical fibre cable and other gas mains in Lecky Road These are planned to be proven.
- Aboriginal heritage areas of significance are located adjacent Cardinia Creek, Gum Scrub Creek and the headwaters of the Stephens Road waterway line. Some assets are located within these areas and cultural heritage management plans will be required.
- Further geotechnical testing is required to confirm ground conditions.
- Further sodic soils testings should be undertaken. Sodic soils are particularly relevant to the design of future waterway, wetland and retarding basin infrastructure as well as construction phase management. Melbourne Water has commenced this project work for this task.
- Further hydrogeological testing is required to confirm the depth and salinity of ground water.
- Further due diligence testing for land contamination should be undertaken opportunistically with the above ground testing.
- Hydrologic and hydraulic modelling needs to be undertaken for the preferred option to confirm flood impacts within the PSP and downstream of the PSP.
- At this stage costing is only comparative. A more detailed cost estimate of the preferred option will need to be prepared.
- Additional fish modelling to be undertaken on the preferred option to measure it effects on the existing Grayling fish habitat in Cardinia Creek.

The next steps are to confirm with Melbourne Water that the preferred option is Option 1F and then commence the functional design process. The functional design process will involve refining the preferred option, including addressing some of the above risks and limitations. As further surveys and analysis are undertaken, as described in the points above, it is likely that Option 1F will provide the greatest flexibility/security to the yet unknown risks associated with sodic/dispersive soils, gas crossing, high groundwater, and impacts to fish. For instance, Option 1F has a larger land take compared to the other Options which could allow for shallower RBs to minimise impacts of high groundwater.

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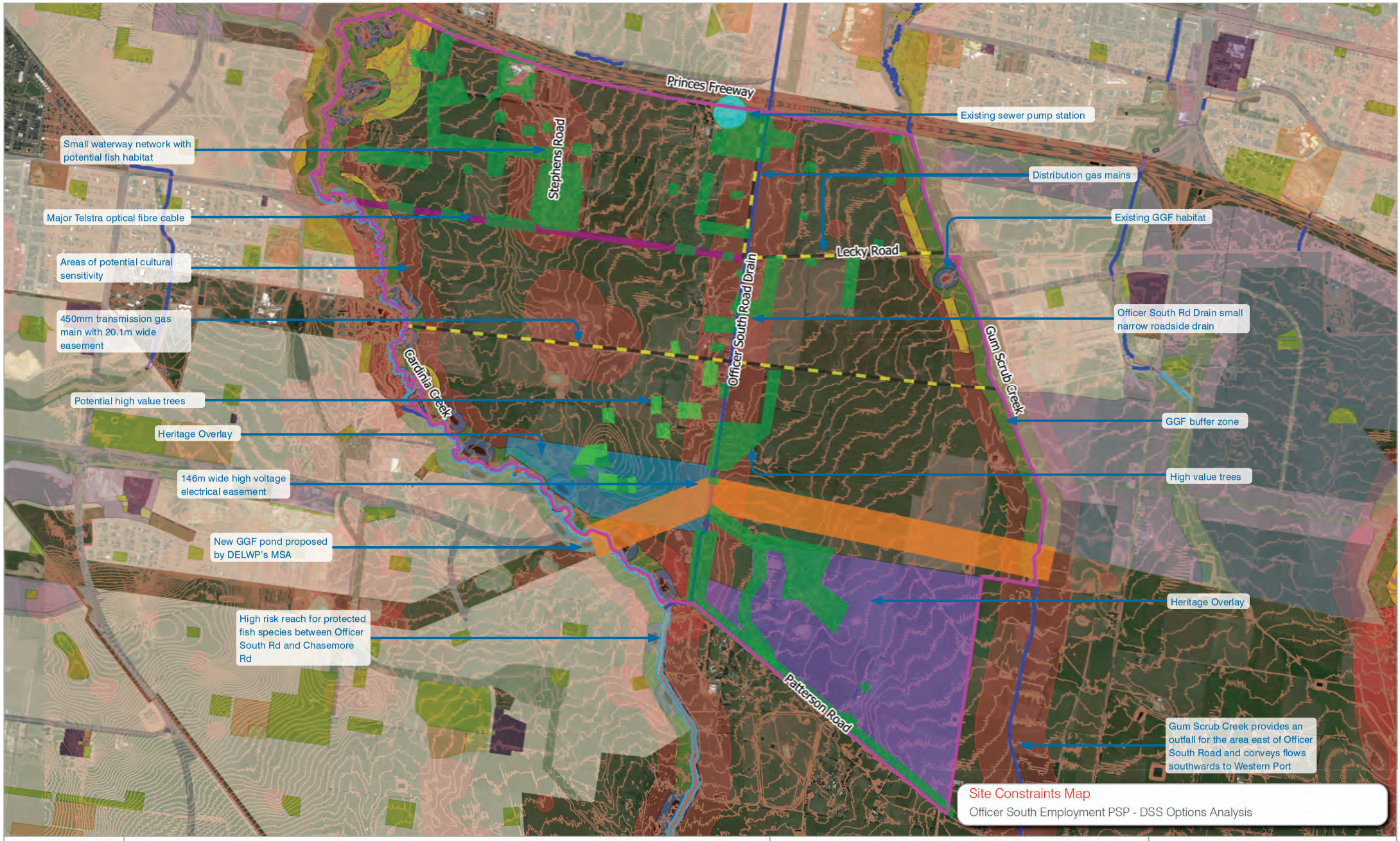
Appendix A Constraints Map



Site Constraints Map

Officer South Employment PSP - DSS Options Analysis

NOTATIONS

File Ref: 308981
Plan: W GIS 308981
Rev: A
Date: 30.08.2022

Designed: J.Carroll
Checked: J.Ward
Authorised: J.Ward

LEGEND

- PSP BOUNDARY
- CONTOURS
- PARCELS
- NATURAL WATERWAY
- DRAINAGE CHANNEL
- TELSTRA OPTICAL FIBRE
- DRAINAGE CHANNEL
- GAS MAIN
- ELECTRICITY
- HERTIAGE OVERLAY 91
- HERITAGE OVERLAY 92
- HIGH VALUE TREES
- POTTENTIAL HIGH VALUE TREES
- PUMP STATION
- CULTRUAL HERITAGE SENSITIVITY AREA
- ASI - BUFFER AROUND WATERBODIES
- ASI - EXISTING RETAINED WATERBODY
- ASI - INDICATIVE NEW WETLAND LOCATION
- ASI - INSTREAM POOL
- ASI - OTHER TERRESTRIAL HABITAT
- ASI - TERRESTRIAL HABITAT BUFFER

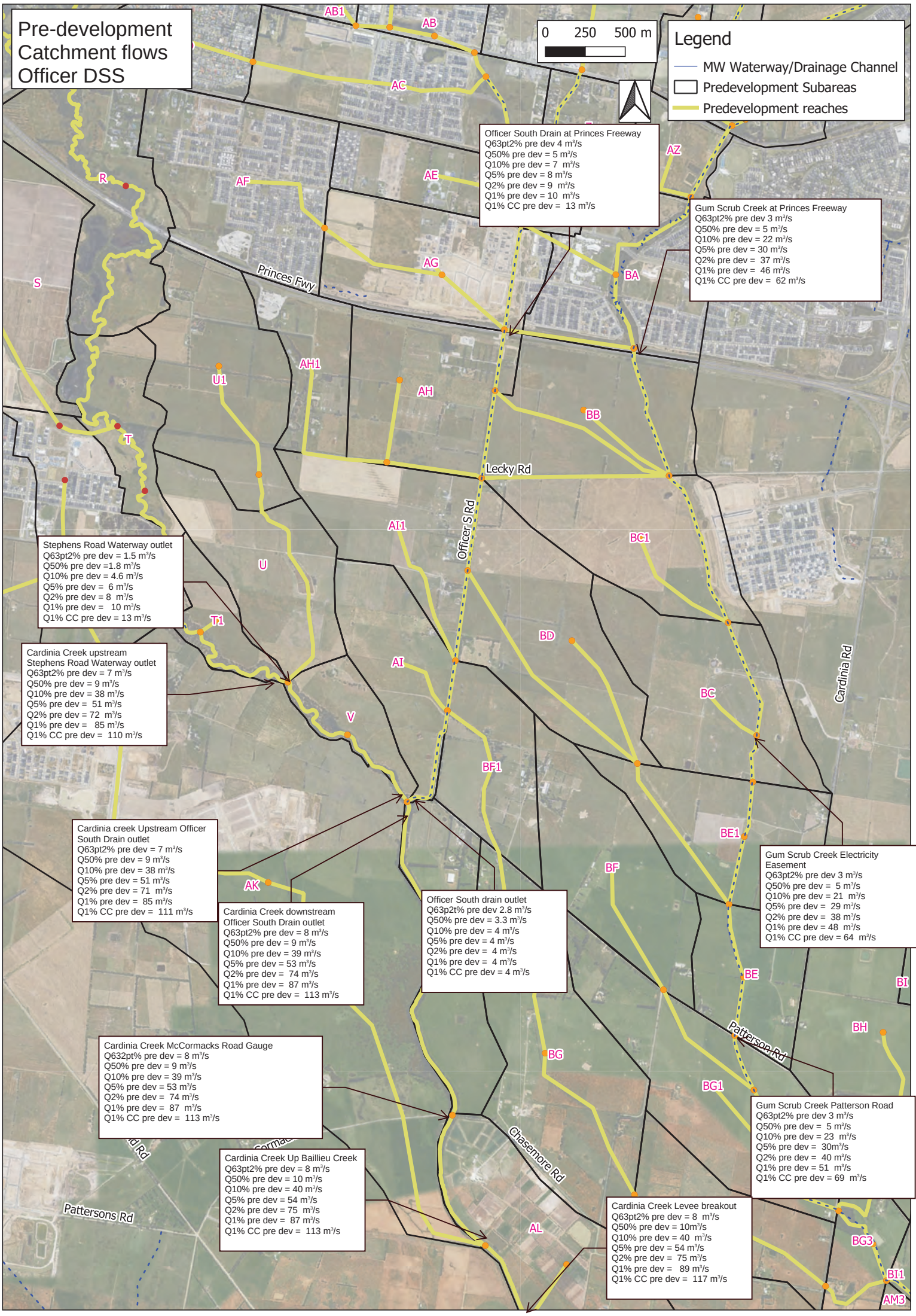
1:20,000

205 0 205 410 615 m

Coordinate System: GDA 1994 MGA Zone 55
Paper size A3 Landscape

Jacobs spiire

Appendix B Predevelopment Flow Map (excerpt of Jacobs, 2022)


Pre-development
Catchment flows
Officer DSS
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Legend
MW Waterway/Drainage Channel
Predevelopment Subareas
Predevelopment reaches
Officer South Drain at Princes Freeway
Q63pt2% pre dev 4 m³/s
Q50% pre dev = 5 m³/s
Q10% pre dev = 7 m³/s
Q5% pre dev = 8 m³/s
Q2% pre dev = 9 m³/s
Q1% pre dev = 10 m³/s
Q1% CC pre dev = 13 m³/s
Gum Scrub Creek at Princes Freeway
Q63pt2% pre dev 3 m³/s
Q50% pre dev = 5 m³/s
Q10% pre dev = 22 m³/s
Q5% pre dev = 30 m³/s
Q2% pre dev = 37 m³/s
Q1% pre dev = 46 m³/s
Q1% CC pre dev = 62 m³/s
Princes Fwy
Lecky Rd
Officer S Rd
Cardinia Rd
Stephens Road Waterway outlet
Q63pt2% pre dev = 1.5 m³/s
Q50% pre dev =1.8 m³/s
Q10% pre dev = 4.6 m³/s
Q5% pre dev = 6 m³/s
Q2% pre dev = 8 m³/s
Q1% pre dev = 10 m³/s
Q1% CC pre dev = 13 m³/s
Cardinia Creek upstream
Stephens Road Waterway outlet
Q63pt2% pre dev = 7 m³/s
Q50% pre dev = 9 m³/s
Q10% pre dev = 38 m³/s
Q5% pre dev = 51 m³/s
Q2% pre dev = 72 m³/s
Q1% pre dev = 85 m³/s
Q1% CC pre dev = 110 m³/s
Cardinia creek Upstream Officer South Drain outlet
Q63pt2% pre dev = 7 m³/s
Q50% pre dev = 9 m³/s
Q10% pre dev = 38 m³/s
Q5% pre dev = 51 m³/s
Q2% pre dev = 71 m³/s
Q1% pre dev = 85 m³/s
Q1% CC pre dev = 111 m³/s
Cardinia Creek downstream
Officer South Drain outlet
Q63pt2% pre dev = 8 m³/s
Q50% pre dev = 9 m³/s
Q10% pre dev = 39 m³/s
Q5% pre dev = 53 m³/s
Q2% pre dev = 74 m³/s
Q1% pre dev = 87 m³/s
Q1% CC pre dev = 113 m³/s
Officer South drain outlet
Q63p2t% pre dev 2.8 m³/s
Q50% pre dev = 3.3 m³/s
Q10% pre dev = 4 m³/s
Q5% pre dev = 4 m³/s
Q2% pre dev = 4 m³/s
Q1% pre dev = 4 m³/s
Q1% CC pre dev = 4 m³/s
Gum Scrub Creek Electricity Easement
Q63pt2% pre dev 3 m³/s
Q50% pre dev = 5 m³/s
Q10% pre dev = 21 m³/s
Q5% pre dev = 29 m³/s
Q2% pre dev = 38 m³/s
Q1% pre dev = 48 m³/s
Q1% CC pre dev = 64 m³/s
Cardinia Creek McCormacks Road Gauge
Q632pt% pre dev = 8 m³/s
Q50% pre dev = 9 m³/s
Q10% pre dev = 39 m³/s
Q5% pre dev = 53 m³/s
Q2% pre dev = 74 m³/s
Q1% pre dev = 87 m³/s
Q1% CC pre dev = 113 m³/s
Patterson Rd
Gum Scrub Creek Patterson Road
Q63pt2% pre dev 3 m³/s
Q50% pre dev = 5 m³/s
Q10% pre dev = 23 m³/s
Q5% pre dev = 30m³/s
Q2% pre dev = 40 m³/s
Q1% pre dev = 51 m³/s
Q1% CC pre dev = 69 m³/s
Cardinia Creek Up Baillieu Creek
Q63pt2% pre dev = 8 m³/s
Q50% pre dev = 10 m³/s
Q10% pre dev = 40 m³/s
Q5% pre dev = 54 m³/s
Q2% pre dev = 75 m³/s
Q1% pre dev = 87 m³/s
Q1% CC pre dev = 113 m³/s
Chasemore Rd
Pattersons Rd
Cardinia Creek Levee breakout
Q63pt2% pre dev = 8 m³/s
Q50% pre dev = 10m³/s
Q10% pre dev = 40 m³/s
Q5% pre dev = 54 m³/s
Q2% pre dev = 75 m³/s
Q1% pre dev = 89 m³/s
Q1% CC pre dev = 117 m³/s
AB1
AB
AC
AZ
AE
AF
AG
BA
R
S
T
U1
AH1
AH
BB
U
T1
AI1
BC1
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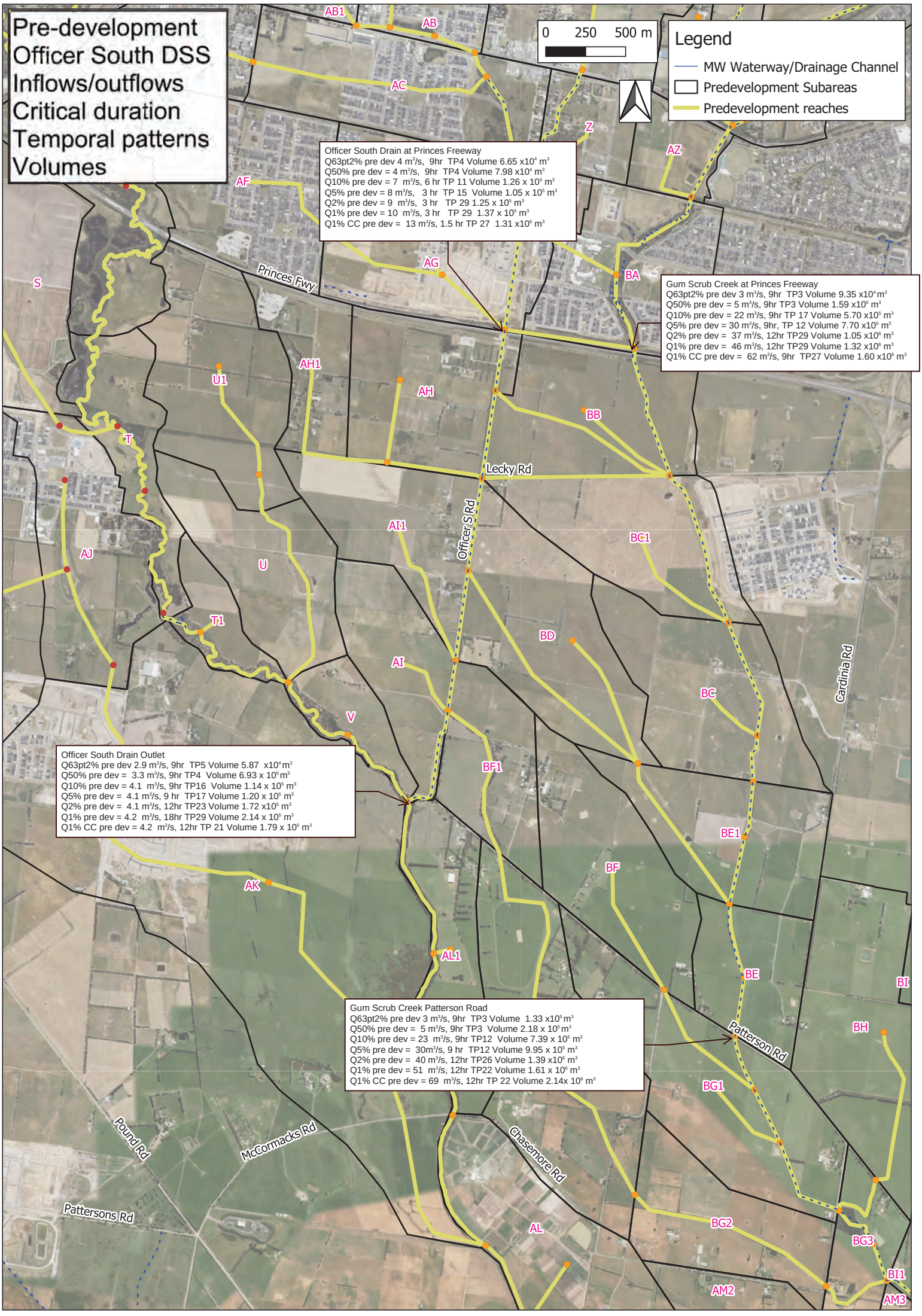
Pre-development
Officer South DSS
Inflows/outflows
Critical duration
Temporal patterns
Volumes
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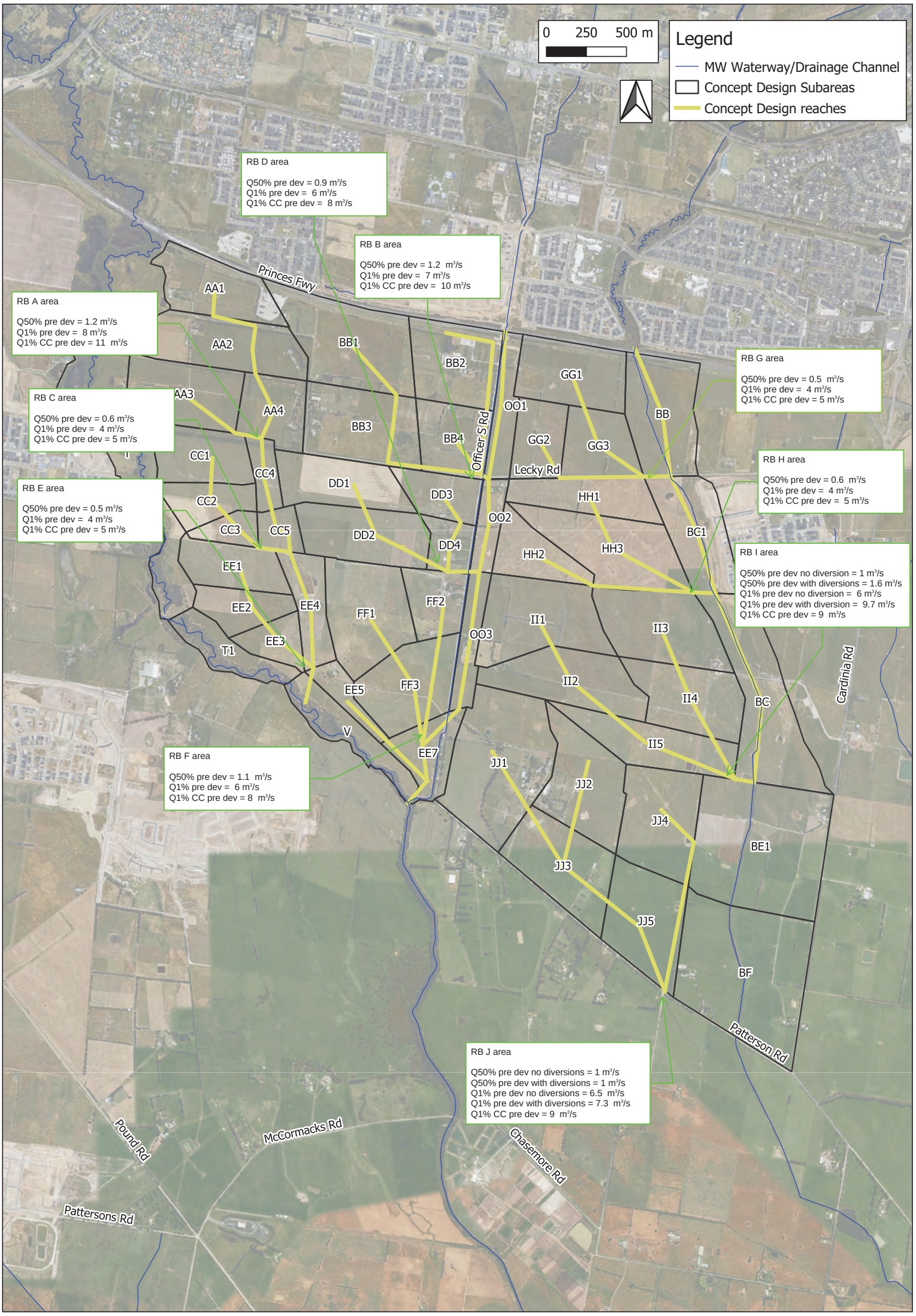
Legend
MW Waterway/Drainage Channel
Predevelopment Subareas
Predevelopment reaches
Officer South Drain at Princes Freeway
Q63pt2% pre dev 4 m³/s, 9hr TP4 Volume 6.65 x10⁴ m³
Q50% pre dev = 4 m³/s, 9hr TP4 Volume 7.98 x10⁴ m³
Q10% pre dev = 7 m³/s, 6 hr TP 11 Volume 1.26 x 10⁵ m³
Q5% pre dev = 8 m³/s, 3 hr TP 15 Volume 1.05 x 10⁵ m³
Q2% pre dev = 9 m³/s, 3 hr TP 29 1.25 x 10⁵ m³
Q1% pre dev = 10 m³/s, 3 hr TP 29 1.37 x 10⁵ m³
Q1% CC pre dev = 13 m³/s, 1.5 hr TP 27 1.31 x10⁵ m³
Gum Scrub Creek at Princes Freeway
Q63pt2% pre dev 3 m³/s, 9hr TP3 Volume 9.35 x10⁴ m³
Q50% pre dev = 5 m³/s, 9hr TP3 Volume 1.59 x10⁵ m³
Q10% pre dev = 22 m³/s, 9hr TP 17 Volume 5.70 x10⁵ m³
Q5% pre dev = 30 m³/s, 9hr, TP 12 Volume 7.70 x10⁵ m³
Q2% pre dev = 37 m³/s, 12hr TP29 Volume 1.05 x10⁶ m³
Q1% pre dev = 46 m³/s, 12hr TP29 Volume 1.32 x10⁶ m³
Q1% CC pre dev = 62 m³/s, 9hr TP27 Volume 1.60 x10⁶ m³
Officer South Drain Outlet
Q63pt2% pre dev 2.9 m³/s, 9hr TP5 Volume 5.87 x10⁴ m³
Q50% pre dev = 3.3 m³/s, 9hr TP4 Volume 6.93 x 10⁵ m³
Q10% pre dev = 4.1 m³/s, 9hr TP16 Volume 1.14 x 10⁵ m³
Q5% pre dev = 4.1 m³/s, 9 hr TP17 Volume 1.20 x 10⁵ m³
Q2% pre dev = 4.1 m³/s, 12hr TP23 Volume 1.72 x10⁵ m³
Q1% pre dev = 4.2 m³/s, 18hr TP29 Volume 2.14 x 10⁵ m³
Q1% CC pre dev = 4.2 m³/s, 12hr TP 21 Volume 1.79 x 10⁵ m³
Gum Scrub Creek Patterson Road
Q63pt2% pre dev 3 m³/s, 9hr TP3 Volume 1.33 x10⁶ m³
Q50% pre dev = 5 m³/s, 9hr TP3 Volume 2.18 x 10⁶ m³
Q10% pre dev = 23 m³/s, 9hr TP12 Volume 7.39 x 10⁵ m³
Q5% pre dev = 30m³/s, 9 hr TP12 Volume 9.95 x 10⁵ m³
Q2% pre dev = 40 m³/s, 12hr TP26 Volume 1.39 x10⁶ m³
Q1% pre dev = 51 m³/s, 12hr TP22 Volume 1.61 x 10⁶ m³
Q1% CC pre dev = 69 m³/s, 12hr TP 22 Volume 2.14x 10⁶ m³
AB1
AB
AC
Z
AZ
AF
AG
BA
S
Princes Fwy
U1
AH1
AH
BB
T
Lecky Rd
Officer S Rd
AI1
BC1
AJ
U
T1
BD
AI
Cardinia Rd
BC
V
BF1
BE1
AK
BF
AL1
BE
BI
BH
Patterson Rd
BG1
Pound Rd
McCormacks Rd
Chasemore Rd
Pattersons Rd
AL
BG2
BG3
BI1
AM2
AM3


0 250 500 m
Legend
MW Waterway/Drainage Channel
Concept Design Subareas
Concept Design reaches
RB D area
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Q1% CC pre dev = 8 m³/s
RB B area
Q50% pre dev = 1.2 m³/s
Q1% pre dev = 7 m³/s
Q1% CC pre dev = 10 m³/s
RB A area
Q50% pre dev = 1.2 m³/s
Q1% pre dev = 8 m³/s
Q1% CC pre dev = 11 m³/s
RB G area
Q50% pre dev = 0.5 m³/s
Q1% pre dev = 4 m³/s
Q1% CC pre dev = 5 m³/s
RB C area
Q50% pre dev = 0.6 m³/s
Q1% pre dev = 4 m³/s
Q1% CC pre dev = 5 m³/s
RB H area
Q50% pre dev = 0.6 m³/s
Q1% pre dev = 4 m³/s
Q1% CC pre dev = 5 m³/s
RB E area
Q50% pre dev = 0.5 m³/s
Q1% pre dev = 4 m³/s
Q1% CC pre dev = 5 m³/s
RB I area
Q50% pre dev no diversion = 1 m³/s
Q50% pre dev with diversions = 1.6 m³/s
Q1% pre dev no diversion = 6 m³/s
Q1% pre dev with diversion = 9.7 m³/s
Q1% CC pre dev = 9 m³/s
RB F area
Q50% pre dev = 1.1 m³/s
Q1% pre dev = 6 m³/s
Q1% CC pre dev = 8 m³/s
RB J area
Q50% pre dev no diversions = 1 m³/s
Q50% pre dev with diversions = 1 m³/s
Q1% pre dev no diversions = 6.5 m³/s
Q1% pre dev with diversions = 7.3 m³/s
Q1% CC pre dev = 9 m³/s
Princes Fwy
Officer S Rd
Lecky Rd
Cardinia Rd
Patterson Rd
Pound Rd
McCormacks Rd
Chasemore Rd
Pattersons Rd
AA1
AA2
AA3
AA4
BB1
BB2
BB3
BB4
BB
CC1
CC2
CC3
CC4
CC5
DD1
DD2
DD3
DD4
EE1
EE2
EE3
EE4
EE5
EE7
FF1
FF2
FF3
GG1
GG2
GG3
HH1
HH2
HH3
II1
II2
II3
II4
II5
JJ1
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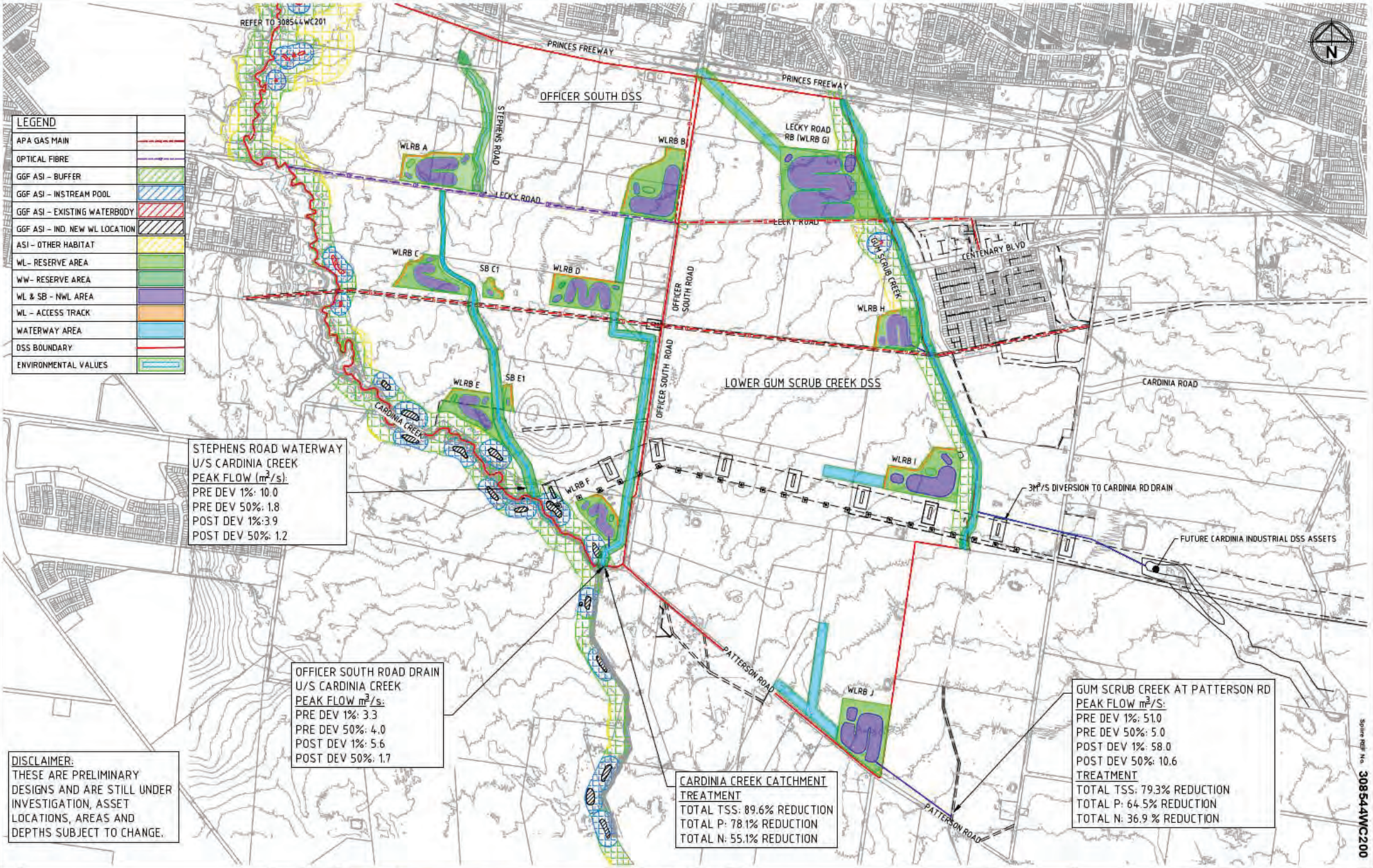
OO3
T1
V
BC
BC1
BE1
BF

Appendix C Options Layouts



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CHECKED: K.WILKINSON

AUTHORISED: 24-03-2022 J.WARD

SHEET 1 OF 1

MELBOURNE WATER

CARDINIA SHIRE COUNCIL

OFFICER SOUTH DSS

OVERALL OPTION 1B LAYOUT

PRELIMINARY

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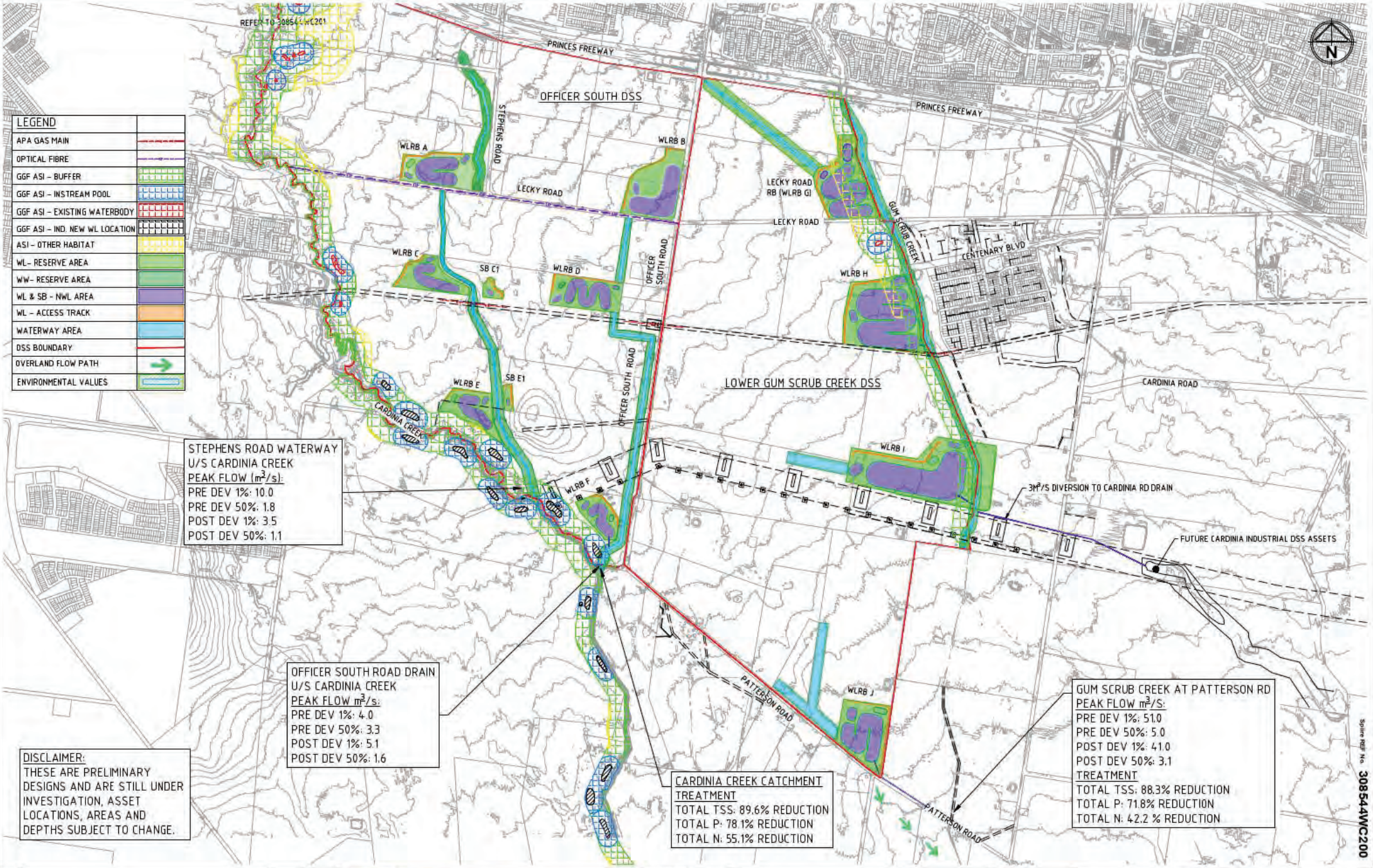

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CHECKED: K.WILKINSON
AUTHORISED: 30-05-2022 J.WARD
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MELBOURNE WATER
CARDINIA SHIRE COUNCIL
OFFICER SOUTH PSP DSS CONCEPT 1D
OVERALL OPTION 1D LAYOUT

PRELIMINARY

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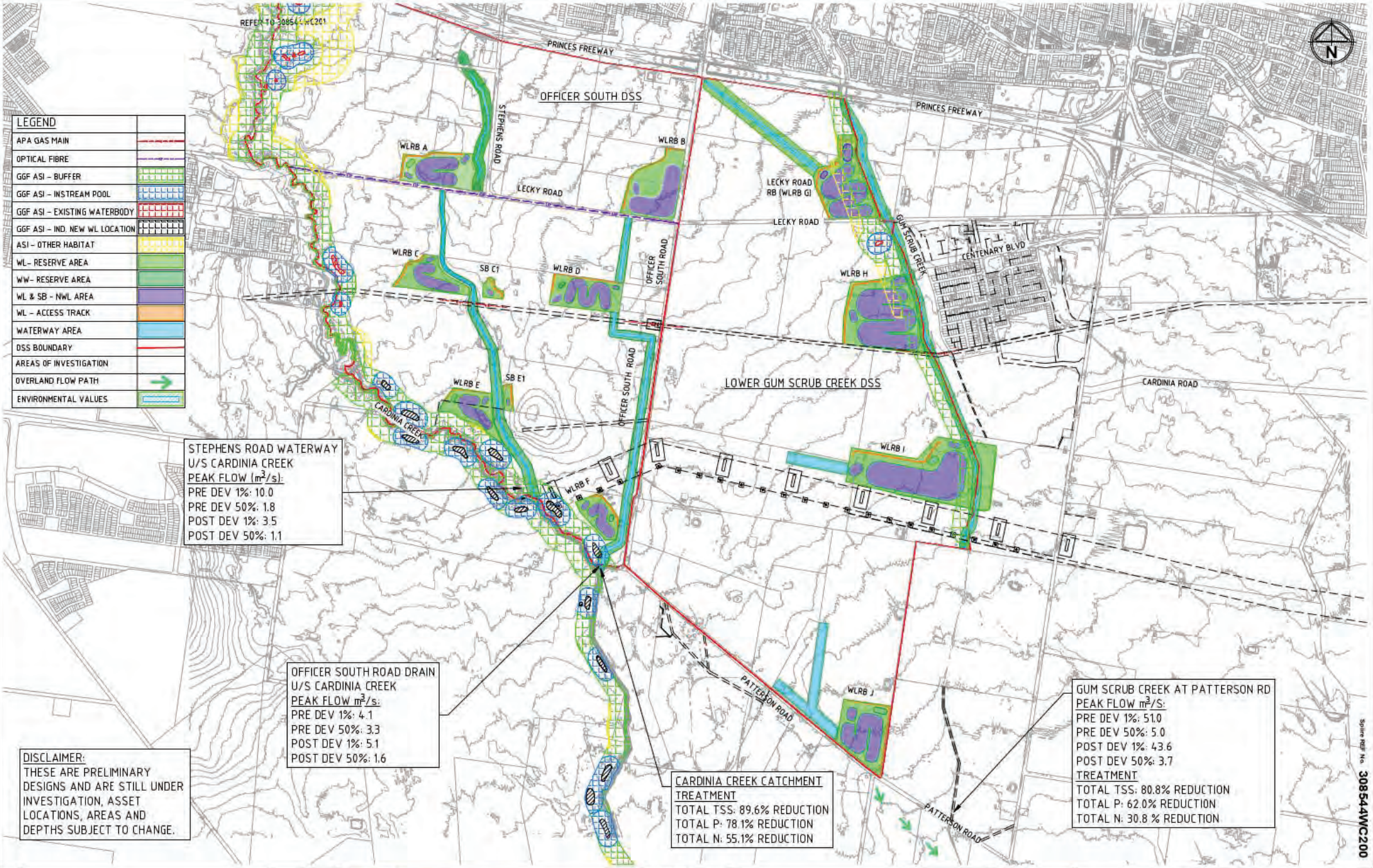

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AUTHORISED: 30-05-2022 J.WARD

SHEET 1 OF 1

MELBOURNE WATER

CARDINIA SHIRE COUNCIL

OFFICER SOUTH PSP DSS CONCEPT 1E

OVERALL OPTION 1E LAYOUT

PRELIMINARY

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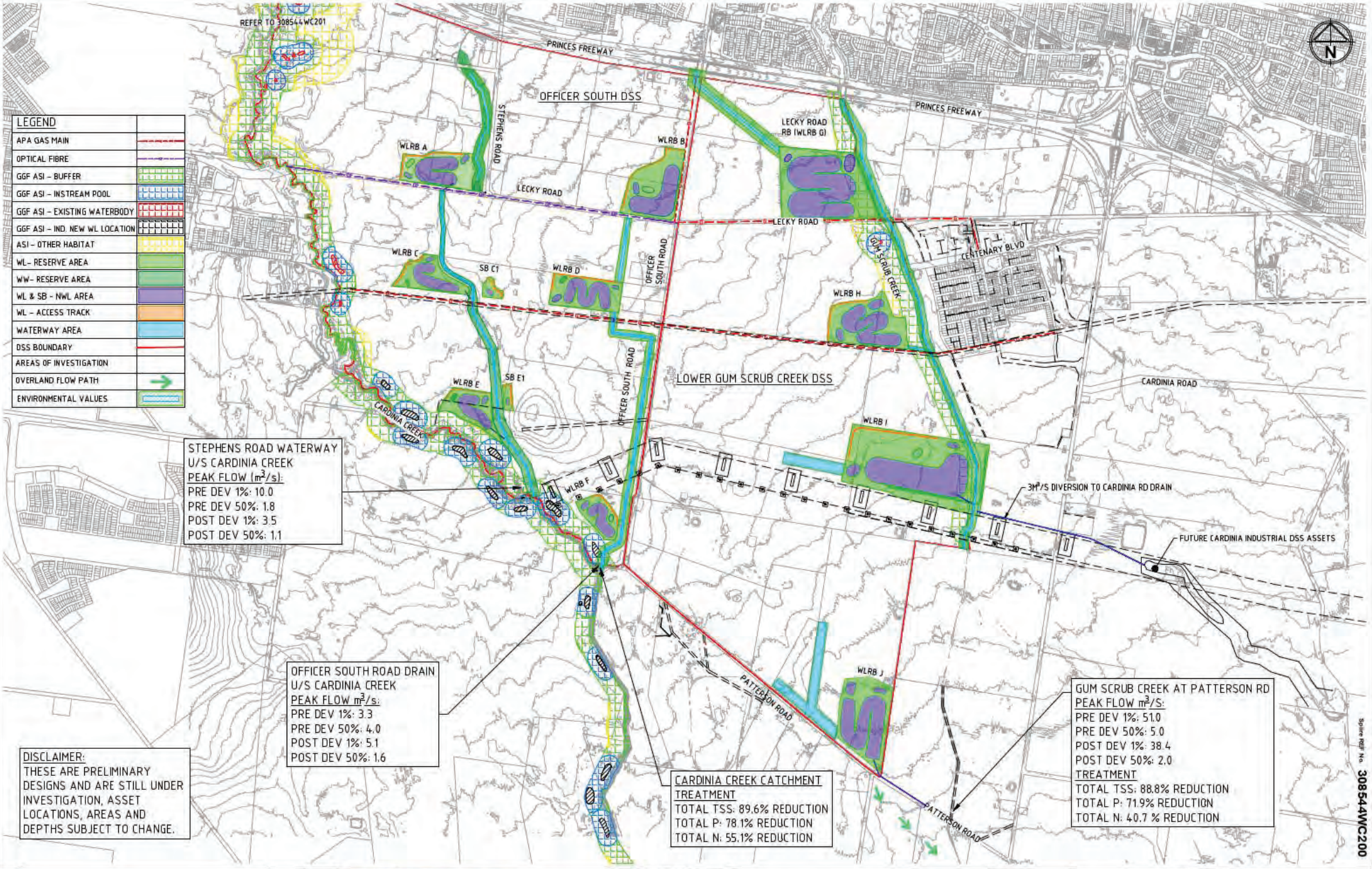

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SHEET 1 OF 1

MELBOURNE WATER
CARDINIA SHIRE COUNCIL

OFFICER SOUTH PSP DSS CONCEPT 1F

OVERALL OPTION 1F LAYOUT

PRELIMINARY

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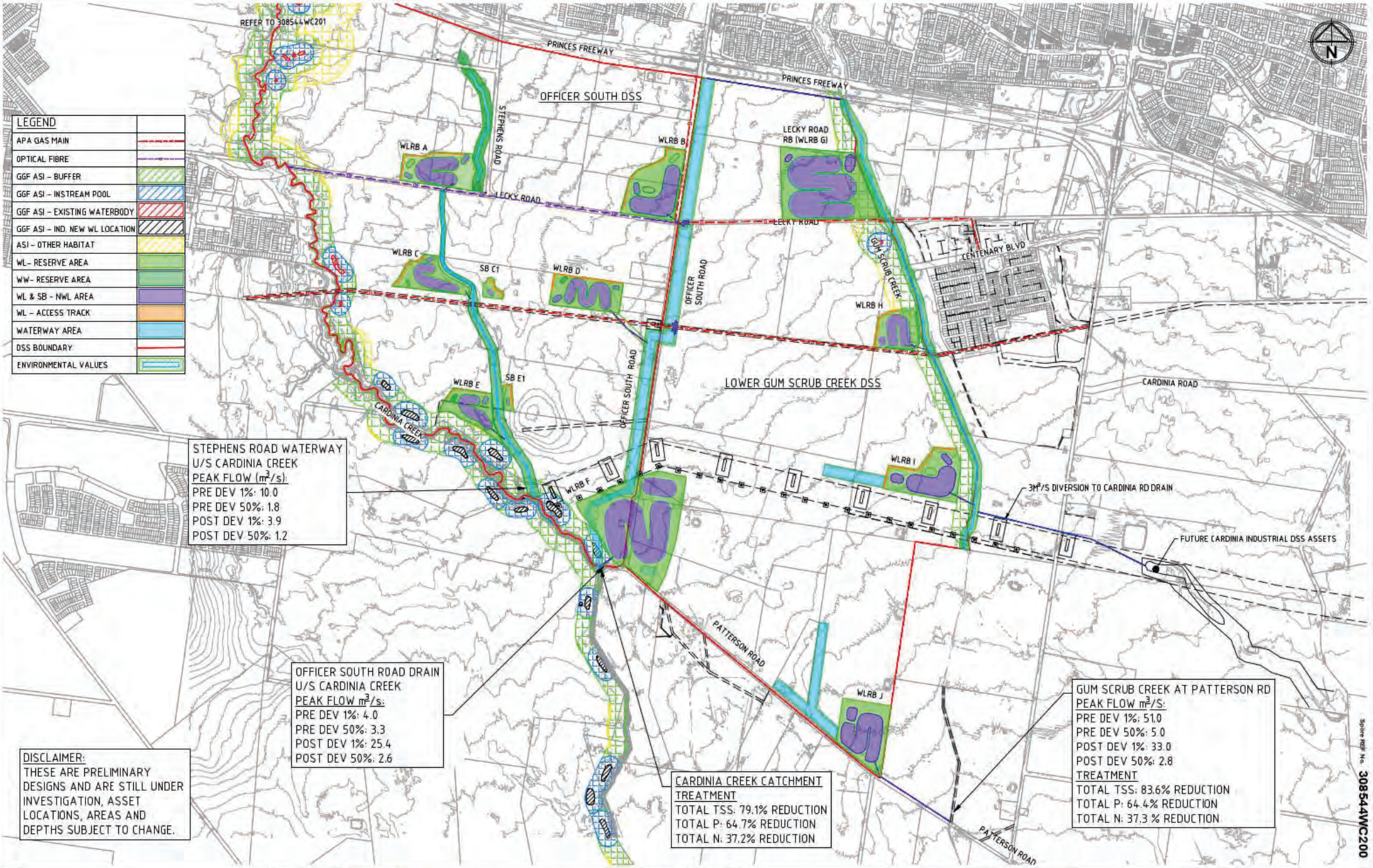

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CHECKED: K.WILKINSON

AUTHORISED: 24-03-2022 J.WARD

SHEET 1 OF 1

MELBOURNE WATER

CARDINIA SHIRE COUNCIL

OFFICER SOUTH DSS

OPTION 2C OVERALL LAYOUT

PRELIMINARY

DWG NO. 308824 1

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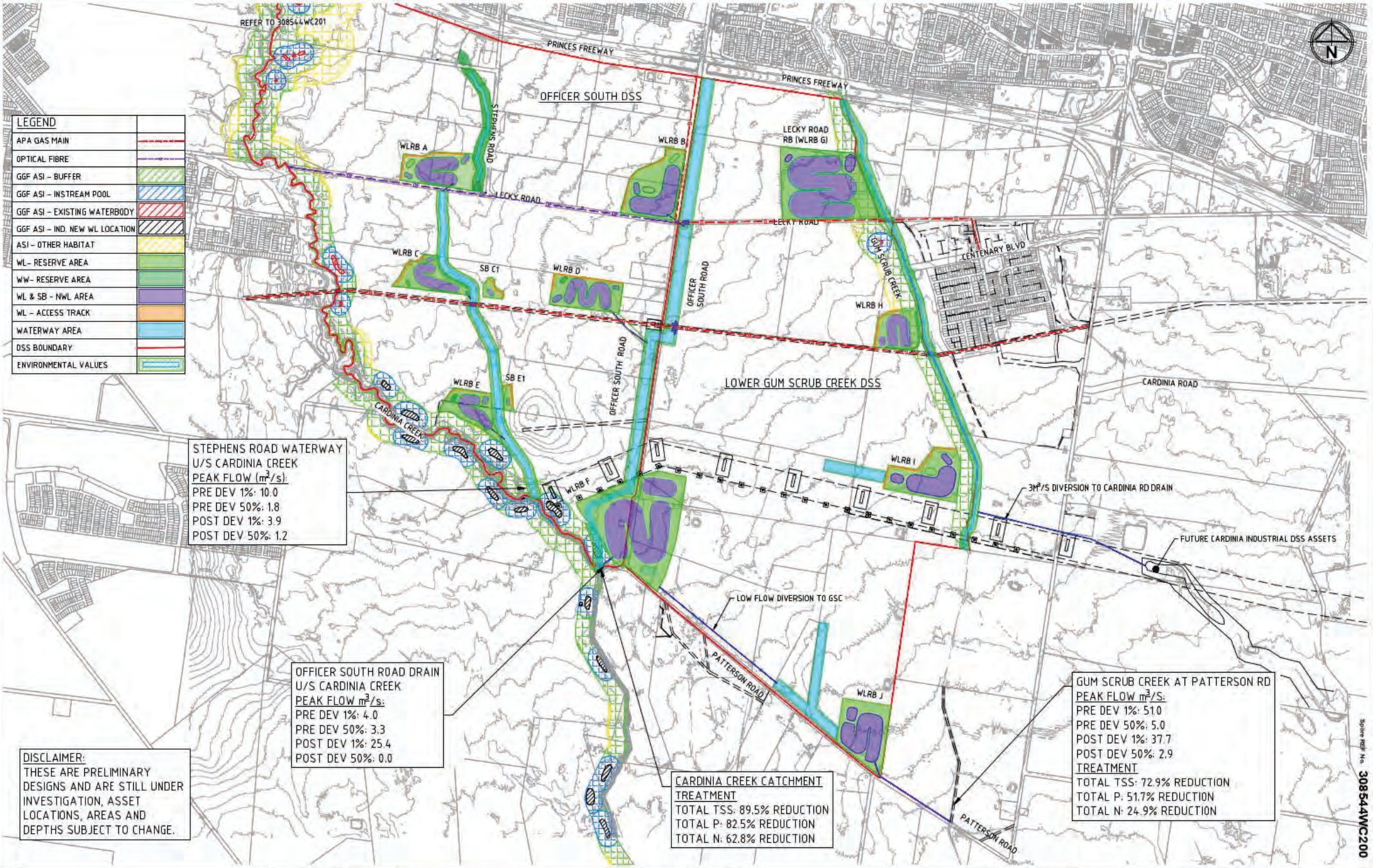

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AUTHORISED: 24-03-2022 J.WARD

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MELBOURNE WATER

CARDINIA SHIRE COUNCIL

OFFICER SOUTH DSS

OPTION 3B OVERALL LAYOUT

PRELIMINARY

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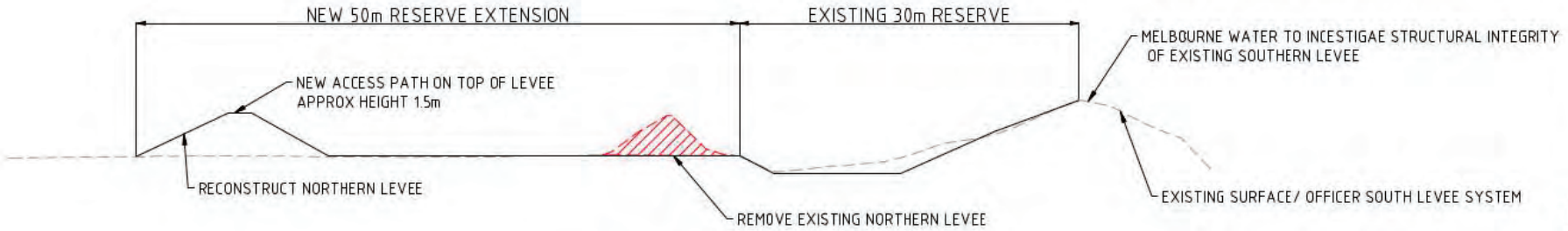
Appendix D Gas Main Crossing and Levee Upgrade Concepts

Gas main crossings under design investigations



CARDINIA CREEK OUTFALL LEVEE RE-WORK
SECTION A-A (TYPICAL SECTION)
V SCALE: 1:100
H SCALE: 1:200

INDICATIVE LEVEE SECTION ONLY. DOES NOT REFLECT FINISHED LEVEE ACCURATELY. TO BE USED FOR DISCUSSION ONLY.

Spiire REF No. 308544WC210- LEVEE

REV.	AMENDMENTS	APP'D	DATE

Melbourne Water

H 1 : 3000 SCALE @ A1 V 1 : 3000 0 30 60 90 120 150

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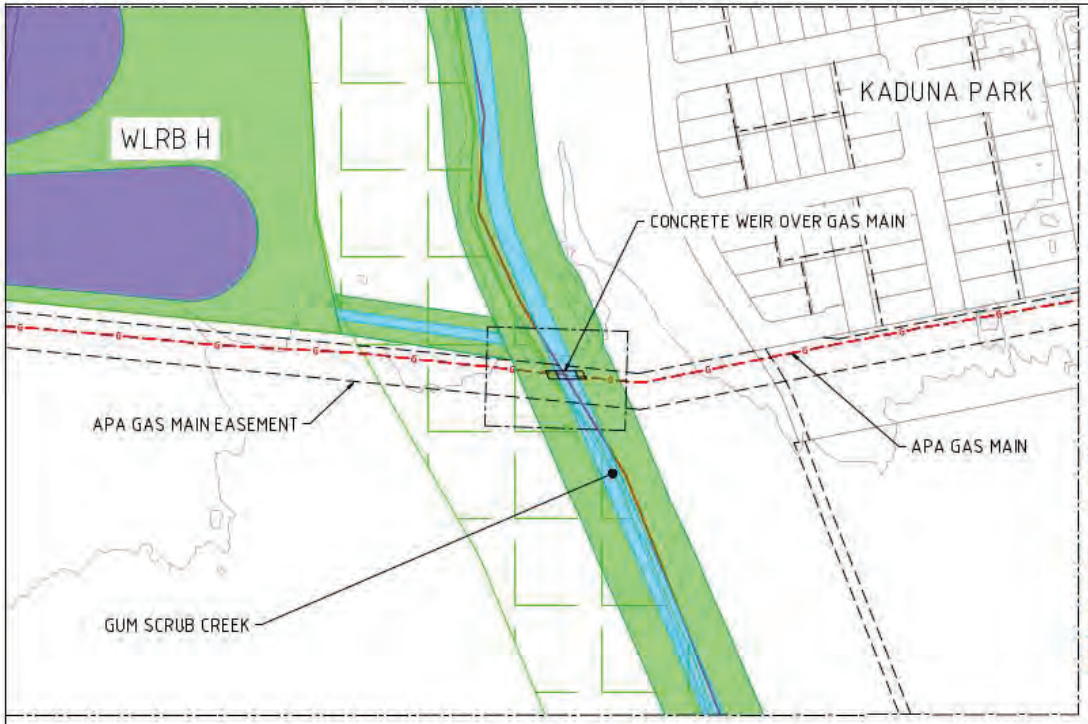

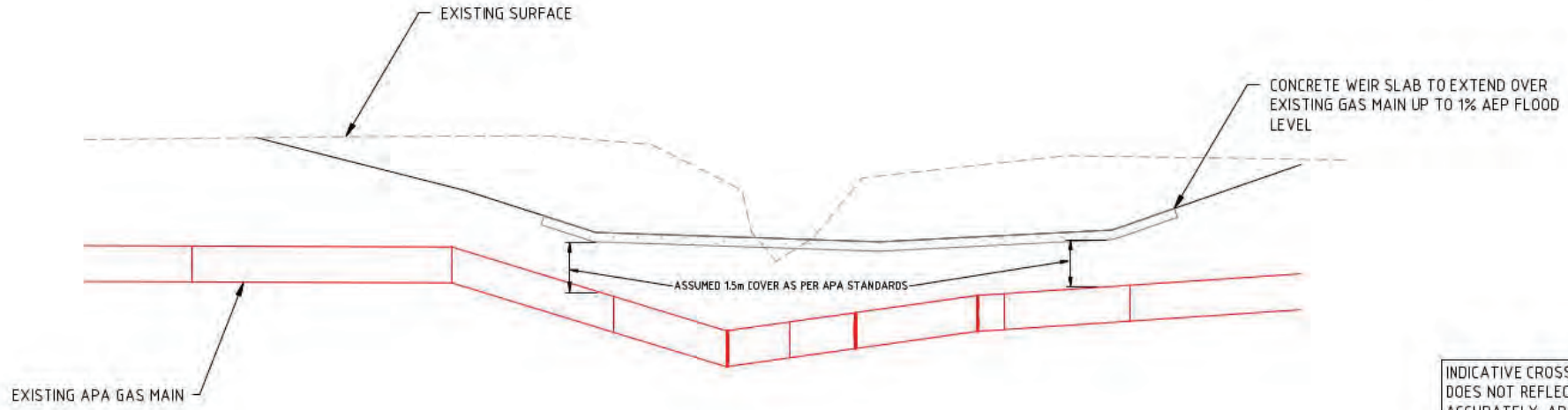

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CARDINIA SHIRE COUNCIL

OFFICER SOUTH PSP DSS CONCEPT

APA GAS MAIN CROSSING - GUM SCRUB CREEK

PRELIMINARY

DWG NO: 308824

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Appendix E Asset Design Parameters

Table 71 Option 1B Asset Design Parameters

	RBWL A	RBWL B	RBWL C	RBWL D	RBWL E	RBWL F	RBWL	RBWL H	RBWL I	RBWL J
RESERVE AREA (ha)	7.81	10.30	5.54	7.42	5.37	3.91	21.19	5.29	9.24	9.68
WETLAND AREA (ha)	3.34	4.19	2.18	3.18	1.92	1.59	11.72	2.19	3.31	4.55
STORAGE (m^3)	60,365	152,650	22,162	41,854	49,550	57,158	32,1320	32,013	191,900	136,020
RB DEPTH TO SPILLWAY (m)	1.1	2.34	0.9	1.0	1.55	2.3	2	1	3	2
SPILLWAY LENGTH (m)	20	20	20	20	20	20	30	50	50	20
SPILLWAY IL (m AHD)	31.5	27.45	28.9	26	25.55	21.3	24	20	18	14
PIPES (mm)	750	825	525	600	750	1200	50	825	900	750
PIPES IL (m AHD)	30	25.15	28	24.9	24	19.1	22	19	15	12

Table 72 Option 1D Asset Design Parameters

	RBWL A	RBWL B	RBWL C	RBWL D	RBWL E	RBWL F	RBWL	RBWL H	RBWL I	RBWL J
RESERVE AREA (ha)	7.81	10.30	5.54	7.42	5.37	3.92	11.12	16.88	24.43	9.38
WETLAND AREA (ha)	3.34	4.19	2.18	3.18	1.92	1.59	5.74	10.08	10.18	4.55
STORAGE (m^3)	60365	152650	22162	41854	49550	57158	172450	127640	511080	136020
RB DEPTH TO SPILLWAY (m)	1.1	2.34	2.0	1.0	1.55	2.3	2	1	3	2
SPILLWAY LENGTH (m)	20	20	20	20	20	20	30/50	50	50	20
SPILLWAY IL (m AHD)	31.5	27.45	28.9	26	25.55	21.3	23/24	20	18	14
PIPES (mm)	750	825	525	600	750	1200	900*3	750*3	4*1050 4*1050	750

PIPES IL (m) AHD	30	25.15	28	24.9	24	19.1	22	19	15/16	12

Table 73 Option 1F Asset Design Parameters

	RBWL A	RBWL B	RBWL C	RBWL D	RBWL E	RBWL F	RBWL	RBWL H	RBWL I	RBWL J
RESERVE AREA (ha)	7.81	10.30	5.54	7.42	5.37	3.92	21.19	10.94	31.16	14.26
WETLAND AREA (ha)	3.34	4.19	2.18	3.18	1.92	1.59	11.72	4.68	10	6.81
STORAGE (m^3)	60365	152650	22162	41854	49550	57158	321320	68354	596380	178630
RB DEPTH TO SPILLWAY (m)	1.1	2.34	2.0	1.0	1.55	2.3	2	1	3	2
SPILLWAY LENGTH (m)	20	20	20	20	20	20	30/50	50	50	20
SPILLWAY IL (m AHD)	31.5	27.45	28.9	26	25.55	21.3	23/24	20	18	14
PIPES (mm)	750	825	525	600	750	1.2	3*900	750	4*1050 10*1050	750
PIPES IL (m AHD)	30	25.15	28	24.9	24	19.1	22	19	15/16	12

Table 74 Asset Design Parameters

	RBWL A	RBWL B	RBWL C	RBWL D	RBWL E	RBWL F	RBWL	RBWL H	RBWL I	RBWL J
RESERVE AREA (ha)	7.81	10.30	5.54	7.42	5.37	26.34	21.19	5.29	9.24	9.68
WETLAND AREA (ha)	3.34	4.19	2.18	3.18	1.92	10.6	11.72	2.19	3.31	4.55
STORAGE (m^3)	60365	152650	22162	41854	49550	509468	321320	32013	191900	136020
RB DEPTH TO SPILLWAY (m)	1.5	2.34	0.9	1.0	1.55	1.2	1/2	1	3	2
SPILLWAY LENGTH (m)	20	20	20	20	20	50	30/50	50	50	20

SPILLWAY IL (m AHD)	31.5	27.45	28.9	26	25.55	21.5	23/24	20	18	14
PIPES (mm)	750	825	525	600	750	1*1200 10*1050	900	825	900	750
PIPES IL (m AHD)	30	25.15	28	24.9	24	19.1 20.3	22	19	15	12

Table 75 Option 3B Asset Design Parameters

	RBWL A	RBWL B	RBWL C	RBWL D	RBWL E	RBWL F	RBWL	RBWL H	RBWL I	RBWL J
RESERVE AREA (ha)	7.81	10.30	5.54	7.42	5.37	26.34	21.19	5.29	9.24	9.68
WETLAND AREA (ha)	3.34	4.19	2.18	3.18	1.92	10.6	11.72	2.19	3.31	4.55
STORAGE (m^3)	60365	152650	22162	41854	49550	509468	321320	32013	191900	136020
RB DEPTH TO SPILLWAY (m)	1.5	2.3	0.9	1.0	1.55	1.2	1/2	1	3	2
SPILLWAY LENGTH (m)	20	20	20	20	20	50	30/50	50	50	20
SPILLWAY IL (m AHD)	31.5	27.45	28.9	26	25.55	21.5	23/24	20	18	14
PIPES (mm)	750	825	525	600	750	1*1200 10*1050	900	825	900	750
PIPES IL (m AHD)	30	25.15	28	24.9	24	19.1 20.3	22	19	15	12

Appendix F RORB Results

The RORB peak flow results have been provided at key locations within and around the PSP. As the retarding basins along Gum Scrub Creek were treating the upstream catchments understanding their effectiveness was critical, whilst the key factor for the Cardinia Creek catchment were the outfalls to the creek. Further detail can be obtained from the RORB models.

Table 76 Option 1B Peak Flows

LOCATIONS	50% AEP (m^3/s)	Duration/ TP	10 % AEP (m^3/s)	Duration/TP	1% AEP (m^3/s)	Duration/TP	1% AEP CC (m^3/s)	Duration/ TP
OSR PRINCES FWY	15.05	1.5hr/TP6	25.74	2hr/TP19	41.1	1.5hr/TP27	51.63	1.5hr/TP27
STEPHENS RD WW U/S CARD CK	1.20	9hr/tp7	2.19	9hr/TP16	3.94	24hr/TP26	5.31	9hr/TP25
OSR U/S CARD CREEK	1.74	9hr/TP5	2.94	9hr/TP16	5.61	9hr/TP25	6.57	9hr/TP25
GSC PRINCES FWY	18.71	3hr/TP4	34.39	9hr/TP12	54.58	9hr/TP25	70.77	1.5hr/TP27
LECKY RD INFLOW	19.39	3hr/TP4	35.62	9hr/TP12	61.47	9hr/TP25	71.62	2hr/TP27
LECKY RD OUTFLOW	12.90	9hr/TP3	31.74	9hr/TP12	54.72	12hr/TP30	64.39	12hr/TP30
RB H INFLOW	3.24	1.5hr/TP1	5.42	30min/TP18	8.70	30min/TP28	11.31	30min/TP28
RB H OUTFLOW	0.40	9hr/TP3	0.63	18hr/TP19	2.83	9hr/TP25	3.34	9hr/TP28
GSC GAS MAIN	13.17	9hr/TP3	32.62	9hr/TP12	56.71	12hr/TP29	66.11	12hr/TP30
RB I INFLOW	6.12	1.5hr/TP3	9.63	45min/TP19	15.60	20min/TP27	20.10	20min/TP27
RB I OUTFLOW	0.97	9hr/TP3	1.54	6hr/TP11	2.53	20min/TP27	3.02	12hr/TP22
RB J INFLOW	6.69	1.5hr/TP3	10.86	1hr/TP17	17.66	1hr/TP27	22.69	1hr/TP28
RB J OUTFLOW	0.46	18hr/TP2	1.00	18hr/TP19	1.73	24hr/TP26	2.25	24hr/TP26
GSC PATTERSON RD	10.58	9hr/TP3	31.05	9hr/TP17	57.99	12hr/TP22	67.90	12hr/TP29

Table 77 Option 1D Peak Flows

LOCATIONS	50% AEP (m^3/s)	Duration/ TP	10 % AEP (m^3/s)	Duration/TP	1% AEP (m^3/s)	Duration/TP	1% AEP CC (m^3/s)	Duration/ TP
OSR PRINCES FWY	15.05	1.5hr/TP6	25.74	2hr/TP19	41.1	1.5hr/TP27	51.63	1.5hr/TP27
STEPHENS RD WW U/S CARD CK	1.10	9hr/TP4	2.02	9hr/TP16	3.54	9hr/TP28	5.31	9hr/TP25
OSR U/S CARD CREEK	1.60	9hr/TP6	2.72	9hr/TP12	5.12	9hr/TP25	6.57	9hr/TP25
GSC PRINCES FWY	18.54	1.5hr/TP1	34.26	2hr/TP17	56.39	1.5hr/TP27	70.77	1.5hr/TP27
LECKY RD INFLOW	18.94	3hr/TP4	35.75	2hr/TP17	57.12	2hr/TP28	71.62	2hr/TP27
LECKY RD OUTFLOW	15.65	9hr/TP4	30.82	4.5hr/TP18	54.32	9hr/TP27	68.15	9hr/TP27
RB H INFLOW	16.36	9hr/TP6	31.76	4.5hr/TP16	54.38	9hr/TP27	69.11	4.5hr/TP27
RB H OUTFLOW	11.25	9hr/TP3	30.07	9hr/TP17	51.26	12hr/TP30	66.29	9hr/TP27
GSC GAS MAIN	11.25	9hr/TP3	30.07	9hr/TP17	51.26	12hr/TP30	66.29	9hr/TP27
RB I INFLOW	8.15	9hr/TP3	27.82	9hr/TP17	50.42	12hr/TP29	64.24	12hr/TP29
RB I OUTFLOW	2.80	9hr/TP3	16.78	9hr/TP20	39.74	12hr/TP29	56.08	12hr/TP29
RB J INFLOW	6.66	1.5hr/TP3	11.21	1hr/TP17	18.61	1hr/TP27	22.69	1hr/TP28
RB J OUTFLOW	0.40	18hr/TP2	0.89	18hr/TP10	1.40	24hr/TP26	2.25	2hr/TP26
GSC PATTERSON RD	3.12	9hr/TP3	17.33	9hr/TP20	40.98	12hr/TP29	62.17	12hr/TP29

Table 78 Option 1E Peak Flows

LOCATIONS	50% AEP (m^3/s)	Duration/ TP	10 % AEP (m^3/s)	Duration/TP	1% AEP (m^3/s)	Duration/TP	1% AEP CC (m^3/s)	Duration/ TP
OSR PRINCES FWY	15.05	1.5hr/TP6	25.74	2hr/TP19	41.1	1.5hr/TP27	51.63	1.5hr/TP27
STEPHENS RD WW U/S CARD CK	1.10	9hr/Tp4	2.02	9hr/TP16	3.54	9hr/TP28	5.30603	9hr/TP25
OSR U/S CARD CREEK	1.60	9hr/TP6	2.72	9hr/TP12	5.11	9hr/TP25	6.5692	9hr/TP25
GSC PRINCES FWY	18.54	1.5hr/TP1	34.26	2hr/TP17	56.39	4.35hr/TP27	70.774	1.5hr/TP27
LECKY RD INFLOW	18.94	3hr/TP4	35.75	2hr/TP17	57.12	2hr/TP28	71.6208	2hr/TP27
LECKY RD OUTFLOW	15.65	9hr/Tp4	30.81	4.5hr/TP18	54.32	9hr/TP27	68.1535	9hr/TP27
RB H INFLOW	16.36	9hr/TP6	31.76	4.5/TP16	54.38	9hr/TP27	69.1142	4.5hr/TP27
RB H OUTFLOW	11.25	9hr/TP3	30.07	9hr/TP17	51.26	12hr/TP30	66.2917	9hr/TP27
GSC GAS MAIN	11.25	9hr/TP3	30.07	9hr/TP17	51.26	12hr/TP30	66.2917	9hr/TP27
RB I INFLOW	11.15	9hr/TP3	30.82	9hr/TP17	53.42	12hr/TP29	67.2392	12hr/TP29
RB I OUTFLOW	3.45	9hr/TP3	18.41	9hr/TP20	42.31	12hr/TP29	60.1152	12hr/TP29
RB J INFLOW	6.66	1.5hr/TP3	11.21	1hr/TP17	18.61	1hr/TP27	22.6939	1hr/TP28
RB J OUTFLOW	0.40	18hr/TP2	0.89	18hr/Tp19	1.40	24hr/TP26	2.2494	2hr/TP26
GSC PATTERSON RD	3.74	9hr/TP3	19.04	9hr/TP20	43.58	12hr/TP29	62.1695	12hr/TP29

Table 79 Option 1F Peak Flows

LOCATIONS	50%AEP (m^3/s)	Duration/ TP	10 % AEP (m^3/s)	Duration/ TP	1% AEP (m^3/s)	Duration/TP	1% AEP CC (m^3/s)	Duration/ TP
OSR PRINCES FWY	15.05	1.5hr/TP6	25.74	2hr/TP19	41.1	1.5hr/TP27	51.63	1.5hr/TP27
STEPHENS RD WW U/S CARD CK	1.10	9hr/TP4	2.02	9hr/TP16	3.54	9hr/TP28	5.36	9hr/TP25
OSR U/S CARD CREEK	1.60	9hr/TP6	2.72	9hr/TP12	5.11	9hr/TP25	6.57	9hr/TP25
GSC PRINCES FWY	18.54	1.5hr/TP1	34.26	2hr/TP17	56.39	1.5hr/TP27	70.77	1.5hr/TP27
LECKY RD INFLOW	18.89	3hr/TP4	35.64	9hr/TP17	57.06	2hr/TP28	71.39	2hr/TP22
LECKY RD OUTFLOW	10.93	9hr/TP3	28.96	2hr/TP17	50.35	12hr/TP30	64.31	12hr/TP30
RB H INFLOW	4.79	20min/TP3	8.20	1.5hr/TP20	13.59	20min/TP28	16.4	20, in/TP28
RB H OUTFLOW	3.17	24hr/TP4	4.04	24hr/TP16	5.44	9hr/TP29	6.29	9hr/TP28
GSC GAS MAIN	8.57	9hr/TP3	28.60	9hr/TP17	51.18	12hr/TP30	65.69	12hr/TP30
RB I INFLOW	6.19	30min/TP5	25.38	9hr/TP17	49.95	12hr/TP29	64.17	12hr/TP29
RB I OUTFLOW	1.71	9hr/TP4	14.81	9hr/TP20	37.82	12hr/TP29	52.5	12hr/TP29
RB J INFLOW	6.66	1.5hr/TP3	11.21	1hr/TP17	18.6	1hr/TP27	22.69	1hr/TP28
RB J OUTFLOW	0.37	18hr/TP4	0.77	30hr/TP20	1.23	24hr/TP26	1.4	36hr/TP25
GSC PATTERSON RD	1.98	9hr/TP4	15.10	9hr/TP20	38.4	12hr/TP29	53.63	12hr/TP29

Table 80 Option 2C Peak Flows

LOCATIONS	50%AEP (m^3/s)	Duration/ TP	10 % AEP (m^3/s)	Duration/ TP	1% AEP (m^3/s)	Duration/TP	1% AEP CC (m^3/s)	Duration/ TP
OSR PRINCES FWY	15.05	1.5hr/TP6	25.74	2hr/TP19	41.1	1.5hr/TP27	51.63	1.5hr/TP27
STEPHENS RD WW U/S CARD CK	1.2	9hr/TP7	2.19	9hr/TP16	3.93	24hr/TP26	5.3	9hr/TP25
OSR U/S CARD CREEK	2.61	18hr/TP6	10.26	18hr/TP19	25.36	24hr/TP26	28.76	9hr/TP21
GSC PRINCES FWY	6.63	1.5hr/TP7	15.24	9hr/TP12	27.44	12hr/TP29	34.77	12hr/TP22
LECKY RD INFLOW	8.67	1.5hr/TP6	16.02	9hr/TP12	31.56	12hr/TP29	36.39	12hr/TP29
LECKY RD OUTFLOW	2.27	9hr/TP4	12.66	9hr/TP17	29.65	12hr/TP29	34.72	12hr/TP22
RB H INFLOW	3.24	1.5hr/TP1	5.41	30min/TP18	8.7	30min/TP28	33.35	30min/TP28
RB H OUTFLOW	0.4	9hr/TP3	0.63	18hr/TP19	2.83	9hr/TP25	3.34	9hr/TP28
GSC GAS MAIN	2.46	9hr/TP4	13.24	9hr/TP17	31.19	12hr/TP29	36.15	12hr/TP29
RB I INFLOW	6.12	1.5hr/TP3	9.63	45min/TP19	15.58	20min/TP27	20.17	20min/TP27
RB I OUTFLOW	0.97	9hr/TP4	1.54	6hr/TP11	2.53	9hr/TP21	3.02	12hr/TP22
RB J INFLOW	6.36	1.5hr/TP3	10.23	1.5hr/TP16	16.4	1hr/TP27	21.03	1hr/TP28
RB J OUTFLOW	0.41	18hr/TP2	0.93	18hr/TP19	1.45	24hr/TP26	1.56	24hr/TP26
GSC PATTERSON RD	2.75	9hr/TP7	12.09	18hr/TP19	33.034	12hr/TP26	38.71	12hr/TP30

Table 81 Option 3B Peak flows

LOCATIONS	50%AEP (m^3/s)	Duration/TP	10 % AEP (m^3/s)	Duration/TP	1% AEP (m^3/s)	Duration/TP	1% AEP CC (m^3/s)	Duration/TP
OSR PRINCES FWY	15.05	1.5hr/TP6	25.74	2hr/TP19	41.1	1.5hr/TP 28	51.63	1.5hr/TP27
STEPHENS RD WW U/S CARD CK	1.2	9hr/TP7	2.19	9hr/TP16	3.93	24hr/TP25	5.3	9hr/TP25
OSR U/S CARD CREEK	0	20min/TP1	7.26	18hr/TP19	25.36	24hr/TP26	25.76	9hr/TP21
GSC PRINCES FWY	6.63	1.5hr/TP7	15.24	9hr/TP12	29.56	12hr/TP29	34.78	12hr/TP22
LECKY RD INFLOW	8.67	1.5hr/TP6	16.02	9hr/TP12	31.56	12hr/TP29	36.39	12hr/TP29
LECKY RD OUTFLOW	2.27	9hr/TP4	12.66	9hr/TP17	29.66	12hr/TP29	34.72	12hr/TP22
RB H INFLOW	3.24	1.5hr/TP1	5.41	30min/TP18	8.75	30min/TP28	11.31	30min/TP28
RB H OUTFLOW	0.4	9hr/TP3	0.63	18hr/TP19	2.83	9hr/TP25	3.34	9hr/TP28
GSC GAS MAIN	2.46	9hr/TP4	13.24	9hr/TP17	31.19	12hr/TP29	36.15	12hr/TP29
RB I INFLOW	6.12	1.5hr/TP2	9.63	45min/TP19	15.66	20min/TP27	20.08	20min/TP27
RB I OUTFLOW	0.97	9hr/TP4	1.54	6hr/TP11	2.53	9hr/TP21	3.02	12hr/TP22
RB J INFLOW	6.36	1.5hr/TP3	10.25	1.5hr/TP16	16.42	12hr/TP26	21.09	1hr/TP27
RB J OUTFLOW	1.28	30hr/TP8	4.39	30hr/TP19	7.48	24/TP21	7.93	24hr/TP29
GSC PATTERSON RD	2.85	9hr/TP4	13.28	18hr/TP19	37.67	12/TP26	43.46	12hr/TP26

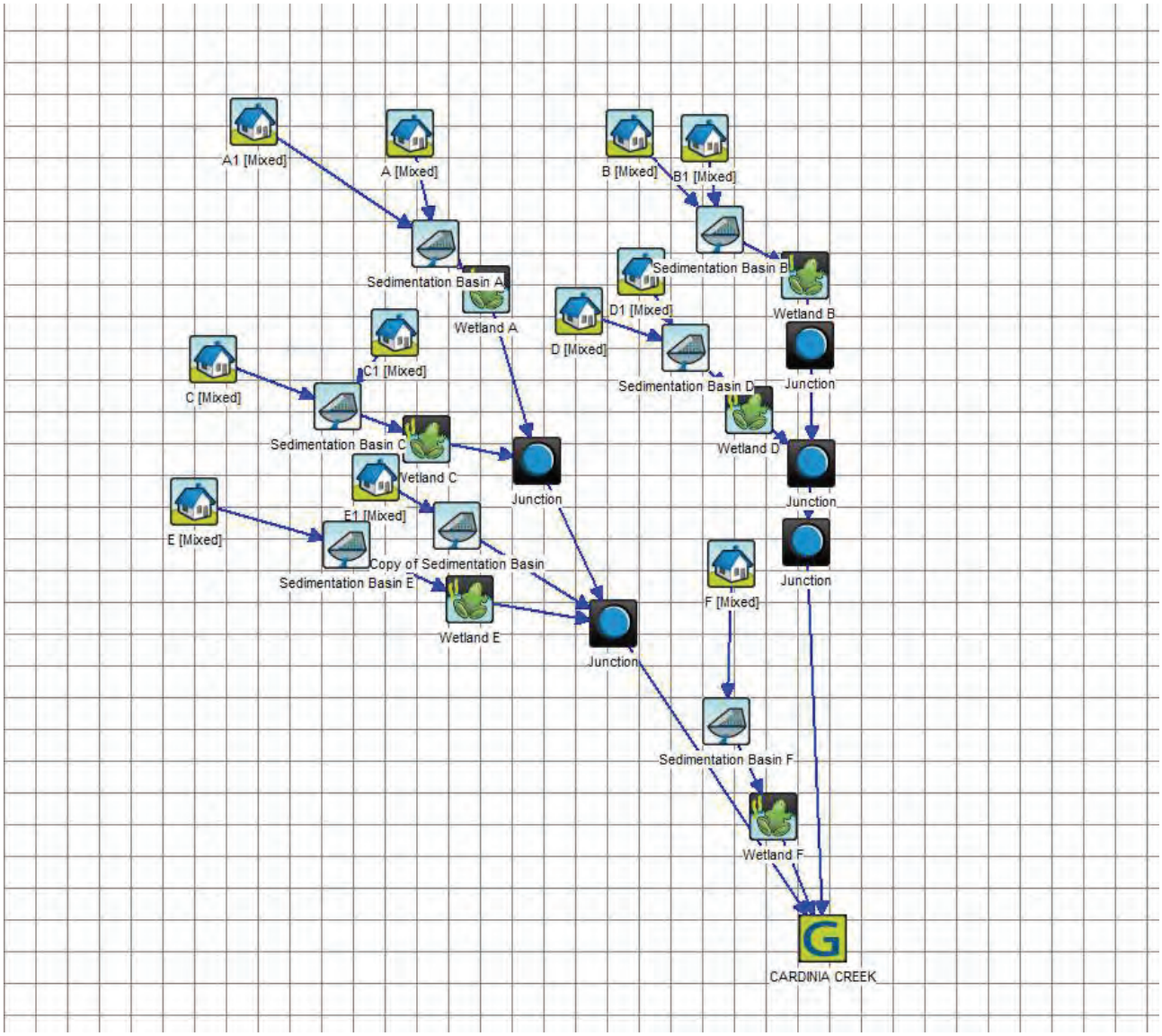
Appendix G MUSIC Models and Assumptions

This Appendix illustrates the model set up in MUSIC as shown in the below images and describes further assumptions that were adopted (that are not described in the main report). These key assumptions are:

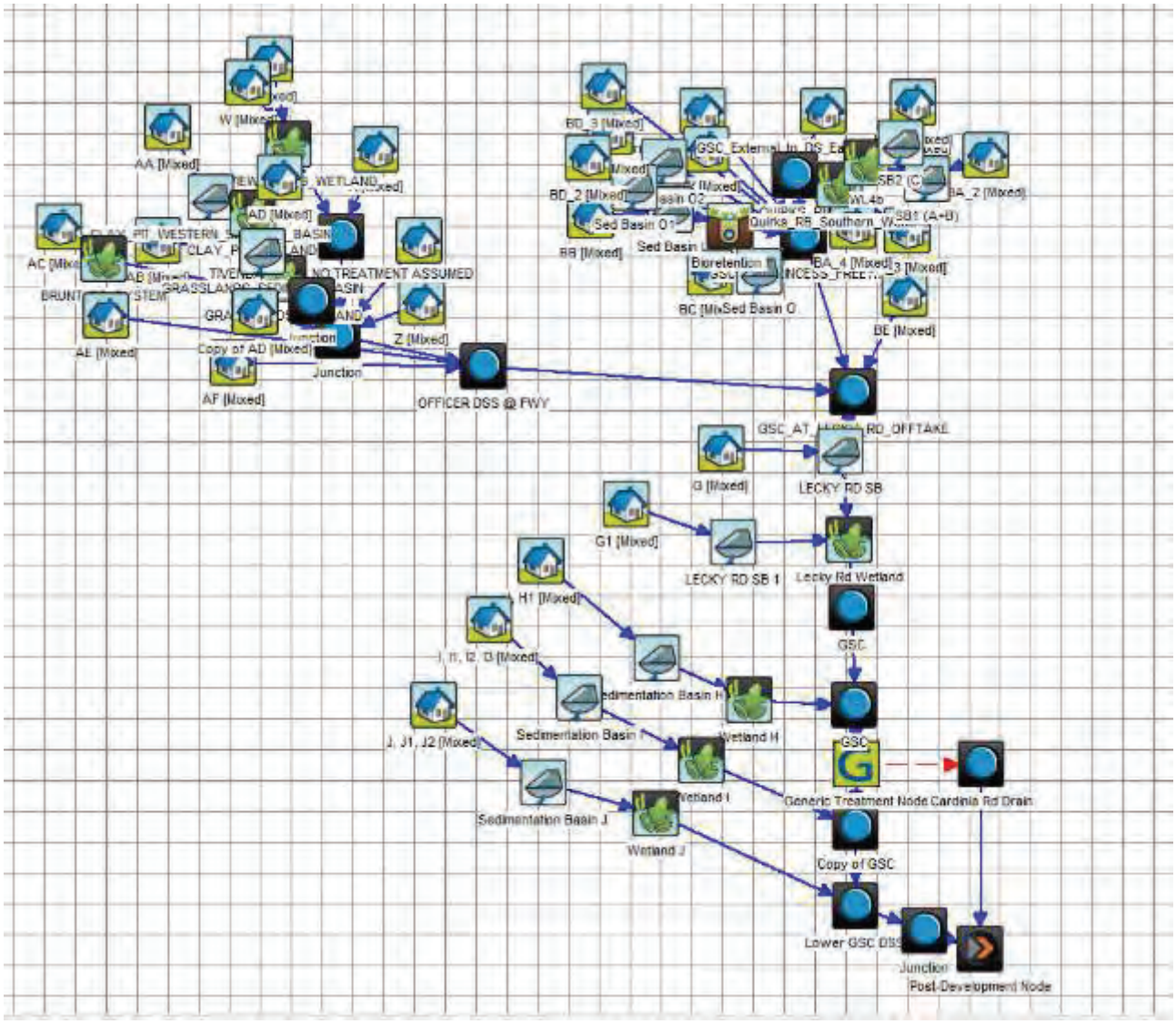
- The models created were based off SWS (2020) models and adapted for the PSP area taking into consideration the assets proposed in each option. In general, the areas upstream of the Princes Freeway were untouched from the SWS models, with the exception of the wetland ORD1, which was removed as a waterway was constructed in this location rather than a wetland. No routing was used in the MUSIC models.
- The fraction impervious values may not match exactly with the most recent Future Urban Structure Plan due to recent changes, however, the source nodes are consistent across all options and sufficient to undertake a comparative analysis. Once a preferred option is selected, the values will be updated.
- The one instance where the guidelines were not followed was in relation to the large online wetlands which are treating the large, undertreated[2] catchments. These assets are generally proposed along Gum Scrub Creek, however, also applies to Wetland F in some options (Options 2C and 3B, refer to Section 3 for full description). For these large wetlands it's proposed that the EDD is 0.15m rather than 0.35m. The rationale for the reduction in EDD is because of the large catchments – the normal water level (NWL) will be exceeded for long periods of time, which is a risk to the plants within the wetland. In addition, MWC suggested that this was a prudent approach. A summary of the MUSIC results can be found in Section 2.3 (main report).
- For the majority of the options, at least one diversion was included in the MUSIC model described as follows:
    - The most common diversion is from Gum Scrub Creek to Cardinia Road Drain where it was assumed that low medium flow of $3m^3/s$ was being transferred from the respective Creeks.
    - Two other diversions were also included in Options 2C and 3B (Refer to Section 3 for a description of Options), one representing the existing 600mm diameter pipeline from Officer South Drain to Gum Scrub Creek (northern) and the other taking flows up to $3m^3/s$ from the Officer South Drain to Gum Scrub Creek (southern). In order to accurately represent the diversions between Cardinia Creek Catchment and Gum Scrub Creek catchments in Option 2C and 3B the models were required to be combined. All the diversions were set up with a Generic Node with the flow parameters adjusted accordingly.
- It's important to note that whilst the options with diversions from Gum Scrub Creek to Toomuc Creek provide higher treatment for Gum Scrub Creek than those which don't have diversions, the overall pollutant reduction between the two options may be similar. The reason for the higher treatment along Gum Scrub Creek is due to the fact that a significant volume of water (in the order of 3GL/yr) is being diverted to the Cardinia Road Drain/Toomuc Creek catchment, and therefore removed from pollutant reduction calculations. The quality of water of the diverted runoff does not meet BPEM, , however, the intent is that it will be retreated through the online wetland systems of the Cardinia Industrial DSS, as discussed in in the main report.
- The stormwater quality treatment (SWQT) results are based on catchment wide treatment (i.e. including the catchment north of the Princes Freeway) as opposed to localised treatment. The reason is that local catchments are being treated to best practice and the key difference in the options is how well the upstream catchments are being treated.

Option 1B

Cardinia Creek Catchment (Same for all Option 1)

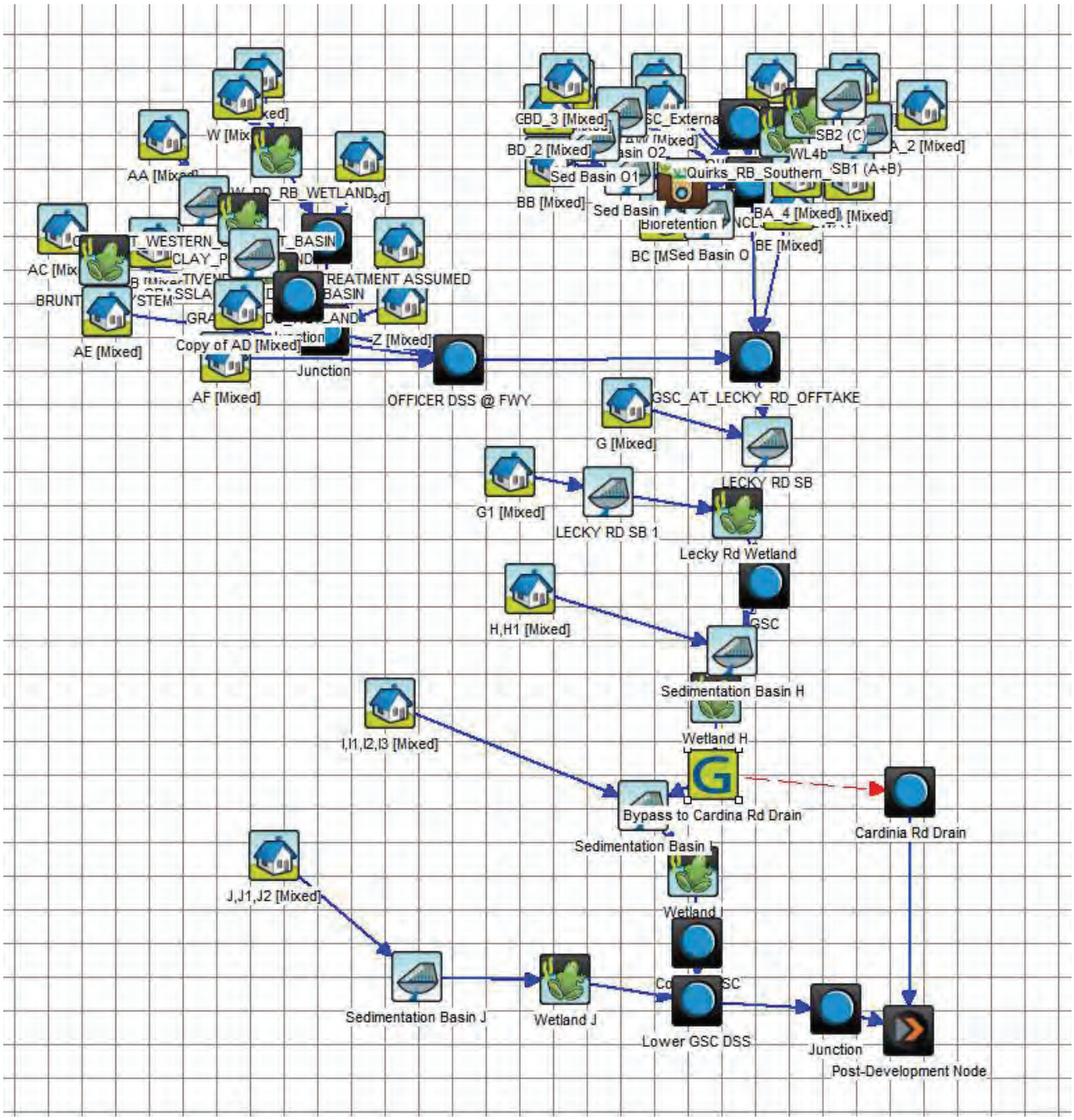


Gum Scrub Creek Catchment



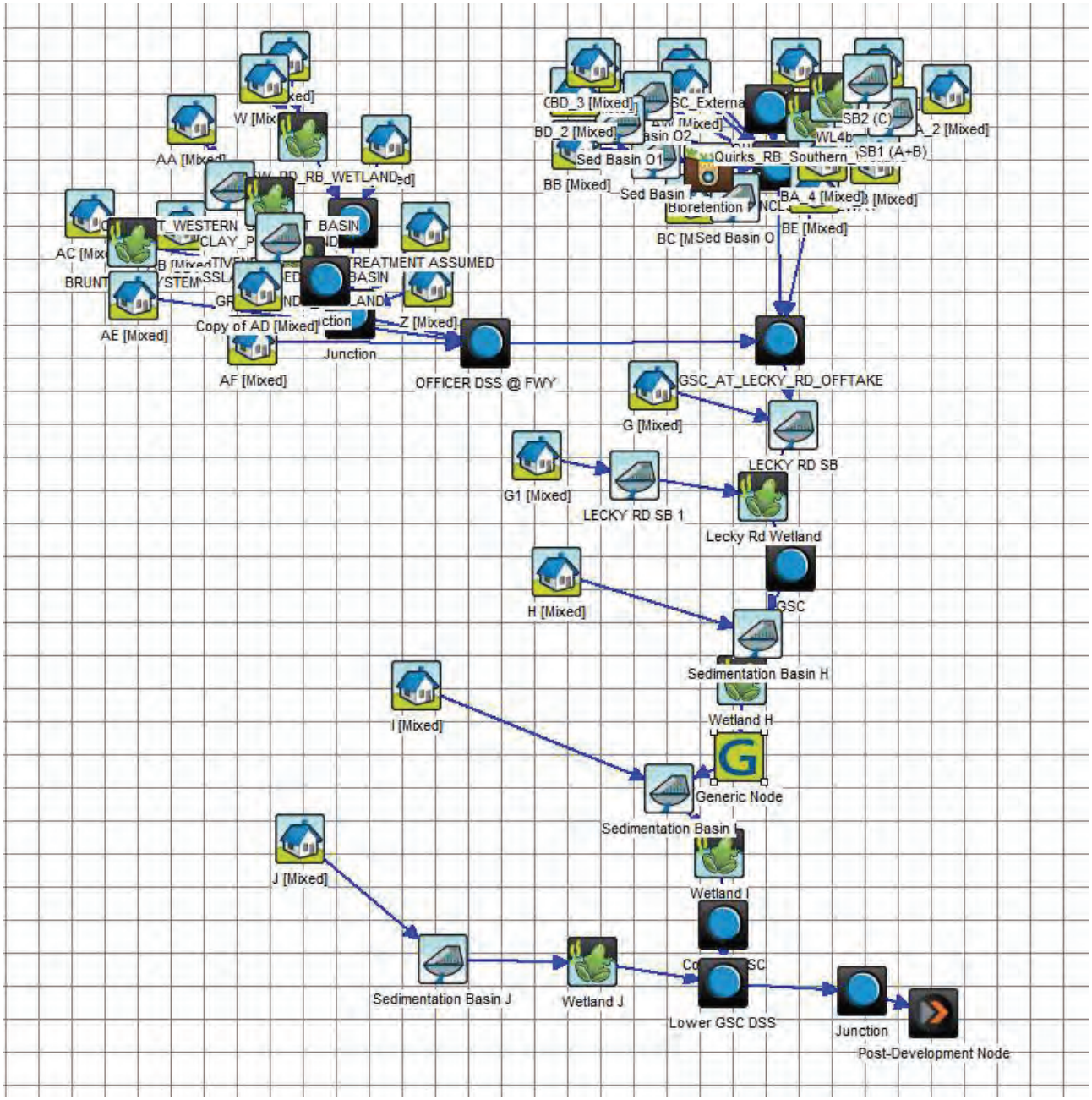
Option 1D

Gum Scrub Creek Catchment



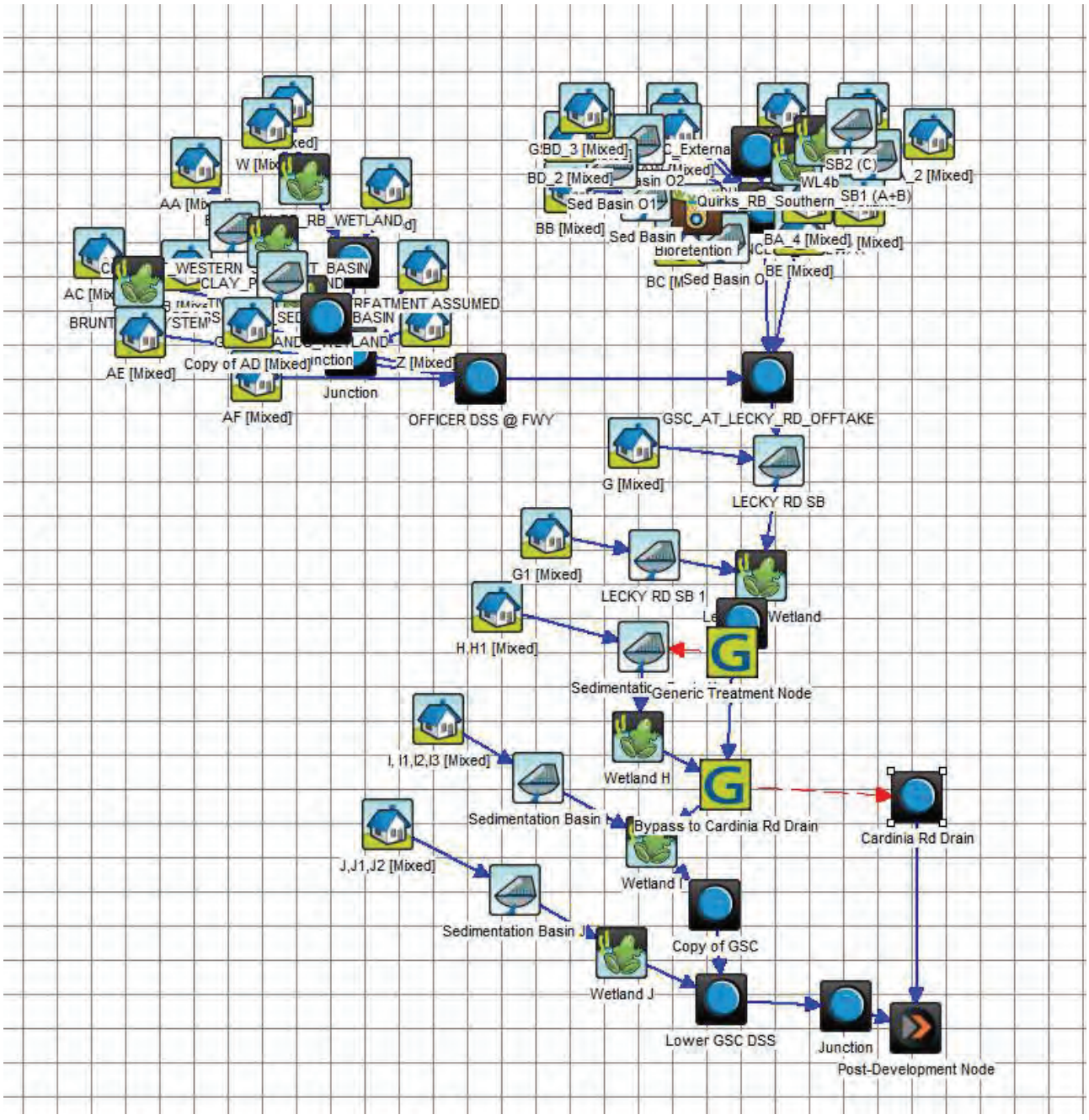
Option 1E

Gum Scrub Creek Catchment



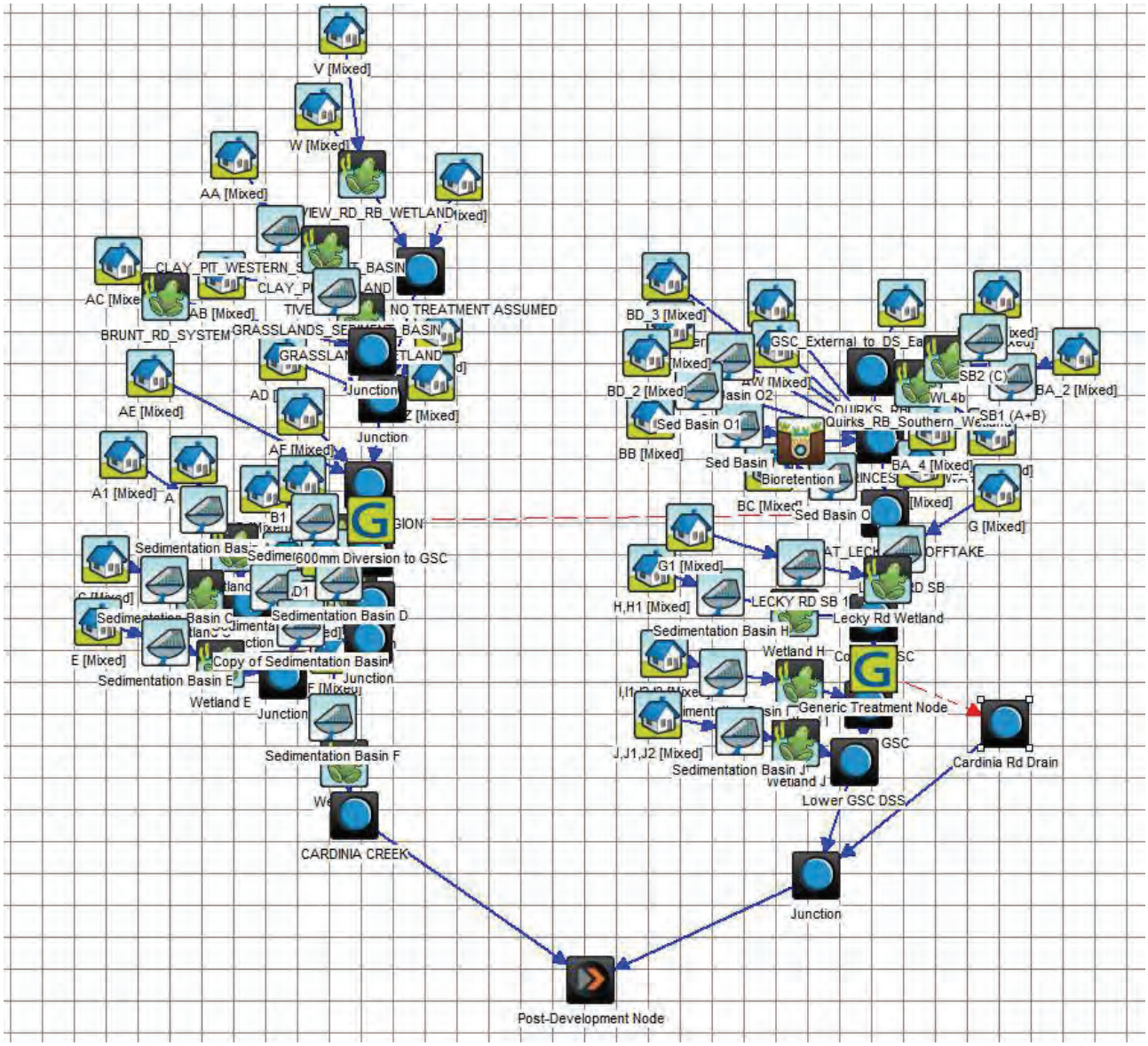
Option 1F

Gum Scrub Creek Catchment



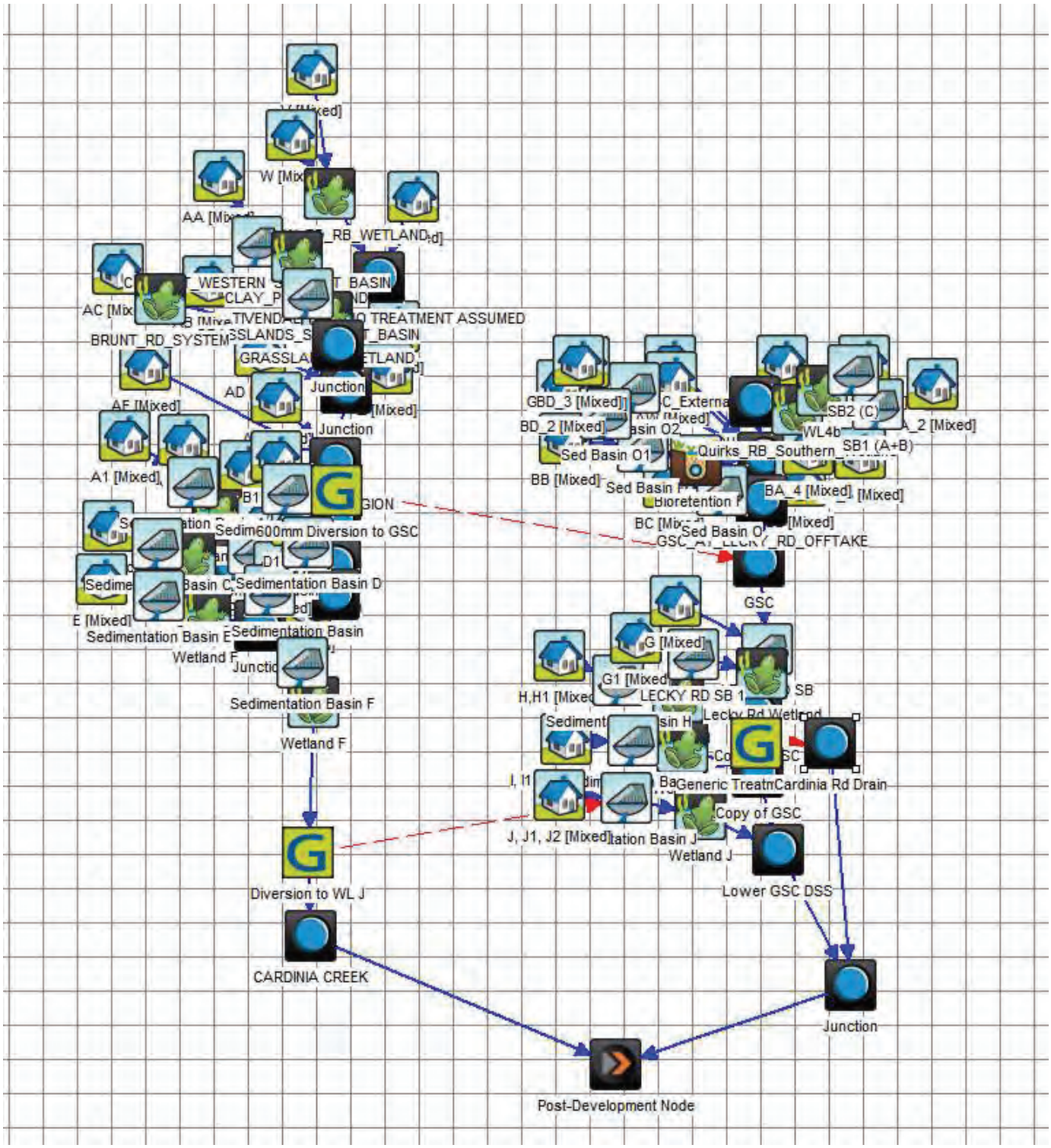
Option 2C

Cardinia Creek and Gum Scrub Creek Catchment



Option 3B

Cardinia Creek and Gum Scrub Creek Catchment



Appendix H Cost Estimates

These cost items shown below are used for the MCA assessment only and are not to be used to inform any financial assessment purposes or proposals .

Officer South DSS Options Cost Estimates:

Item	Rate	Unit	1D	1E	1F	2C	3B	1D ($M)	1E ($M)	1F ($M)	2C ($M)	3B ($M)
Wetlands (incl sediment basins)	$2,800,000	ha	50	50	53	52	52	141	141	149	145	145
Wetlands incl planting	$500,000	ha	50	50	53	52	52	25	25	27	26	26
Retarding Basins	$500,000	ha	52	52	78	57	57	26	26	39	28	28
Waterways (Small)	$2,500	m	4015	2990	2990	2822	1685	10	7	7	7	4
Waterways (Large)	$3,000	m	4881	4880	4880	7060	7060	15	15	15	21	21
Culvert Crossings (Single Barrel)	$10,000	m	40	40	40	20	20	0.4	0.4	0.4	0.2	0.2
Culvert Crossings (Multiple Barrel)	$30,000	m	0	0	0	40	40	0	0	0	1	1
Toomuc Pipe Diversion	$1,650	m	1030	0	1030	1030	1030	2	0	2	2	2
Land acquisition flood reserve	$100,000	ha	28	28	28	22	11	3	3	3	2	1
Land acquisition property reserve	$2,000,000	ha	107	107	136	102	114	213	213	271	205	228
Outfall/Levees (1 km upgrade)	$1	Item	0	0	0	2.7	2.7	0	0	0	3	3
Gas Crossing	$10,000,000	Item	0	0	0	0	0	0	0	0	0	0
Design (10%)	10	%						43	43	51	44	46
Sub-Total								**478**	**473**	**564**	**483**	**504**
Contingency (30%)	30	%						143	142	169	145	151
Total								**622**	**615**	**734**	**628**	**656**

Clarifications / Assumptions:

- No contaminated soil
- A local source of clay is available
- All top soil to be stockpiled and used on site. No disposal accounted for.
- Interim works not included
- No groundwater pumping
- No excavation in rock has been accounted for

Appendix I MCA Calculations

MCA Metrics

Metric	Scale	1D	1E	1F	2C	3B
1% AEP Peak Flows from PSP (m3/s)	4.33	50	52	47	62	67
50% AEP Peak Flows from PSP (m3/s)	0.37	6	6.4	5	7	4
Total Nitrogen Removed Cardinia (kg/yr)	-1,210	3,750	3,750	3,750	6,170	6,130
Phosphorus Removed Cardinia (kg/yr)	-423	760	760	760	1,606	1,606
Suspended Solids Removed Cardinia (kg/yr)	-184,833	428,500	428,500	428,500	983,000	983,000
Total Nitrogen Removed GSC (kg/yr)	-1,595	9,000	9,000	8,600	6,200	5,810
Phosphorus Removed GSC (kg/yr)	-420	2,230	2,400	2,230	1,344	1,390
Suspended Solids Removed GSC (kg/yr)	-262,350	1,317,000	1,414,000	1,317,000	747,700	792,300
50% AEP Flows in Cardinia Creek (m3/s)	1	2.7	2.7	2.7	3.81	1.2
Annual flows at West OSR Cardinia Crk (GL/Yr)	1	2.16	2.16	2.16	5.08	1.73
Reserve Area (ha)	-29	102	102	131	108	108
Capital Cost ($M)	112	622	615	734	628	656
Very High Retention Trees Impacted (No)	3	1	1	1	7	7
High Retention Trees Impacted (No)	27	11	11	15	65	65
Frog Habitat Impacted (ha)	9	18	18	12	9	9

MCA Raw Scores at Sub Criteria Level

Metric	Criteria	1D	1E	1F	2C	3B
1% AEP Peak Flows from PSP (m3/s)	1	0.0	-0.6	0.6	-2.9	-4.0
50% AEP Peak Flows from PSP (m3/s)	1	0.0	-1.7	3.1	-2.0	4.0
Total Nitrogen Removed Cardinia (kg/yr)	2	0.0	0.0	0.0	2.0	2.0
Phosphorus Removed Cardinia (kg/yr)	2	0.0	0.0	0.0	2.0	2.0
Suspended Solids Removed Cardinia (kg/yr)	2	0.0	0.0	0.0	3.0	3.0
Total Nitrogen Removed GSC (kg/yr)	2	0.0	0.0	-0.3	-1.8	-2.0
Phosphorus Removed GSC (kg/yr)	2	0.0	0.4	0.0	-2.1	-2.0
Suspended Solids Removed GSC (kg/yr)	2	0.0	0.4	0.0	-2.2	-2.0
50% AEP Flows in Cardinia Creek (m3/s)	3	0.0	0.0	0.0	-2.0	2.7
Annual flows at West OSR Cardinia Crk (GL/Yr)	3	0.0	0.0	0.0	-2.0	0.3
Reserve Area (ha)	4	0.0	0.0	1.0	0.2	0.2
Capital Cost ($M)	5	0.0	0.1	-1.0	-0.1	-0.3
Very High Retention Trees Impacted (No)	6	0.0	0.0	0.0	-2.0	-2.0
High Retention Trees Impacted (No)	6	0.0	0.0	-0.1	-2.0	-2.0
Frog Habitat Impacted (Ha)	6	0.0	0.0	0.7	1.0	1.0

MCA Raw Scores by Criteria

Criteria	Criteria	1D	1E	1F	2C	3B
1. Peak Flows downstream of the PSP	1	0.0	-1.1	1.8	-2.5	0.0
2. Stormwater Quality	2	0.0	0.1	0.0	0.2	0.2
3. Fish Preservation	3	0.0	0.0	0.0	-2.0	1.5
4. Liveability	4	0.0	0.0	1.0	0.2	0.2
5. Cost	5	0.0	0.1	-1.0	-0.1	-0.3
6. Environment & Heritage	6	0.0	0.0	0.3	-0.5	-0.5

Weighted MCA Scores Weighting Scenario 1 - Initial

Criteria	Weight	1D	1E	1F	2C	3B
1. Peak Flows in and downstream of the PSP?	20%	0.0	-0.2	0.4	-0.5	0.0
2. Stormwater Quality	10%	0.0	0.0	0.0	0.0	0.0
3. Fish Preservation	10%	0.0	0.0	0.0	-0.2	0.1
4. Liveability	10%	0.0	0.0	0.1	0.0	0.0
5. Cost	40%	0.0	0.0	-0.4	0.0	-0.1
6. Environment & Heritage	10%	0.0	0.0	0.0	-0.1	-0.1
Total	100%	0.0	-0.2	0.1	-0.7	0.0

Weighted MCA Scores Weighting Scenario 2 - Fish Preservation

Criteria	Weight	1D	1E	1F	2C	3B
1. Peak Flows downstream of the PSP	20%	-0.2	0.4	-0.5	0.0	-0.2
2. Stormwater Quality	10%	0.0	0.0	0.0	0.0	0.0
3. Fish Preservation	30%	0.0	0.0	-0.6	0.4	0.0
4. Liveability	10%	0.0	0.1	0.0	0.0	0.0
5. Cost	20%	0.0	-0.2	0.0	-0.1	0.0
6. Environment & Heritage	10%	0.0	0.0	-0.1	-0.1	0.0

Criteria	Weight	1D	1E	1F	2C	3B
Total	100%	-0.2	0.3	-1.1	0.4	-0.2

Weighted MCA Scores Weighting Scenario 3 – Downstream Peak Flows

Criteria	Weight	1D	1E	1F	2C	3B
1. Peak Flows downstream of the PSP	40%	0.0	-0.5	0.7	-1.0	0.0
2. Stormwater Quality	10%	0.0	0.0	0.0	0.0	0.0
3. Fish Preservation	10%	0.0	0.0	0.0	-0.2	0.1
4. Liveability	10%	0.0	0.0	0.1	0.0	0.0
5. Cost	20%	0.0	0.0	-0.2	0.0	-0.1
6. Environment & Heritage	10%	0.0	0.0	0.0	-0.1	-0.1
Total	100%	0.0	-0.4	0.7	-1.2	0.1

Weighted MCA Scores Weighting Scenario 4 – Environment & Heritage

Criteria	Weight	1D	1E	1F	2C	3B
1. Peak Flows downstream of the PSP	20%	-0.2	0.4	-0.5	0.0	-0.2
2. Stormwater Quality	10%	0.0	0.0	0.0	0.0	0.0
3. Fish Preservation	10%	0.0	0.0	-0.2	0.1	0.0
4. Liveability	10%	0.0	0.1	0.0	0.0	0.0
5. Cost	40%	0.0	-0.4	0.0	-0.1	0.0
6. Environment & Heritage	20%	0.0	0.1	-0.1	-0.1	0.0
Total	110%	-0.2	0.1	-0.8	0.0	-0.2