



West Fyans – Fyans Street Precinct Structure Plan

Drainage Report Review

City of Greater Geelong

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ACKNOWLEDGEMENT OF COUNTRY

The Board and employees of Water Technology acknowledge and respect the Aboriginal and Torres Strait Islander Peoples as the Traditional Custodians of Country throughout Australia. We specifically acknowledge the Traditional Custodians of the land on which our offices reside and where we undertake our work.

We respect the knowledge, skills and lived experiences of Aboriginal and Torres Strait Islander Peoples, who we continue to learn from and collaborate with. We also extend our respect to all First Nations Peoples, their cultures and to their Elders, past and present.



Artwork by Maurice Goolagong 2023. This piece was commissioned by Water Technology and visualises the important connections we have to water, and the cultural significance of journeys taken by traditional custodians of our land to meeting places, where communities connect with each other around waterways.

The symbolism in the artwork includes:

- Seven circles representing each of the States and Territories in Australia where we do our work
- Blue dots between each circle representing the waterways that connect us
- The animals that rely on healthy waterways for their home
- Black and white dots representing all the different communities that we visit in our work
- Hands that are for the people we help on our journey



EXECUTIVE SUMMARY

This report provides an update to the West Fyans–Fyans Street Precinct Plan originally prepared by Water Technology in 2018. The update incorporates a comprehensive review of available literature, historical studies, and previously proposed mitigation measures within the precinct. This report recognises that managing flood risk within the precinct is inherently complex, driven by a combination of legacy drainage constraints, existing infrastructure limitations, and the cumulative impacts of future redevelopment. While modelling indicates that changes in land use result in only minor increases in runoff, the existing system is already operating with capacity constraints and heightened sensitivity to climate change and intensification pressures.

This report update incorporates recent modelling developments, including draft 1% AEP SSP3 climate change extent for the Barwon River, updated South Geelong SWMS modelling for the SSP3 2100 scenario. These changed climate conditions add further stress to a catchment with legacy drainage constraints and highlight the actions needed to relieve this stress and enable future redevelopment within the precinct.

The review of 2018 reporting confirmed that the asset condition findings documented in the 2018 study remain relevant, as there is no confirmed evidence of significant maintenance or upgrades to the existing drainage infrastructure within the precinct. A review of existing stormwater infrastructure performance under climate change conditions has been undertaken, for the 20% AEP event (as simulated in the South Geelong SWMS). The results indicate that areas most vulnerable to increased flood risk under future climate conditions include Friers Reserve and Barwon Terrace.

A reassessment of both historical and potential mitigation options has been undertaken in consultation with the City. As part of this report update, the precinct has been divided into two key areas reflecting differing stormwater management approaches:

- Western sub-area (west of Latrobe Terrace): This area is constrained by broader catchment influences and requires larger-scale, end-of-line mitigation solutions. These could likely to be delivered through strategic, offset-based infrastructure schemes or large scale infrastructure upgrades to resolve current water quality and flood risks.
- Eastern sub-area: This area is better suited to localised interventions, including pit and pipe upgrades and smaller-scale water quality and detention measures. These solutions are intended to provide cost-effective improvements to system capacity while accommodating projected climate change impacts and ultimate development conditions.

A multi-scale stormwater management approach is required to facilitate redevelopment can proceed while managing both existing deficiencies in the catchment and future risk. This combines interventions at the private, street and precinct (catchment) scales.

Localised measures (e.g. on-site detention, streetscape upgrades and WSUD) are essential to support new development and manage incremental impacts, while larger, end-of-line infrastructure is required to address legacy constraints and deliver meaningful flood risk reduction at a catchment scale.

This integrated approach ensures that infrastructure investment is targeted effectively enabling development, improving system performance over time, and managing residual and climate-driven flood risks across the precinct.

The appendices to this report provide detailed documentation of both historical mitigation options and newly identified opportunities. Based on the updated analysis, a refined prioritised shortlist of recommended stormwater management measures has been developed to support future planning and investment within the precinct.

It is recommended that the City of Greater Geelong consider the findings of this report update (summarised in the table below), engage with stakeholders for advice, and incorporate relevant outcomes from the consultation phase into the final drainage report update.



The appendices to this report provide detailed documentation of both historical mitigation options and newly identified opportunities. Based on the updated analysis, a refined prioritised shortlist of recommended stormwater management measures has been developed to support future planning and investment within the precinct.

Scale	Recommendation	Benefits	Priority
Private Realm	Rainwater harvesting tanks on private properties for non-potable uses.	Water quality Volume	Medium
	On site detention tanks for flood mitigation.	Flooding	Medium
Streetscape	A range of drainage system upgrades including new, and upgrade of existing pits / pipes, and kerb / road pavement raising.	Flooding	High
	Streetscape WSUD enhancement such as passively irrigated street trees and raingardens	Water quality Volume	Medium
Precinct / Catchment	Lambert Avenue diversion and Friers Reserve flood detention	Flooding	High
	Pakington Street diversion and enhanced treatment wetlands	Flooding Water quality	Medium
	Gross pollutant treatment of existing untreated outfalls	Water quality	High
	End of line bioretention basins on untreated catchment outfalls	Water quality	Medium
	Balyang Golf Course stormwater treatment and harvesting wetlands	Water quality Volume	Medium
	Balyang Sanctuary wetland renewal	Water quality	Low

It is recommended that the City of Greater Geelong consider the findings of this report update, engage with stakeholders for advice, and incorporate relevant outcomes from the consultation phase into the final drainage report update.



GLOSSARY OF TERMS

Annual Average Damage (AAD)	Refers to estimated yearly average cost of floods, taking into account the possible damage from different sized floods, and how often they are expected to happen. AAD are calculated based on properties and dwellings shown as affected during flood events of different probability, taking into a number of factors, including flood extent, depth and response time. A number of methodologies are available to calculate AAD, such as the Rapid Appraisal Method for Floodplain Management.
Annual Exceedance Probability (AEP)	Refers to the probability or risk of a rainfall event of a given magnitude (intensity and duration) occurring or being exceeded in any given year. A 90% AEP event has a high probability of occurring or being exceeded; it would occur quite often and would be a relatively minor rainfall event. A 1% AEP event has a low probability of occurrence or being exceeded; it would be rare, but it would be likely to cause extensive damage.
Australian Height Datum (AHD)	A common national surface level datum approximately corresponding to mean sea level. Introduced in 1971 to eventually supersede all earlier datum's.
Average Recurrence Interval (ARI)	Refers to the average time interval between a given flood magnitude occurring or being exceeded. A 10-year ARI flood is expected to be exceeded on average once every 10 years. A 100 year ARI flood is expected to be exceeded on average once every 100 years. The AEP is the ARI expressed as a percentage.
Cadastre, cadastral base	Information in map or digital form showing the extent and usage of land, including streets, lot boundaries, water courses etc.
Catchment	The area draining to a site. Generally relates to a particular location and may include the catchments of tributary streams as well as the main stream.
CCTV	Closed circuit Television method used to capture the condition of the existing pit and pipe network.
Cover	The distance between the top of a pipe and the ground surface.
Design flood	A significant event to be considered in the design process; various works within the floodplain may have different design standards. A design flood will generally have a nominated AEP or ARI (see above).
Digital Elevation Model (DEM)	A generic term used to describe a collation of digital terrain models. Water Technology creates digital elevation models by manipulating and combining DTM data sets.
Digital Terrain Model (DTM)	A topographic model containing spatial elevation data of the bare earth or natural surface. The terrain is presented in a digital format that can be manipulated by computer programs. This is often used in flood analysis.
Discharge	The rate of flow of water measured in terms of volume over time. It is to be distinguished from the speed or velocity of flow, which is a measure of how fast the water is moving rather than how much is moving.
Drainage system	A series of drains and waterways into which surface and storm water flows. Features of a drainage system can include underground pipe drains, open channels, retarding basins, floodways, waterway



improvements, water quality works and environment protection measures.

Finished Flood Levels (FFL)	Refers to the height of the slab relative to a datum, generally but not always Australian Height Datum (AHD). Current planning guidelines dictates that FFL of buildings must be at least 300mm above the 1% AEP flood level.
Flash flooding	Sudden unexpected flooding caused by local heavy rainfall or rainfall in another area. Often defined as flooding which occurs within six hours of the rain which causes flooding.
Flood	Relatively high stream flow which overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or overland runoff before entering a watercourse and/or coastal inundation resulting from elevated sea levels and/or waves overtopping coastline defences.
Flood damage	The tangible and intangible costs of flooding.
Flood hazard	Potential risk to life and limb caused by flooding. Flood hazard combines the flood depth and velocity.
Flood mitigation	A series of works to prevent or reduce the impact of flooding. This includes structural options such as levees and non-structural options such as planning schemes and flood warning systems.
Floodplain	Area of land adjacent to a creek, river, estuary, lake, dam or artificial channel, which is subject to inundation by the probable maximum flood.
Flood storages	Those parts of the floodplain that are important for the temporary storage, of floodwaters during the passage of a flood.
Freeboard	A factor of safety above design flood levels typically used in relation to the setting of floor levels or crest heights of flood levees. It is usually expressed as a height above the level of the design flood event.
Geographical systems (GIS)	information A system of software and procedures designed to support the management, manipulation, analysis and display of spatially referenced data.
Hydraulics	The term given to the study of water flow in a river, channel or pipe, in particular, the evaluation of flow parameters such as stage and velocity.
Hydrograph	A graph that shows how the discharge changes with time at any particular location.
Hydrology	The term given to the study of the rainfall and runoff process as it relates to the derivation of hydrographs for given floods.
Hyetograph	A graphical representation of the distribution of rainfall over time.
Intensity frequency duration (IFD) analysis	Statistical analysis of rainfall, describing the rainfall intensity (mm/hr), frequency (probability measured by the AEP), duration (hrs). This analysis is used to generate design rainfall estimates.
LiDAR	Light Detection and Ranging, is a remote sensing method that uses light in the form of a pulsed laser to measure ranges (variable distances) to



the Earth. This is used to determine topography and elevation levels of the catchment.

MUSIC

Model for Urban Stormwater Improvement Conceptualisation – predicts the performance of stormwater **quality** management systems

Peak flow

The maximum discharge occurring during a flood event.

Probability

A statistical measure of the expected frequency or occurrence of flooding. For a fuller explanation see Average Recurrence Interval.

Risk

Chance of something happening that will have an impact. It is measured in terms of consequence and likelihood. For this study, it is the likelihood of consequences arising from the interaction of floods, communities and the environment.

RORB

A hydrological modelling tool used in this study to calculate the runoff generated for design rainfall events.

Runoff

The amount of rainfall that actually ends up as stream or pipe flow, also known as rainfall excess.

Stage

Equivalent to 'water level'. Both are measured with reference to a specified datum.

Stage hydrograph

A graph that shows how the water level changes with time. It must be referenced to a particular location and datum.

SWMP

Stormwater Management Plan

Topography

A surface which defines the ground level of a chosen area.

TUFLOW

A hydraulic modelling tool used in this study to simulate the flow of flood water through the floodplain. The model uses numerical equations to describe the water movement.

WSUD

Water sensitive urban design (WSUD) is an approach to designing our towns and cities so they are 'water sensitive', resilient, liveable and sustainable. A water sensitive city manages urban stormwater runoff to mitigate its impacts on natural waterways, wetlands and bays.



CONTENTS

1	INTRODUCTION	13
1.1	Study Area	13
1.2	Methodology	15
2	LITERATURE REVIEW AND EXISTING STUDIES	16
2.1	Bridge St / Western Gully Main Drainage Study (BMT WBM, 2008)	16
2.2	Fyans – West Fyans Precinct Structure Plan (2009)	17
2.3	City of Greater Geelong Stormwater Quality Strategy (2015)	18
2.4	Fyans – West Fyans Precinct Drainage Report (2018)	19
2.5	Catchment Management Plan (2021)	19
2.6	EPA Urban Stormwater Management Guidelines (2021)	19
2.7	In-lieu Stormwater Treatment Developer Contribution Scheme (2022)	20
2.8	CCMA Climate Change Review – Barwon and Moorabool River (2025)	21
2.9	South Geelong Stormwater Management Strategy (2026)	21
2.10	Proposed Planning Scheme Amendment (2026)	23
3	ASSET CONDITION ASSESSMENT	24
3.1	Blue Stone Kerb and Channel	26
3.2	Informal Drainage	29
3.3	Existing Drainage Capacity	29
3.4	Climate Change Drainage Impacts	35
4	HYDROLOGY AND HYDRAULIC MODELLING	38
4.1	Overview	38
4.2	Hydrologic Modelling	39
4.2.1	Existing Conditions	39
4.2.2	Climate Change Methodology Updates	42
4.2.3	Ultimate Developed Conditions	43
4.2.4	Lower Barwon and Moorabool RORB Model	45
4.3	Hydraulic Modelling	46
4.3.1	South Geelong Stormwater Model	46
4.3.2	Developed Conditions Climate Change Results	51
4.4	Floodplain Development Controls	51
5	STORMWATER QUALITY AND QUANTITY	55
5.1	Modelling	55
5.2	Water and Pollutant Balance	56
5.3	Alternative Water Demands	58
6	STORMWATER MANAGEMENT OPTIONS ASSESSMENT	60
6.1	Flood Mitigation Options	60
6.1.1	List of Historic and New Precinct Flood Mitigation Options	60



6.1.2	Lambert Avenue Diversion and Friers Reserve Detention	62
6.1.3	Fyans Street Pipe Upgrades and Barwon Terrace Road Raising	64
6.1.4	Fyans Street Kerb Raising	65
6.1.5	Pakington Street Outfall	66
6.2	Water Quality Treatment Options	67
6.2.1	List of Historic and New Water Quality Treatment Options	67
6.2.2	Primary treatment of existing Barwon River outfalls via new Gross Pollutant Traps	70
6.2.3	Pakington Street Diversion Pipe and Wetlands	70
6.2.4	Latrobe Boulevard WSUD Enhancement	73
6.2.5	Streetscape Raingardens and Bioretention	75
6.3	Summary of Options	76
	RECOMMENDATIONS	78
7	78	
7.1	Private Realm	78
7.2	Street Scale	79
7.3	Precinct Scale	79
7.4	Summary	82
8	REFERENCES	84

APPENDICES

Appendix A	Bridge Street And Main Drain Pipe Upgrades
Appendix B	Lambert Avenue Diversion and Friers Reserve Detention
Appendix C	Updates to the Special Building Overlay (SBO)
Appendix D	Shortlisted
Appendix E	Fyans Street Pipe Upgrades and Barwon Terrace Road Raising
Appendix F	Flooded Road Closure Sign
Appendix G	Fyans Street Kerb Raising
Appendix H	Ongoing Pipe Maintenance
Appendix I	West Fyans Street Mixed Use Rezoned area
Appendix J	WSUD Enhancement Opportunities
Appendix K	Primary treatment of existing Barwon River outfalls via new Gross Pollutant Traps
Appendix L	Balyang Golf Course Stormwater Treatment and Harvesting Scheme
Appendix M	Pakington Street Diversion Pipe and Constructed Wetlands

LIST OF FIGURES

Figure 1.1	Fyans-West Fyans Street Precinct study area	13
Figure 1.2	Land tenure within Fyans-West Fyans Precinct	14
Figure 2.1	West Fyans-Fyans Precinct proposed rezoning	23
Figure 3.1	Eastern study area (Moorabool Street - Swanston Street) SER grading	24
Figure 3.2	Western study area (Shannon Avenue - Moorabool Street) SER grading	25
Figure 3.3	Eastern study area (Moorabool Street - Swanston Street) STR grading	25



Figure 3.4	Western study area (Shannon Avenue - Moorabool Street) STR grading	26
Figure 3.5	CCTV photographs showing defects on the Latrobe Boulevard alignment	26
Figure 3.6	Open drain locations west (top) & east (bottom)	27
Figure 3.7	Blue stone open drains on Bellerine St 2018 (during a storm event), Right: outflanked area that is becoming undermined	28
Figure 3.8	Blue stone open drain on Bellerine St in 2020 and further eroding after a storm in March 2025	28
Figure 3.9	20% AEP pipe capacity	31
Figure 3.10	20% AEP percent of time pipe is full	32
Figure 3.11	1% AEP pipe capacity	33
Figure 3.12	1% AEP percent of time pipe is full	34
Figure 3.13	20% AEP new pits surcharging under climate change	36
Figure 3.14	20% AEP new pipes surcharging under climate change	37
Figure 4.1	Model schematisation	40
Figure 4.2	South Geelong RORB existing model fraction impervious	41
Figure 4.3	1% AEP IFD comparison	43
Figure 4.4	South Geelong RORB ultimate developed model fraction impervious	44
Figure 4.5	South Geelong flood model setup	48
Figure 4.6	South Geelong stormwater model existing land use	49
Figure 4.7	South Geelong stormwater model ultimate developed land use	50
Figure 4.8	Existing vs ultimate developed 1% AEP SSP3 2100 water level difference	52
Figure 4.9	Ultimate developed scenario stormwater flood depth 1% AEP SSP3 2100	53
Figure 4.10	Barwon River flood depth plot 1% AEP SSP3 2100	54
Figure 5.1	MUSIC model – catchments (existing planning zone conditions)	56
Figure 5.2	Stormwater runoff volume (ML/yr) generated in the West Fyans Precinct for pre-development, existing and proposed conditions	57
Figure 5.3	Stormwater pollutant volumes (kg/yr) produced in the West Fyans Precinct for pre-development, existing and proposed conditions. TSS volume on secondary axis.	58
Figure 5.4	Opportunities for alternative water reuse (open space irrigation) within and adjacent to the precinct	59
Figure 6.1	Friers Reserve pipe upgrades	63
Figure 6.2	Friers Reserve detention and Lambert Street diversion pipe flood level difference plot	63
Figure 6.3	Fyans Street pipe upgrades and Barwon Terrace road raising	64
Figure 6.4	Fyans Street pipe augmentation and Barwon Terrace road raising flood depth difference plot	65
Figure 6.5	West Fyans-Fyans Street kerb raising locations	66
Figure 6.6	Mitigation Option 1 (Pakington Street diversion pipe) flood level difference plot	67
Figure 6.7	Proposed GPT locations	70
Figure 6.8	Pakington Street diversion pipe and constructed wetlands concept	72
Figure 6.9	WSUD enhancement of Latrobe Boulevard: potential streetscape raingarden catchments and WSUD asset locations	74
Figure 6.10	Streetscape raingarden (sourced from WSUD Engineering Procedures: Stormwater, Melbourne Water)	76
Figure 6.11	Overview of options assessed for the Fyans – West Fyans Precinct	77
Figure 7.1	Summary of recommended stormwater management options at various scales	78
Figure 7.2	West Fyans Street (west) precinct recommended stormwater opportunities	80
Figure 7.3	Fyans Street (east) precinct recommended stormwater opportunities	81



Figure B-2	Mitigation Option 2 Lambert Street diversion mitigation flood level difference plot	6
Figure E-1	Fyans Street Pipe Upgrades and Barwon Terrace Road raising	16
Figure E-2	Fyans Street pipe augmentation and Barwon Terrace Road raising flood depth difference plot	17
Figure 8-1	West Fyans-Fyans Street kerb raising locations	24
Figure A10-4	Streetscape Raingarden (sourced from WSUD Engineering Procedures: Stormwater, Melbourne Water	42
Figure J-4	WSUD enhancement of Latrobe Boulevard: potential streetscape raingarden catchments and WSUD asset locations	47
Figure A1.1	Proposed GPT locations	114
Figure A1.2	Location of ponds on the Balyang Par 3 Golf Course	117
Figure A1.3	Proposed constructed wetlands and stormwater harvesting concept	119
Figure A1.1	Mitigation Option 1 (Pakington Street Diversion Pipe) flood level difference plot	124
Figure A1.2	Pakington Street diversion pipe and constructed wetlands concept	126

LIST OF APPENDIX FIGURES

Figure A-1	Reduction in flooded properties – Bridge Street Main Drain Study Scheme 3
Figure A-2	Bridge Street Main Drain preferred mitigation scheme (Scheme 3)
Figure A-3	Flood damages assessment – Bridge Street Main Drain Study Scheme 3
Figure A-4	Change in 1% AEP peak flood height Bridge Street Main Drain Preferred Mitigation Scheme
Figure B-1	Mitigation option alignments modelled
Figure B-3	Friers Reserve pipe upgrades
Figure B-4	Friers Reserve Detention and Lambert Street Diversion pipe flood level difference plot
Figure B-5	Climate Change Adapted Friers Reserve Detention and Lambert Street Diversion Pipe flood level difference plot
Figure C-1	Current and proposed Special Building Overlay (SBO)
Figure C-2	Current and proposed Special Building Overlay (SBO) filtered depth comparison
Figure C-3	Proposed SBO 1% AEP 2030
Figure C-4	Proposed SBO 1% AEP 2100
Figure D-1	Alternative Riversdale Road diversion
Figure D-2	Hampton Street diversion
Figure E-3	Fyans Street pipe augmentation, Barwon River outfall Upgrades and Barwon Terrace Road raising flood depth difference plot
Figure F-1	Barwon Terrace flooded road closure sign
Figure J-1	LaTrobe Boulevard WSUD opportunities
Figure J-2	Example of a passively irrigated street tree showing at-surface water storage and underlying soil volume
Figure J-3	MUSIC model setup
Figure J-5	Model schematic for streetscape raingardens to meet BPEM for local catchment

LIST OF TABLES

Table 2-1	BCR for Bridge Street mitigation schemes (BMT WBM, 2008)	17
Table 4-1	Hydrology model summary	39
Table 4-2	Design initial and continuing losses for climate change events	42



Table 4-3	Key Subarea Fraction Impervious values	44
Table 4-4	Change in peak flow rates for 1% AEP SSP3 2100 events (without additional storage)	45
Table 4-5	Change in flow volumes generated for 1% AEP critical events	45
Table 4-6	Key TUFLOW parameters	46
Table 5-1	Pollutant Mean Annual Loads estimated with MUSIC for pre-development, existing and proposed development scenarios	57
Table 5-2	Long term stormwater volume and pollutant reduction targets for the Fyans – West Fyans Precinct	58
Table 6-1	Structural flood mitigation options	61
Table 6-2	Water quality treatment and flow volume reduction options	67
Table 6-3	WSUD elements nominated for Latrobe Boulevard	73
Table 7-1	Summary of recommendations	82
Table 8-1	Prioritised List of Kerb Raising	24
Table 8-2	Outfall treatment prioritisation for Fyans-West Fyans Precinct	113
Table 8-3	Balyang Golf Course concept design summary	122
Table 8-4	Balyang Golf Course concept design summary	127

LIST OF APPENDIX TABLES

Table J-1	WSUD elements nominated for Latrobe Boulevard	
Table J-2	Design considerations for an example council preferred design response	
Table J-3	Typical tree pit designs	
Table J-4	Design considerations and preferred design responses	
Table J-5	Performance of 750m ² of bioretention basins in Barwon River corridor	

1 INTRODUCTION

1.1 Study Area

The Fyans-West Fyans Precinct study area is located in South Geelong, bounded by the Barwon River to the South, Shannon Avenue to the West, Swanston Street to the East and West Fyans and Fyans Street to the North (Figure 1.1). The upper part of the precinct consists largely of residential and commercial. Whilst, the lower portion of the study area which sits close to the Barwon River is predominantly mixed use, namely commercial, industrial, residential and recreational.

The study area was subject to a Precinct Structure Plan in 2009, which resulted in the approval of Amendment C205 to the City of Greater Geelong Planning Scheme in 2011. The amendment is intended to be implemented in 2 stages. The majority of the precinct (Stage 1) has been rezoned to Mixed Use Zone, with a smaller portion zoned Commercial 2 Zone. Stage 2 comprises the western half of the precinct.

The study area has a diverse history of land use including residential, industrial, commercial, landfill and recreation. Consequently, a number of legacy constraints are present, particularly in relation to contaminated land and land fill sites distributed across the precinct.



Figure 1.1 Fyans-West Fyans Street Precinct study area

A substantial portion of the study area comprises crown land under the management of multiple public agencies, as illustrated in Figure 1.2. The Corangamite Catchment Management Authority (CCMA) is responsible for managing a large portion of the Barwon River floodplain and the southern boundary of the study area, in accordance with the Barwon through Geelong Management Plan (Thompson Berrill Landscape Design Pty Ltd and Ecology Partners P/L, 2007).

The management of the waterway and riparian corridor of the Barwon River by public agencies presents key opportunities for recreation, amenity, connectivity and water quality treatment outcome within the study area. These opportunities are explored further throughout this report.



Figure 1.2 Land tenure within Fyans-West Fyans Precinct



1.2 Methodology

This report provides an update to the West Fyans Precinct Structure Plan that reflect the current climate change guidance and associated regulatory expectations. It also assesses the implications of climate change on current stormwater management infrastructure and identifies appropriate mitigation measures and adaptation strategies.

Existing conditions relating to drainage infrastructure, flooding behaviour and stormwater quantity and quality have been reviewed, drawing on Water Technology's involvement in the most recent Stormwater Management Strategy for South Geelong. Previous studies have identified opportunities to enhance amenity and address drainage constraints, and have recommended further investigation within the precinct, as well as potential funding pathways to support the implementation of WSUD initiatives and drainage upgrades.

The project has been undertaken in a staged manner, comprising

- Literature review and consolidation of existing studies
- Hydrological and hydraulic assessment of design scenarios
- Stormwater quality assessment of design scenarios
- Stormwater volume management and reduction assessment of design scenarios

This report outlines the relevant background, describes existing drainage conditions, presents the outcomes of the investigations, and provides recommendations for future implementation.



2 LITERATURE REVIEW AND EXISTING STUDIES

A number of previous study reports have been prepared within the study area. This section summarises those reports applicable to the current drainage study review and provides comment on any relevant changes since the reports publication. A summary of relevant historic reports include:

- Bridge Street / Western Gully Main Drain Study (BMT WBM, 2008)
- Fyans – West Fyans Precinct Structure Plan (2009),
- City of Greater Geelong Stormwater Quality Strategy (2015),
- Fyans – West Fyans Precinct Drainage Report (2018),
- City of Greater Geelong Catchment Management Plan (2021),
- In-lieu Stormwater Treatment Developer Contribution Scheme (Offset Scheme) (2022)
- CCMA Climate Change Review – Barwon and Moorabool River (2025), and
- South Geelong Stormwater Management Strategy (2026).

2.1 Bridge St / Western Gully Main Drainage Study (BMT WBM, 2008)

This flood mapping study, carried out in 2008 (BMT WMB, 2008), covered much of the western end of the current project study area (west of Latrobe Terrace). The study formed the basis for the Special Building Overlay (SBO) planning layers within the City of Greater Geelong (City) planning scheme.. The study also covered the Western Gully Main Drain which flows north east to Corio Bay and is not part of the current study area. The key objectives of the study were:

- Define and map existing flooding characteristics and system deficiencies within the two catchments,
- Assess the nature and magnitude of tangible and intangible impacts associated with existing flooding impacts,
- Identify potential mitigation strategies to reduce damages associated with flooding impacts, and
- Evaluate and identify opportunities of funding capital and maintenance works associated with the recommendations of the study.

The flood modelling was undertaken using a rainfall-on-grid methodology which was a relatively new concept at the time and was benchmarked against a traditional hydrologic modelling approach (using XP-RAFTS). Flood maps were produced for a suite of design rainfall events with flood levels determined for the 1%, 5% and 20% AEP design floods. The results indicated 20 properties were likely to be flooded above floor level within the Bridge Street catchment for the 1% AEP design flood, 14 properties in a 5% AEP design flood and 8 properties in a 20% AEP design flood. The 1% AEP design flood mapping was filtered (depths below 3 cm were removed) and the extents were used to update the planning scheme and form the basis of the current Special Building Overlay (SBO).

Three mitigation scheme concepts for the Bridge Street Catchment were assessed as part of the study alongside a “do nothing” option, as described below:

Mitigation Scheme 1 - A new trunk drainage pipe extending from Pakington Street, along West Fyans Street, continuing under Frier Reserve and along Lambert Avenue, passing under the industrial estate to Bridge Street, and subsequently under Riversdale Road. This network is also to be supplemented by a series of new feeder pipes.

Mitigation Scheme 2 – This options is consistent with Scheme 1, with the exception that the main trunk pipeline extends along Lambert Avenue (rather than traversing beneath the industrial estate to Bridge Street



as per Scheme 1) continuing under Riversdale Road before discharging to the existing open channel. An extended feeder pipe along Fairview Avenue is also included.

Mitigation Scheme 3 - New Pipe along West Fyans Street, beneath Frier Reserve, along Lambert Avenue to Riversdale Road, discharging to the downstream existing open channel.

Results indicated that Scheme 1 is able to reduce the number of properties flooded above floor by 9, Scheme 2 by 9 and Scheme 3 also by 9 properties. Based on the flood damages assessment undertaken for the three mitigation schemes, the results were compared using a Benefit-Cost-Ratio (BCR) to evaluate the relative economic performance of each option. The three options yielded relatively low BCR values due largely to the significant capital costs for the pipe upgrades (Table 2-1).

Other factors assessed included the relatively low environmental impact associated with the already disturbed nature of the site, minor disruptions to local roads and public amenities during construction and the difficulties of the construction including steep grades and the land fill site along the proposed alignment.

Mitigation Scheme 3 was recommended as the preferred option with the report indicating that implantation of both the Bridge Street and Western Gully Main Drain works could be carried out over 13 years by increasing council funding for drainage works to pay for the public benefit.

Table 2-1 BCR for Bridge Street mitigation schemes (BMT WBM, 2008)

	Existing	Scheme 1	Scheme 2	Scheme 3
Damages (Per Annum)	\$ 147,000	\$ 81,000	\$ 79,000	\$ 91,000
Benefit (Per Annum)		\$ 66,000	\$ 68,000	\$ 56,000
Benefit (Net Present Value)		\$ 819,000	\$ 844,000	\$ 695,000
Capital Cost		\$ 2,739,000	\$ 2,434,000	\$ 1,611,000
Maintenance (Per Annum)		\$ 66,000	\$ 58,000	\$ 39,000
Maintenance (Net Present Value)		\$ 899,000	\$ 755,000	\$ 493,000
Total Option Cost		\$ 3,638,000	\$3,189,000	\$ 2,104,000
BCR		0.23	0.26	0.33

2.2 Fyans – West Fyans Precinct Structure Plan (2009)

In 2009 the City of Greater Geelong adopted a study undertaken by Coomes Consulting Group for a precinct structure plan for the West Fyans/Fyans Street area. The structure plan had four key outcomes:

- *Identify key strategic planning issues for the study area,*
- *Determine the preferred future planning directions,*



- *Identify appropriate planning controls and amendments to the Greater Geelong Planning Scheme to achieve the preferred vision,*
- *Provide an implementation plan identifying infrastructure works required to achieve the preferred vision.*

The study assessed the key influences at the time, which identified a transition from the current land use towards a mix of land uses which was reflected in the changes to zoning of land through a planning scheme amendment within the study area in 2009. The amendment to the planning scheme to “mixed use” encourages consolidation of residential housing through alternative measures, as well as a mix of commercial and activity centre opportunities within the study area. The amendment does not encourage the growth of industrial activities over the long term, but recognises the existing industrial activities within the study area through the application of the planning scheme amendment in two stages, with exclusion of rezoning of land west of Hampton Street and south of Riversdale Road.

The report also provided an emphasis on the constraints to development including flooding and drainage, infrastructure services, transport and maintaining areas of open space. The use of a “precinct-based land use directions” approach to the structure plan allows for relevant objectives and outcomes to be applied based on the characteristics of each precinct.

Sections of the report relevant to the current study, particularly in relation to drainage include;

- Urban Growth (infill development and managing intensification of residential areas),
- Infrastructure (infrastructure servicing report),
- Environment and Landscape (riverscape and Barwon River interface),
- Urban Design (stormwater attenuation and treatment).

Since this report was undertaken in 2009, there had been a significant shift in the land use within the study area. Much of this included the development of commercial operations within the Pakington Street Activity area at the western end of the study area. An increase in fitness businesses (gyms, fitness and wellbeing centres, rock climbing), growth in participation at the YMCA centre on Riversdale Road, studio and office space and cafes has increased the traffic rates through the area as well as highlighting the need for the management of overland flow paths through the study area. Another significant change between 2009 to 2018 was the increase in new and used car storage within the Study area. City of Greater Geelong identified a large increase in this land use and the acquisition of residential land for these purposes. The accumulation of residential parcels within the study area offers greater opportunities for stormwater management at a lot scale compared with individual allotments where space and streetscape limitations lend stormwater management towards an end-of-line treatment option.

2.3 City of Greater Geelong Stormwater Quality Strategy (2015)

The Stormwater Quality Strategy (Browne, Roberts, Markwell, & Breen, 2015) outlines the process to ensure stormwater runoff from new developments is treated to best practice standards under the SEPP and *Best Practice Environmental Management Guidelines* (1999). The work involved strategy steps through opportunities and constraints for the implementation of different WSUD and stormwater quality measures. It provided a timeframe for council to work towards meeting water quality measures. The strategy provides key definitions and sets out processes and targets for improved stormwater quality management, including:

- the objectives of implementing WSUD within the municipality and the targets to be met;
- clarification of the waterway values and identification of stormwater threats across the municipality;
- identification of opportunities to mitigate such threats through stormwater management investments, with a focus on high risk catchments;
- understanding of the current WSUD asset management framework and WSUD asset portfolio;



- understanding of growth impacts on Council's WSUD asset portfolio; and,
- identification of opportunities and development of an implementation plan to better manage WSUD assets and include future WSUD capital and operating expenditure within the broader asset management and financial systems.

2.4 Fyans – West Fyans Precinct Drainage Report (2018)

The West Fyans Precinct Drainage Report (Water Technology, 2018) detailed a drainage investigation undertaken to support an update to the West Fyans Precinct Structure Plan developed in 2009. The report documents the technical analyses completed by Water Technology and includes an assessment of potential stormwater quality treatment measures.

A review of the current planning scheme including Design and Development Overlay – Schedule 26 (DDO26) which covers the precinct and previous drainage studies was also undertaken. No changes to the current SBO were recommended at the time, minor changes to the LSIO and FO along the Barwon River were deemed likely to occur following the completion of the Lower Barwon River Flood Study, which was subsequently completed in 2019.

The report provided recommendations on drainage infrastructure upgrades, funding models for the implementation of end-of-line and at-site water quality treatment options and any land acquisition that was required. A workshop was carried out at council offices on February 22, 2018 to inform the recommendations in the final report. A summary table of the drainage projects recommended is presented in with CPI adjusted costing. Where practicable, it was recommended that future works associated with redevelopment be designed to deliver multiple benefits for the precinct including enhancing recreation and open space, traffic connectivity, improved amenity and streetscape.

2.5 Catchment Management Plan (2021)

The Catchment Management Plan (City of Greater Geelong, 2021) is the City of Greater Geelong's overarching plan to manage stormwater impacts on receiving waterways across the municipality. The Plan splits the municipality into catchment management units (CMU's) and provides a context specific overview of key opportunities and risks affecting the CMU. Each CMU is assigned a priority and specific recommendations to improve respective waterways.

The Fyans – West Fyans precinct is located within the South Geelong CMU and is assigned high overall priority. Very high waterway values are identified for the catchment including cultural, biodiversity, social and economic significance. Significant values of downstream receiving environments are also recognised including reaches of the Barwon River and Lake Connewarre. Key threats include gully erosion, industrial land uses, high imperviousness and acid sulphate soils. The overall risk score is by far the highest in the Greater Geelong catchment.

High pollutant loads are generated by the catchment that threaten water quality in the waterways and receiving environments. Significant retrofit of water quality improvement infrastructure is required to achieve best practice pollutant removal and will contribute to improve water quality in the Barwon River.

The Catchment Management Plan highlights the importance of improving water quality and protecting values in the South Geelong CMU. The plan is explicit in identifying catchments, such as South Geelong, which should be prioritised for improved treatment due to the level of risk associated with those catchments.

2.6 EPA Urban Stormwater Management Guidelines (2021)

The Victorian Environment Protection Authority's Urban Stormwater Management Guidelines, Publication 1739.1 (EPA, 2021) sets out urban stormwater performance objectives for flow volume reduction. These



objectives are dependent on a classification of specific waterway priority and are dependent on what is considered reasonably practicable¹. The flow objectives are comprised of two components:

- Harvesting/ evapotranspiration (expressed as a percentage of mean annual impervious runoff) and
- Infiltration/ filtering. (expressed as a percentage of mean annual impervious runoff)

The EPA defines the infiltration and filtering as:

Runoff from impervious surfaces that soaks into the ground (infiltrates) or is slowly (mimics the infiltration rates of the surrounding soil) released to the drainage system from a stormwater management system (filter).

In 2026, various Victorian Planning Provisions were amended (via Amendment VC365) to update references to Best Practice Environmental Management Guidelines (Victoria Stormwater Committee, 1999) to the EPA Guidance. This change provides local governments across the state with a mechanism to mandate consideration of stormwater volumes in development applications with respect to developer obligations under the General Environmental Duty (GED).

Following the release of the EPA Guidance, EPA Victoria has worked together with government agencies throughout Victoria to establish major waterways' priority status that is aligned and reflects current scientific and industry knowledge. City of Geelong has advised that the Barwon River has been identified as a *priority* waterway and as such, the following stormwater volume reduction targets are applicable to all new developments and redevelopment areas within the South Geelong catchment, including the Fyan-West Fyan precinct:

- **Harvesting / evapotranspiration: 75% reduction**
- **Infiltration / filtering: 6% reduction**

2.7 In-lieu Stormwater Treatment Developer Contribution Scheme (2022)

A feasibility study (Marsden Jacob Associates, 2022) was undertaken to develop a low-risk voluntary contribution mechanism to fund precinct scale water sensitive urban design (WSUD) projects in City of Greater Geelong. The voluntary contribution mechanism aims to assist developers to meet their stormwater compliance obligations, and City of Greater Geelong to improve the quality of their stormwater runoff.

For many developers, achieving full compliance with Planning Scheme requirements (such as Clause 53.18) is overly difficult and/or expensive, and may result in less beneficial asset mix. More environmentally, socially, and economically beneficial outcomes may be achieved by considering off-site capital works, with the developer contributing financially towards these public assets to meet their 'Best Practice' stormwater treatment obligations on their development.

The purpose for the stormwater quality WSUD voluntary contribution mechanism (also known as a *Stormwater Quality Offset Scheme*) is to provide an alternative pathway for development to meet stormwater management obligations under Clause 53.18. The proposed mechanism:

- provides flexibility for new developments to meet stormwater treatment obligations, where on-site treatment to meet best practice standards would be impractical or cost prohibitive.
- achieves planning requirements (such as Clause 53.18) at an equivalent or lower cost than on-site works.
- better facilitates appropriate WSUD asset management by Council to increase the likelihood of long-term WSUD asset function.

¹ <https://www.epa.vic.gov.au/about-epa/laws/new-laws/what-is-reasonably-practicable>



- provides Council the opportunity to raise revenue from one or more sources towards the costs of providing precinct-scale WSUD projects.
- is flexible so that the mechanism can respond to changes in policy and market conditions.
- is practical to estimate, simple to implement, minimises green tape, and is fair and transparent for Council, developers and the community.

The mechanism is available to all developers required to ensure their development complies with on-site WSUD requirements under Clause 53.18. Council retains the right to reject applications and require developers to achieve full compliance on site. The contribution mechanism is a voluntary 'opt-in' mechanism. This means developers can elect to either comply with Council's stormwater management requirements fully through on-site works, or they can contribute to Council's WSUD voluntary contribution mechanism in-lieu of a proportion of on-site works, including up to 100% contribution.

The proposed in-lieu fee is determined by considering the cost of building and maintaining a proposed program of works and the cost of delivering on-site works to meet Clause 53.18 requirements (willingness-to-pay). The recommended offset charge is calculated using the formula below:

$$\text{In-lieu fee \$} = 65 \times A_i \times S\%$$

Where A_i = total development impervious area in square metres, $S\%$ = the percentage obligation to be offset through the in-lieu scheme.

Implementation of the In-lieu Stormwater Treatment Developer Contribution Scheme presents an opportunity for the City to collect contributions from developers within the Fyans – West Fyans (and other) precincts to fund significant projects that improve stormwater quality in the Barwon River. This mechanism is particularly suitable for developments with limited options for meeting stormwater treatment planning requirements on site.

2.8 CCMA Climate Change Review – Barwon and Moorabool River (2025)

The CCMA Climate Change Review project was undertaken to provide insight into the multiple hydrological analysis tools available for climate change assessment. The Barwon and Moorabool River component of this project involved a climate change assessment of the catchment through the use of the Ready Reckoner tool, the Climate Change Calculator (CCC) tool (developed by WMA water) and an update RORB model. This climate change assessment sought to identify the potential impact of the SSP3-7.0 and SSP5-8.5 conditions for the 2100 projection on the river, with each tool providing estimated flows, allowing for comparison between tools.

A RORB model was developed for the entire catchment, utilising multiple gauge locations for model validation, with the model being validated to the 1973, 1995 and 2022 events. These gauge locations include Barwon River @ Geelong, Barwon River @ Inverleigh, Barwon River @ Ricketts Marsh, Barwon River @ Pollocksford and Moorabool River @ Batesford. Once a range of RORB design parameters were determined for each validation event, they were adjusted and refined in order to align with flows from the previous Lower Barwon and Moorabool Study (Water Technology 2018).

Following the model validation, the RORB model parameters were scaled based on both the SSP3-7.0 and SSP5-8.5 for the 2100 climate change conditions.

2.9 South Geelong Stormwater Management Strategy (2026)

The South Geelong Stormwater Management Strategy was driven by the need to reduce stormwater flooding risk and implement catchment-wide practices that guide sustainable growth, the two high priority objectives in the South Geelong Area. The study includes development of a RORB hydrology model and a TUFLOW



hydraulic model of the entire catchment. The TUFLOW model was validated to historical events, inclusive of the January 2016, January 2022, October 2022 and October 2024 events.

High pollutant loads are generated by the South Geelong catchment that threaten water quality in the waterways and receiving environments. Significant values of downstream receiving environments are also recognised including reaches of the Barwon River and Lake Connemara downstream. Significant retrofit of water quality improvement infrastructure is required to achieve best practice pollutant removal and may help to reduce water quality issues in the Barwon River.

Key flood hotspots are identified within the catchment, including Elcho Street, Friers Reserve, Pakington Street, Bridge Street Drain, Douglas Place, Kardinia Park, Barwon Terrace, upstream of the Melbourne – Geelong railway line, Thomson Reserve and Geelong Showgrounds.

Overall, the study recognises that many existing stormwater assets in the South Geelong catchment are not performing adequately to meet the current day design standard, including 20% AEP capacity for the minor drainage system and 1% AEP capacity for the major drainage system. The stormwater network is assessed under various climate change scenarios to understand where pits are likely to surcharge under increased rainfall conditions. Areas most at risk to climate change in the catchment include Friers Reserve, Thomson Reserve and Hitchcock Street. A damage assessment was undertaken in the catchment, with the current annual average damages cost estimated at \$3,102,218 per year.

A long list of small and large scale mitigation opportunities were identified through technical analysis, alongside stakeholder and community engagement. A subset of opportunities was further evaluated through detailed modelling. The small scale opportunities assessed in the flood model included pipe upgrades on Fellmongers Road, pit upgrades on Hitchcock Street and pipe upgrades in Douglas Place.

Large scale opportunities that underwent a detailed assessment included stormwater diversion and water quality treatment at Rotary Centennial Park, pipe upgrades and stormwater harvesting at Thomson Reserve, wetlands and stormwater harvesting at Balyang Golf Course, pipe upgrades at Kardinia Park and gross pollutant trap installation along the Barwon River. High level costs were compared to a range of monetised benefits for these opportunities, including consideration of AAD reduction, potable water savings and pollutant (Total Nitrogen) removal.

Updated flood modelling at Kardinia Park demonstrates that pipe upgrades alone were not an effective solution and that detailed analysis and master planning at a precinct scale is required to reduce and otherwise manage flooding, while pursuing other urban greening, cooling, water quality and alternative water use outcomes onsite.

The three large scale mitigation opportunities that were recommended for inclusion in the City of Geelong forward works program, in order of priority, are as follows:

1. Rotary Centennial Park stormwater diversion, storage and treatment including downstream pipe and pit upgrades.
2. Balyang Golf Course constructed wetland and stormwater harvesting.
3. Thomson Reserve stormwater diversion, treatment and harvesting including drainage pipe and pit upgrades.

Small scale pipe upgrades at Douglas Place and Hitchcock Street were recommended to proceed. Several other opportunities were identified but require further investigation to better understand their feasibility, constraints, and potential impacts. A range of non-structural opportunities were also recommended to support the implementation of the South Geelong Stormwater Management Strategy. These non-structural measures included planning scheme amendment to the Special Building Overlay, consideration of climate change adaptation, precinct planning for Kardinia Park, the use flood resilient building materials and initiatives to



improve community awareness regarding flood risk (including around driving through floodwaters and road closure). Additional measures include the installation of automatic gates and the development of blue-green infrastructure master planning. It was recommended that City of Greater Geelong consider the findings of this report in ongoing management of stormwater within the South Geelong catchment.

2.10 Proposed Planning Scheme Amendment (2026)

The City of Greater Geelong is currently reviewing the West Fyans–Fyans Street Precinct Structure Plan and proposing rezoning of selected areas within the precinct. The proposed rezoning, as shown in Figure 2.1, affects approximately one-third of the precinct and includes transitions from Mixed Use to Residential, and from Industrial to Mixed Use zoning.

The review of the 2018 Drainage Report has been undertaken to support the anticipated increase in development density and changes in land use associated with the proposed rezoning. The West Fyans–Fyans Street Precinct's strategic location, close to Central Geelong and immediately adjacent to the Barwon River, makes it well suited to higher-density residential and mixed-use development, as well as the adaptive reuse of legacy industrial and commercial sites.

Achieving this redevelopment vision will require careful management of stormwater and flood risk impacts associated with increased development. In particular, increased impervious surfaces, altered overland flow paths, and the need to maintain effective onsite flood storage resulting from redevelopment, all of which must be appropriately addressed to ensure that flood risk is not exacerbated across the precinct.

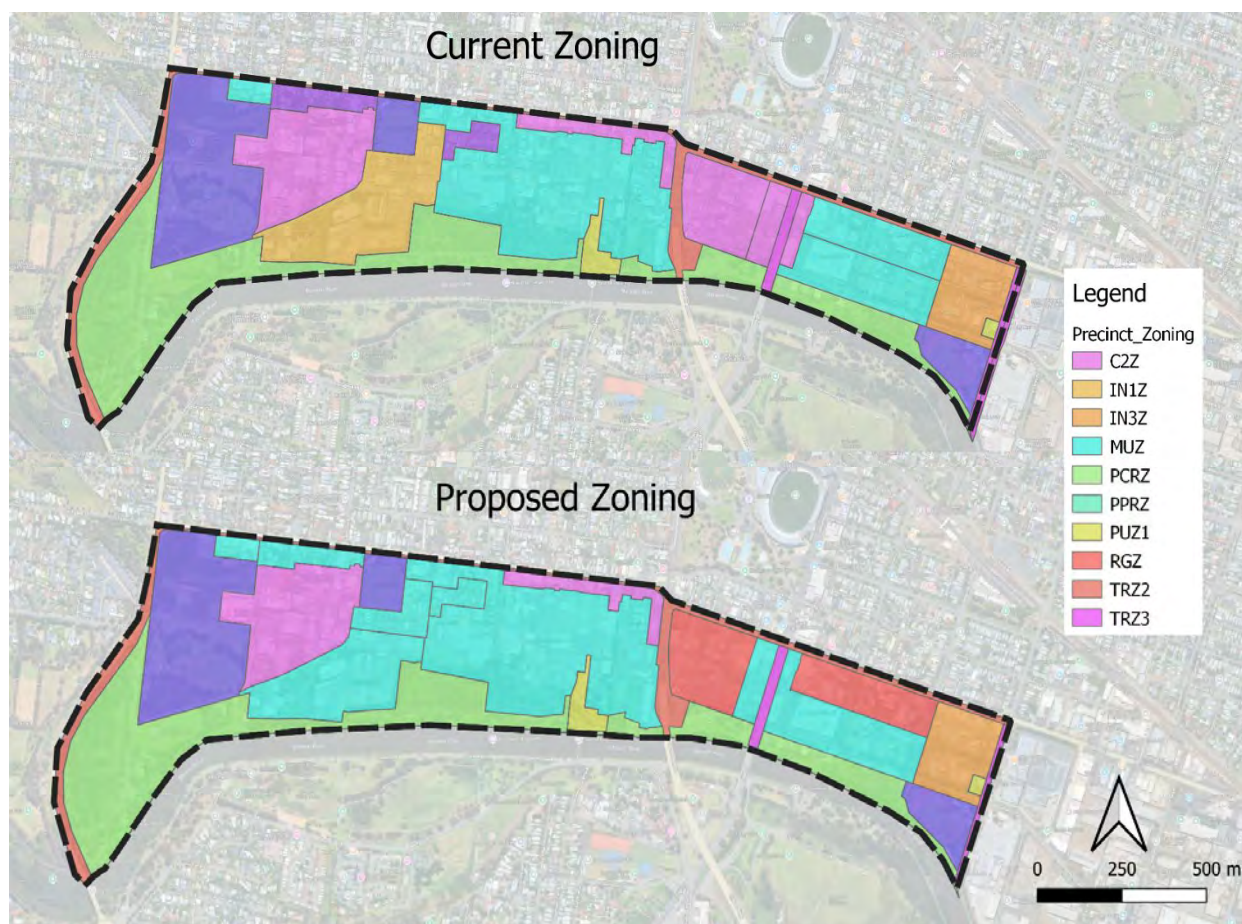


Figure 2.1 West Fyans-Fyans Precinct proposed rezoning



3 ASSET CONDITION ASSESSMENT

In the 2018 Fyans-West Fyans Precinct Structure Plan an assessment of the condition of existing assets was undertaken. The assessment undertaken in 2018 remains relevant to the current study update and has therefore been retained within this report.

Bartlett's Environmental was engaged in 2018 to undertake a CCTV condition assessment of eleven key drainage alignments within the study area. The CCTV survey capture the majority of the pipes, with the exception of a small section along Bellerine Street (sealed pit), Latrobe Terrace and Lambert Avenue (steepness). Pipes were assessed by Bartlett's Environmental using a camera on a remote-controlled vehicle placed inside the pipe, where accessible via a pit lid could be achieved. This methodology enabled the collection of comprehensive information on pipe characteristics and visible defects.

Each section of pipe was measured for length and diameter with observed defects noted and photographed. Each section of pipe was also provided with two gradings. The gradings used in this instance are those applied by the City of Greater Geelong on accepting greenfield assets. These gradings are based on the Water Services Association of Australia "scoring of defects and the preliminary grading of apparent condition of stormwater drains".

STR: Structural Grading - based on any cracking, magnitude of the crack displacement of lining.

SER: Serviceability Grading – based on how well the pipe will service (convey flow) as it was designed to. This incorporates any structural damage and includes any debris or blockages within the pipe (i.e. poor joining, loss of rubber rings).

Figure 3.1 and Figure 3.2 below show the "Serviceability Grading" for the underground drainage network within West Fyans and Fyans Street precincts. Figure 3.3 and Figure 3.4 show the "Structural Grading" for each respective section of pipe. The pipes have been coloured to represent a good grading (1) as green through to a poor grading (5) in red.



Figure 3.1 Eastern study area (Moorabool Street - Swanston Street) SER grading

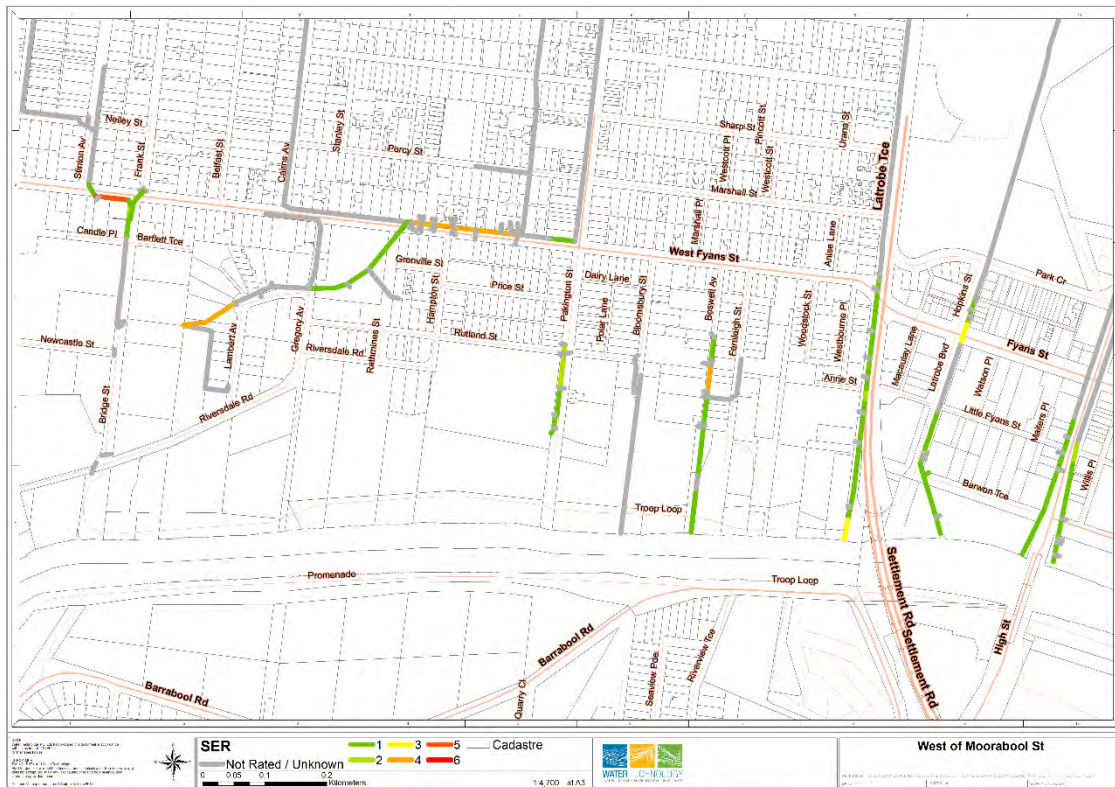


Figure 3.2 Western study area (Shannon Avenue - Moorabool Street) SER grading



Figure 3.3 Eastern study area (Moorabool Street - Swanston Street) STR grading



Figure 3.4 Western study area (Shannon Avenue - Moorabool Street) STR grading

Based on the assessment provided by Bartletts Environmental, the main area identified for priority upgrade is Latrobe Terrace. The CCTV footage revealed movement of the brickwork, displacement of the brickwork and soil visible through the defect at the culvert running beneath Fyans Street. Examples of the defects are shown in Figure 3.5. All reports and CCTV footage were supplied to the City at the time of the study. It is unknown whether any repairs have been undertaken to the pipe network at these locations since 2018.



Figure 3.5 CCTV photographs showing defects on the Latrobe Boulevard alignment

3.1 Blue Stone Kerb and Channel

Several blue stone kerb and channel, and open drains are present within the study area as shown in Figure 3.6, with the majority confined to the western end of the study area around the Bridge Street outfall. The City of



Greater Geelong provided a listing of all drains within the catchment identified under the Heritage Victoria Act and referenced in a report undertaken in 2007 (Authentic Heritage Services). None of the features listed as channels/spoon drains listed in the report to be retained were located within this study area. It is recommended that an audit of the current condition of open drains along Bellerine and Bridge Street be undertaken. Anecdotal evidence suggests the capacity of the spoon drains are exceeded on a regular basis, making them prone to erosion and undermining risk as well as public safety risk due to high velocities in the open drains. Figure 3.7 shows the open spoon drain on Bellerine Street in 2018 during a flow event (left) and erosion following a storm event (right). Since the drainage report was written in 2018, the condition of this drain has further eroded after heavy rainfall in 2020, 2022 and 2025 (Figure 3.8). Measures to address the capacity of the drainage and reduce the flood hazard safety risk and potential erosion most likely require renewal of the drains or redesign to include piping of the open drains.



Figure 3.6 Open drain locations west (top) & east (bottom)



Figure 3.7 Blue stone open drains on Bellerine St 2018 (during a storm event), Right: outflanked area that is becoming undermined



Figure 3.8 Blue stone open drain on Bellerine St in 2020 and further eroding after a storm in March 2025



3.2 Informal Drainage

The study area also includes several informal drainage paths consisting of open channels (spoon drains) that convey runoff from impervious surfaces such as roads and car parks (Figure 3.6). Two key drainage corridors are located at the western extent of the catchment, at Riversdale Road and Newcastle Street..

The southern side of Riversdale Road does not have a kerb and channel from Gregory Avenue to Bridge Street. A site inspection identified evidence of erosion along the roadside, along with anecdotal evidence indicating this section of the road is used for parking for the YMCA centre. In contrast the northern side of the road is serviced by a barrier kerb and channel that convey flows from Gregory Avenue to Lambert Avenue. The runoff is then piped north along Lambert Avenue into the Bridge Street Main Drain.

Newcastle Street is also a sealed road with no formalised drainage. Spoon drains are present on either side of the roadway and appear to convey flows to a low point in the drain, discharging under Newcastle Street and into the Balyang Golf Course. The spoon drain on the Northern side of Newcastle Street has been identified as a potential public safety hazard with stagnant water pooling in the drain which can not drain away properly. This drain also appears to collect runoff and sub-surface flows from the area to the north (The Hill Mountain Bike Park).

Council officers have identified these two areas as requiring further investigation to assess options for formalising the existing drainage systems. In the case of Riversdale Road, any drainage upgrade will need to carefully consider potential impacts on existing on-street parking. Upgrading to a conventional kerb and channel system along the southern side of Riversdale Road may provide opportunities to incorporate WSUD elements and improve pedestrian connectivity between the precinct and the river frontage, while also addressing existing flood hazard and erosion issues associated with the informal drainage conditions.

Similarly, upgrading the drainage along Newcastle Street would address the identified risks associated with stagnant water ponding, while also providing an opportunity to deliver a formal footpath and enhance connectivity within the area.

High level cost estimates were prepared for the upgrade of both sides of Riversdale Road (550 m total) to a traditional kerb and channel with associated pit/pipe drainage infrastructure along with the construction of a footpath along the southern side of the road (350 m). The cost estimate for the upgrade was estimated to be in the order of \$250,000 for drainage works only (this did not include road resurfacing or provisions for service realignments).

A high-level cost estimate for the upgrade of the northern side of Newcastle Street (230 m) to a traditional kerb and channel and pit/pipe network along with the construction of a footpath between Marnock Road and Bridge Street (300 m). This was estimated to be in the order of \$150,000 for drainage works only (this did not include road -resurfacing or provisions for service realignments).

3.3 Existing Drainage Capacity

An assessment of the performance of stormwater assets within the West-Fyans Precinct was undertaken as part of the South Geelong SWMS study in 2025. Drainage capacity were assessed for the critical 20% and 1% Annual Exceedance Probability (AEP) storm events. Results from the South Geelong flood model were reviewed to identify locations where deficiencies in asset performance may exist.

Pipes coloured in red in Figure 3.9 and Figure 3.11 indicate assets that are at capacity during the 20% and 1% AEP respectively, meaning they cannot receive any more water and their capacity is exceeded. In the 20% AEP, approximately 73% of pipes are shown to be at full capacity, which is concerning for an event of this magnitude given current design standards.



In Figure 3.10 and Figure 3.12, the percent time full is mapped for the 20% AEP and 1% AEP respectively. Mapping the time full highlights areas where infrastructure capacity is under stress throughout a storm event. Areas that are unable to adequately convey the current 20% AEP storm are indicated by the red and dark orange pipes in Figure 3.9. Key locations identified as experiencing the most significant capacity constraints include Friers Reserve, the Moorabool Street underpass, and Thomson Reserve.

Overall, most stormwater assets within the West-Fyans Fyans precinct are shown to not performing adequately under the current day design standard: 20% AEP event.

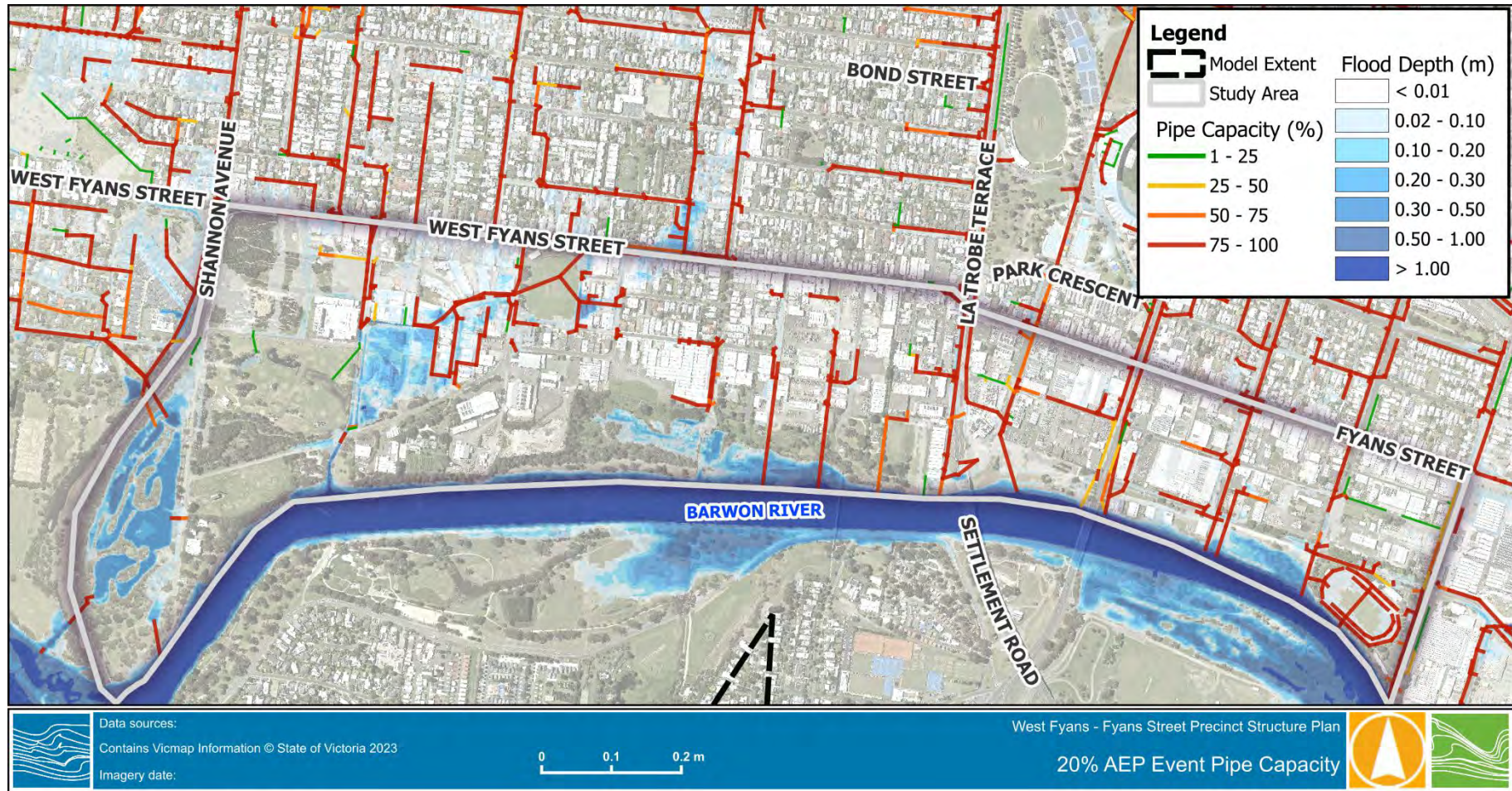


Figure 3.9 20% AEP pipe capacity

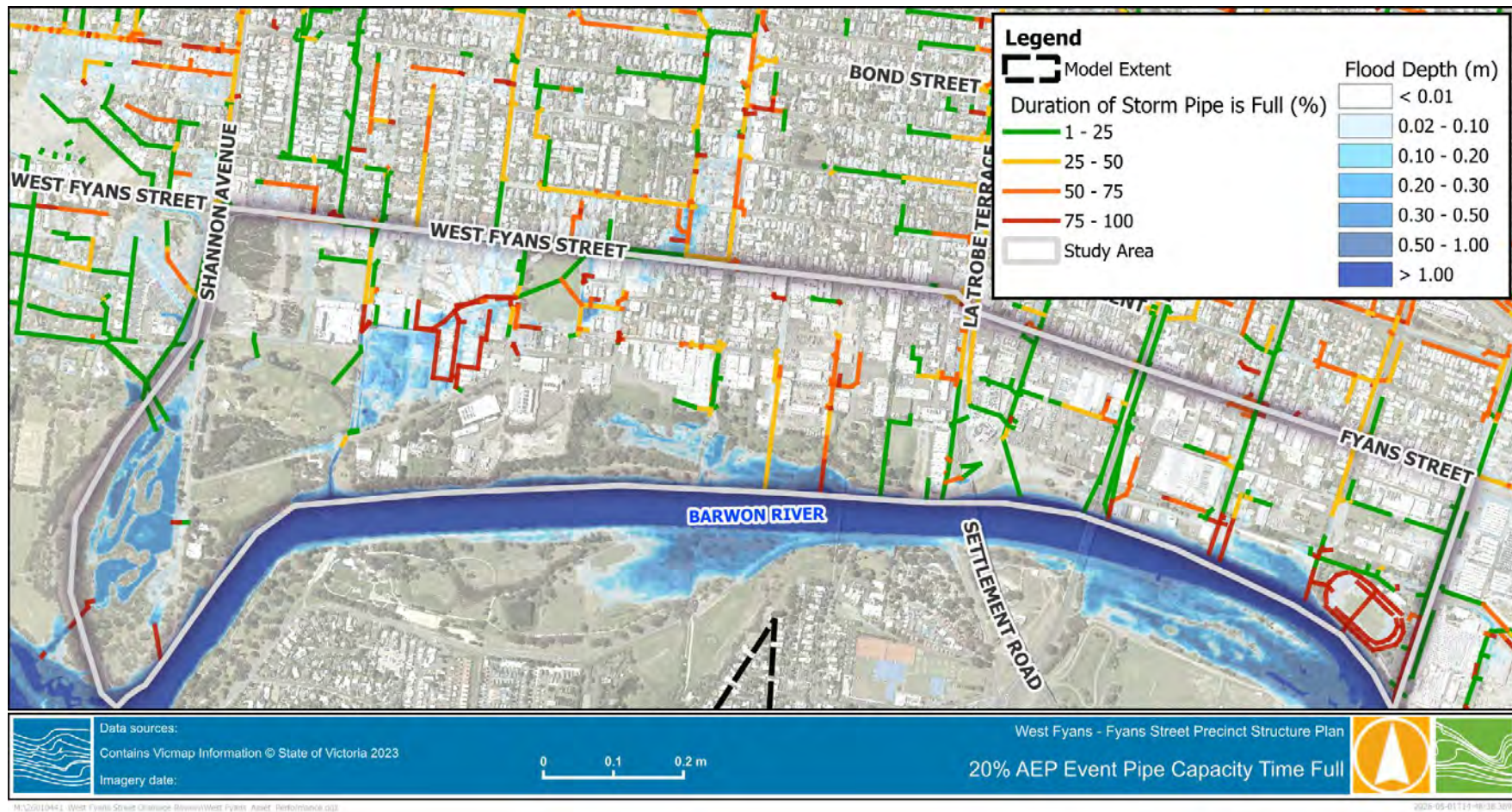


Figure 3.10 20% AEP percent of time pipe is full

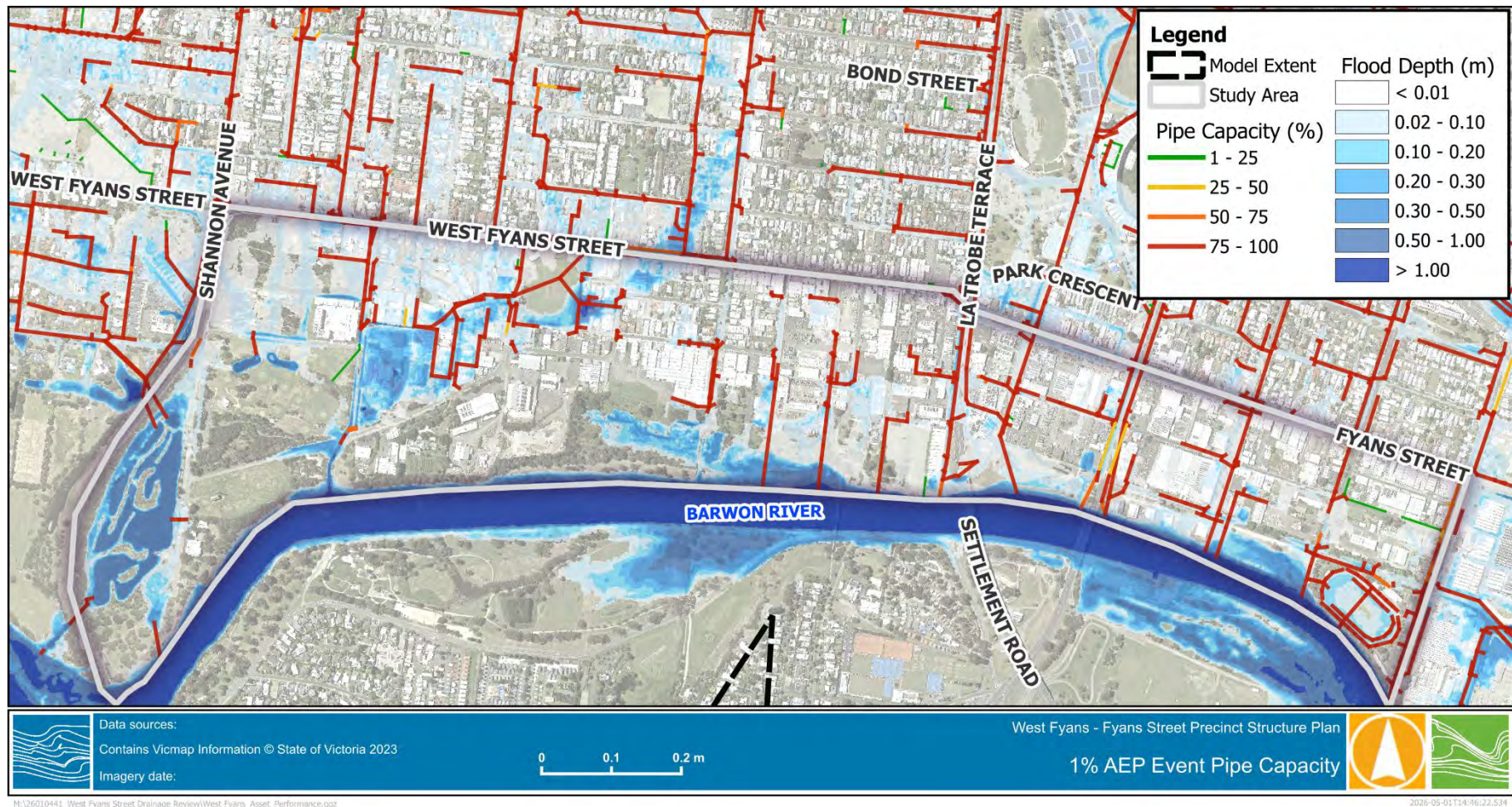


Figure 3.11 1% AEP pipe capacity

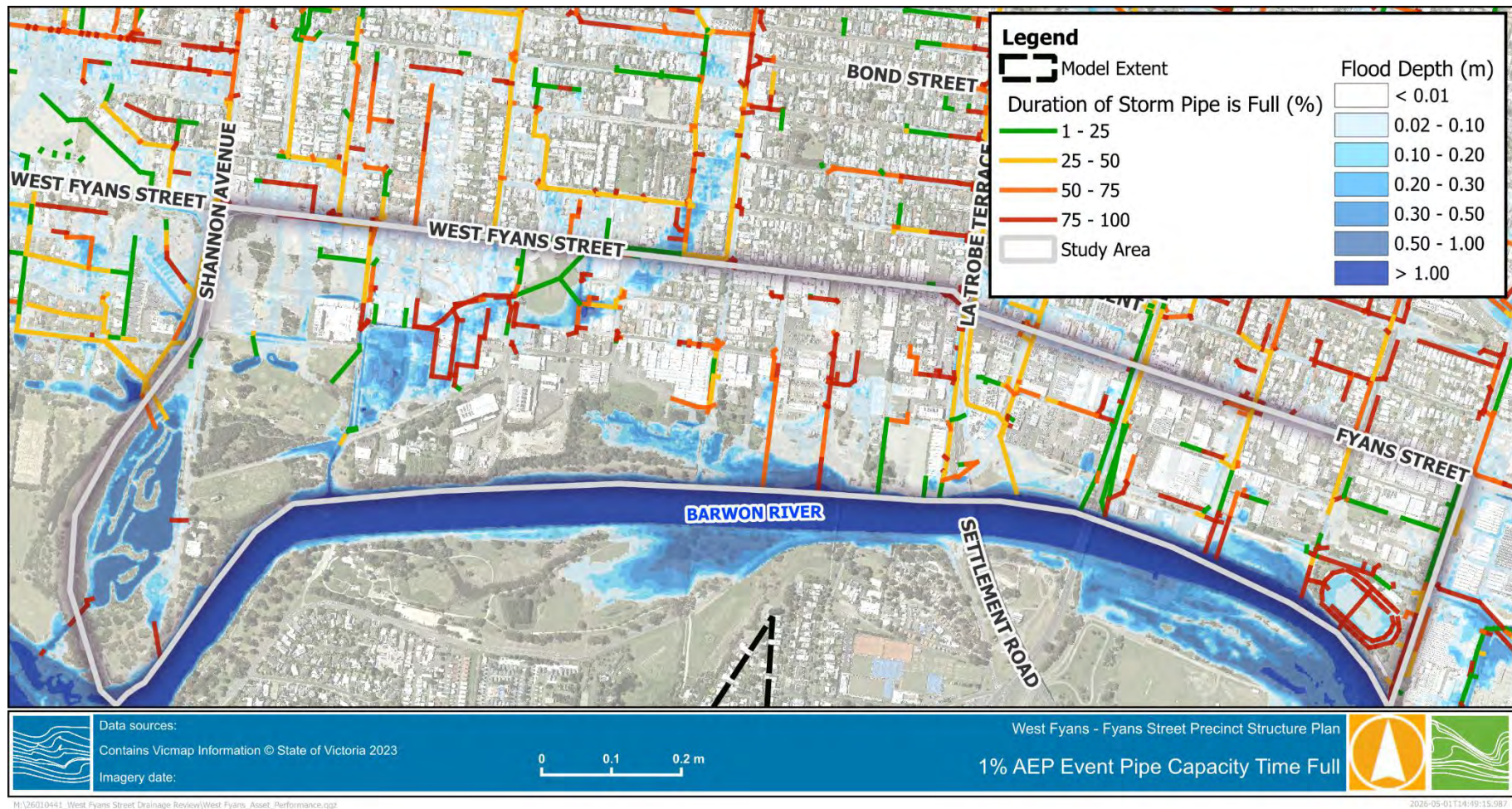


Figure 3.12 1% AEP percent of time pipe is full



3.4 Climate Change Drainage Impacts

The potential impacts of climate change on the stormwater network in Fyans – West Fyans precinct are assessed by comparing baseline (current day) hydraulic modelling outputs with those under projected under future climate conditions (SSP5 year 2100). This analysis assesses changes in the hydraulic performance of the pipe network and identifies additional pits predicted to surcharge and pipes at capacity due to increased rainfall intensity.

This assessment considers the 10% AEP event, under the 2100 (SSP3) climate scenario. Performance of the pit and pipe network was compared against modelling under the current climate (2016 IFDs) to identify areas most affected by future increases in rainfall intensity.

The 20% AEP was selected as it represents a relatively frequent event, and its impacts are expected to be more noticeable to the community during regular flooding. It is anticipated that the impacts of the 10% and 1% AEP events would follow similar patterns.

3.4.1.1 Impacted pits

Results for the 20% AEP show impacts to a number of pits as shown in Figure 3.13. Findings highlight areas most at risk from increased rainfall intensity, particularly where clusters of pits are predicted to experience increased flow and surcharge under future climate conditions. These areas are illustrated as red dots on the map. Locations within the precinct that are most affected include Friers Reserve and the southern end of Yarra Street

3.4.1.2 Impacted pipes

Results for pipes most affected by increases to rainfall intensity are presented below in Figure 3.14. The most affected segments are highlighted in red, indicating increased backflow and flow volume, signifying locations where pipes are significantly at capacity (running full). The same areas identified above, characterised by significant clustering of surcharging pits, continue to experience flooding impacts. Additional affected locations within the catchment include Moorabool Street, Barwon Terrace, and Wood Street in South Geelong.

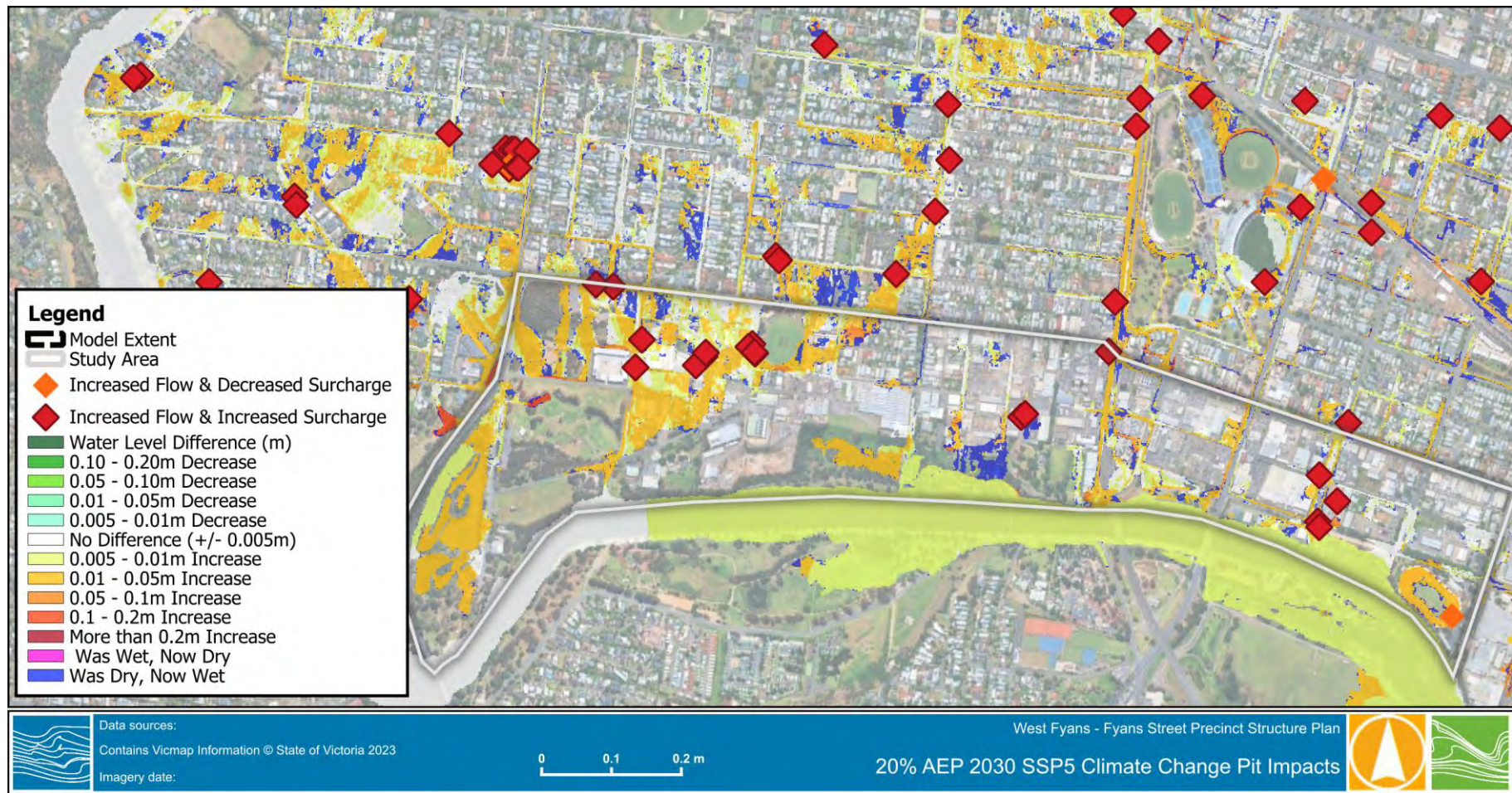


Figure 3.13 20% AEP new pits surcharging under climate change

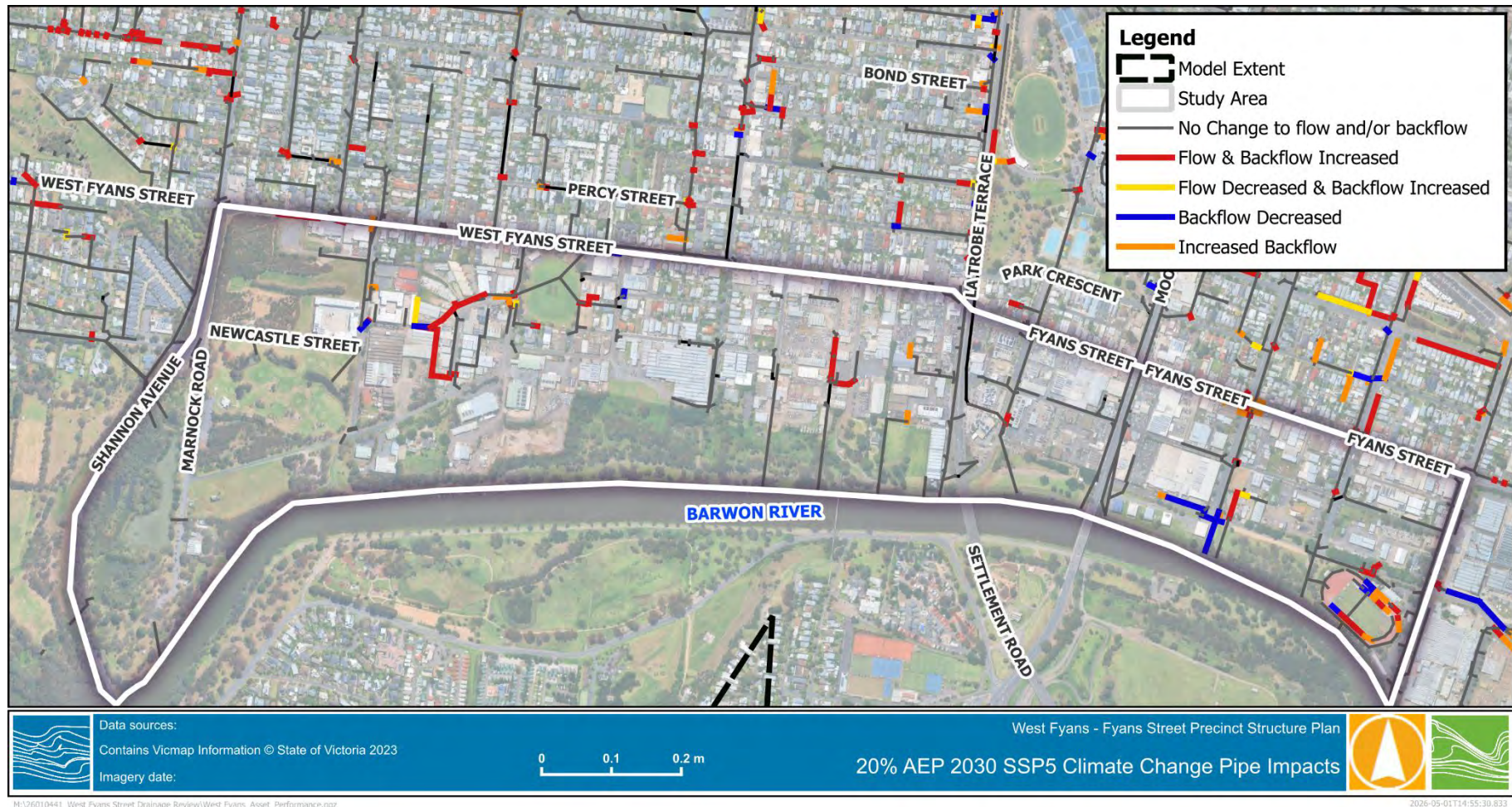


Figure 3.14 20% AEP new pipes surcharging under climate change



4 HYDROLOGY AND HYDRAULIC MODELLING

This section outlines the existing and additional hydrologic and hydraulic analyses undertaken for the Fyans – West Fyans precinct. It describes how these models have been used to assess existing conditions and identify additional mitigation measures associated with the proposed rezoning.

4.1 Overview

Two hydrologic models have been developed for the study area:

- The South Geelong urban (stormwater) model and
- The Lower Barwon and Moorabool (riverine) model.

The South Geelong RORB model was developed in 2024 in accordance with ARR v4.2 guidance as part of the South Geelong Flood Study. Modelled flows were validated against the West Fyans–Fyans RORB model (developed for the 2018 West Fyans–Fyans study) and also compared with outputs from the 2025 South Geelong TUFLOW hydraulic model. These comparisons demonstrated good agreement, particularly within the West Fyans–Fyans study catchment.

Further details on model schematisation, parameter selection, and validation are provided in the *South Geelong Design Hydrology and Hydraulic Modelling Report* (Water Technology, 2025).

The Lower Barwon and Moorabool RORB model was developed by Water Technology as part of the *Lower Barwon River and Lower Moorabool River Flood Study (2019)*. This riverine model was used to simulate representative 2025 to reflect updated 2025 climate guidance, with resulting flows used in an updated TUFLOW hydraulic model for floodplain assessment. The updated Barwon River flows and resultant flood extent are currently in draft form and have been used in this study for the purpose of indicating areas of potential increased flood risk within the proposed rezoned areas. This model hasn't been simulated for any further scenarios as part of this report update.

The South Geelong RORB model has been used in this study to provide an estimate of updated flows in an ultimate developed scenario, as determined by the proposed rezoning.

A summary of available climate change hydrology and hydraulic modelling is summarised below in Table 4-1



Table 4-1 Hydrology model summary

Hydrology Model	Hydraulic Model	Date	Guideline Compliance
South Geelong SWMS RORB Model	South Geelong SWMS Hydraulic Model (TUFLOW HPC and Quadtree)	2025	Existing results available compliant with the updated ARR4.2. Climate Change conditions simulated for the South Geelong SMWS: ■ 20% (SSP5 2030) existing conditions ■ 10% (SSP5 2030) existing conditions ■ 1% (SSP5 2030) existing conditions ■ 1% (SSP5 2050) existing conditions ■ 1% (SSP5 2100) existing conditions Climate Change conditions simulated for this study: ■ 1% AEP (SSP3 2100) existing conditions ■ 1% AEP (SSP3 2100) ultimate developed conditions
Lower Barwon and Moorabool RORB Model	Barwon River Flood Model Update (MIKE developed model migrated to TUFLOW HPC)	2025	Estimated 1% AEP SSP3 2100

4.2 Hydrologic Modelling

This section details hydrologic model climate change updates and catchment condition updates to represent the proposed rezoning.

4.2.1 Existing Conditions

The South Geelong RORB model schematisation, including sub-catchment boundaries and the extent of the West Fyans–Fyans precinct, is presented in Figure 4.1. The spatial distribution of fraction imperviousness across the model domain is shown in Figure 4.2. No modifications to catchment delineation or imperviousness assumptions were required for this study, and the existing South Geelong RORB model configuration was adopted without change to represent current conditions.

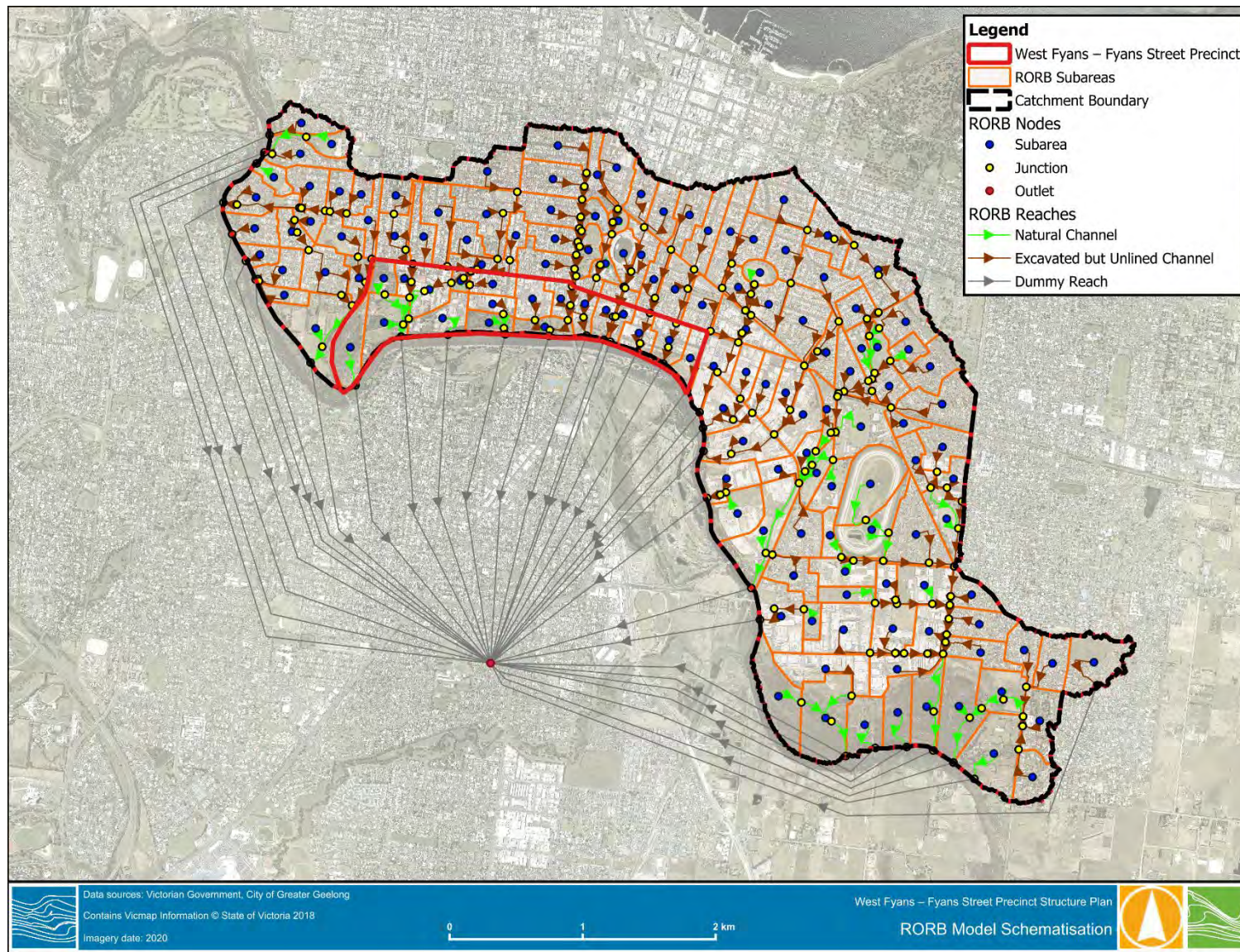


Figure 4.1 Model schematisation

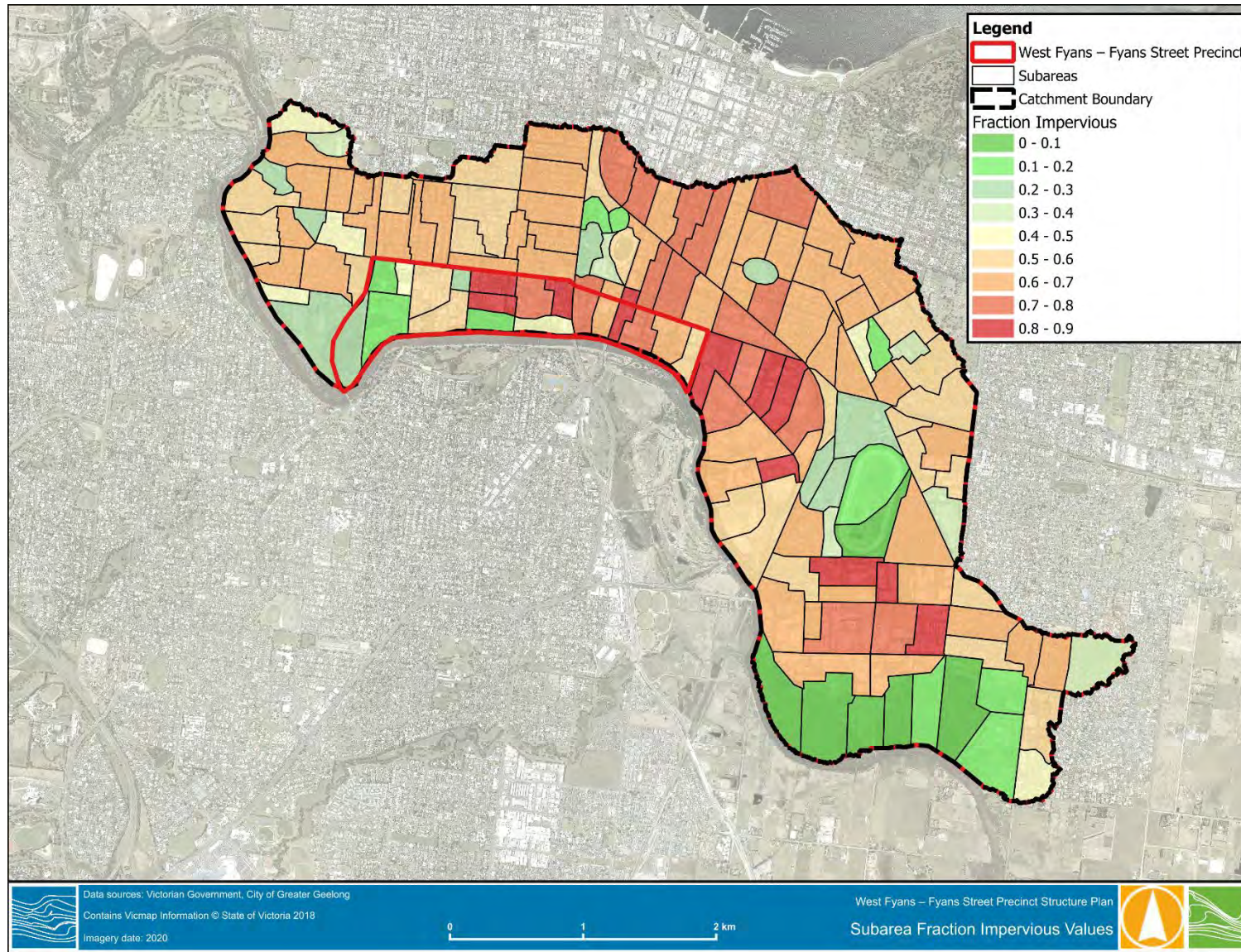


Figure 4.2 South Geelong RORB existing model fraction impervious



4.2.2 Climate Change Methodology Updates

The design parameters adopted for the South Geelong RORB model were derived in accordance with established industry guidelines and best practice (ARR V4.2). The routing parameter (kc) was estimated using the Victorian Mean Annual Rainfall (MAR) relationship applicable to catchments with MAR less than 800 mm, resulting in an adopted kc value of 2.6.

Initial and continuing loss parameters for the South Geelong catchment were sourced from the ARR Data Hub and subsequently adjusted to reflect urban hydrologic response, consistent with the methodology outlined in Section 4.3.5 of Melbourne Water's Flood Mapping Project Specifications (Melbourne Water, 2025). Losses were spatially differentiated into Directly Connected Impervious Areas (DCIA, also referred to as Effective Impervious Area – EIA), Indirectly Connected Impervious Areas (ICIA), and Pervious Areas (PA) to capture varying runoff generation characteristics.

The RORB model was configured to simulate design events up to the 1% AEP under several climate scenarios. Adopted loss parameters for 1% AEP events across a range of climate scenarios are summarised in Table 4.2. Preburst was incorporated into the modelling reflective of event duration. A comparative assessment of factored IFD rainfall depths is presented in Figure 4.3, which indicates that the currently adopted 1% AEP RCP8.5 scenario previously adopted by the is broadly comparable to the 2030 SSP3 1% AEP design event.

Table 4-2 Design initial and continuing losses for climate change events

		1% AEP				
		Baseline	SSP3 2100	SSP 5 2030	SSP5 2050	SSP5 2100
PA	IL (mm)	17.0	19.55	17.90	18.40	20.2
	CL (mm/h)	3.00	4.02	3.33	3.54	4.32
DCIA	IL (mm)	1.5	1.50	1.50	1.50	1.50
	CL (mm/h)	0.0	0.00	0.00	0.00	0.00
ICIA	IL (mm)	8.2	9.75	8.70	9.00	10.20
	CL (mm/h)	1.0	1.00	1.00	1.00	1.00

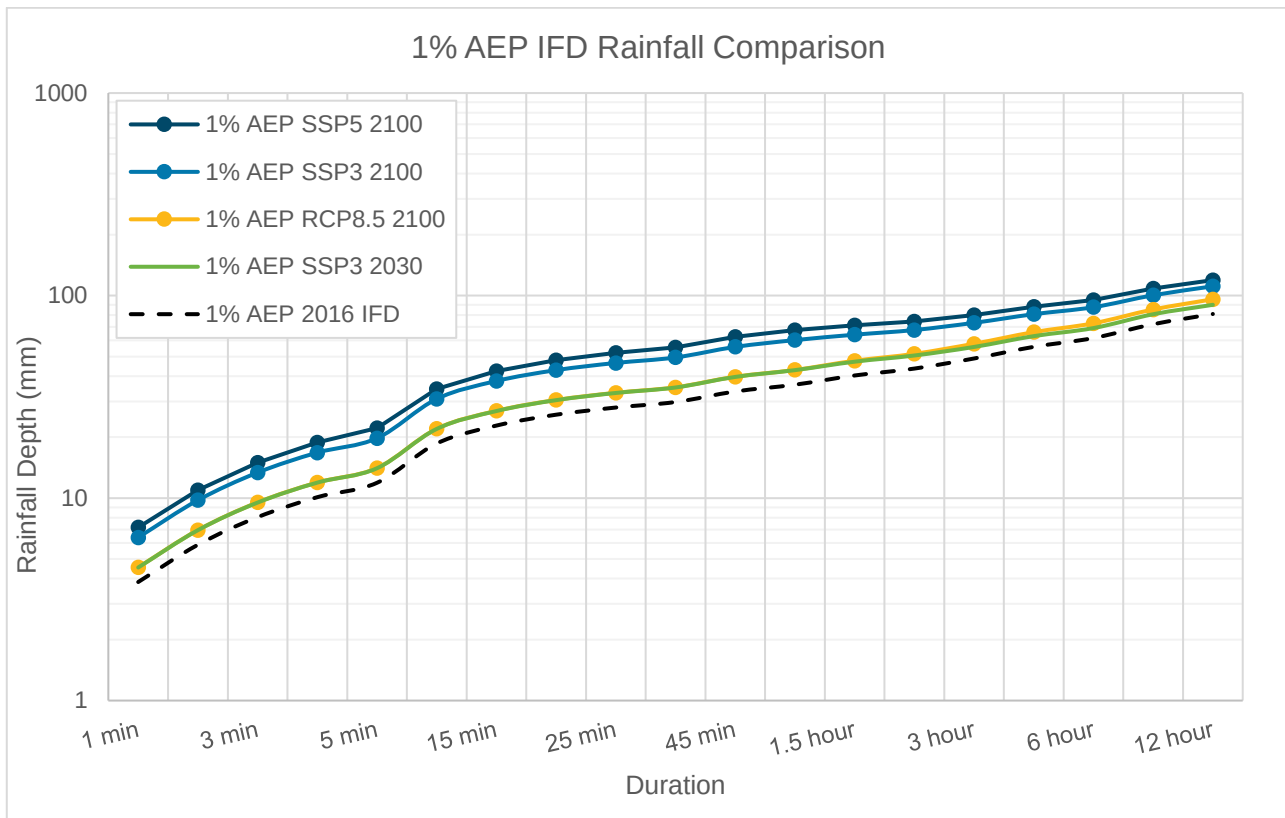


Figure 4.3 1% AEP IFD comparison

4.2.3 Ultimate Developed Conditions

To assess the impact of changed zoning within the precinct on peak runoff and runoff volume, the fraction impervious of the impacted lots within the study area (excluding the open space along the river frontage) were adjusted to 0.80 from existing conditions. This is consistent with methodology adopted in the previous version of the West Fyans-Fyans Precinct Plan in 2018. The fraction imperviousness for the study area is shown in Figure 4.4, with the subareas covered by the proposed zoning changes highlighted in Table 4-3. Of note is that the existing land surface within the study area is already relatively highly urbanised, so the proposed zoning changes do not have a significant impact on the fraction impervious values.

The above resulted in a minor increase (negligible) in peak flow rates (Table 4-4) and volumes generated within some parts of the study area (Table 4-5). Overall, the results indicate that the change in land use from predominantly industrial and commercial to mixed use and residential does not have a significant impact on runoff volumes and peak flows generated across the study area. Based on this assessment, augmentation of existing drainage infrastructure is not required to account for any additional runoff resulting from infill development within the study area, notwithstanding existing and future capacity constraint.

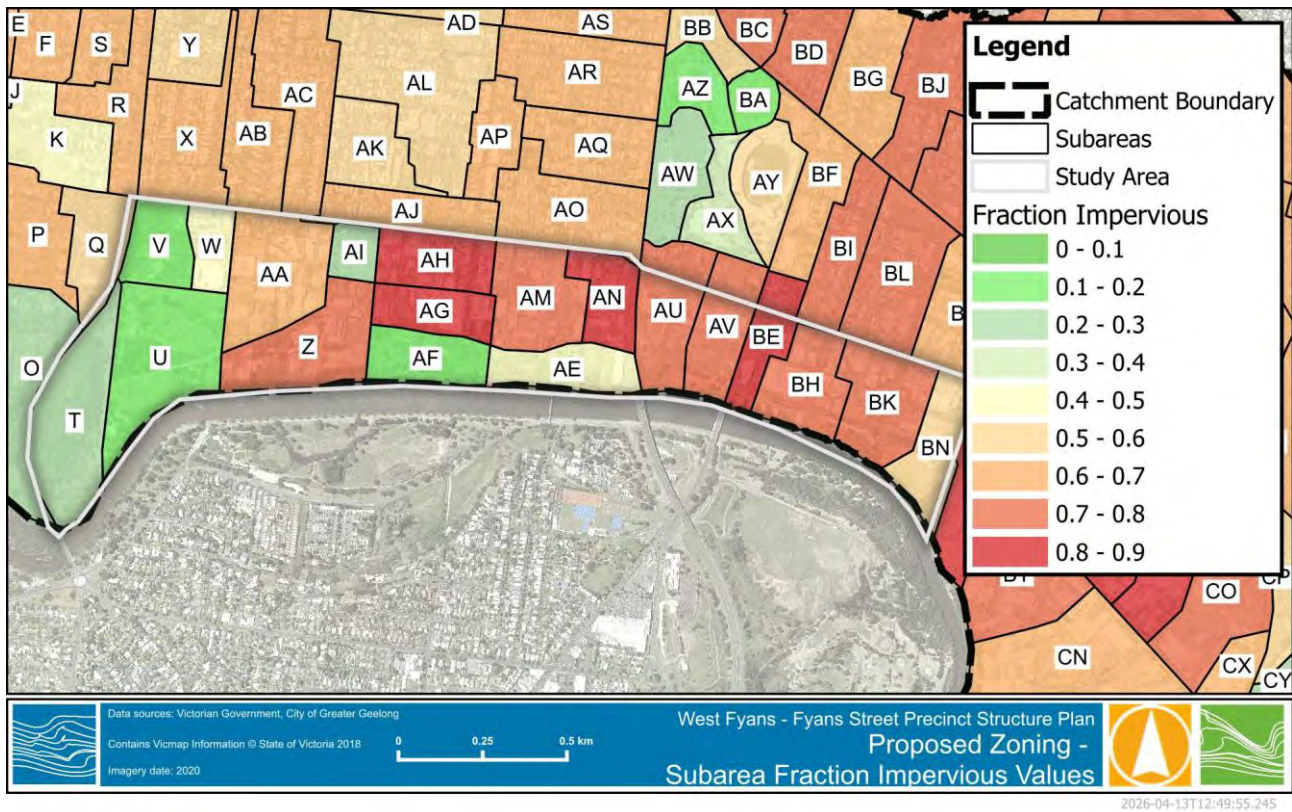


Figure 4.4 South Geelong RORB ultimate developed model fraction impervious

Table 4-3 Key Subarea Fraction Impervious values

Subarea	Existing	Developed
Z	0.60	0.70
AA	0.59	0.65
AG	0.80	0.80
AH	0.78	0.81
AU	0.71	0.74
AV	0.68	0.70
BE	0.79	0.78
BH	0.72	0.72
BK	0.65	0.70



Table 4-4 Change in peak flow rates for 1% AEP SSP3 2100 events (without additional storage)

Outfall Location	Existing SSP3 2100 Climate Peak Flow (m ³ /s)	Ultimate Developed SSP3 2100 Climate Peak Flow (m ³ /s)	Change in Peak Flow (m ³ /s)
Bridge Street	11.20 (1 hour TP07)	11.22 (1 hour TP07)	0.02
Latrobe Terrace West	9.38 (1 hour TP08)	9.38 (1 hour TP08)	0.0
Latrobe Terrace East	4.52 (1 hour TP03)	4.52 (1 hour TP03)	0.0
Moorabool Street	3.56 (1 hour TP07)	3.56 (1 hour TP07)	0.0
Yarra Street	3.59 (30 min TP08)	3.59 (30 min TP08)	0.0

Despite the change in peak flow rates within the study area not being significant, the hydrology model has shown an increase in the runoff volumes generated from the study area due to increased impervious area. The volume comparison for the above five outfalls is shown below for the 1% AEP critical duration and temporal patterns as presented above. Given the outfall of the study area is directly to the Barwon River, any minor increase in flow volume will have negligible impact on the receiving waterway.

Table 4-5 Change in flow volumes generated for 1% AEP critical events

Outfall Location	Existing Volume (m ³)	Ultimate Developed Volume (m ³)	Change in Volume (m ³)
Bridge Street	128,263	128,517	254
Latrobe Terrace West	78,373	78,373	0
Latrobe Terrace East	43,616	43,650	34
Moorabool Street	30,489	30,489	0
Yarra Street	18,784	18,784	0

4.2.4 Lower Barwon and Moorabool RORB Model

No or updates have been made to the current hydrological model representing the lower Barwon River. It is understood that adjustments have been made to the model to represent an updated 1% AEP SSP3 2030 scenario. This analysis is currently in draft form, and this model has not been used for any further analysis as part of this report update. The draft 1% AEP SSP3 2030 extent have been examined in the hydraulic modelling section below to highlight any updated areas of risk within the precinct.



4.3 Hydraulic Modelling

This section details the model updates and summarises the updated hydraulic modelling undertaken within the West Fyans–Fyans Precinct.

4.3.1 South Geelong Stormwater Model

A hydraulic model of South Geelong was developed in 2024 as part of the South Geelong SWMS (Water Technology, 2026) to assess localised stormwater inundation. This model covers the West-Fyans Fyans Precinct and is used in this report update.

TUFLOW Quadtree functionality was adopted and was built with a 4 metre grid within the Barwon River, with a more refined 2 metre cell size within the urban catchment. The model utilised TUFLOW's sub-grid sampling (SGS) capabilities to represent terrain within each grid cell. Hydraulic structures were represented as 1-dimensional structures (culverts and pipes). While model topography utilised the City of Greater Geelong 2019 captured LiDAR dataset.

A summary of key model parameters has been provided in Table 3-1 below. A detailed description of other model parameters can be found in the South Geelong Design Hydrology and Hydraulic Modelling Report (Water Technology, 2025).

Updates to the model included representation of the future land use and additional simulations for the 1% AEP under SSP3 2100 climate conditions. Model configuration is presented below in Figure 4.5. Existing land use and ultimate developed land use in the hydraulic model are presented below in Figure 4.6 and Figure 4.7 respectively.

Table 4-6 Key TUFLOW parameters

Parameter	Value
Model Build	2023-03-AE-iSP-w64
Model Precision	Single Precision
Grid Cell Size	4 metres (riverine) and 2 metres (stormwater)
Model Orientation	Oriented to direction of flow north-east to south-west. Oriented to Latrobe Terrace and along West Fyans Street.
Sub Grid Sampling	1 metre sample distance
Solution Scheme	HPC
Inflows	Steady state peak riverine flow from Barwon River Flood Study TUFLOW migrated model (riverine) Rainfall excess from RORB output (stormwater)
Outflow	Riverine: Height vs Time downstream boundary levels adopted from Barwon River flood Study Stormwater: Height-Flow Slope of 1% at catchment (upstream) boundaries
Hydraulic Roughness	Manning's 'n', varies with land use
1-Dimensional elements	Culverts and pipes linked to 2-D domain



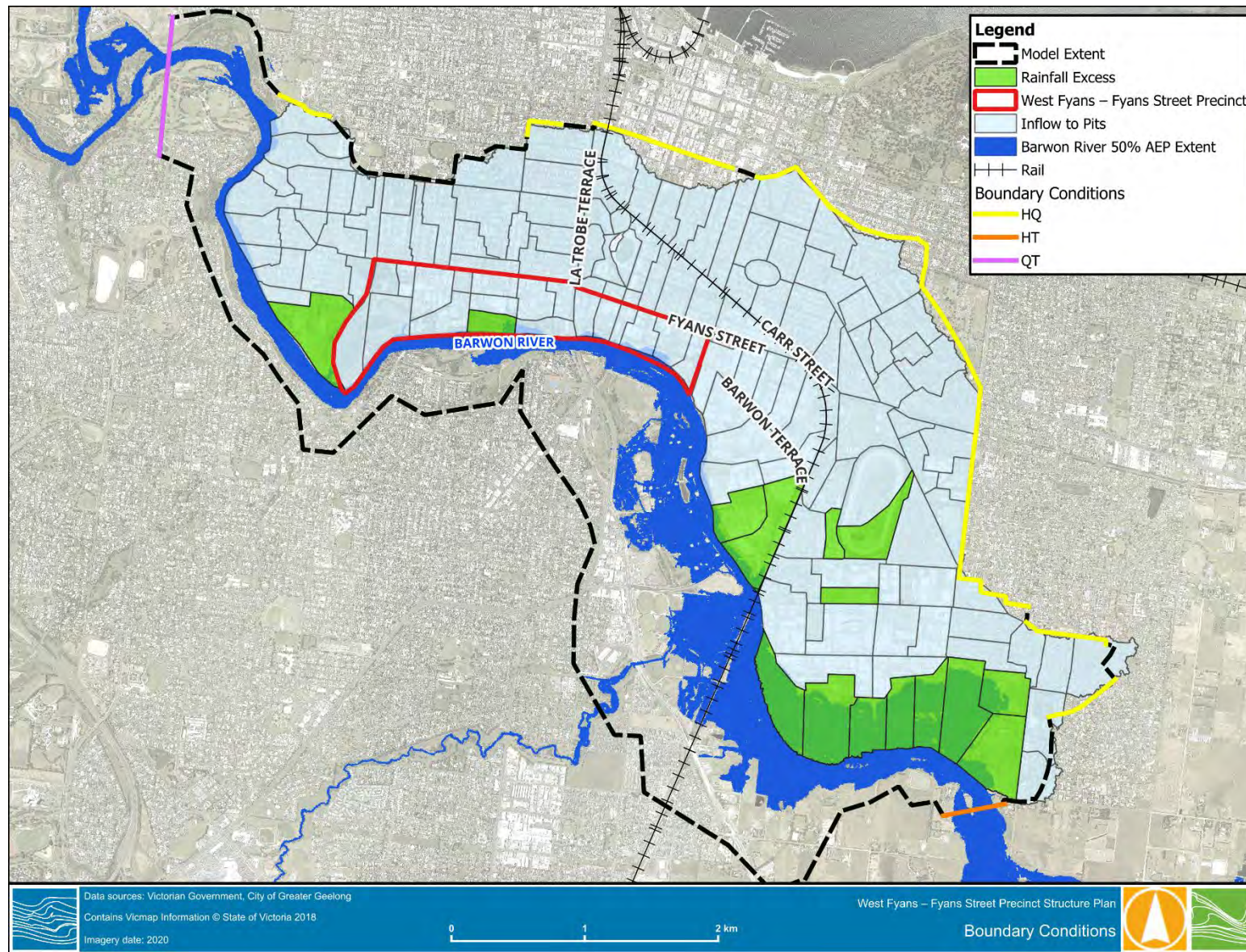


Figure 4.5 South Geelong flood model setup

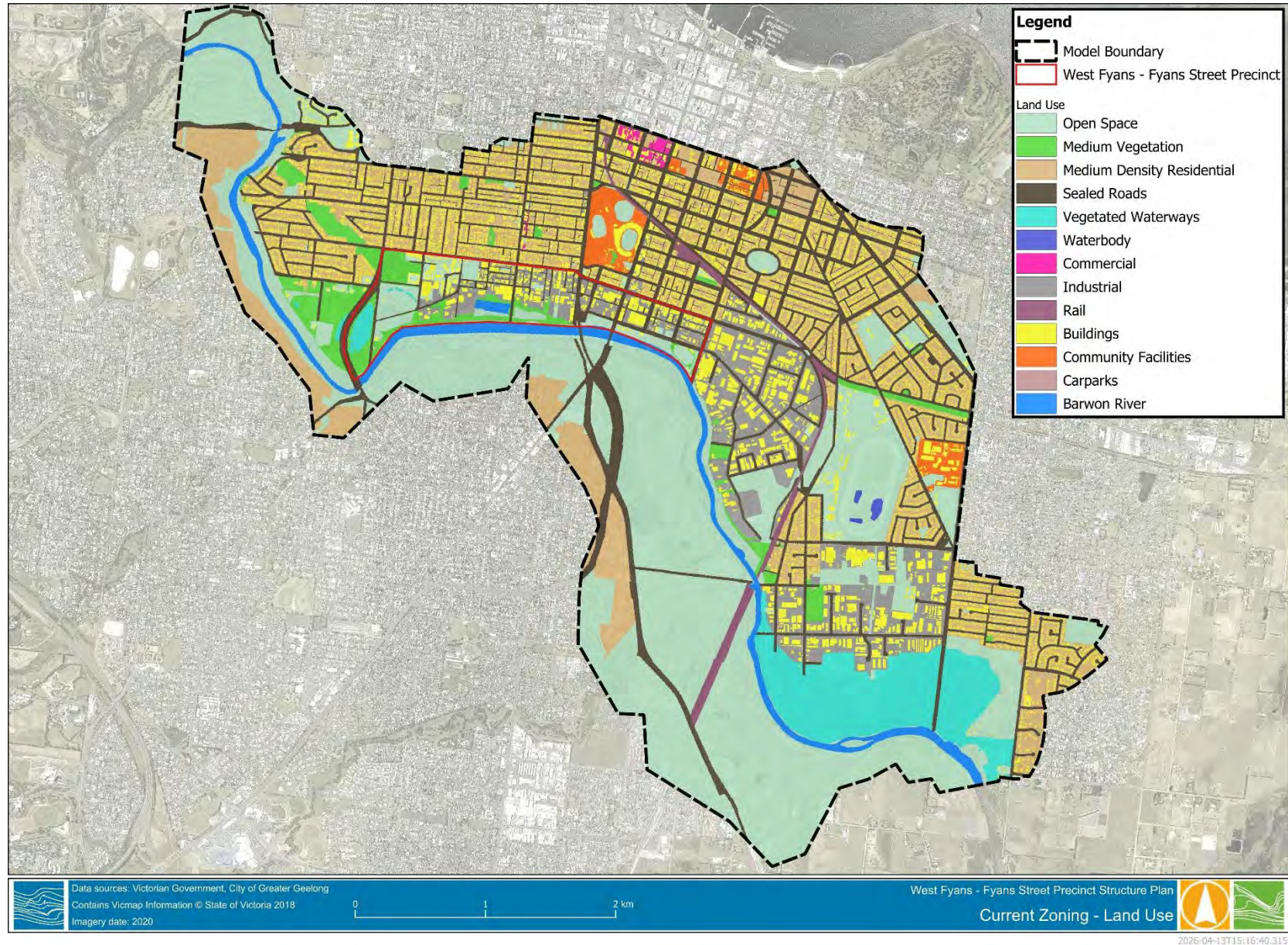


Figure 4.6 South Geelong stormwater model existing land use

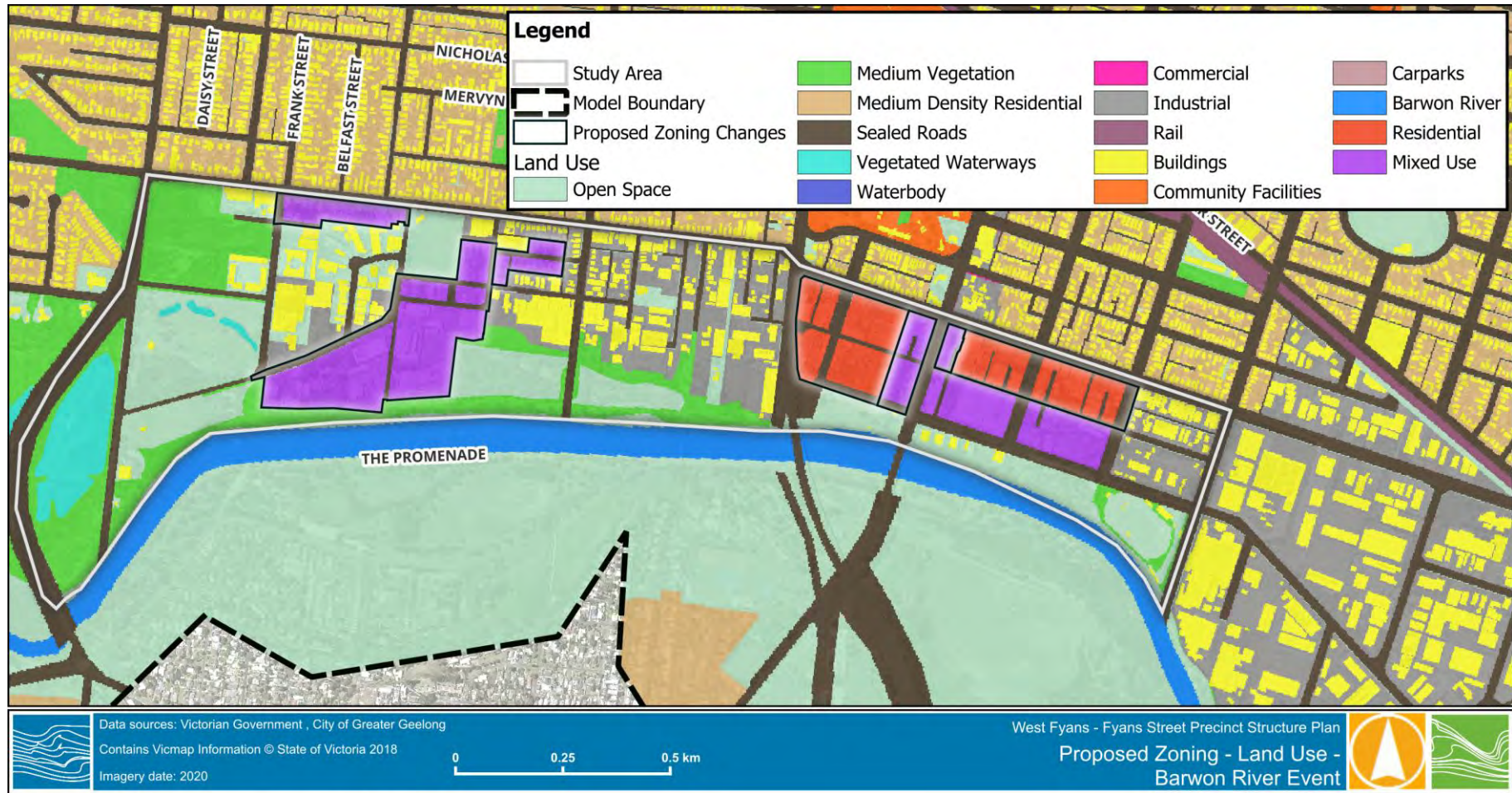


Figure 4.7 South Geelong stormwater model ultimate developed land use



4.3.2 Developed Conditions Climate Change Results

Inflow hydrographs from the RORB modelling discussed in Section 4.2.3 were used to simulate the runoff generated from a suite of durations for the 1% AEP SSP3 2100 design storm. The model results for both AEP design storms were enveloped together to provide the maximum flood levels across the study area.

To assess impact of increased development in the proposed rezoning areas the flood model has been simulated for the 1% AEP SSP3 2100 under existing and ultimate developed scenarios and compared as shown in Figure 4.8. Peak flood depth under the ultimate developed scenario 1% AEP SSP3 2100 is presented in Figure 4.9.

The results indicate that the increased Manning's roughness values within the rezoned areas, together with the increased fraction impervious, result in minor changes to flood levels. These changes are most evident within the rezoned area adjacent to West Fyans Street which shows increases in water level of up to 150mm. In contrast, the rezoned areas located to the south of Friers Reserve are largely unaffected by the change in zoning and are shown to be not significantly impacted by stormwater flooding.

4.4 Floodplain Development Controls

Under current planning arrangements in Victoria, Catchment Management Authorities (CMA's) are the relevant Floodplain Management agencies outside of Melbourne Water's area of responsibility. CMA's are referral authorities under the Victorian planning regime and are recommending authorities.

Any development applications within the current or future LSIO (or any other flood related overlays associated with the Barwon River in the study area) will be referred to the CCMA for their response. These applications would be guided by DELWP development guidelines, which underpin the CMA's assessment of development in flood-prone areas. In responding to such referrals the CCMA would be expected to take into account standard floodplain principles such as:

- Flood impacts on adjoining land;
- Any impacts on the waterway or floodplain environmental assets (such as wetlands);
- Erosion potential;
- Any impact of flood conveyance and flood storage;
- Potential for flood damage; and
- Safety and access.

A comparison between the baseline 1% AEP flood extent, developed in accordance with ARR 4.1 guidance, and the draft updated climate change modelling of the Barwon River based the draft 1% AEP SSP3 2100 scenario is presented in Figure 4.10. This comparison indicates minor increases in flood extent within the proposed rezoned areas, most notably to the west of Moorabool Street, immediately upstream of Barwon Terrace.

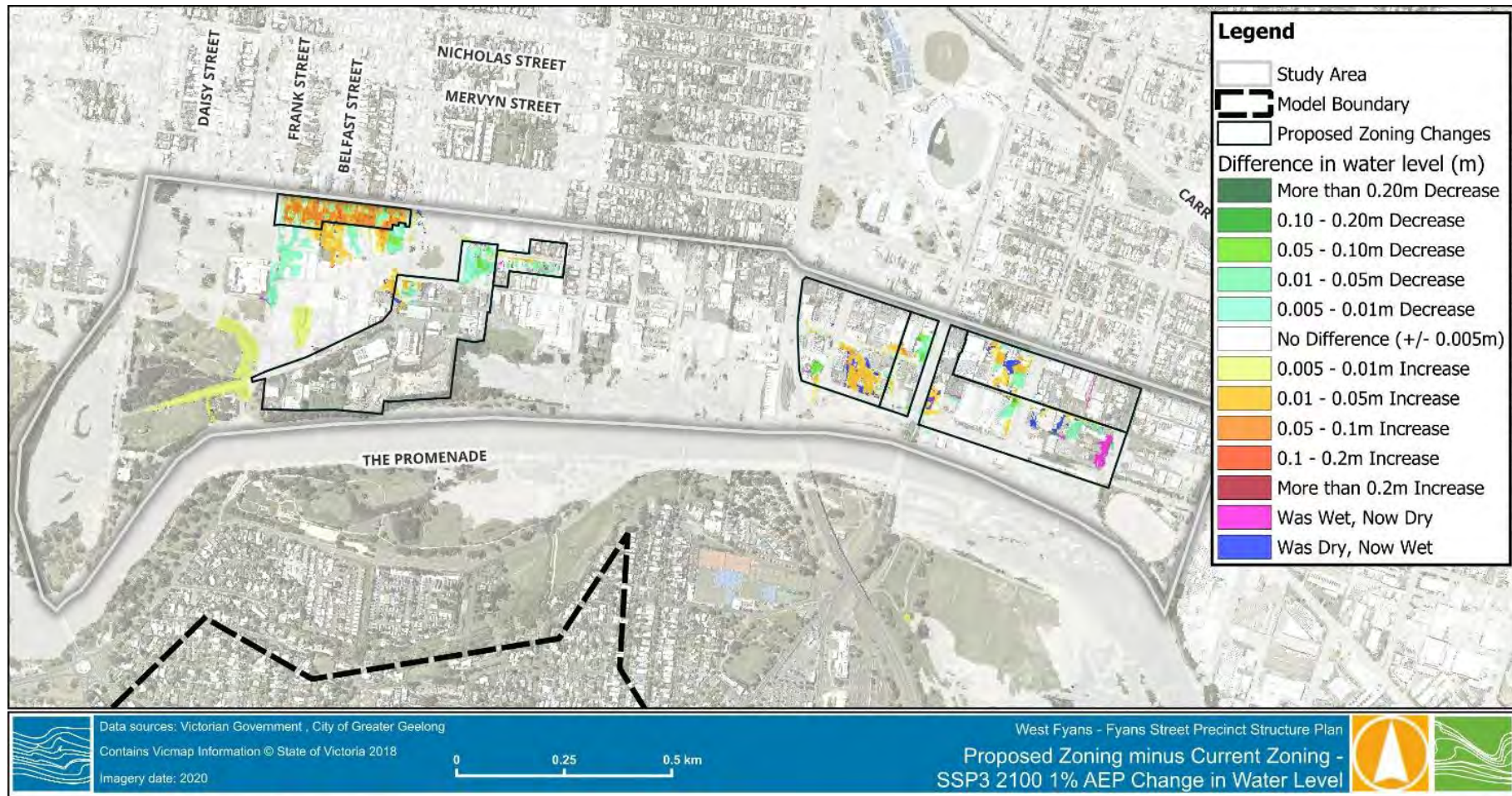


Figure 4.8 Existing vs ultimate developed 1% AEP SSP3 2100 water level difference

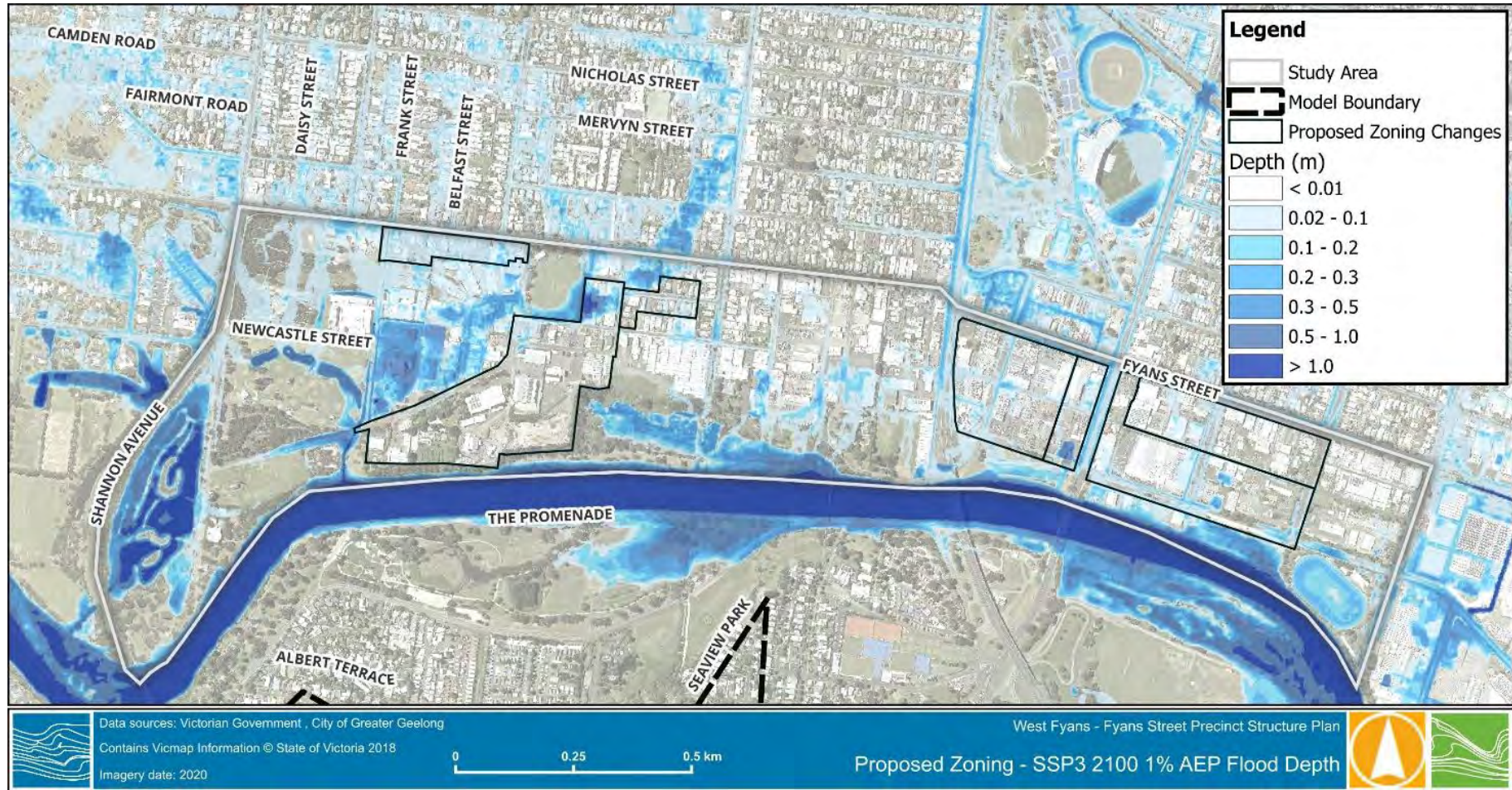


Figure 4.9 Ultimate developed scenario stormwater flood depth 1% AEP SSP3 2100

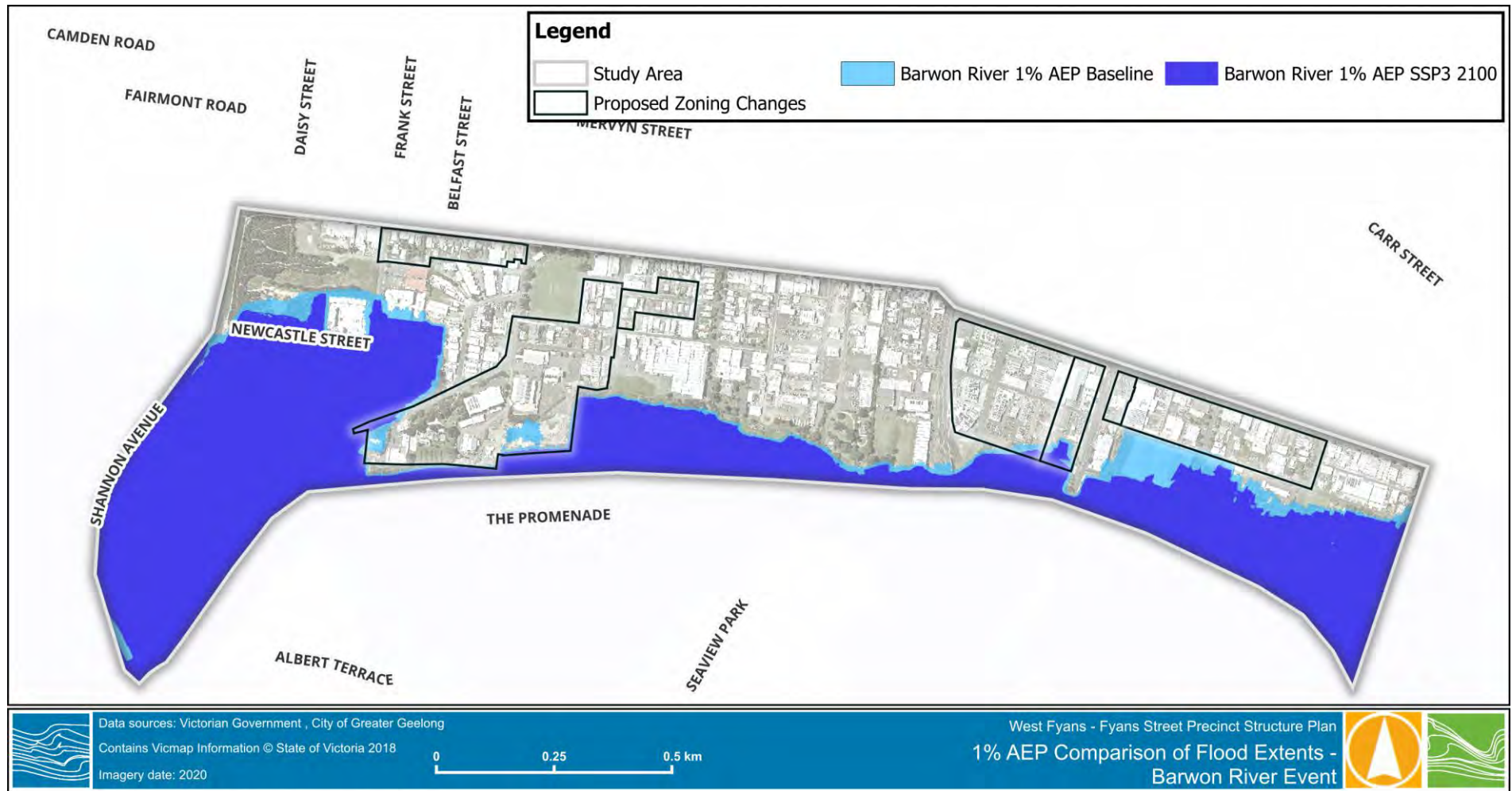


Figure 4.10 Barwon River flood depth plot 1% AEP SSP3 2100



5 STORMWATER QUALITY AND QUANTITY

The South Geelong Catchment Management Unit is identified as the highest priority for stormwater in the Greater Geelong region (City of Greater Geelong, 2021). Protecting and improving the health of receiving environments through stormwater treatment and excess reduction is therefore essential to plan for into the future.

Long term targets need to be understood for the catchment with respect to stormwater quality improvement and volume reduction. Establishment of targets ensures planning and infrastructure investment decision-making transparently addresses protection and enhancement of receiving environment values. This is especially important when facing the challenge of growth in an established, untreated urban catchment and a changing climate.

Water quality and quantity targets, when understood in conjunction with flooding, land use and water consumption within the precinct, give vision to opportunities to improve outcomes that may otherwise go unnoticed.

5.1 Modelling

The MUSIC (Version 6.3) water quality modelling for the catchment was developed in accordance with the City of Greater Geelong MUSIC Parameters Guidelines (City of Greater Geelong, 2019) and where locally relevant, the latest Melbourne Water MUSIC Guidelines (Melbourne Water, 2024).

The rainfall timeseries from the Geelong North pluviographic station (087133) was used in the MUSIC model for the period 1971 to 1990. This period was selected based on the recommended 20-year template consistent with the City of Greater Geelong MUSIC modelling guidelines (City of Greater Geelong, 2019). Monthly evapotranspiration data recorded at the same station (as recommended in the Geelong MUSIC Guidelines) was adopted. The MUSIC model was run with a 6-minute time interval.

Source nodes within the precinct were created for each catchment consistent with the parameters used in the RORB model (shown in Figure 5.1) including area and fraction impervious.

The fraction impervious for each catchment is adopted by applying standard planning zone imperviousness in line with Melbourne Water's Music Guidelines (Melbourne Water, 2024) for the pre-development, current and future conditions. The proposed development scenario involves a marginal increase in impervious fraction for several source nodes in the model, representing areas nominated for rezoning. The predevelopment scenario considers the precinct in an undeveloped state by reducing impervious fraction to 0% of all source nodes. This scenario gives an understanding of the historical impacts of development on stormwater pollutant and volume generation.

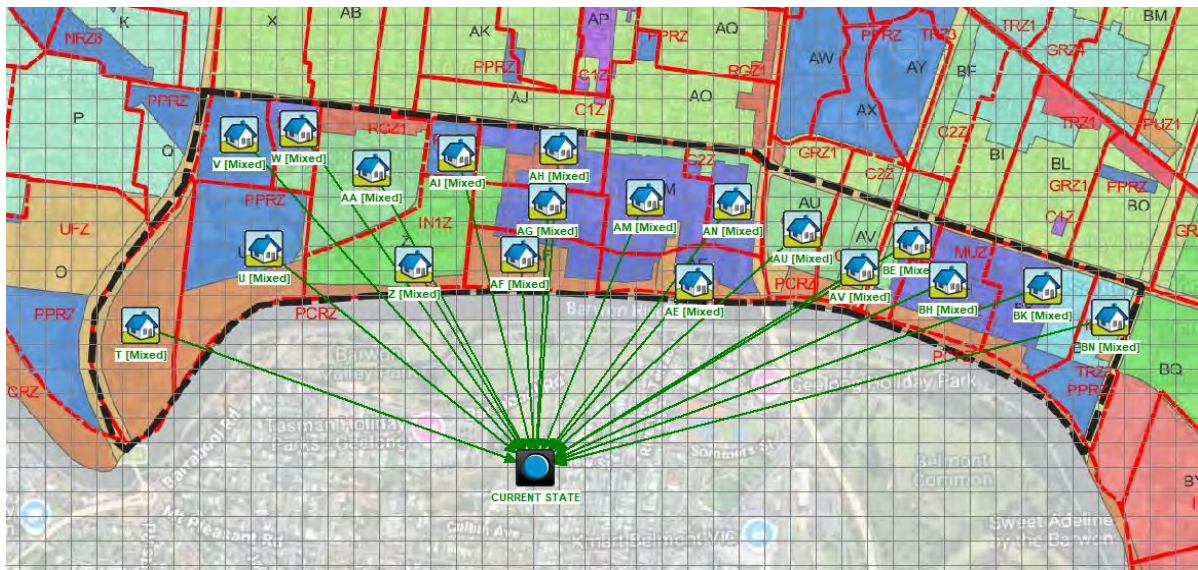


Figure 5.1 MUSIC model – catchments (existing planning zone conditions)

5.2 Water and Pollutant Balance

A water and pollutant balance was completed to understand the historical, current and future impacts of stormwater excess on the Barwon River and downstream systems (as it related to this precinct). Modelling was undertaken to estimate the stormwater volume and pollutant loads generated from the precinct area in its undeveloped state. These results are compared to the current developed and future rezoned state of development to gain an appreciation of the changes and impacts that have occurred to date and can be expected into the future, respectively.

The water balance for the precinct as shown in Figure 5.2 includes quantification of the volume of stormwater excess generated by existing development and future design scenarios including any urbanisation or densification from future development.

This draws from previous modelling inputs such as the South Geelong SWMS MUSIC unit model (Water Technology, 2025). The target volumetric reductions are quantified for the precinct consistent with EPA publication 1739.1 (EPA, 2021), including determination of waterway priority, and the applicable catchment scale stormwater harvesting/evapotranspiration and infiltration targets.

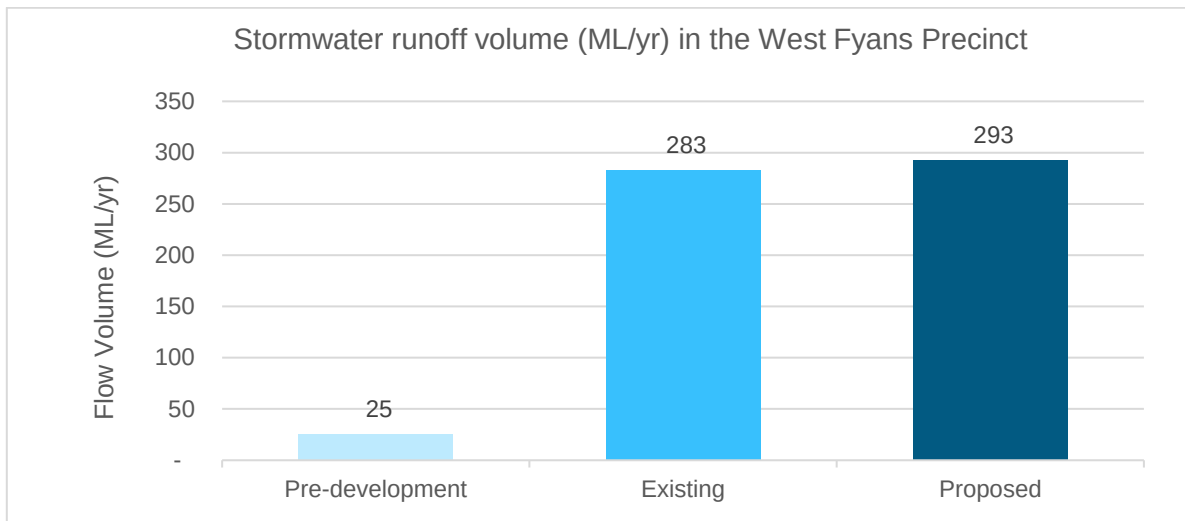


Figure 5.2 Stormwater runoff volume (ML/yr) generated in the West Fyans Precinct for pre-development, existing and proposed conditions

The MUSIC model is used to estimate the sources of stormwater pollution (in terms of nutrients and sediment) across the municipality and size stormwater treatment features. Table 5-1 shows indicative pollutant loads generated in the Fyans – West Fyans precinct. Stormwater pollutant volumes produced in the precinct for the three scenarios is presented in Figure 5.3. The model results do not consider any water quality treatment provided by existing assets, such as the various informal swales and billabongs in the Barwon River floodplain or the existing ponds on the Balyang Golf Course. These landscape features are not formal WSUD assets and are therefore not expected to provide a reliable water quality treatment benefit in their current form.

Table 5-1 Pollutant Mean Annual Loads estimated with MUSIC for pre-development, existing and proposed development scenarios

Catchment	Runoff (ML per year)	Total Suspended Solids (tonnes per year)	Total Phosphorus (kg per year)	Total Nitrogen (kg per year)
Pre-development	25	1	5	56
Existing	283	57	116	813
Proposed	293	59	120	840

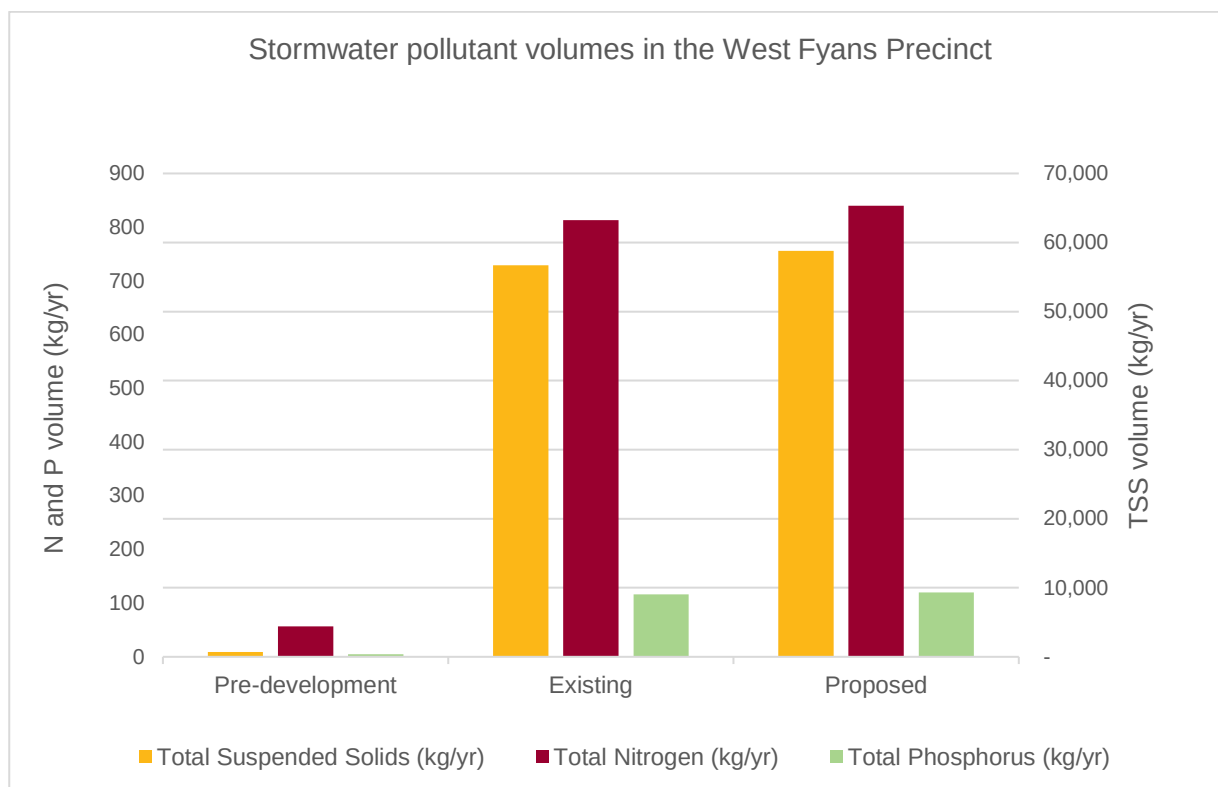


Figure 5.3 Stormwater pollutant volumes (kg/yr) produced in the West Fyans Precinct for pre-development, existing and proposed conditions. TSS volume on secondary axis.

The results indicate that the proposed redevelopment has minimal effect on the quality and quantity of stormwater excess generated in comparison to current conditions. This is due to the existing built state of the catchment and relatively minor increase in fraction impervious when redeveloped in line with updated zoning. Using the target reductions for stormwater volume and quality as per (EPA, 2021) and the modelled precinct-wide water and pollutant generation, the long-term aspirational targets for the precinct are shown in Table 5-2.

Table 5-2 Long term stormwater volume and pollutant reduction targets for the Fyans – West Fyans Precinct

Type	Reduction Target	% Reduction
Stormwater volume reduction – Total	227 ML/y	81%
Harvesting / evapotranspiration	210 ML/y	75%
Infiltration	17 ML/y	6%
Stormwater pollutant reduction		
Total Suspended Solids TSS	47,000 kg/y	80%
Total Phosphorus TP	54 kg/y	45%
Total Nitrogen TN	380 kg/y	45%

5.3 Alternative Water Demands

Demands for alternative water are primarily identified in and adjacent to the precinct as open space irrigation areas, namely where potable water is being used in an existing irrigation system. Secondary opportunities exist where a vegetated or open space facility is not being currently irrigated, yet the availability of alternative water (such as harvested stormwater) may present an opportunity to commence formal irrigation. These



demands will be harder to justify financially in the short term due to the capital cost of installing an irrigation system, however, may become more attractive opportunities when progressing towards greater pollution and excess management in the catchment.

A map of all identified open space irrigation demands is shown in Figure 5.4 below. Key open space irrigation demands within the precinct include Friers Reserve, Balyang Par 3 Golf Course and Landy Field. Notable potable water demands adjacent to the catchment include the King Lloyd Reserve and Kardinia Park.

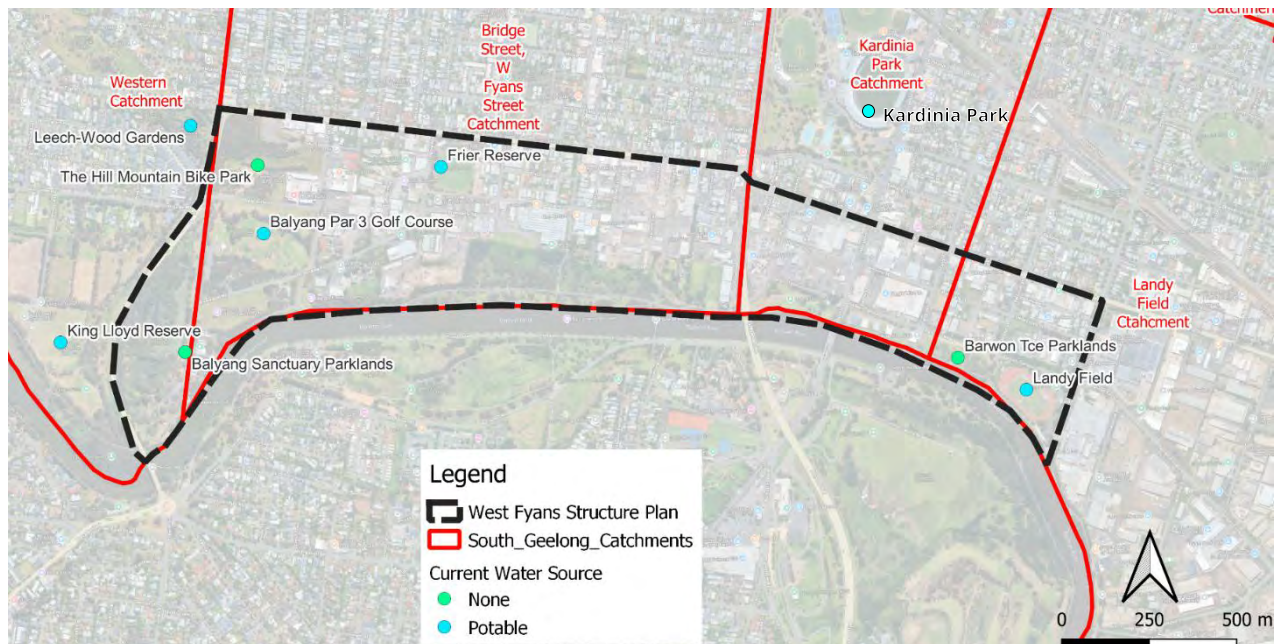


Figure 5.4 Opportunities for alternative water reuse (open space irrigation) within and adjacent to the precinct



6 STORMWATER MANAGEMENT OPTIONS ASSESSMENT

A range of mitigation options have been identified for further assessment in response to the updated flood modelling (Section 4), water quality modelling and volume reduction targets (Section 5).

A range of options, including newly identified alternatives, were subject to detailed assessment and validation using the updated modelling and design. The preferred options were determined based on feedback provided by City of Geelong officers during a workshop held on 14 April 2026. The outcomes of the detailed assessment are summarised in this section and discussed in detail in the appendices. Specific appendix reference for each mitigation option is included in Table 6-1 for flood mitigation and Table 6-2 for water quality and volume.

The new options taken to detailed assessment include:

- Pipe and pit upgrades in Fyans St (east) precinct and raising of Barwon Terrace (Appendix E) was tested in the updated flood model for climate change scenarios.
- The Pakington Street constructed wetland option was designed and costed in conjunction with the Pakington Street catchment diversion pipe (Appendix M), whereby a larger wetland treatment area is nominated to meet best practice for the diverted catchment.
- Lambert Avenue Diversion and Friers Reserve detention, updated to accommodate increases in runoff due to climate change.
- Prioritised Kerb raising along West Fyans and Fyans Streets.
- A water sensitive urban design (WSUD) enhancement pilot opportunity for LaTrobe Boulevard (Appendix J-1) is designed and costed, including details of the performance incorporating:
 - Passively irrigated street trees in the streetscape
 - Streetscape raingarden stormwater treatment cells for local redevelopment, and
 - End of line bioretention systems to treat the upstream, untreated Kardinia Park catchment.

A spatial summary of the various options assessed and revalidated is provided in Figure 6.11.

6.1 Flood Mitigation Options

This section includes a summary and key results of recommended flood mitigation options proposed in this report update. Detailed discussion on each option is included in the appendices, with referenced appendix section shown in and , for water quality treatment.

6.1.1 List of Historic and New Precinct Flood Mitigation Options

A consolidation of the previously assessed flood focused, water quality and volume mitigation options is summarised in , including a summary of each option, an estimate of cost and priority. Options drawn from previous studies have been re-costed and/or adjusted in line with the Consumer Price Index (CPI) (Australian Government, 2025).



Table 6-1 Structural flood mitigation options

Source	Project	Priority	Cost (2025 adjusted)	Change/Upgrade Recommended	Funding	Appendix Reference
2008 Bridge Street Main Drain and Western Gully Main Drain Flood Study Report (BMT WMB, 2008)	Pipe Upgrades through Friers Reserve	High	\$2,500,000	New pipe along West Fyans Street, under Friers Reserve along Lambert Avenue to Riversdale Road under Riversdale Road then down to existing open channel. Calculated BCR of 0.33.	Unknown	Appendix A
2018 West Fyans-Fyans Structure Plan (Water Technology, 2018)	Pakington St Outfall	High	\$320,000	Upgrade required to address Hazard and Erosion	Council	Appendix M
	Pakington St Diversion	Low	\$2,530,000	Reduction in Flood Risk and increase water quality treatment	Council	Appendix M
	Frier Reserve RB*	Low	\$630,000	Reduction in Flood Risk	DCP/ Council	Appendix B
	Lambert Avenue Diversion*	Low	\$1,400,000	Reduction in Flood Risk	Council	Appendix B
	Riversdale Rd Drainage	High	\$320,000	Reduction in Flood Hazard and Erosion issues	Council	Appendix D-1
	Newcastle St Drainage	High	\$190,000	Reduction in Flood Hazard and Erosion issues	Council	Section 3.2.
	Pipe Maintenance	High	\$630,000	Asset Maintenance - Flood Risk	Council	Appendix H
	Update Planning Controls for Riverine Flooding	High	\$63,000	Update LSIO & FO based on ARR2016 guidelines for Barwon River Study	Council	N/A
	Update Planning Controls for Urban Flooding	High	\$127,000	Undertake detailed mapping of study area and upper catchment to produce SBO mapping (see below, undertaken in South Geelong SWMS 2025)	Council	N/A



Source	Project	Priority	Cost (2025 adjusted)	Change/Upgrade Recommended	Funding	Appendix Reference
2025 South Geelong SWMS (Water Technology, 2026)	Flooded road/ road closure sign on Barwon Terrace at Moorabool Street	Low	Low – not costed	To prevent driving east on Barwon Terrace during stormwater and riverine flood events.	Council	Appendix F
	Update Planning Controls for Urban Flooding	High	N/A	Undertake detailed mapping of study area and upper catchment to produce SBO mapping	Council	Appendix C
New Options	Alternative Riversdale Road Diversion	Not considered	N/A	Option shortlisted but not advised by City to proceed with further analysis	N/A	Appendix D-1
	Hampton Street Diversion	Not considered	N/A	Option shortlisted but not advised by City to proceed with further analysis	N/A	Appendix D-2
	Fyans Street Pipe Upgrades and Augmentation	Medium		Upgrade and augment pipes for future rezoning	Funding joint with proposed developments and City.	Appendix E

6.1.2 Lambert Avenue Diversion and Friers Reserve Detention

This area is recognised as a significant flood risk location within both the catchment and the precinct. As such, large-scale mitigation measures are likely to be the only interventions capable of materially reducing flood impacts. Smaller or localised measures are unlikely to provide meaningful flood relief unless an easement is secured along a substantial portion of Lambert Avenue, allowing the diversion to function as an open drainage channel.

Variations to this option were also investigated to provide additional flood mitigation under climate change conditions. For the enhanced mitigation scenario, an additional 2 ML of storage was incorporated, increasing total storage to 4 ML, along with an additional pipe barrel following the alignment of the existing stormwater system. The resulting changes in water levels for this increased storage option are presented in .

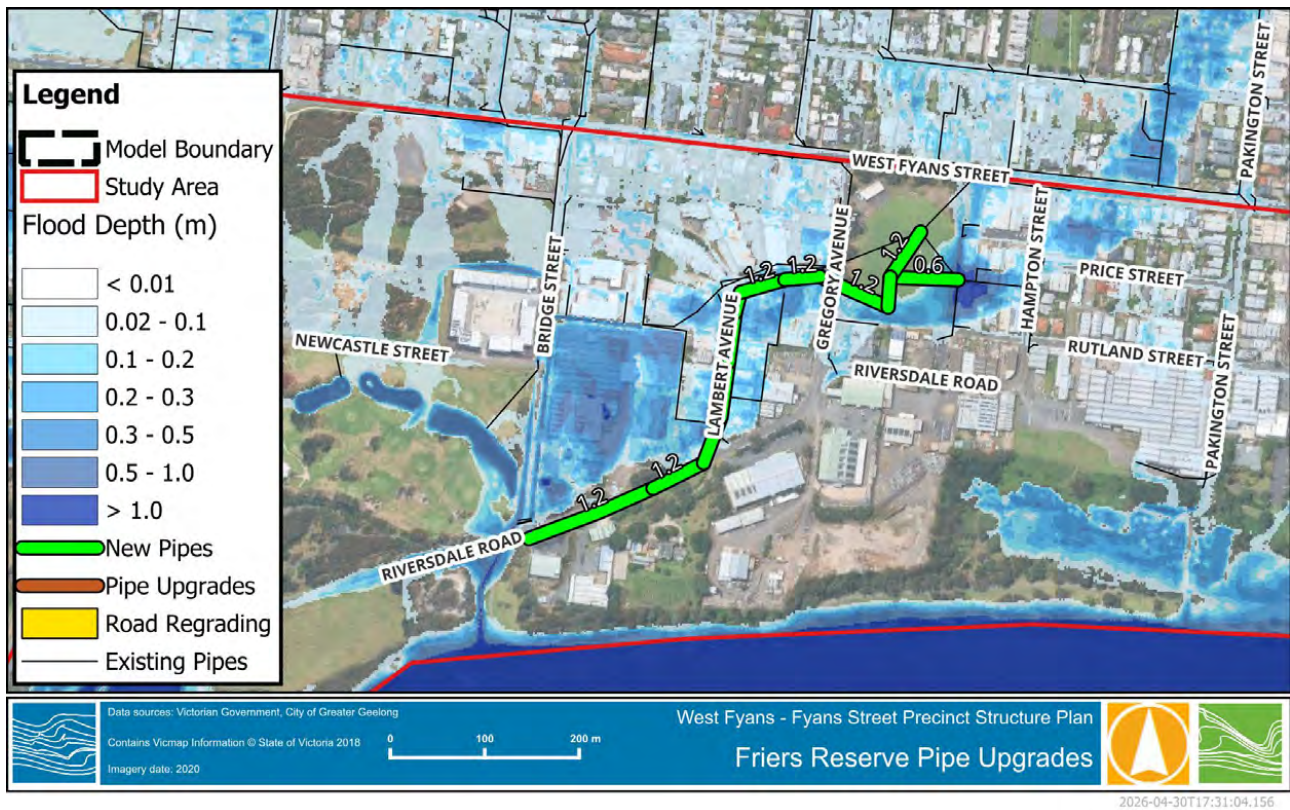


Figure 6.1 Friers Reserve pipe upgrades

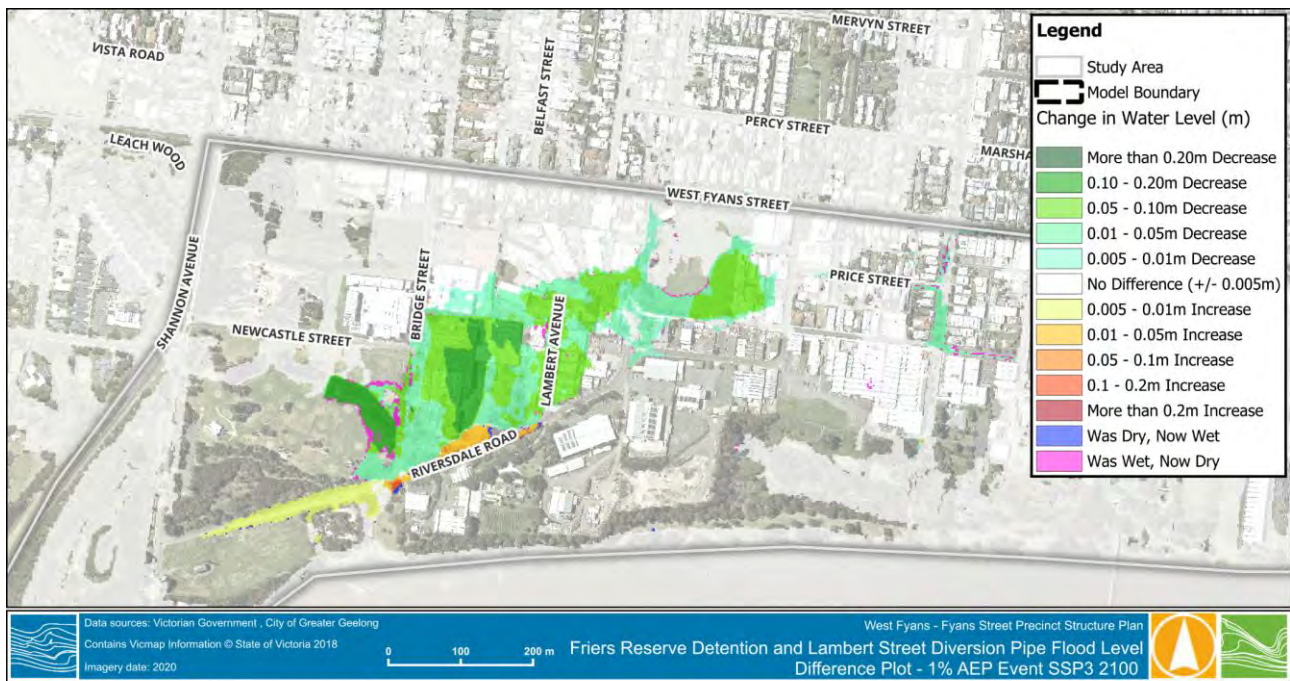


Figure 6.2 Friers Reserve detention and Lambert Street diversion pipe flood level difference plot



6.1.3 Fyans Street Pipe Upgrades and Barwon Terrace Road Raising

Key flooding issues on the eastern side of the precinct are concentrated along the lower section of Little Fyans Street between Wills Place and Bellarine Street. This area is inundated under the future 1% AEP Barwon River flood extent, while low points along Barwon Terrace are overtopped under the future 1% AEP stormwater flood event. This results in the loss of north to south through-traffic along Barwon Terrace. In consultation with Council, a mitigation option is proposed that involves raising the low points along Barwon Terrace to future-proof the road against climate change increases in rainfall intensity and to improve trafficability during storm events. This option indicates alignments of stormwater that will likely need to be updated to adapt to future increases in rainfall and increased fraction impervious. The details of the proposed pipe upgrades and sizing are presented below in .

It should be noted that the pipe upgrades were assessed both with and without upgrading the outfall pipe at the end of Yarra Street. This approach was taken because any works adjacent to the Barwon River require a more complicated approval process with CCMA. The results show that excluding the outfall upgrade () or including it () does not change impacts upstream of the Barwon River. This indicates that the pipe upgrades can proceed without the need to upgrade the outfall.

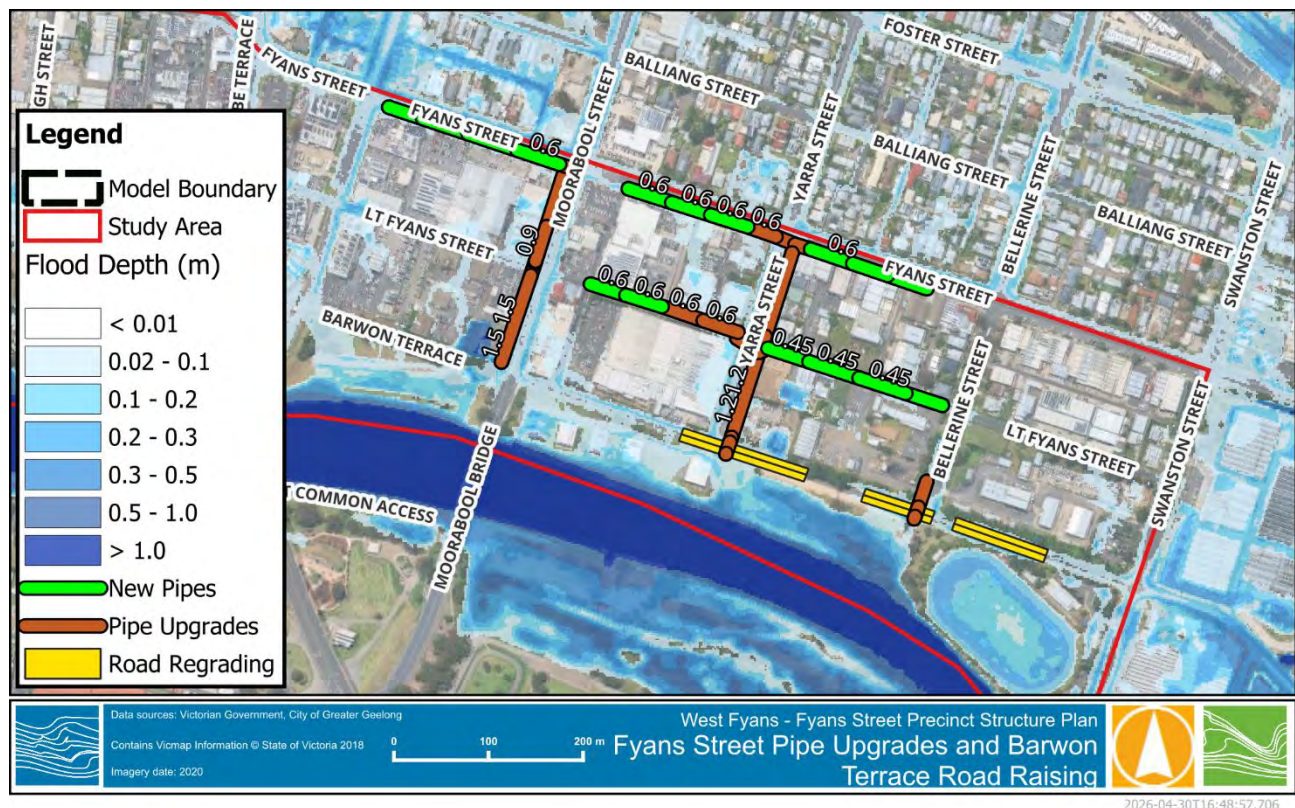


Figure 6.3 Fyans Street pipe upgrades and Barwon Terrace road raising

Flood level difference plots for the pipe augmentation and road-raising works are presented in . Impacts with outfalls upgraded are shown in Appendix E. The modelling results indicate reductions in flood depths of up to 60 mm within the road reserve along Fyans Street, Moorabool Street and Yarra Street. The proposed road raising along Barwon Terrace also allows the road to become trafficable during the climate change 1% AEP event. Some isolated increases in flood depth are of up to 180mm are predicted on the upstream side of Barwon Terrace due to of ponding caused by the raised road levels. These areas present an opportunity to incorporate distributed water sensitive urban design measures, such as irrigated street trees, 'urban sponges'



or landscaped verge areas. These asset types can contain flooding while storing and absorbing excess floodwaters adjacent to the roadway

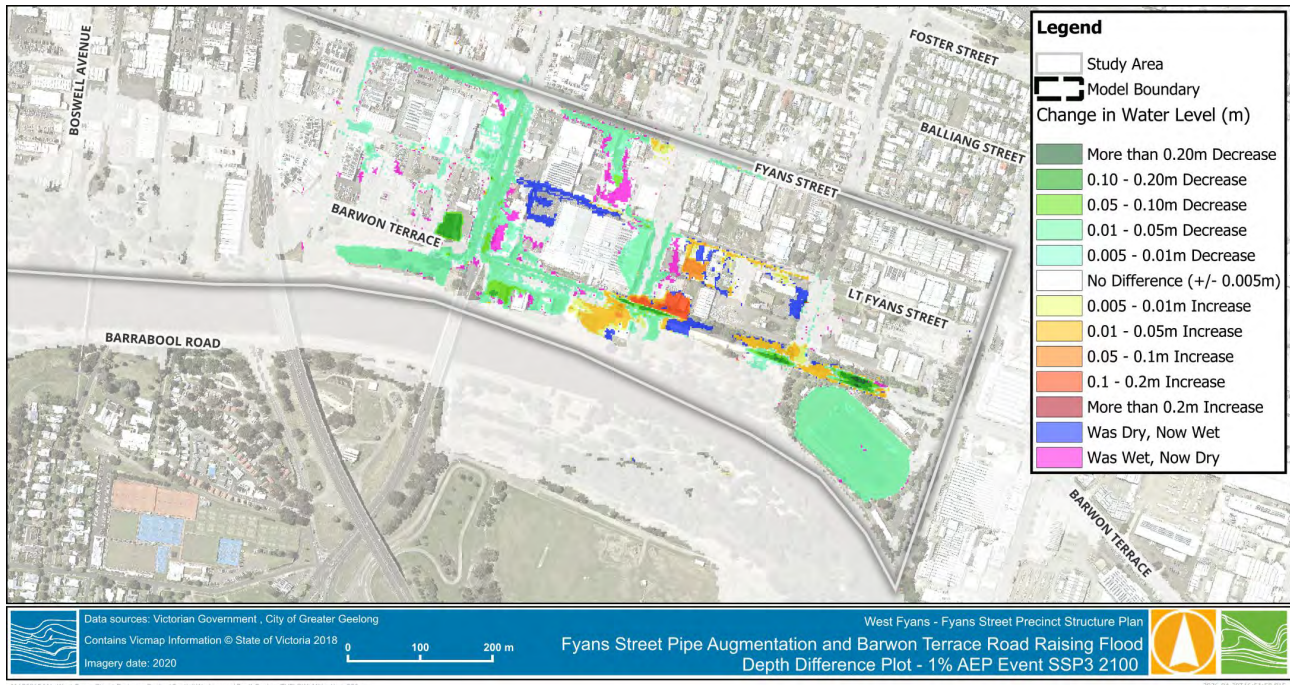


Figure 6.4 Fyans Street pipe augmentation and Barwon Terrace road raising flood depth difference plot

6.1.4 Fyans Street Kerb Raising

Due to the predominantly north–south direction of stormwater flooding, combined with the steep grades of streets running perpendicular to West Fyans–Fyans Street, the lower side of the street is subject to overland flow. Inspection of existing kerb heights along these streets indicates that the kerb and channel infrastructure is aged and may not achieve the current maximum kerb height. To future-proof West Fyans–Fyans Street and downstream properties against increased rainfall intensity associated with climate change, it is recommended to upgrade the kerbs to the maximum allowable height of 150 mm. This maximum height is in accordance with the Infrastructure Design Manual (Local Government Infrastructure Design Association, 2025). The recommended kerb height upgrades within the precinct are shown in .

Where adjacent lots are proposed for redevelopment, The City might consider requiring the developer to lift the kerb to alleviate the existing flooding issues fronting the property. A full prioritised list of segments of the kerb to be raised, based on severity of stormwater flooding and areas proposed to be rezoned is provided in Appendix G. Two sections of kerb that are recommended as highest priority to update are the following:

1. 290m segment of kerb between Frank Street to Gregory Avenue, and
2. 373 segment of kerb between Gregory Avenue to Percy Street.

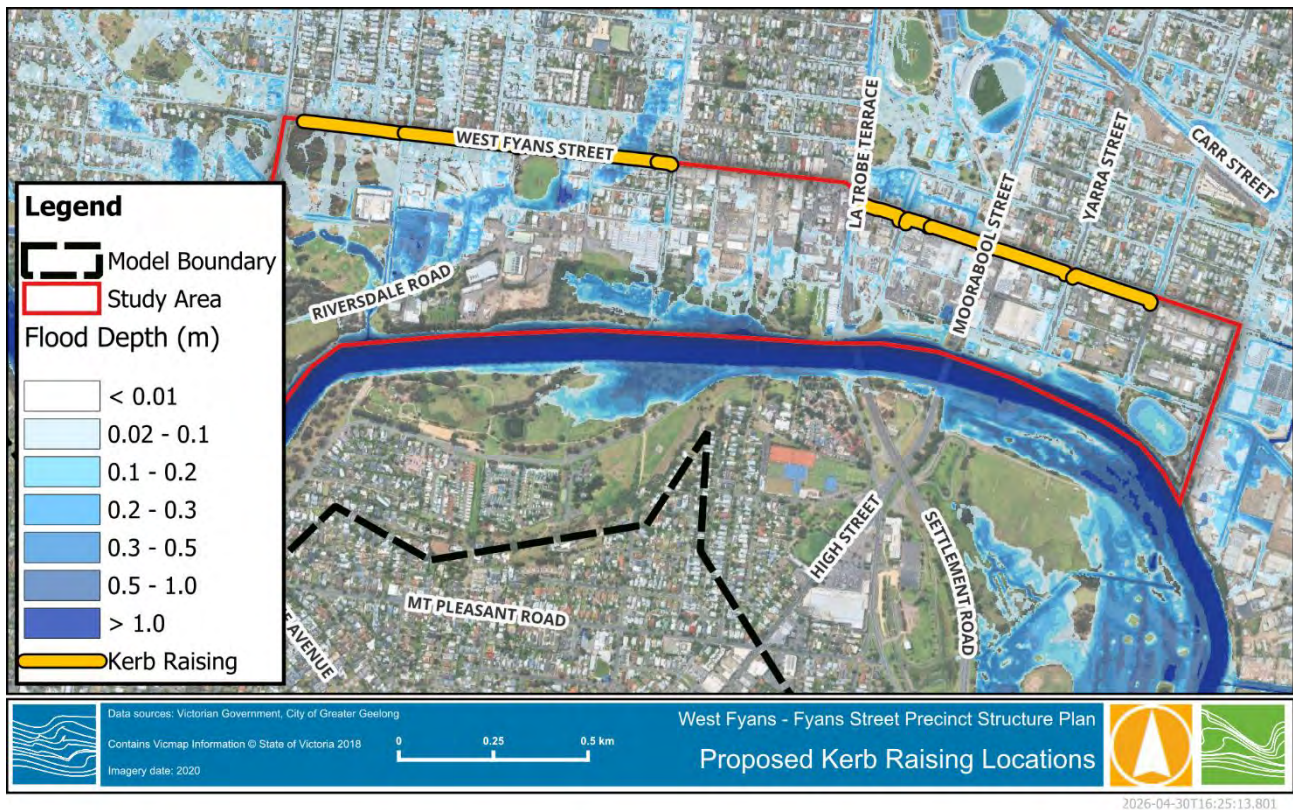


Figure 6.5 West Fyans-Fyans Street kerb raising locations

6.1.5 Pakington Street Outfall

The Pakington Street diversion, originally proposed in the 2108 West Fyans-Fyans precinct structure plan has been reconsidered and updated for this 2026 report update. The effectiveness of this option at diverting water away from Friers Reserve and proposed rezoning lots is presented below in Figure 6.6. This option was not retested in the South Geelong SWMS but its effectiveness when coupled with a wetland at the southern end of Pakington Street is recommended, as described in concept in Appendix M.

The Pakington Street diversion pipe option incorporates new pipe alignments along Pakington Street, south of Nicholas Street, that collects flows from underground drains in Nicholas, Mervyn and Percy Street's. The diversion pipe directs flows along Pakington Street South and outfalls to the Barwon River floodplain in the vicinity of the existing pipe outfall. While this option is likely to have a number of constraints relating to services and disruptions along Pakington Street, it offers additional opportunities to improve the quality of water flowing to the Barwon River. This improvement could be accomplished by formalising a constructed stormwater treatment wetland in the Barwon River floodplain at the location of the existing small informal wetland. This proposed constructed wetland can treat stormwater runoff beyond best practice prior to flows entering the Barwon River, improving water quality in the receiving environment and resolving legacy catchment water quality issues for the diverted catchment.

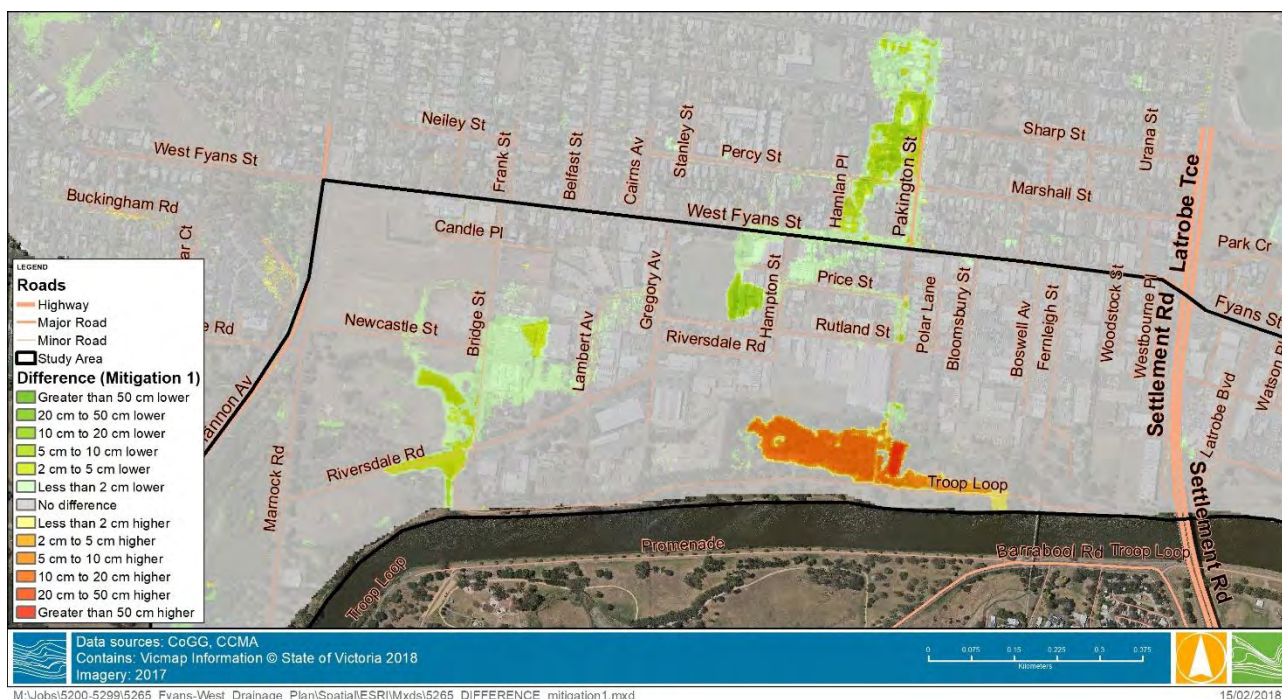


Figure 6.6 Mitigation Option 1 (Pakington Street diversion pipe) flood level difference plot

6.2 Water Quality Treatment Options

Key water quality treatment options that are proposed in the precinct as part of this 2026 report update are discussed below. For detailed concept and calculations of each option, refer to its appendix section as referenced in . A range of options at private, street and precinct scale are proposed within the West Fyans-Fyans precinct to

6.2.1 List of Historic and New Water Quality Treatment Options

A consolidation of the previously assessed water quality and volume mitigation options is summarised in , including a summary of each option, an estimate of cost and priority. Options drawn from previous studies have been re-costed and/or adjusted in line with the Consumer Price Index (CPI) (Australian Government, 2025).

Table 6-2 Water quality treatment and flow volume reduction options

Source	Project	Priority	Cost (\$2025)	Change/Upgrade Recommended	Funding	Appendix Ref.
2018 West Fyans-Fyans Structure Plan Drainage Assessment	Pakington St Wetland	Medium	\$800,000	Formalisation of small constructed wetland to treat small Pakington Street South industrial catchment	Developer's Council Offsets	Concept updated in Appendix M.



Source	Project	Priority	Cost (\$2025)	Change/Upgrade Recommended	Funding	Appendix Ref.
(Water Technology, 2018)	Barwon Terrace Wetland	Low	\$1,250,000	Construction of wetland in parklands adjacent to Landy Reserve to intercept existing untreated outfalls to Barwon River	DCP/ Council	Not progressed.
	Balyang Golf Course Wetland	Low	\$600,000	Divert existing drainage and configure golf course ponds to treat stormwater from Bridge St catchment	DCP/ Council	Concept updated in Appendix L.
	Floodplain Riparian Woodland	Low	\$500,000	Improved water quality / aesthetic & ecological values by directing stormwater to regularly soak the vegetation community	Council	Concept updated in Appendix L.
2026 South Geelong SWMS (Water Technology, 2026)	Gross Pollutant treatment on existing untreated outfalls	High	\$450,000 for top 10 (\$1,600,000 with 50 years of maintenance)	Installation of GPT's on existing untreated outfalls to the Barwon River. 16 of these outfalls sit within the study area	Council	Appendix K



Source	Project	Priority	Cost (\$2025)	Change/Upgrade Recommended	Funding	Appendix Ref.
	Balyang Golf Course stormwater treatment, harvesting and irrigation	High	\$1,340,000	Alternative configuration to (Water Technology, 2018) to include formalised constructed wetlands, harvesting for golf course irrigation, flooding of riparian woodland with excess treated stormwater and updated costing	Council	Appendix L
Balyang Waterbodies Maintenance Plan Summary (E2Designlab, 2013)	Renewal of the Balyang Sanctuary stormwater treatment wetlands	High	Not costed	Various upgrade and maintenance recommendations to ensure health and functionality of the stormwater treatment wetlands within the Balyang Sanctuary complex.	Unknown	N/A
New Options	Pakington Street diversion and enhanced stormwater treatment wetlands	Medium	\$1,300,000 (diversion) \$1,800,000 (constructed wetlands)	Construction of formal stormwater treatment wetlands to meet Best Practice for the diverted Pakington Street catchment	Council Grants Offsets	Appendix M
	Streetscape enhancements - WSUD	Medium	\$2,000 - \$10,000 per tree	21 new passively irrigated street trees Raingardens in LaTrobe Boulevard Bioretention in Barwon River corridor	Developers	Appendix J-1



6.2.2 Primary treatment of existing Barwon River outfalls via new Gross Pollutant Traps

Sixteen (16) existing outfalls in the precinct currently discharge stormwater to the Barwon River untreated. This concept proposes proprietary gross pollutant traps to intercept untreated flows and improve the quality of stormwater entering the river. The and full prioritised list of upgrades was determined in the South Geelong SWMS (Water Technology, 2026) and is discussed in detail in Appendix K

The outfall locations and reference are shown in Figure 8.2, including upstream catchments and existing land use. Table 8-2 in the appendix details the analysis undertaken to prioritise the rollout of treatment devices, including an estimate of costs and benefits for each identified outfall location. The prioritisation of outfalls is undertaken based on the predicted performance of suitable GPT product over a 50-year operating life considered alongside the present value whole of life cycle cost to purchase, install and maintain the device over the 50 years. The top five (5) prioritised GPT locations include the following:

1. Southern end of Bridge Street downstream of Riversdale Road, Newtown (161)
2. Western side of Settlement Road bridge, South Geelong (162)
3. Eastern side of Barwon Bridge, South Geelong (165)
4. Wills Place, South Geelong (163)
5. Bellerine Street, South Geelong (167b)

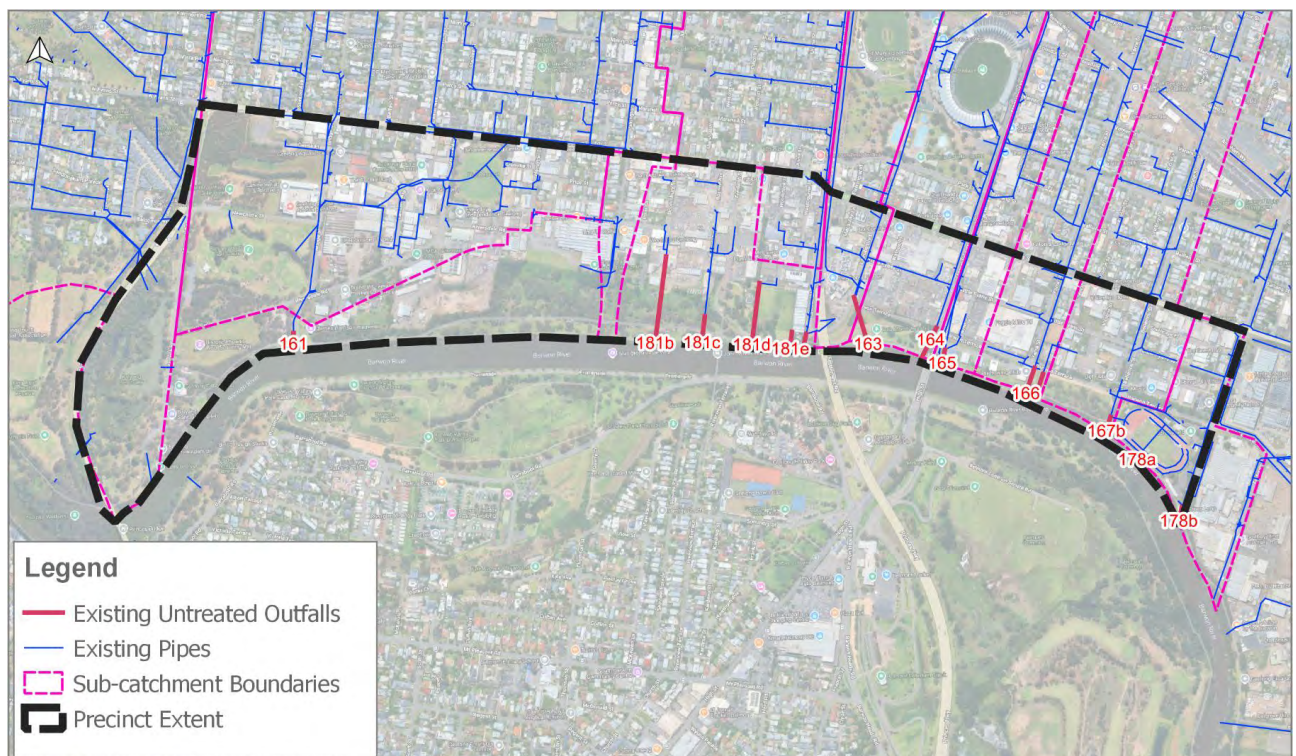


Figure 6.7 Proposed GPT locations

6.2.3 Pakington Street Diversion Pipe and Wetland

A new constructed wetland is proposed within the Barwon River floodplain to treat the diverted Pakington Street catchment to Best Practice. The proposed wetland comprises an inlet pond to capture coarse sediments



and an enhanced macrophyte zone to trap finer sediments and enable biological uptake of nutrients such as nitrogen and phosphorus. Ensuring a residence time in the order of 72 hours will enable sufficient time for biological uptake to occur along with evapotranspiration losses from the standing water bodies contributing to flow volume reduction losses. When the wetland extended detention is full, flows can be directed to bypass the macrophyte zone via overtopping of the inlet pond directly to the Barwon River, protecting the sensitive macrophytes from high velocities and extended inundation periods. The proposed concept for the wetland is shown below in Figure 6.8 and discussed in detail in Appendix M.

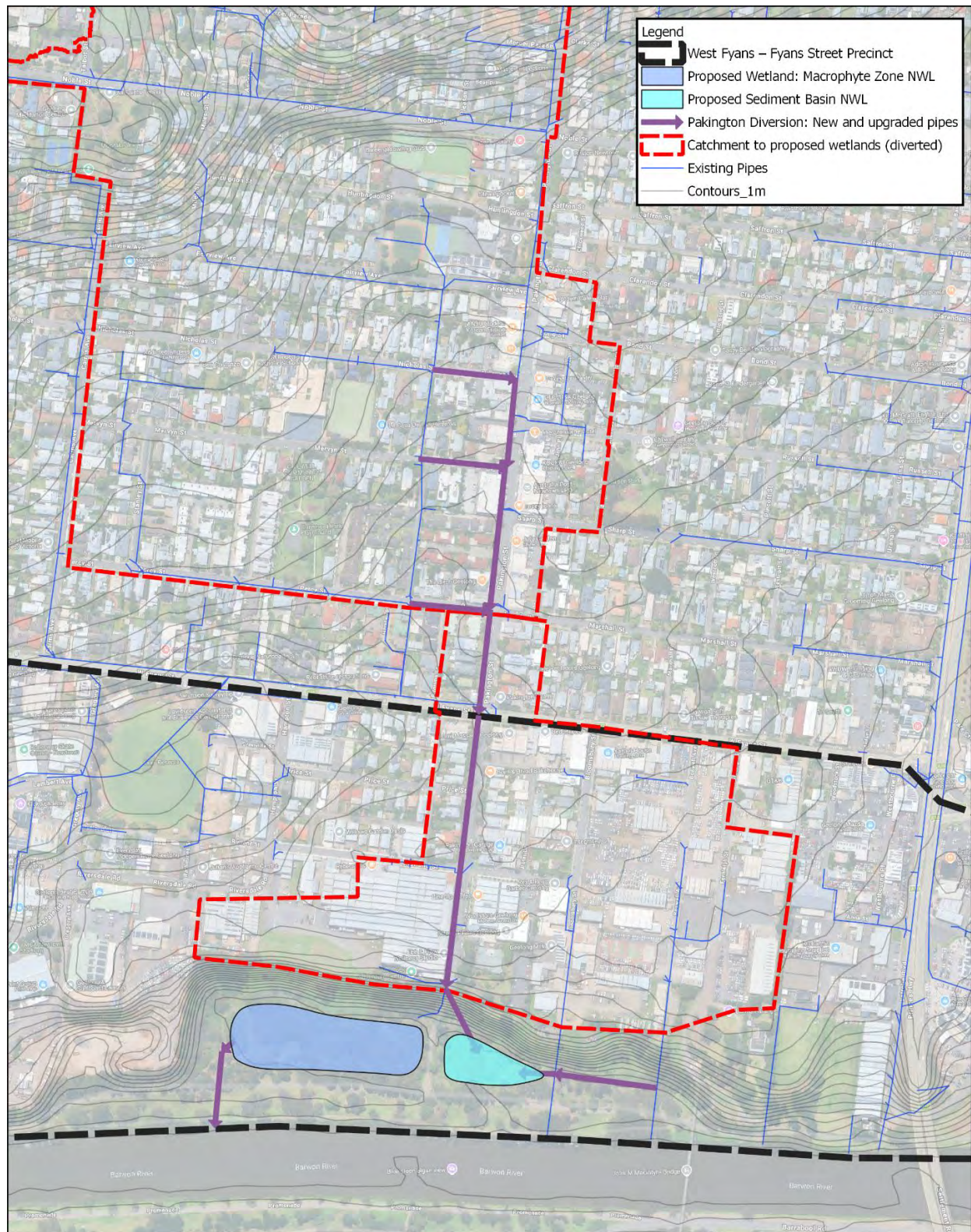


Figure 6.8 Pakington Street diversion pipe and constructed wetlands concept



6.2.4 Latrobe Boulevard WSUD Enhancement

The streetscape of Latrobe Boulevard, south of Fyans St to the Barwon River, is identified as a significant opportunity and potential flagship street to incorporate streetscape water sensitive urban design elements. This street is currently a commercial industrial area with limited pedestrian use.

The properties fronting Latrobe Boulevard are nominated for redevelopment to Residential Growth Zone and will likely form a key public access connection between the landmark Kardinia Park complex to the north, and the Barwon River waterway corridor to the south. Such a change in the zoning will bring urban environment changes that necessitates careful planning, including increased emphasis on public amenity, aesthetics and liveability outcomes.

A WSUD approach to stormwater management in the new residential streetscape can support these and other outcomes that align with City of Greater Geelong strategic priorities. Some WSUD responses suitable for Latrobe Boulevard and their benefits are described in .

The opportunities to incorporate WSUD elements into the Latrobe Blvd streetscape and Barwon River corridor is shown below in and concept discussed in detail in Appendix J-1

Table 6-3 WSUD elements nominated for Latrobe Boulevard

WSUD Type	Catchment	Benefits
Passively irrigated street trees	Public realm impervious surfaces – roads and footpaths	■ Improve greening and tree canopy cover ■ Urban heat mitigation
Streetscape raingardens	Private property impervious surfaces – properties undergoing development / redevelopment	■ Enhance biodiversity ■ Improve soil moisture conditions ■ Water quality improvement
End-of-line bioretention systems	Kardinia Park Main Drain	■ Stormwater volume reduction via infiltration and evapotranspiration ■ Flooding and climate change mitigation

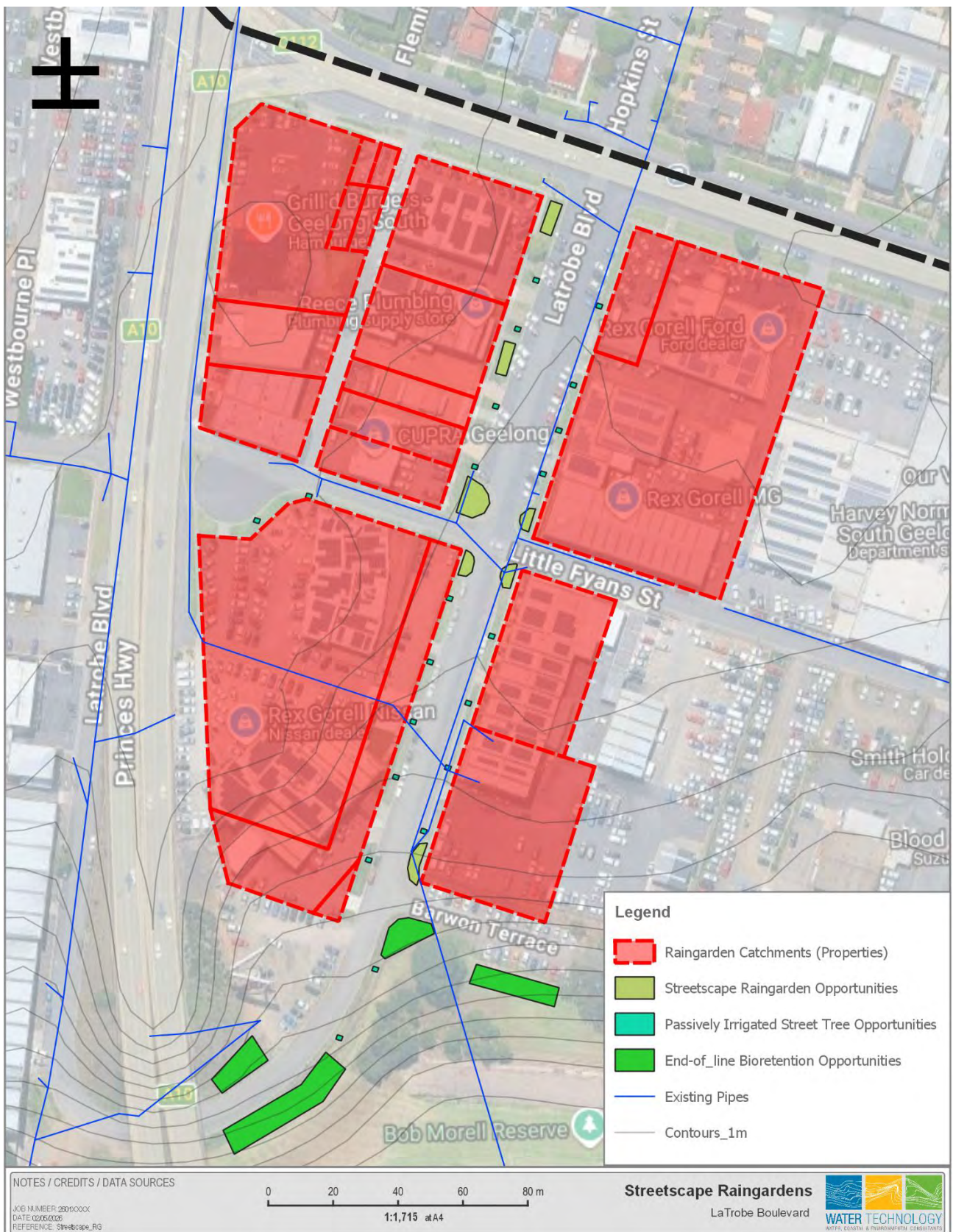


Figure 6.9 WSUD enhancement of Latrobe Boulevard: potential streetscape raingarden catchments and WSUD asset locations



6.2.5 Streetscape Raingardens and Bioretention

Biofilters, often called raingardens or bioretention, receive stormwater flows and allow them to be absorbed into and infiltrate through a filter media. Biofilters can act as both filters and sponges for water. These are recommended throughout the precinct, with detailed analysis of function, adoption and constraints, design considerations and option performance are discussed in Appendix J-3

The media works in combination with vegetation and microbes within the biofilter to naturally filter the water, removing sediment, pollutants and litter from runoff. The pollutants which are trapped within the soil via physical, chemical and biological processes are often then used by the plants as nutrients. Water is then usually directed via an underdrain and conveyed into the underground drainage system. Biofilters allow water to be returned to the atmosphere via evaporation and plant transpiration (evapotranspiration). They are usually not lined and allow water to infiltrate into the underlying soil, recharging groundwater and reducing stormwater excess runoff to downstream receiving waters. The reductions in volume and frequency as well as attenuation allow biofilters to more closely represent the natural environment prior to development in terms of stormwater flows.

Biofilters can be used in a range of sizes and locations, such as above ground planter boxes or as part of streetscape landscaping within median strips or adjacent to footpaths. Given their use throughout urban environments, they can provide habitat and shelter for various plants and animal species, promoting biodiversity and enhancing ecological connectivity. Depending on the size of vegetation used, they can also provide shade and promote cooling through evapotranspiration.

Biofilters typically consist of:

- Extended detention (ponding) with the level of the overflow or bypass above the filter media surface
- Filter media which encourages plant growth as well as filtration of pollutants
- Dense planting throughout the filter media
- Transition and drainage layers which collect filtered water
- An underdrain which provides connection into the drainage network
- High flow bypass structure

Additional features that may be included:

- Sediment control such as a forebay or gross pollutant trap
- Submerged zone: This provides a store of water to help plants survive dry periods and improves overall treatment performance.



Figure 6.10 Streetscape raingarden (sourced from WSUD Engineering Procedures: Stormwater, Melbourne Water)

6.3 Summary of Options

A summary of all stormwater management options proposed within the precinct, incorporating previously recommended options in the 2018 report, South Geelong SWMS and this report updated are presented below in Figure 6.11.

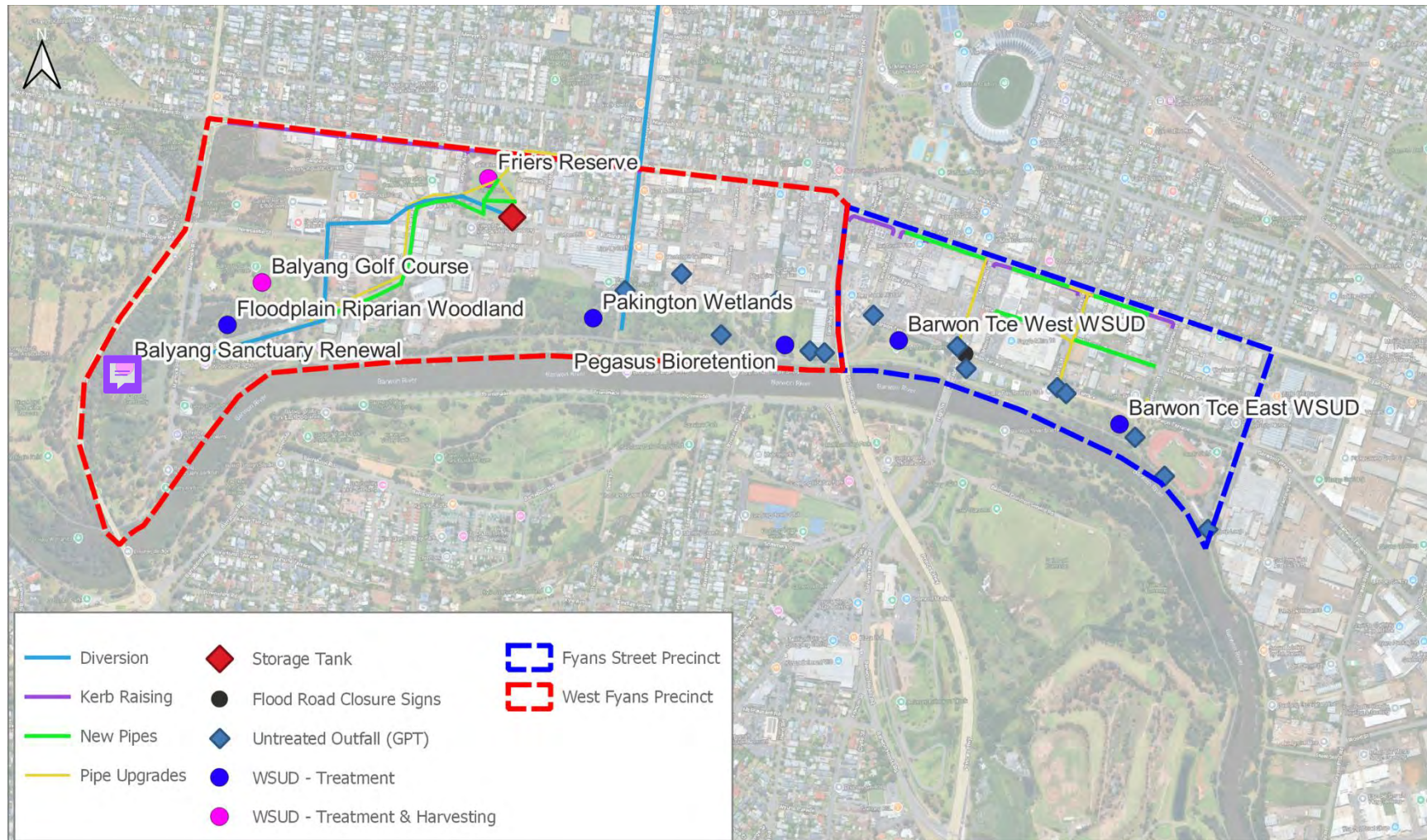


Figure 6.11 Overview of options assessed for the Fyans – West Fyans Precinct



7 RECOMMENDATIONS

A graphical summary of the recommendations at various scales and for various benefits is shown in Figure 7.1.

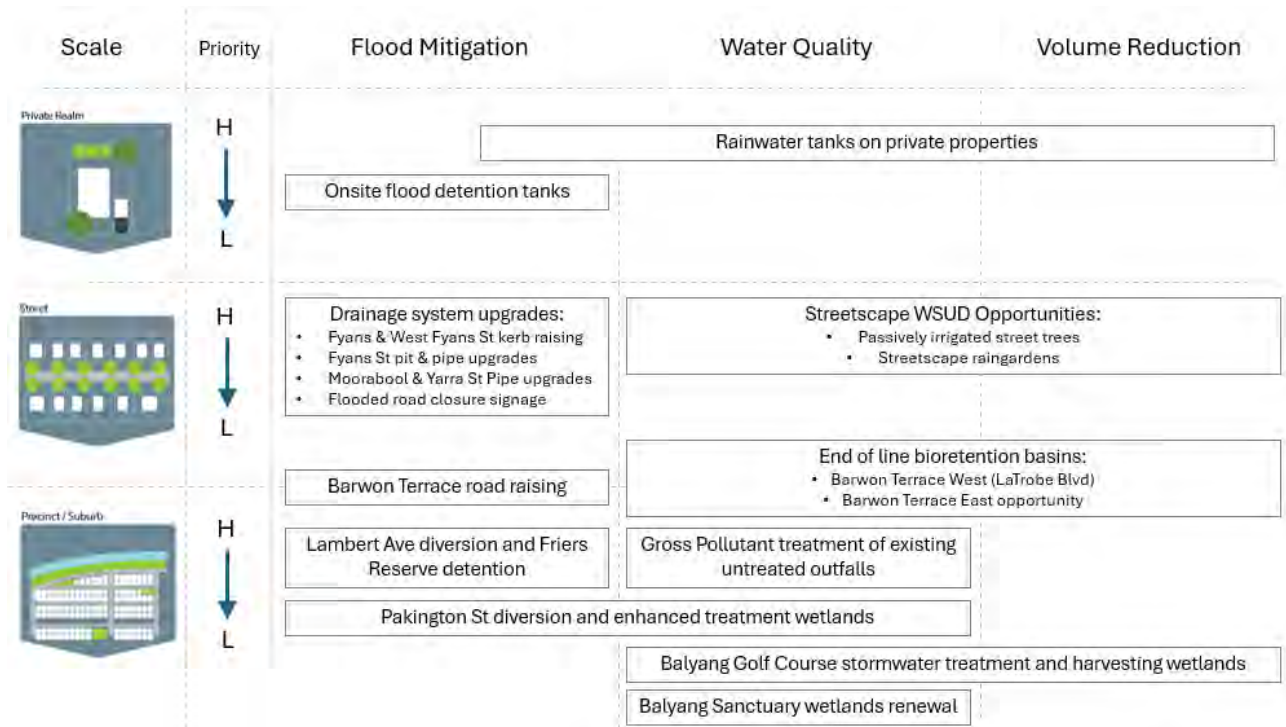


Figure 7.1 Summary of recommended stormwater management options at various scales

7.1 Private Realm

The planned rezoning and any redevelopment that occurs within the precinct presents opportunities to incorporate lot-scale stormwater management on private allotments. Requirements for developers to provide rainwater tanks and onsite flood detention tanks (OSD) at their own cost are well-proven methods for managing stormwater in such scenarios with strong precedent incorporated into many local planning schemes throughout Victoria.

Rainwater tanks can be fed by runoff from roofs and plumbed to households, commercial or industrial buildings to provide alternative water for toilet flushing, laundry use, garden irrigation and other non-potable commercial or industrial uses. Such an arrangement can reduce the demand for potable water supplies by up to 25% (households), while reducing the damaging stormwater excess volumes and pollutants from reaching the downstream waterways. They can be typically mandated for installation and connection for new developers via planning scheme provisions, and incentive programs can be explored to encourage retrofitting on existing dwellings.

On site detention tanks for new redevelopments may be more difficult to mandate due to the rezoning likely to have limited impact on catchment imperviousness compared to existing catchment conditions. This means application of a requirement for developers to install onsite flood detention tanks will be limited to where redevelopment proposes to increase site imperviousness substantially. Implementation could contribute to addressing residual risk so is highly encouraged.



7.2 Street Scale

Substantial opportunities exist for stormwater improvement interventions at the street scale, particularly in the Fyans Street (east) precinct area with respect to flood alleviation and future proofing existing infrastructure via pipe and pit upgrades and road modifications. Key opportunities for stormwater quality and volume reduction are limited to streetscape WSUD enhancements, such as the identified opportunities for passive irrigation and urban greening along LaTrobe Boulevard that runs parallel to Latrobe Terrace. Success of such a test case will encourage other streetscapes throughout the precinct and beyond to be considered for WSUD enhancements to support broader urban biodiversity, liveability and resilience in a changing climate.

Most of the lots proposed for rezoning within the eastern part of the precinct are not currently affected by stormwater flooding. Accordingly, the focus in this area is on identifying locations where new infrastructure and stormwater pipe upgrades can be implemented to support future development and accommodate climate change impacts.

Rezoning presents a key opportunity for a distributed WSUD response to improve water quality and volumetric discharge to the Barwon River beyond the impact of the change in use. These WSUD elements can be delivered by developers and/or Council led initiatives. When well designed, constructed and maintained, a successful WSUD streetscape enhancement can:

- revitalise neighbourhoods by greening and cooling public areas,
- protect service levels of existing infrastructure in a changing climate,
- contribute to urban canopy cover targets and other beneficial biodiversity outcome

7.3 Precinct Scale

Across the whole precinct, various opportunities exist to construct Gross Pollutant Traps (GPT) on existing untreated outfalls to the Barwon River. This option can make the greatest impact to water quality (with respect to litter and coarse sediment removal) in the river for minimal comparative cost, with 5 of the top 10 high priority outfalls identified in the South Geelong SWMS (Water Technology, 2026) falling within the Fyans – West Fyans Precinct boundary. While some of these untreated outfalls may not require a standalone GPT if other stormwater improvement recommendations proceed, the staged flexibility of any delivery program and relative low investment required to proceed with high value outfalls makes this recommendation the highest priority.

Beyond this, the West Fyans Street (west) precinct area presents significant opportunities to address flooding, stormwater quality and excess volume at an end-of-line, precinct scale. Large-scale infrastructure solutions aimed at reducing flood levels along the Bridge Street drain up to and around Friers Reserve can support and integrate significant improvements to stormwater quality and quantity. Importantly, these precinct scale opportunities will provide maximum potential for flood resilience, water quality and volume management in the precinct. They present a strong case for funding applications for state or federal grants, community fundraising campaigns and/or a regional offset program such as that described in Section 2.7.

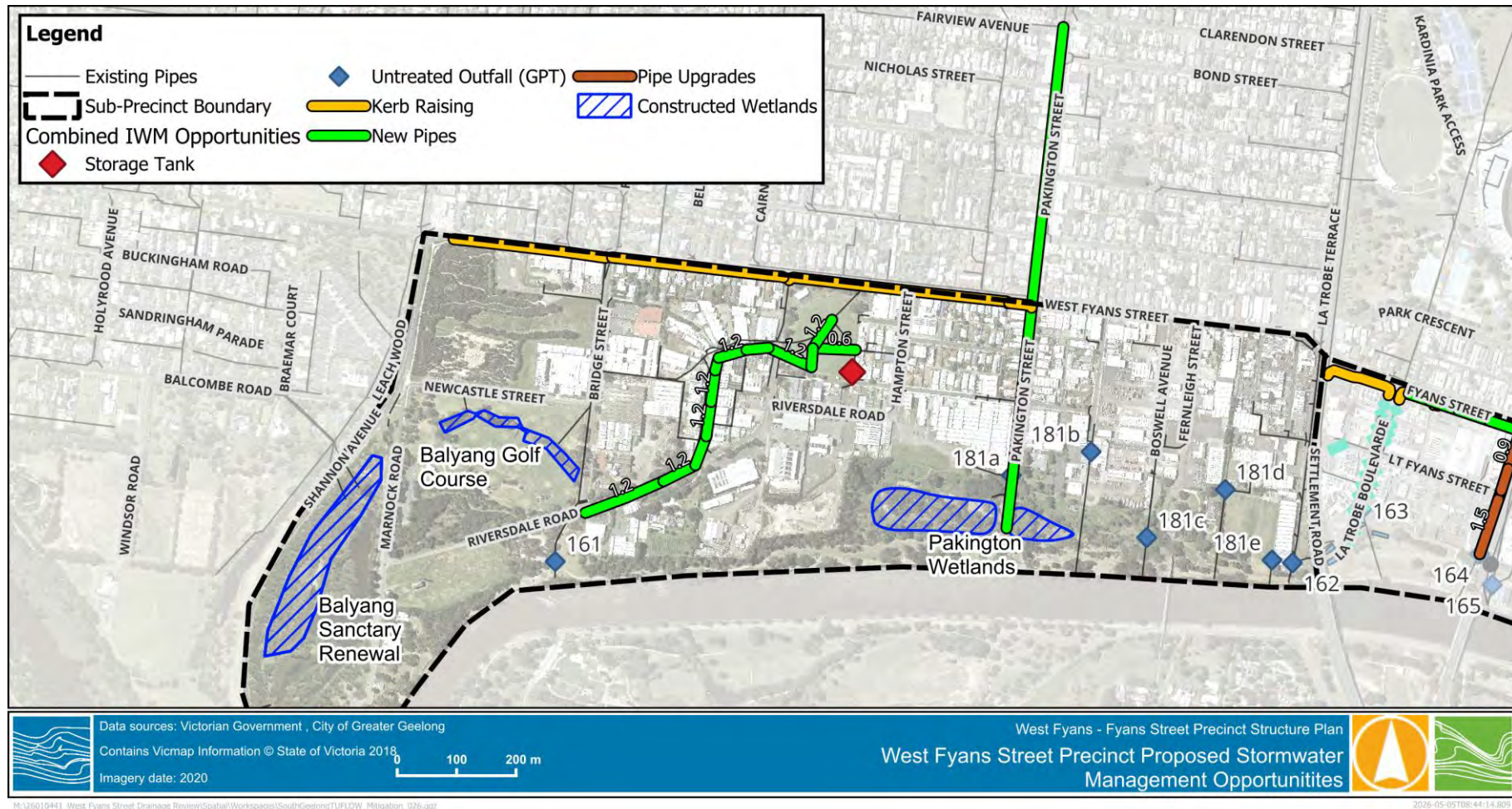


Figure 7.2 West Fyans Street (west) precinct recommended stormwater opportunities



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7.4 Summary

It is recommended that the City of Greater Geelong consider the findings of this report update (summarised in Table 7-1), engage with stakeholders for advice, and incorporate relevant outcomes from the consultation phase into the final drainage report update.

The recommended approach recognises that managing flood risk within the precinct is inherently complex, driven by a combination of legacy drainage constraints, existing infrastructure limitations, and the cumulative impacts of future redevelopment. While modelling indicates that changes in land use result in only minor increases in runoff, the existing system is already operating with capacity constraints and heightened sensitivity to climate change and intensification pressures.

Accordingly, a multi-scale stormwater management approach is required. This combines interventions at the private, street and precinct (catchment) scales to ensure development can proceed while managing both existing deficiencies and future risk.

Localised measures (e.g. on-site detention, streetscape upgrades and WSUD) are essential to support new development and manage incremental impacts, while larger, end-of-line infrastructure is required to address legacy constraints and deliver meaningful flood risk reduction at a catchment scale.

This integrated approach ensures that infrastructure investment is targeted effectively enabling development, improving system performance over time, and managing residual and climate-driven flood risks across the precinct.

Table 7-1 Summary of recommendations

Scale	Recommendation	Benefits	Priority
Private Realm	Rainwater harvesting tanks on private properties for non-potable uses.	Water quality Volume	Medium
	On site detention tanks for flood mitigation.	Flooding	Medium
Streetscape	A range of drainage system upgrades including new, and upgrade of existing pits / pipes, and kerb / road pavement raising.	Flooding	High
	Streetscape WSUD enhancement such as passively irrigated street trees and raingardens	Water quality Volume	Medium
Precinct / Catchment	Lambert Avenue diversion and Friers Reserve flood detention	Flooding	High
	Pakington Street diversion and enhanced treatment wetlands	Flooding Water quality	Medium
	Gross pollutant treatment of existing untreated outfalls	Water quality	High
	End of line bioretention basins on untreated catchment outfalls	Water quality	Medium
	Balyang Golf Course stormwater treatment and harvesting wetlands	Water quality Volume	Medium



	Balyang Sanctuary wetland renewal	Water quality	Low
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APPENDIX A

BRIDGE STREET AND MAIN DRAIN PIPE UPGRADES





The 2008 *Bridge Street and Western Gully Main Drain Study* undertook mitigation modelling for drainage upgrades within Friers Reserve and the Bridge Street Drain. The study recommended a preferred option, referred to as Scheme 3, which demonstrated a reduction in flood levels within Friers Reserve and the surrounding area. Exerts from the 2008 study including change in flooding above floor and a flood damages assessment are shown below in Figure A-1 and Figure A-3 respectively. The configuration of the recommended upgrade is shown in Figure A-2 with change in flood level shown in Figure A-4.

AEP	No. Flooded Grounds*		Reduction	No. Flooded Floors**		Reduction
	Existing	Scheme 3		Existing	Scheme 3	
1%	946	895	51	20	11	9
5%	829	767	62	14	9	5
20%	756	694	62	8	7	1

*The number of flooded grounds is based on flood mapping down to a flood depth of 0.03m.

**No. flooded floors are base on properties surveyed. Refer to Section 3.3.

Figure A-1 Reduction in flooded properties – Bridge Street Main Drain Study Scheme 3



Figure A-2 Bridge Street Main Drain preferred mitigation scheme (Scheme 3)



Event		Scheme 3			
(Years ARI)	AEP	House Damages	Indirect Damages	Total Damages	Incremental Average Annual Damages
PMF ⁺	0.0%			\$ 401,000	
100	1%	\$ 292,000	\$ 88,000	\$ 379,000	\$ 7,000
20	5%	\$ 224,000	\$ 67,000	\$ 291,000	\$ 13,000
5	20%	\$ 170,000	\$ 51,000	\$ 221,000	\$ 38,000
2	50%	\$ -	\$ -	\$ -	\$ 33,000
Average Annual Damage					\$ 91,000

⁺Note – PMF damages are an extrapolation of the 1% AEP data, ie, they were not calculated using PMF flood levels

Figure A-3 Flood damages assessment – Bridge Street Main Drain Study Scheme 3

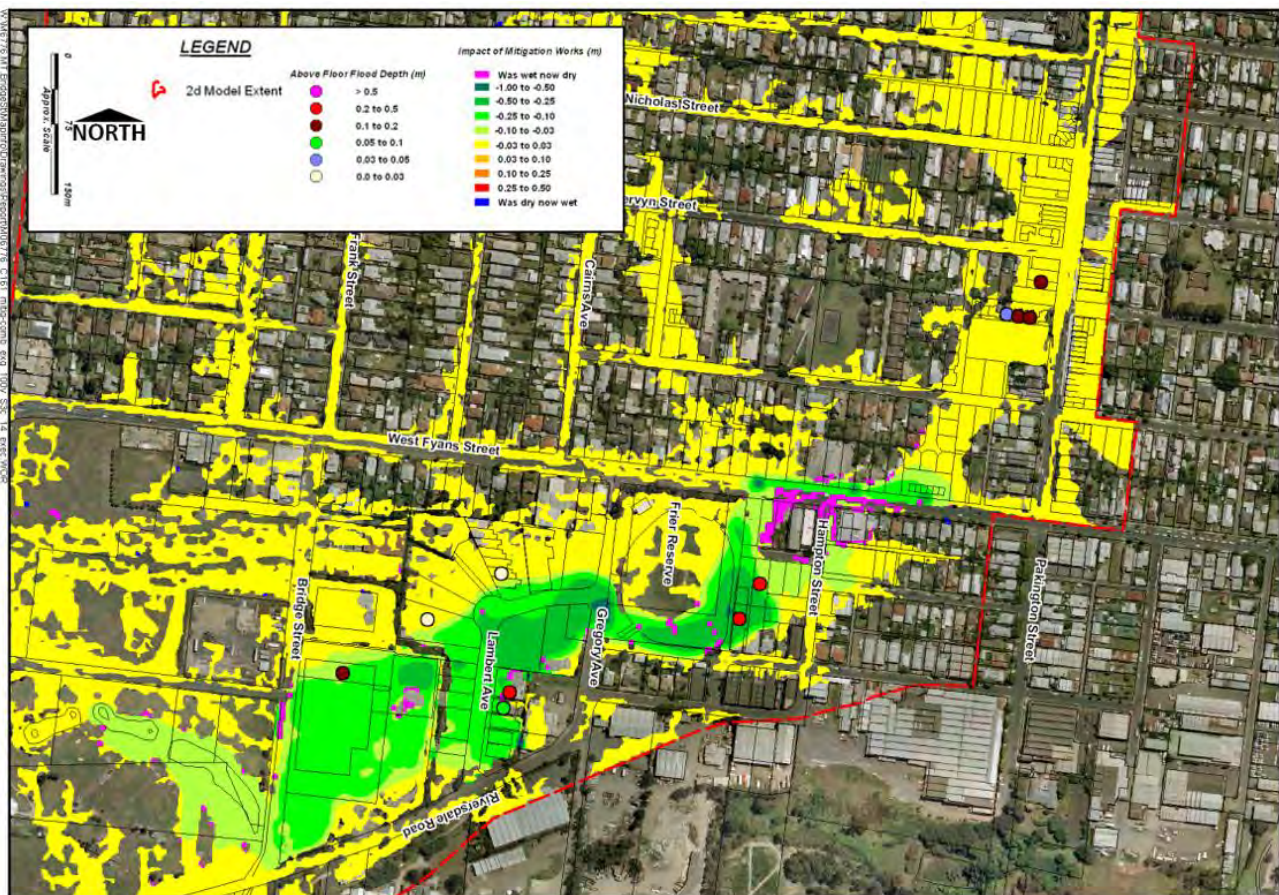


Figure A-4 Change in 1% AEP peak flood height Bridge Street Main Drain Preferred Mitigation Scheme



APPENDIX B

LAMBERT AVENUE DIVERSION AND FRIERS RESERVE DETENTION





Based on the updated flood modelling and a review of the Bridge Street and Western Gully MD Flood Study (WBM, 2008) Water Technology developed three mitigation options (see Figure B-1) in 2018 as part of the West Fyans-Fyans Precinct Structure Plan. These options aimed to reduce the impact of flooding through the Lambert Avenue, Bridge Street area (shown in Figure B-2). These options were developed at a conceptual stage and aim to mitigate existing flood risk. The Pakington Street diversion pipe is shown in the below Figure B-1 as Mitigation Option 1, this is further discussed in Appendix M and its combined benefit when coupled with the end of line constructed wetlands. The Lambert Street Diversion Pipe discussed in this section was assessed as an independent option (Mitigation Option 2 from the 2018 drainage report) as well as combined with Friers Reserve Detention (Mitigation Option 3 from the 2018 drainage report).



Figure B-1 Mitigation option alignments modelled

A2.1 Lambert Avenue Diversion Pipe

The WBM study completed in 2007 undertook modelling of an additional drainage alignment along Lambert Avenue beginning further upstream along West-Fyans Street. The mitigation option tested in the West Fyans-Fyans Precinct Structure Plan begins at the Lambert Avenue/ Gregory Avenue intersection and follows Lambert Avenue along to Riversdale Road before heading west towards Bridge Street. This would include 475 m of 1200 mm diameter RCP. Several additional pits located along Lambert Avenue would help collect overland flow coming off Frier Reserve and from within Lambert Avenue. This alignment would likely be restricted by existing services and subject to geotechnical testing of the site due to the former landfill areas. The impact of the Lambert Avenue diversion pipe showed a reduction in flood levels through the Lambert Avenue and Bridge Street area (Figure B-2). The Lambert Street diversion alone was only modelled in the 2018 drainage report and not retested in this 2026 update. This mitigation project capital cost was estimated at \$1.4 million.

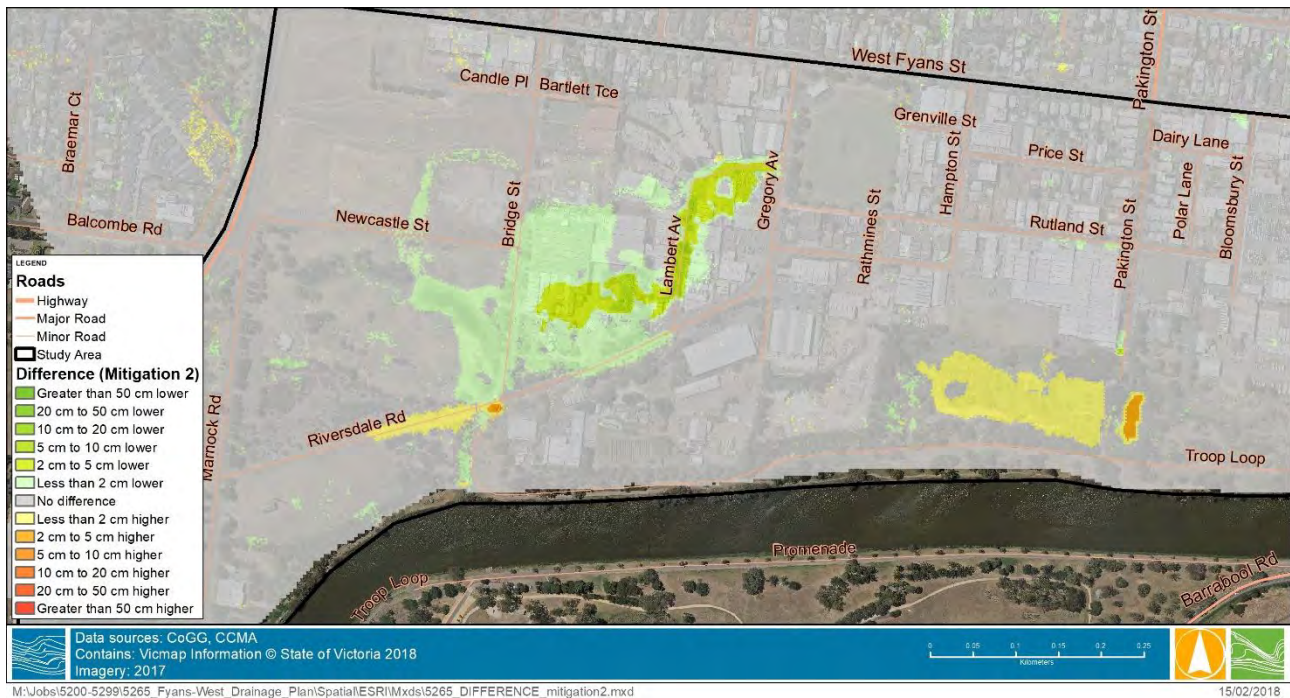


Figure B-2 Mitigation Option 2 Lambert Street diversion mitigation flood level difference plot

B-1-1 Frier Reserve Detention and Lambert Avenue Diversion Pipe

The option was proposed in the 2018 West Fyans–Fyans Drainage Report was requested by Council to be revalidated as part of this 2026 report update. As part of this report update the alignment was reconsidered, and sense checked with larger pipes. The option was simulated under future climate change conditions assuming full development and the proposed rezoning. The 1% AEP water level differences for the SSP3 2100 scenario is presented in Figure B-3. The results indicate that, under future climate conditions, water levels are reduced by up to 200 mm at the low point on the eastern side of Friers Reserve. This option provides considerable decreases to flood levels in Friers Reserve, which as discussed in this report has ongoing undersized capacity issues and very susceptible to increases in rainfall.

A staged approach could be adopted for the delivery of the Lambert Avenue diversion, with works through Friers Reserve potentially constructed independently. However, even if delivered in stages, the detailed design would need to be undertaken holistically to ensure hydraulic performance and integration across the full length of the diversion.

This area is recognised as a significant flood risk location within both the catchment and the precinct. As such, large-scale mitigation measures are likely to be the only interventions capable of materially reducing flood impacts. Smaller or localised measures are unlikely to provide meaningful flood relief unless an easement is secured along a substantial portion of Lambert Avenue, allowing the diversion to function as an open drainage channel.

Variations to this option were also investigated to provide additional flood mitigation under climate change conditions. For the enhanced mitigation scenario, an additional 2 ML of storage was incorporated, increasing total storage to 4 ML, along with an additional pipe barrel following the alignment of the existing stormwater system. The resulting changes in water levels for this increased storage option are presented in Figure B-5

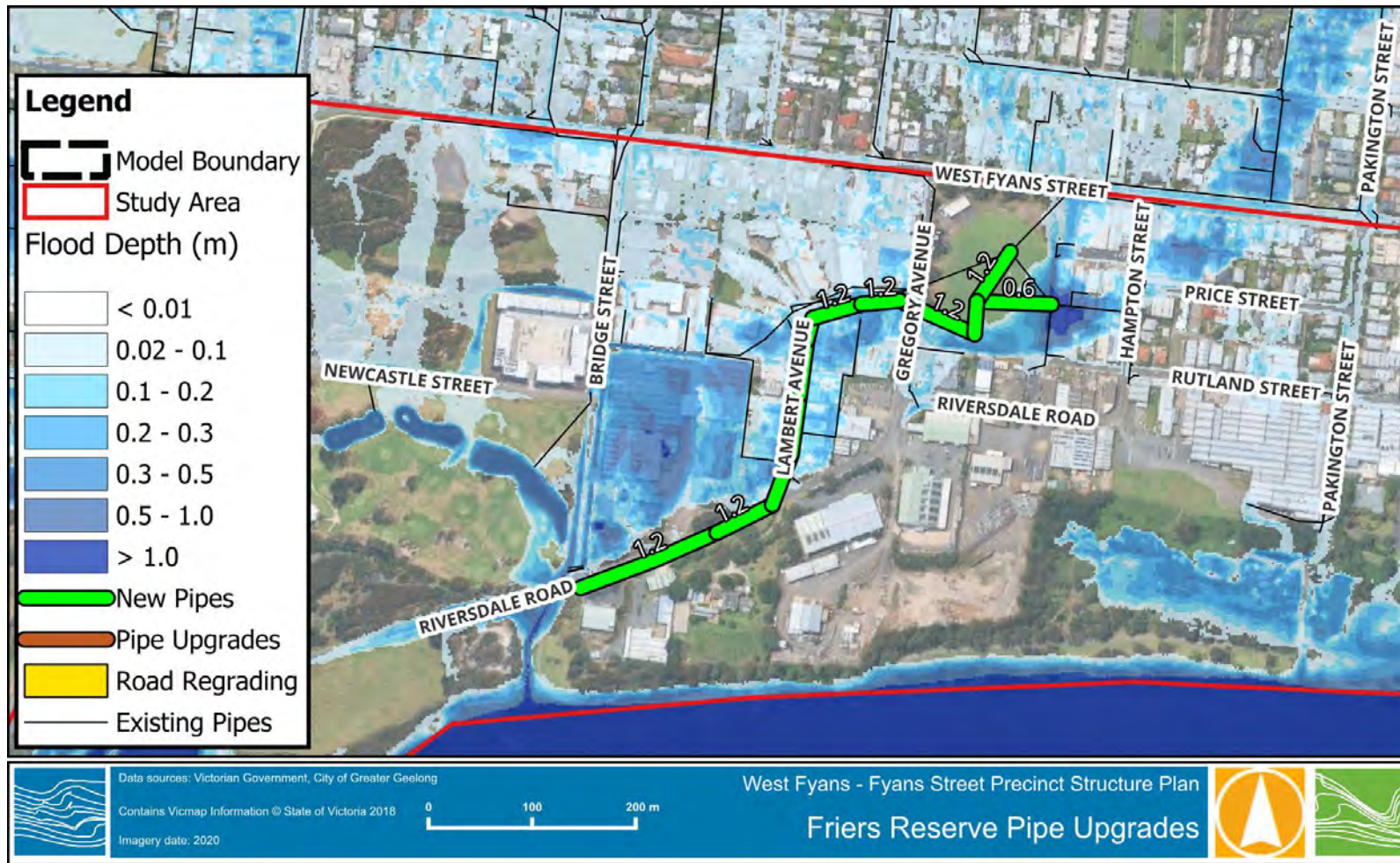


Figure B-3 Friers Reserve pipe upgrades

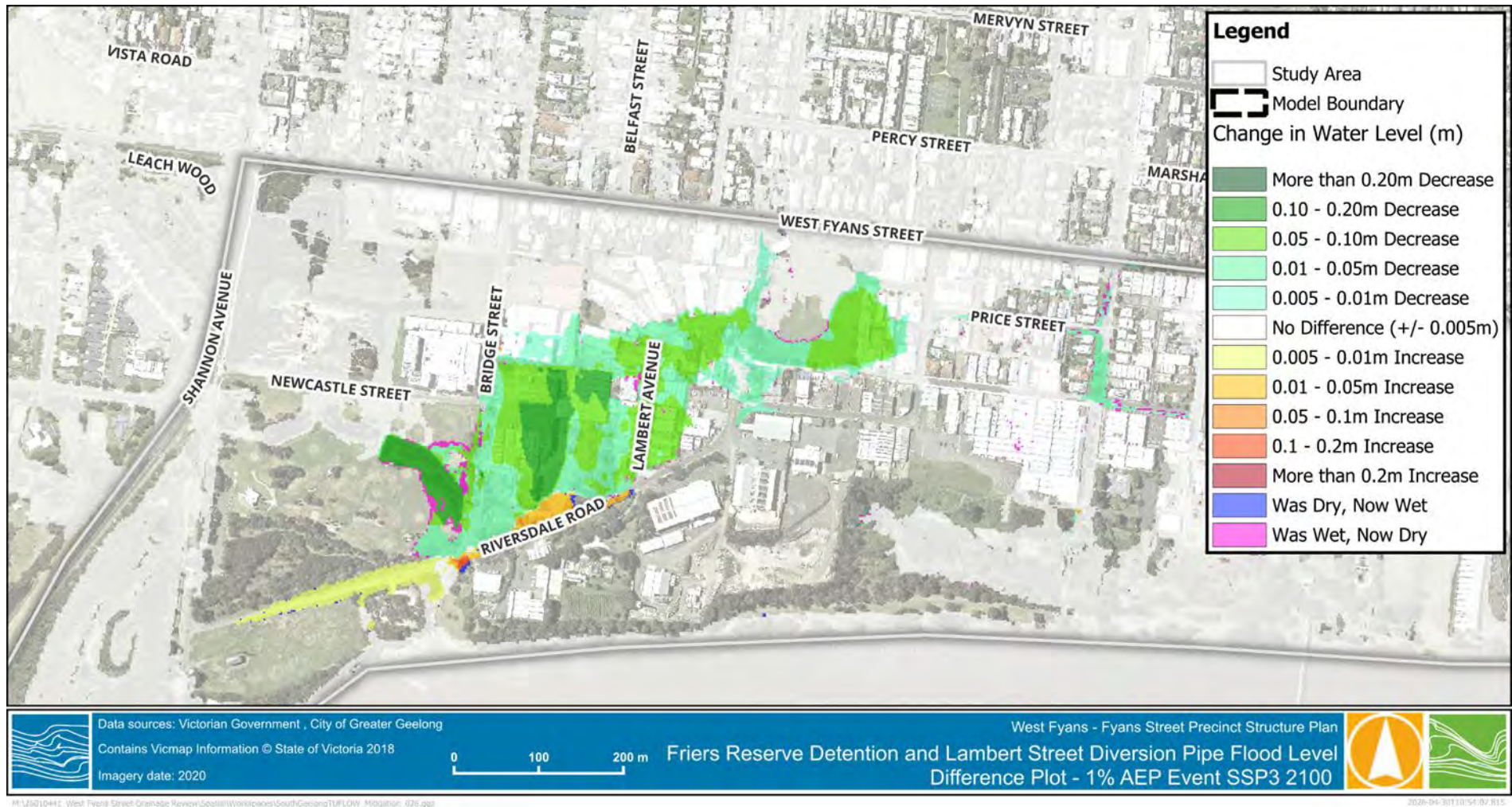


Figure B-4 Friers Reserve Detention and Lambert Street Diversion pipe flood level difference plot

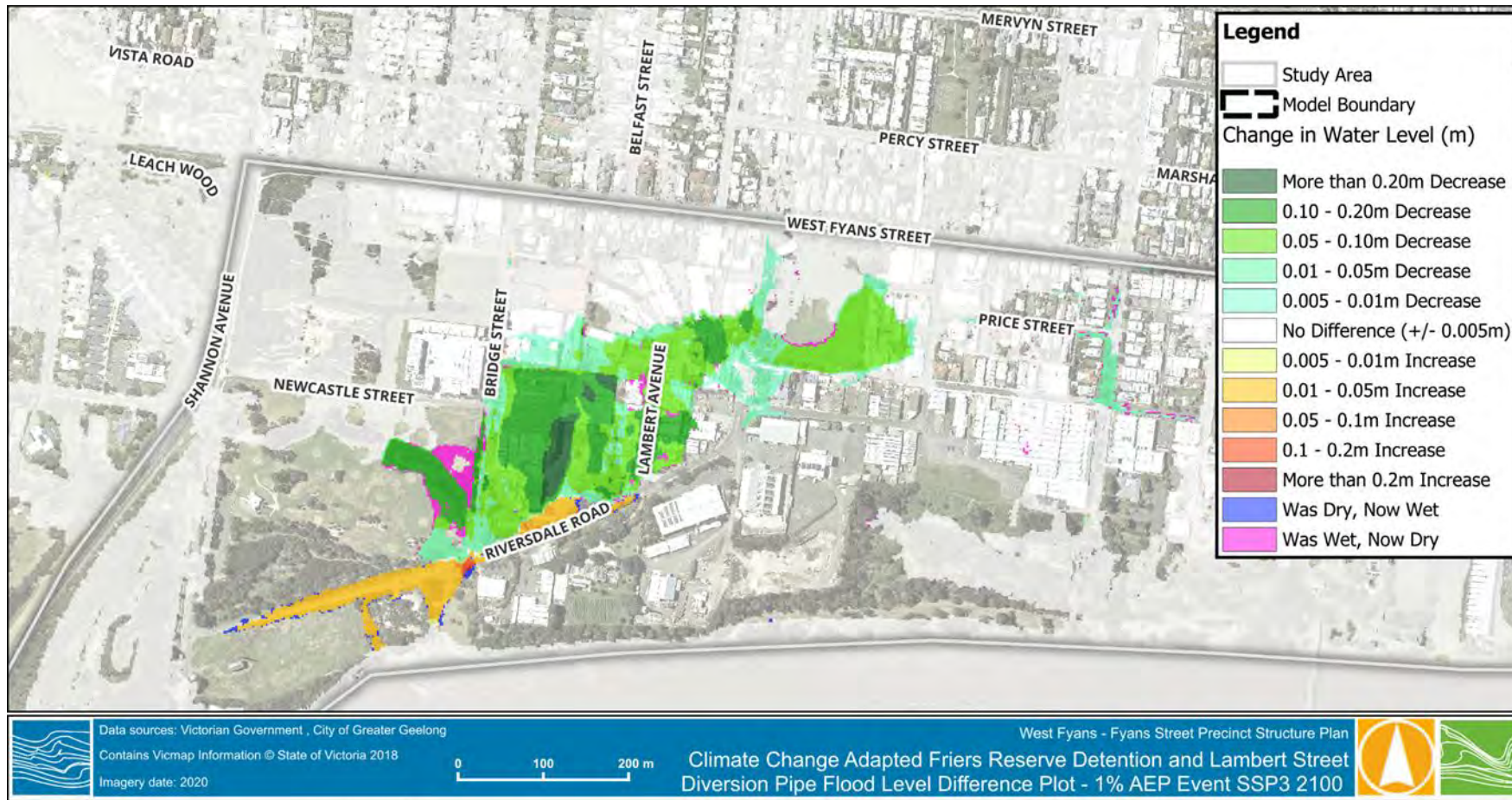


Figure B-5 Climate Change Adapted Friars Reserve Detention and Lambert Street Diversion Pipe flood level difference plot

APPENDIX C
UPDATES TO THE SPECIAL BUILDING
OVERLAY (SBO)



There are three main planning control overlays in Victoria for flooding, these include the Floodway Overlay (FO), Land Subject to Inundation (LSIO) and the Special Building Overlay (SBO). The South Geelong SWMS recommended updating the SBO (only) in response to the updated modelling.

The SBO is used to define flooding from overland flows where stormwater infrastructure plays a controlling role in the inundation (as opposed to water escaping from a waterway). The overlay is generally used within built up areas where the nature of flooding from stormwater has been identified. This planning control is used to ensure that development within these areas identified as flood prone can be undertaken. The purpose objective of the SBO is to ensure that development maintains the free passage and temporary storage of floodwaters, minimises flood damage, is compatible with the flood hazard and local drainage conditions and will not cause any significant rise in flood level or flow velocity (Geelong, 2025)

The existing LSIO and FO within this study area primarily relate to riverine flooding from the Barwon River (as defined by the Lower Barwon and Lower Moorabool Flood Study). The current LSIO and FO overlays that cross the downstream end of the precinct will take precedence over the SBO.

To produce an updated SBO for the South Geelong catchment, filtering criteria was been applied to the 1% AEP flood extent. A comparison of the current SBO to the proposed, under SSP5 year 2030 and 2100 is presented below in Figure C-1. The South Geelong SWMS undertook analysis to prepare the updated overlay on the 1%AEP SSP5 2100. It is understood through consultation with Council that they would like the overlay to be updated to SSP3, instead of SSP5 at the year 2100 which is more similar to the previously used RCP8.5 under ARR4.1 guidance. This will be updated alongside report updates for the West Fyans-Fyans precinct structure plan. Analysis provided in the 2025 South Geelong SWMS for the SSP5 has been provided for initial consultation.

The proposed SBO under SSP5 year 2030 is presented in Figure C-1and for 2100 in Figure C-4. A summary of the criteria used to generate the overlay mapping is as follows:

- The removal of isolated patches mapped outside of the main overland flow extents and not connected to any stormwater infrastructure were removed.
- Flood depths below 10mm were filtered and islands and holes were filled that were less than 0.5 hectares.
- The model results were smoothed on their fringes to create plausible representation of overland flow paths. This removed the irregular 'saw tooth' edge of the mapped flood extent.
- The filtering has been applied to both the 1% AEP SSP5 (RCP8.5) to the year 2030 and 2100 for comparison.
- Areas overlapping with the Floodway Overlay (FO) and Land Subject to Inundation Overlay (LSIO) for the Barwon River have been disregarded as they would be superseded by the FO/LSIO.

When comparing the current SBO to the proposed extent, the updated extents are significantly larger. This is primarily due to differences in rainfall application methodology and application of climate change. Testing of a range of filtering depths was undertaken, a comparison of the 10mm and 50mm cutoff depths is presented below in Figure C-2 for the Sout Geelong catchment.. At a filtering depth of 50 mm, a significant extent of flooding was removed which is likely not protective enough given the purpose of the SBO.

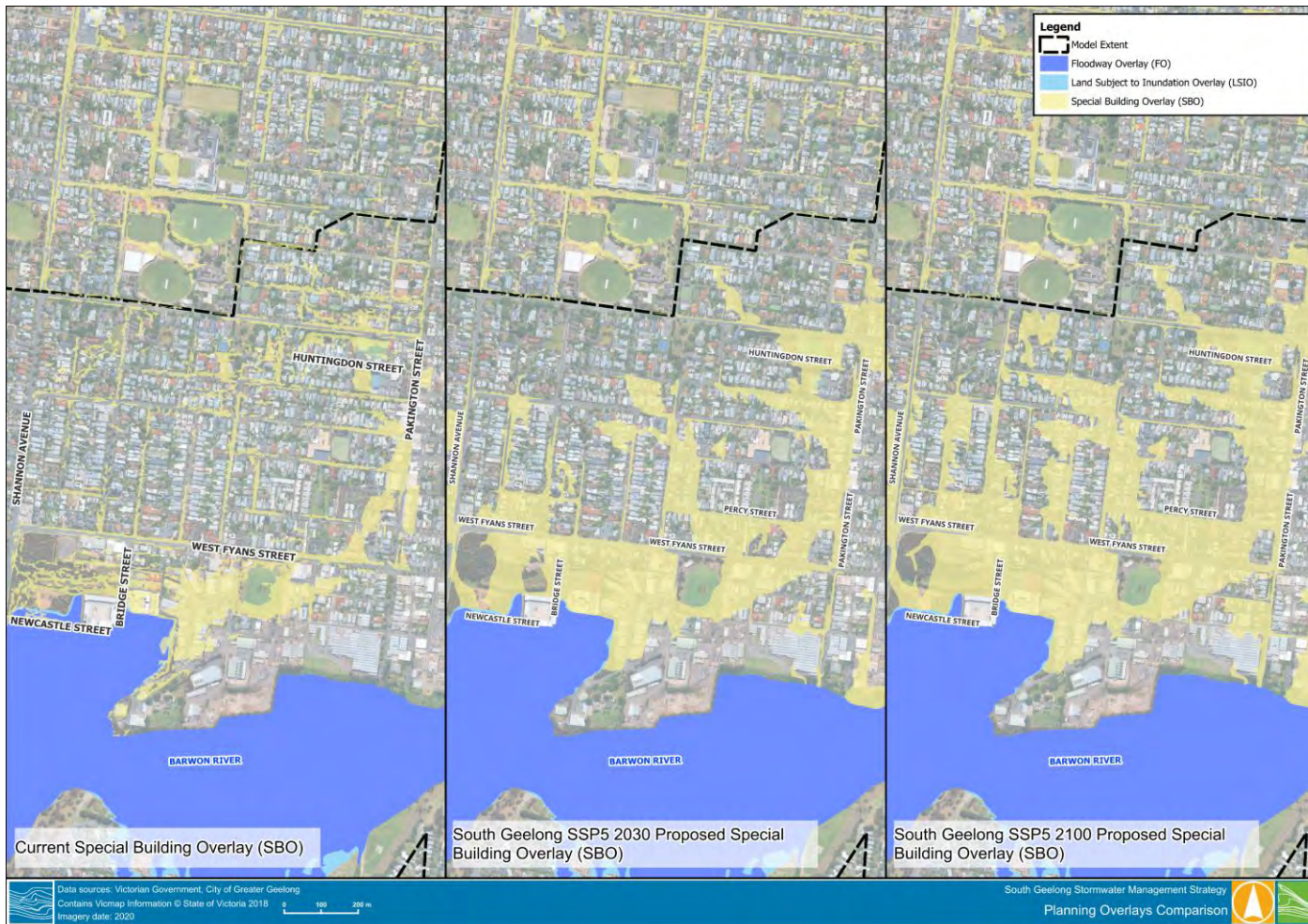


Figure C-1 Current and proposed Special Building Overlay (SBO)

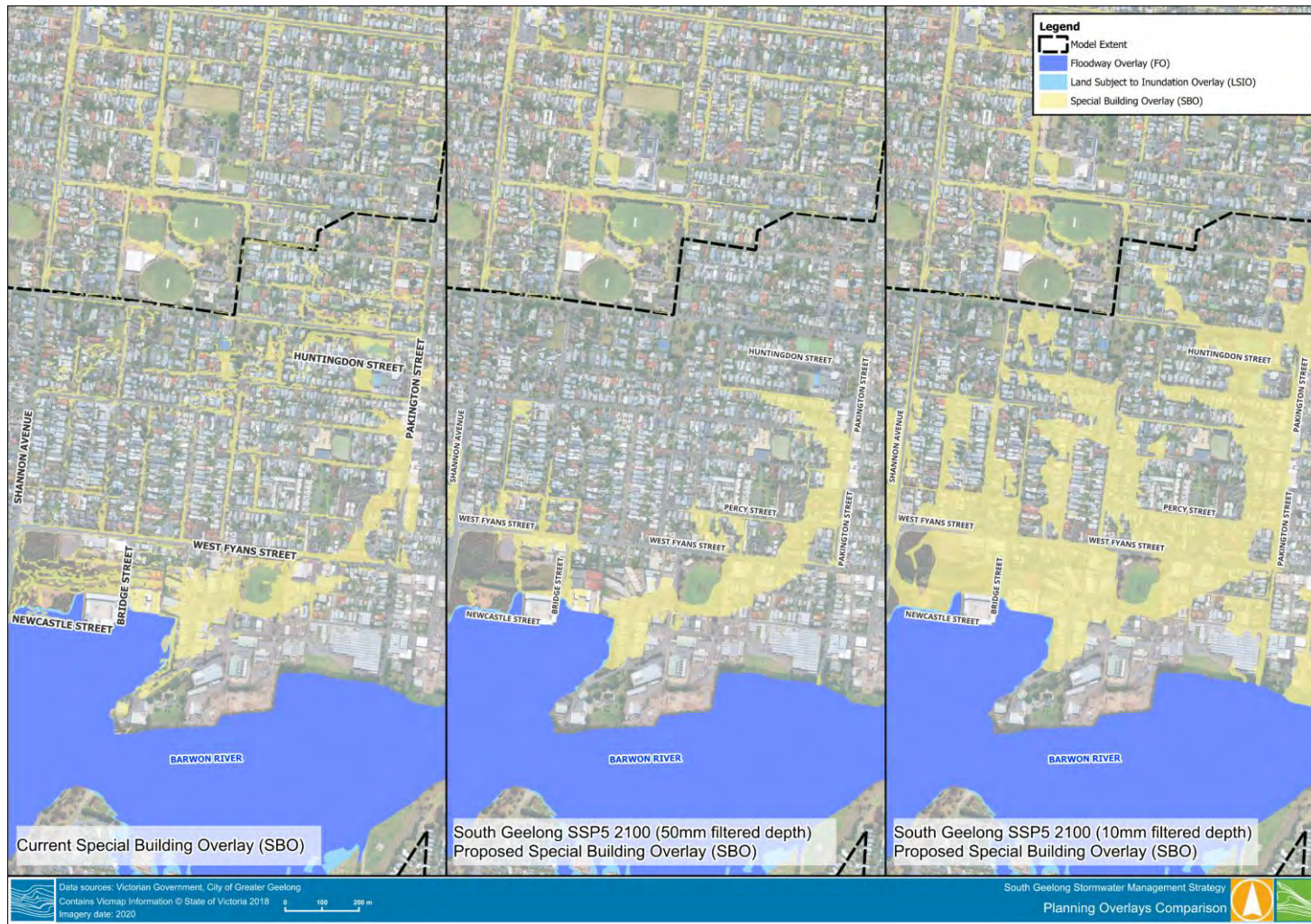


Figure C-2 Current and proposed Special Building Overlay (SBO) filtered depth comparison

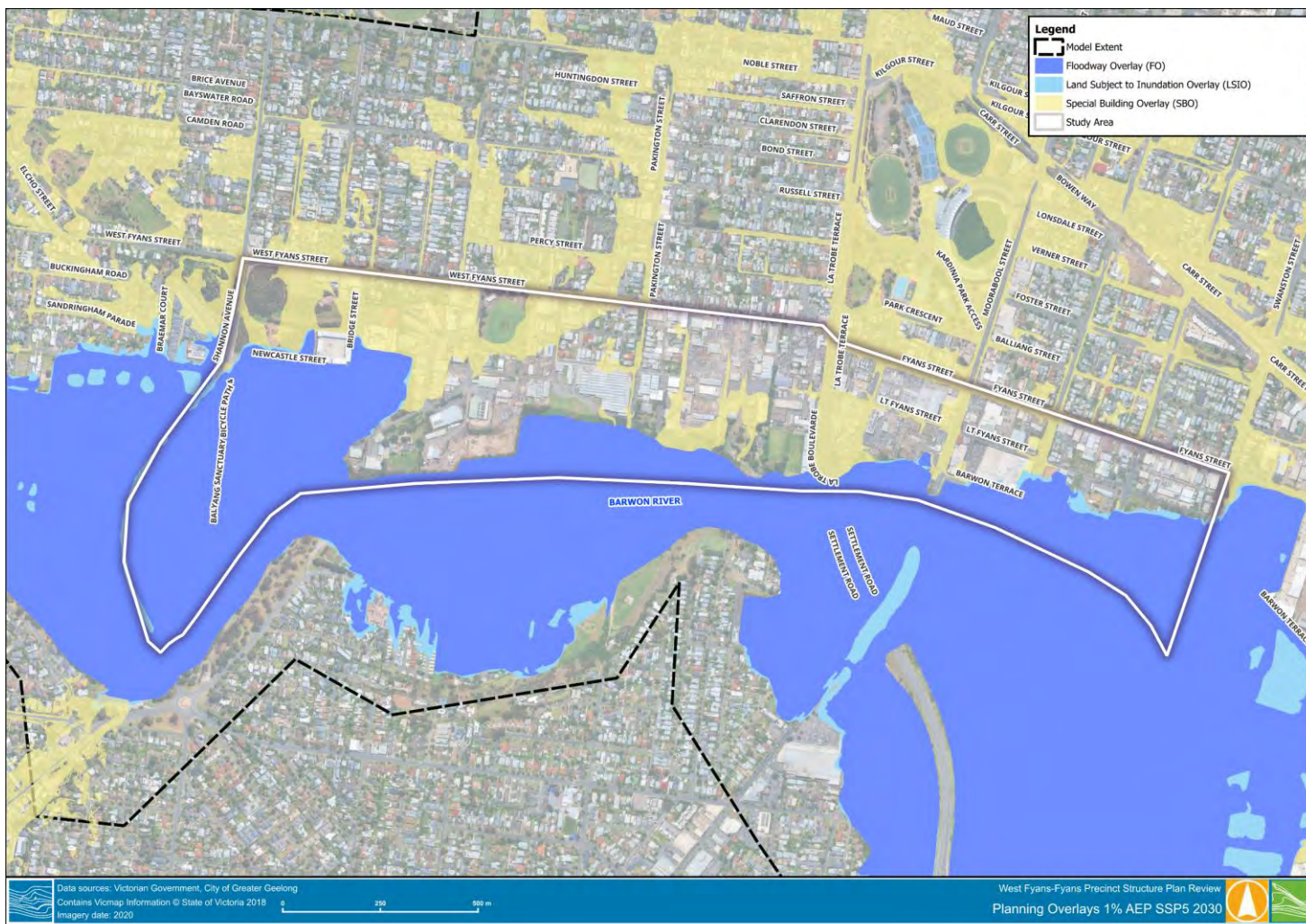


Figure C-3 Proposed SBO 1% AEP 2030

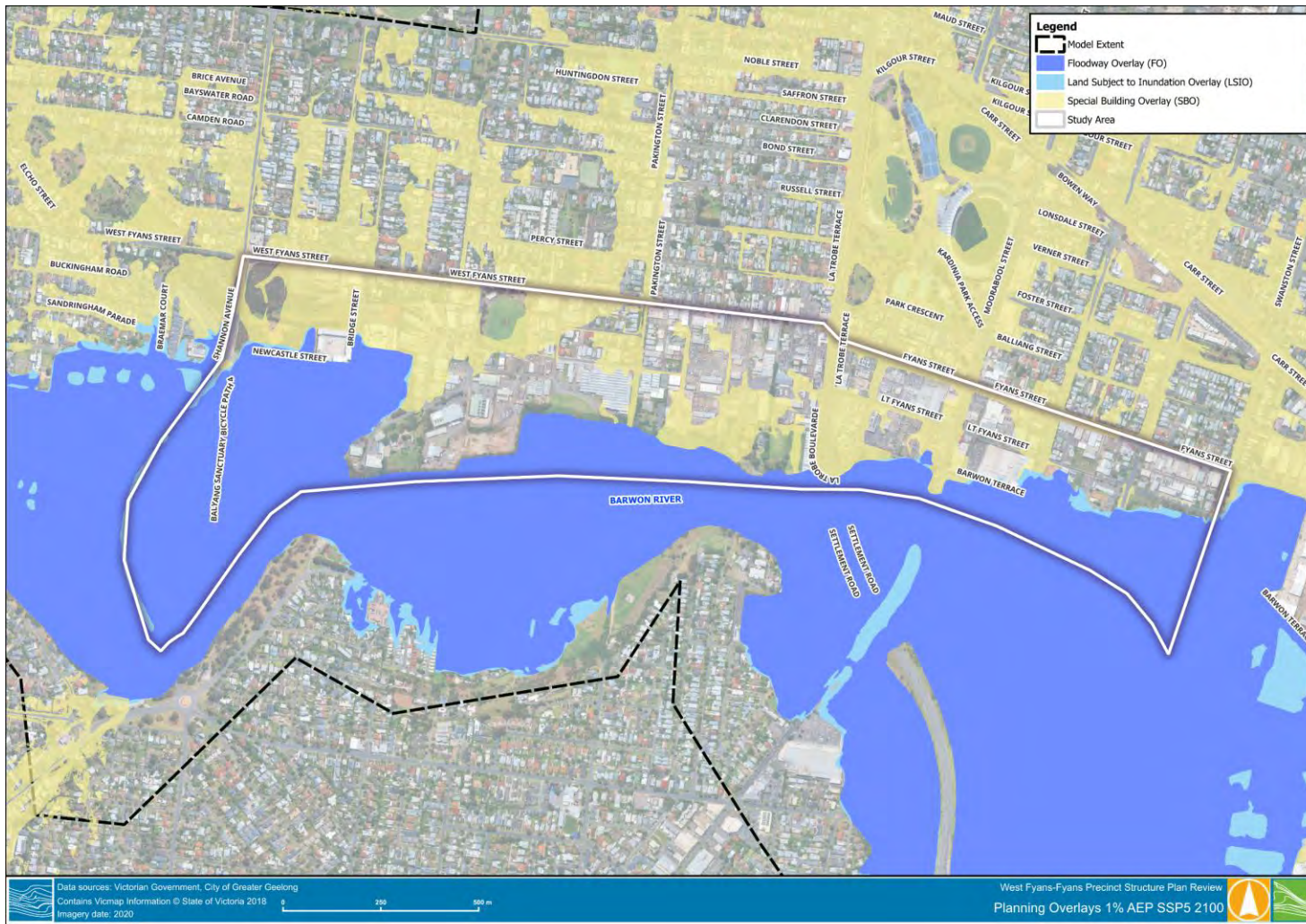


Figure C-4 Proposed SBO 1% AEP 2100

APPENDIX D SHORTLISTED



During initial consultation with Council stakeholders, several additional options were presented for investigation. This was undertaken because four options to mitigate flooding within the Friers Reserve catchment had previously been proposed in 2008 and 2018, with none progressed to construction or detailed design. Accordingly, further options were presented to Council to explore whether alternative stormwater pipe network alignments for managing flooding in and around Friers Reserve may be more favourable from Council's perspective.

D-1 Riversdale Road Diversion

This alternative Riversdale Road diversion aims to capture runoff on West Fyans Street from the overland flow path before it flows through properties on the southern side of West Fyans Street. The option is presented below in Figure D-1 consists of the following details:

- Regrade a portion of the West Fyans Street stormwater network,
- Upgrade existing pipe sizes from 300 mm to 450 mm or 600 mm,
- Additional pipes along West Fyans Street to capture overland flow, including larger inlet pits,
- New pipe alignment down Hampton Street, disconnecting the pipe that currently connects to the main trunk line within Friers Reserve, and
- New pipe along Riversdale Road, out letting at the low point of the Bridge Street drain.

Through consultation with Council, this option was ruled out for testing in the flood model. Council advised that the proposal was constrained by several aspects. This included preference for no 90 degree bends in pits and pipes in accordance with Infrastructure Design Manual (IDM) 16.9, along with depth constraints at Riversdale Road. The option would also require secondary street and legal point of discharge drainage system to service new lots and street drainage, which would be difficult to implement for the initial developer. This is particularly relevant as there have been previous rejections of requests to connect to the trunk main. Council also identified concerns regarding inflows and required inlet capacities along West Fyans Street, potential conflicts with existing services that would likely necessitate new stormwater pipes to be constructed in front of the kerb within parking lanes with limited cover. Council expressed preference for kerb outstand tree pits on street parking along the alignment, including future vehicle crossing locations to enable increased development density



Figure D-1 Alternative Riversdale Road diversion

D-2 Hampton Street Diversion

The Hampton Street diversion also aimed at capturing runoff from the overland flow path before it crosses to the southern side of West Fyans Street. The proposed option is presented below in Figure D-2 with the following details:

- Realignment and upgrade of existing 300 mm pipes on West Fyans Street to 450 mm or 600 mm,
- New line down Hampton Street to capture runoff from the existing low point near the beekeeping area, and
- New line down Rutland Street, tying into upgraded pipes along Pakington Street.

This option was presented to Council for consideration to proceed with mitigation modelling but was not recommended to progress. Council identified several justification and design considerations, including the presence of proposed 90 degree pipe bends, which are not supported under the IDM. Council also noted that this option would likely need to incorporate the previously modelled Pakington Street diversion. In addition, a secondary street drainage or legal point of discharge system would be required to service new lots and street drainage. The works between Friars Reserve and Hampton Street were identified as the primary concern, as the proposed easement is located beneath an existing building. Council further noted that disconnecting the existing trunk drainage would remove system redundancy, which may form part of a long term (30+ year) planning consideration but is not appropriate for the current scope. Potential conflicts with existing services were also identified, likely requiring new stormwater pipes to be constructed in front of the kerb within parking lanes. Council additionally recommended consideration of kerb outstand tree pits within on street parking areas along the proposed alignment.

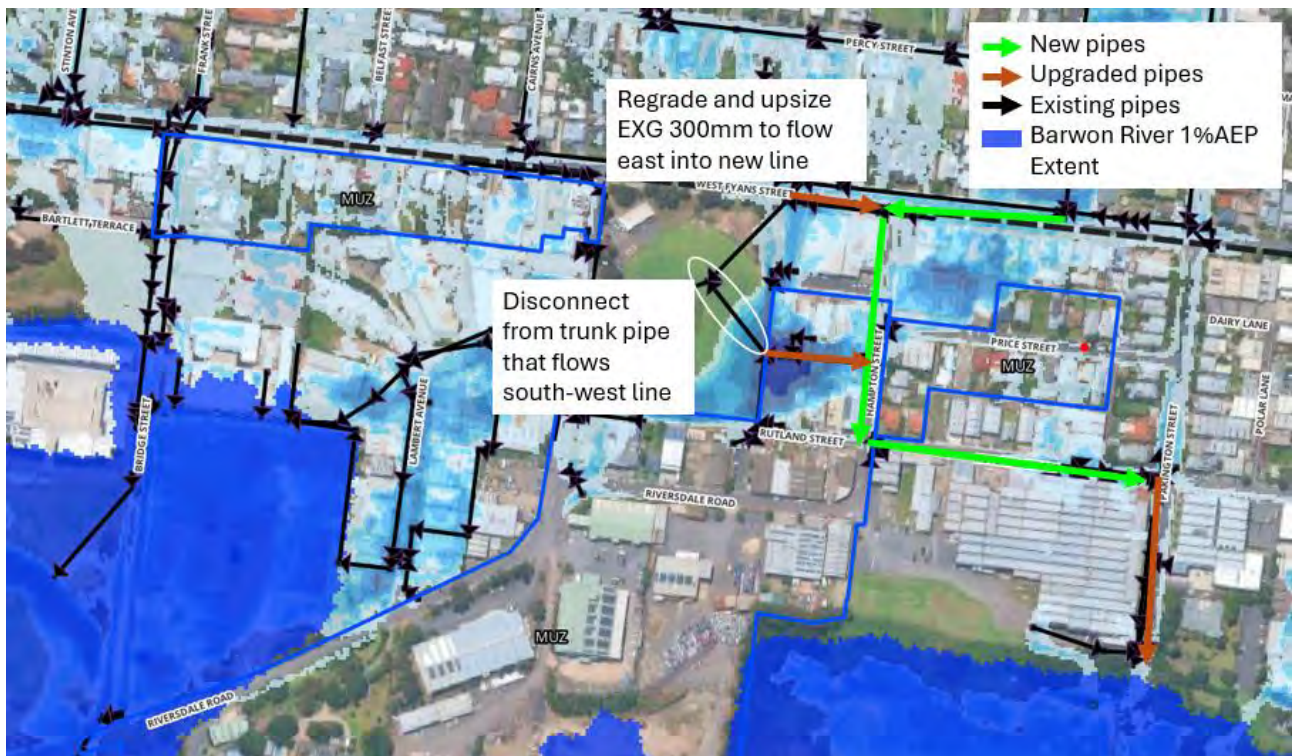


Figure D-2 Hampton Street diversion

APPENDIX E
FYANS STREET PIPE UPGRADES AND
BARWON TERRACE ROAD RAISING



Key flooding issues on the eastern side of the precinct are concentrated along the lower section of Little Fyans Street between Wills Place and Bellarine Street. This area is inundated under the future 1% AEP Barwon River flood extent, while low points along Barwon Terrace are overtopped under the future 1% AEP stormwater flood event. This results in the loss of north to south through-traffic along Barwon Terrace. In consultation with Council, a mitigation option is proposed that involves raising the low points along Barwon Terrace to future-proof the road against climate change increases in rainfall intensity and to improve trafficability during storm events. This option indicates alignments of stormwater that will likely need to be updated to adapt to future increases in rainfall and increased fraction impervious. The details of the proposed pipe upgrades and sizing are presented below in Figure E-1.

It should be noted that the pipe upgrades were assessed both with and without upgrading the outfall pipe at the end of Yarra Street. This approach was taken because any works adjacent to the Barwon River require a more complicated approval process with CCMA. The results show that excluding the outfall upgrade (Figure E-2) or including it (Figure E-3) does not change impacts upstream of the Barwon River. This indicates that the pipe upgrades can proceed without the need to upgrade the outfall.

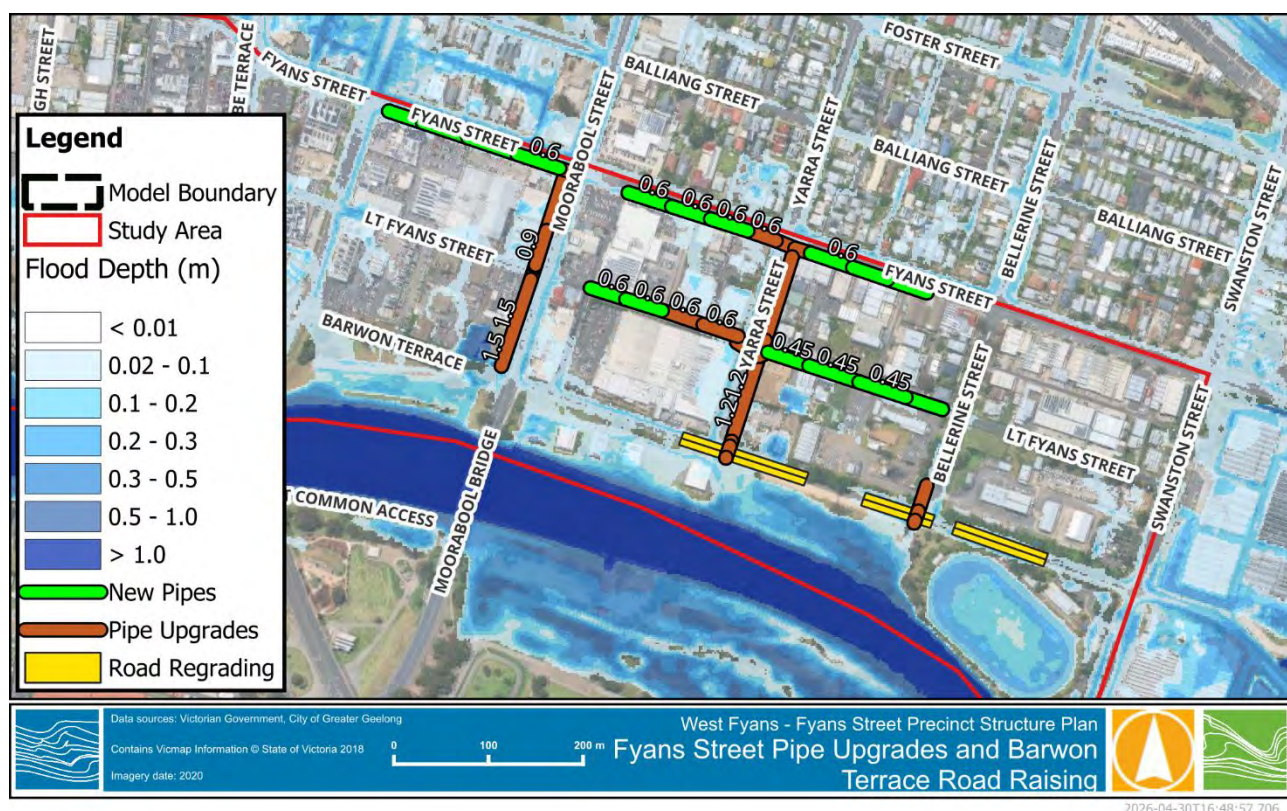


Figure E-1 Fyans Street Pipe Upgrades and Barwon Terrace Road raising

Flood level difference plots for the pipe augmentation and road-raising works are presented in Figure E-2. The modelling results indicate reductions in flood depths of up to 60 mm within the road reserve along Fyans Street, Moorabool Street and Yarra Street. The proposed road raising along Barwon Terrace also allows the road to become trafficable during the climate change 1% AEP event. Some isolated increases in flood depth are of up to 180mm are predicted on the upstream side of Barwon Terrace due to of ponding caused by the raised road levels.

These areas present an opportunity to incorporate distributed water sensitive urban design measures, such as irrigated street trees, 'urban sponges' or landscaped verge areas. These asset types can contain flooding while storing and absorbing excess floodwaters adjacent to the roadway.

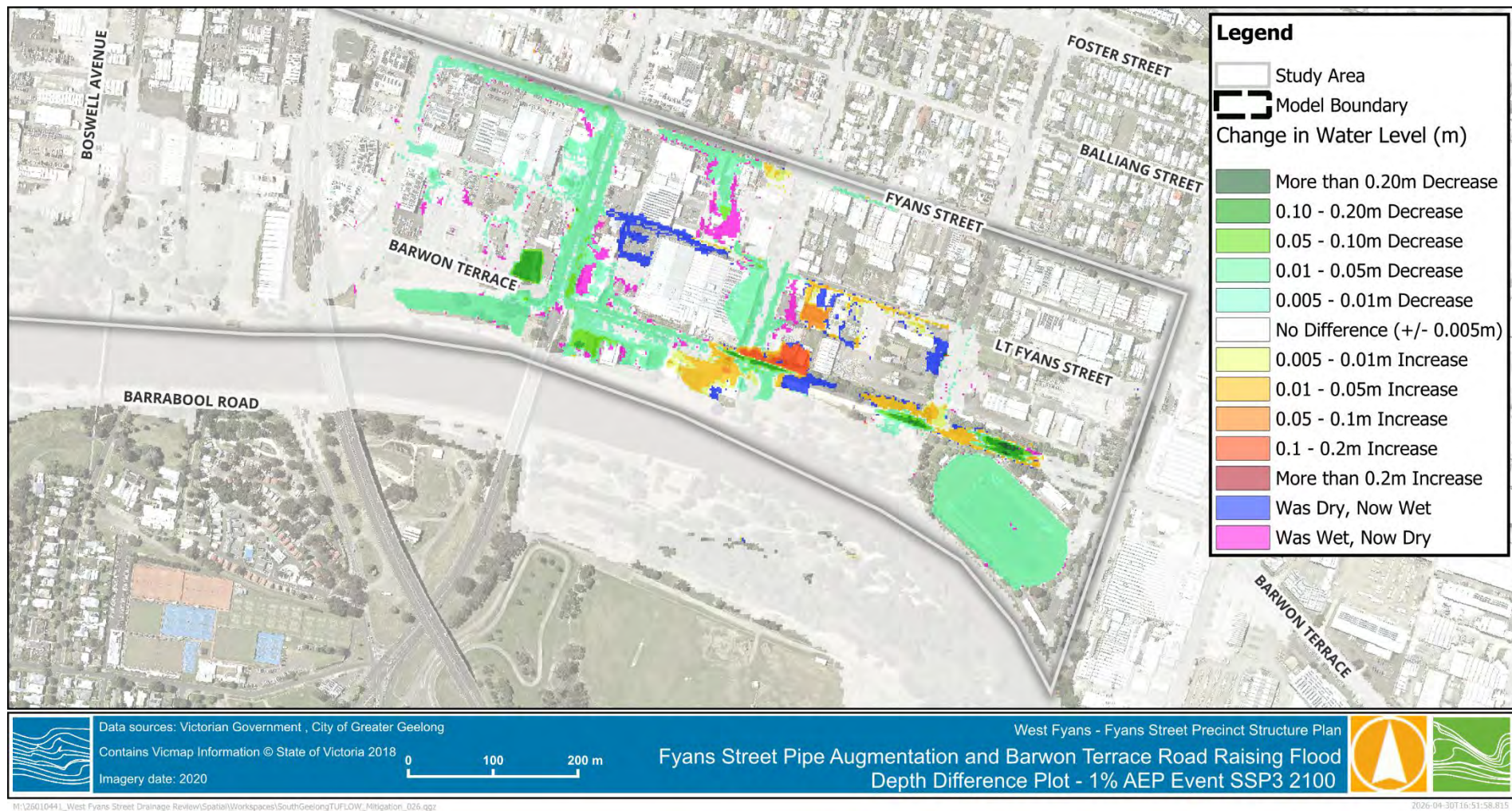


Figure E-2 Fyans Street pipe augmentation and Barwon Terrace Road raising flood depth difference plot

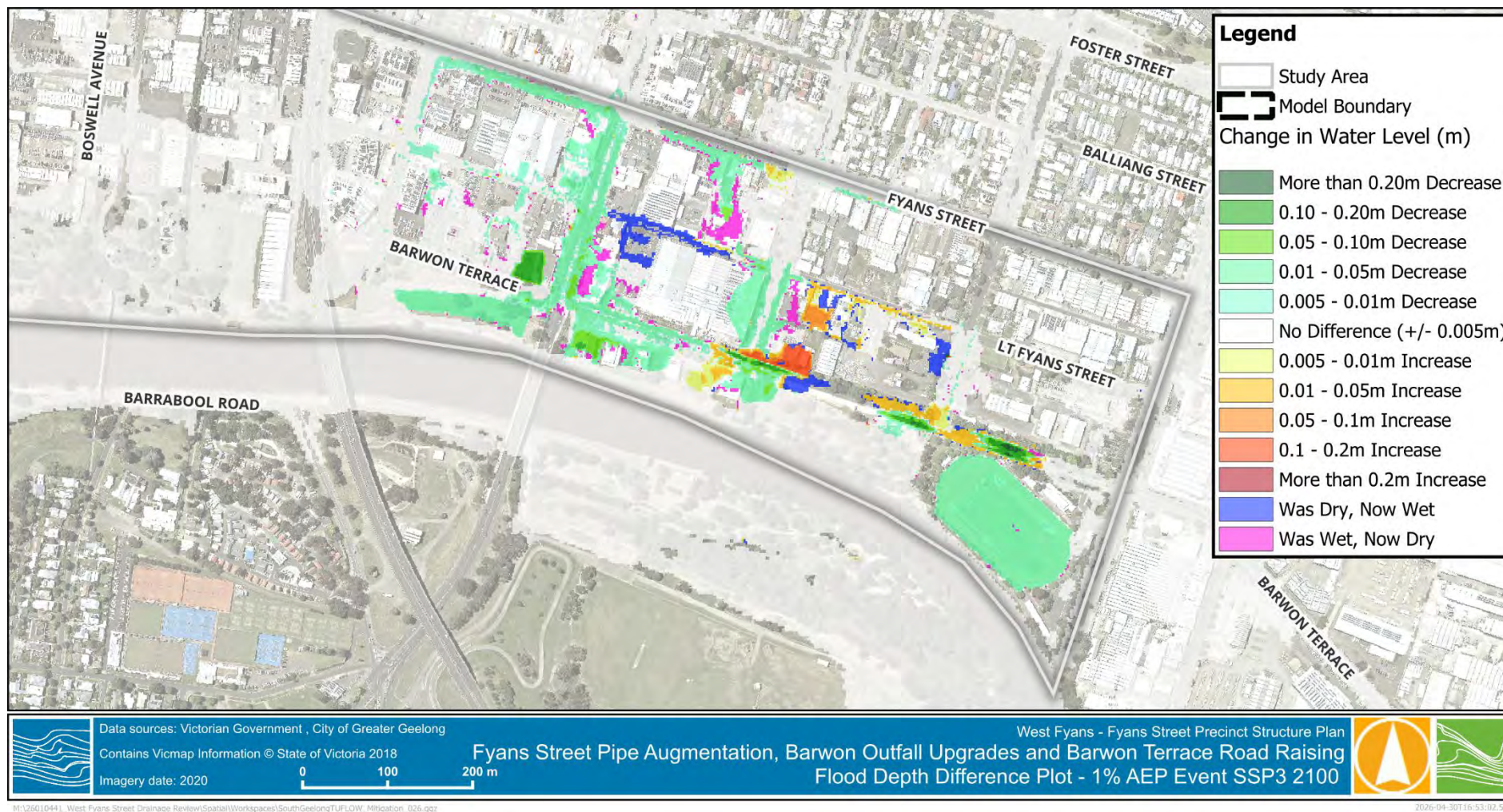


Figure E-3 Fyans Street pipe augmentation, Barwon River outfall Upgrades and Barwon Terrace Road raising flood depth difference plot

APPENDIX F

FLOODED ROAD CLOSURE SIGN



A recommendation of the South Geelong Stormwater Management Strategy (SWMS) was the installation of a flooded road closure warning sign at the western end of Barwon Terrace. The proposed location and 1% AEP SSP3 developed flood depth is presented below in Figure F-1. Raising of Barwon Terrace at three low points within the precinct has also been proposed in this drainage report update in Appendix E. In lieu of acquiring funding for resurfacing of the road along Barwon Terrace, this option is proposed which may be a cheaper and interim solution to mitigate any flood risk caused by the flooded road.

This recommendation is based on flood modelling outcomes and historical records that identify several low points along Barwon Terrace that routinely flood during heavy rainfall events. The installation of a flooded road warning sign is considered a climate-change adaptation soft-engineering measure, aimed at preventing vehicles from entering flooded road sections during storm events. This is particularly important given Barwon Terrace's role as a key movement corridor through the South Geelong precinct and catchment.

It is also noted that any future increase in development density within the precinct is likely to result in higher traffic volumes and an influx of residents who may be unfamiliar with the history and location of flooding along Barwon Terrace. This increases the risk of motorists inadvertently driving into floodwaters during extreme rainfall events.

The proposed warning sign could be automatically triggered via a water-level sensor installed at one of the identified low points, or alternatively manually activated by the City of Greater Geelong or the SES during storm events. In addition to improving road user safety, this measure would provide operational benefits by reducing the demand on SES resources, who are currently required to deploy physical flooded road signage at Barwon Terrace and other locations during significant rainfall events.

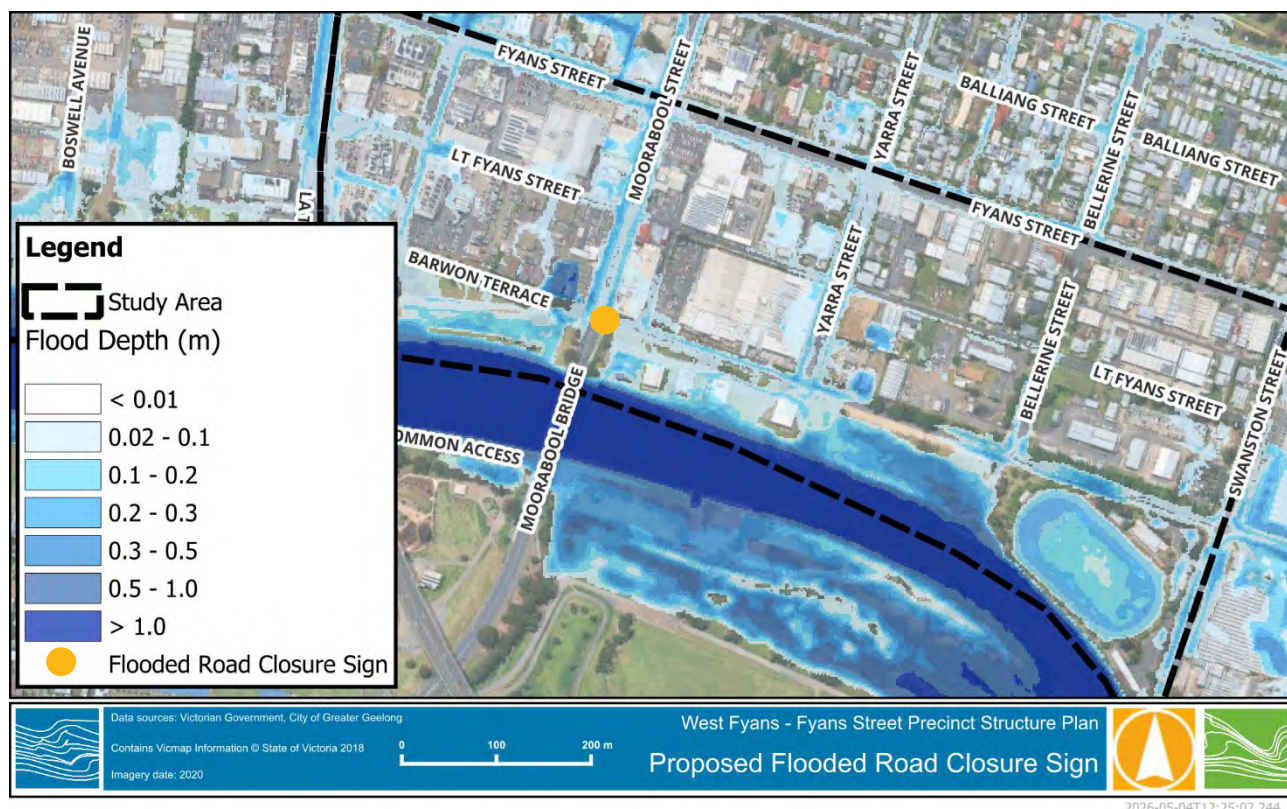


Figure F-1 Barwon Terrace flooded road closure sign

APPENDIX G

FYANS STREET KERB RAISING



Due to the predominantly north–south direction of stormwater flooding, combined with the steep grades of streets running perpendicular to West Fyans–Fyans Street, the lower side of the street is subject to overland flow. Inspection of existing kerb heights along these streets indicates that the kerb and channel infrastructure is aged and may not achieve the current maximum kerb height. To future-proof West Fyans–Fyans Street and downstream properties against increased rainfall intensity associated with climate change, it is recommended to upgrade the kerbs to the maximum allowable height of 150 mm. This maximum height is in accordance with the Infrastructure Design Manual (Local Government Infrastructure Design Association, 2025). The recommended kerb height upgrades within the precinct are shown in ..

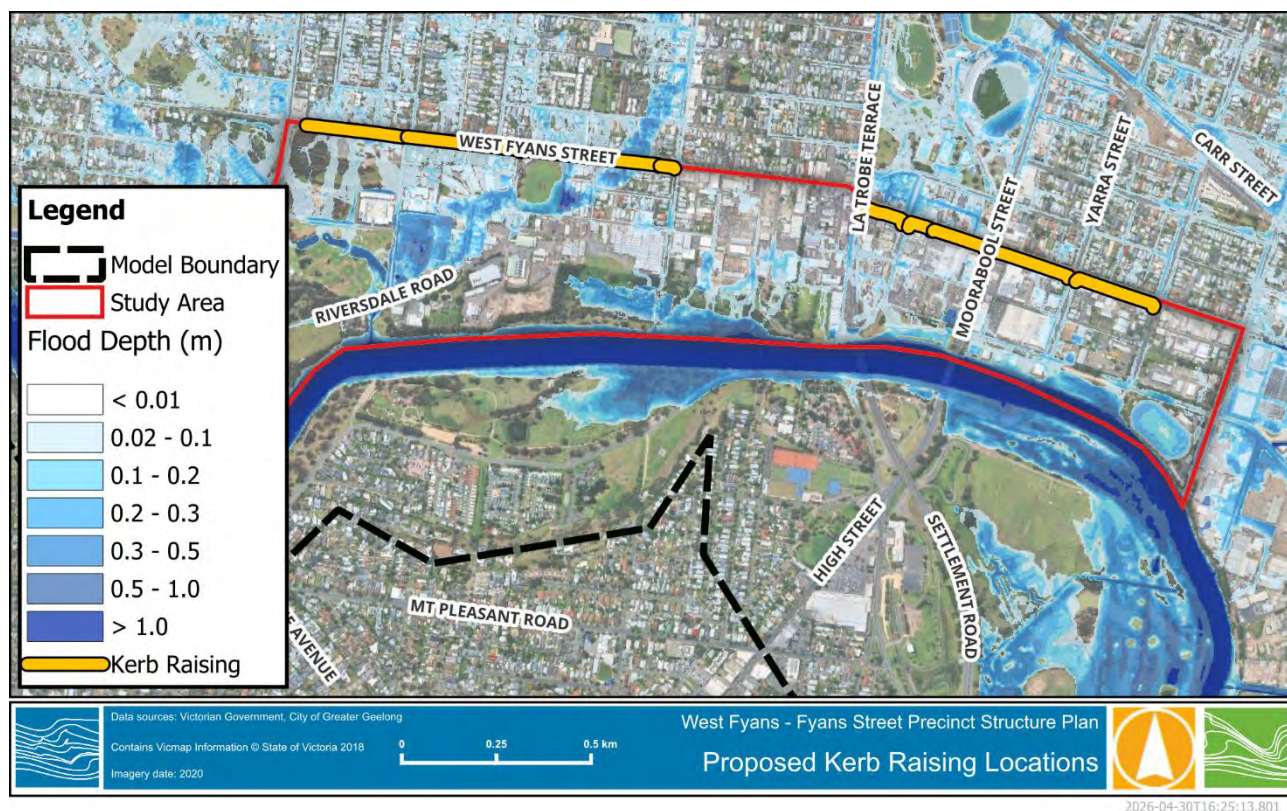


Figure 8-1 West Fyans-Fyans Street kerb raising locations

Where adjacent lots are proposed for redevelopment, The City might consider requiring the developer to lift the kerb to alleviate the existing flooding issues fronting the property.

Table 8-1 Prioritised List of Kerb Raising

Segment	Length	Priority
Frank Street to Gregory Avenue	290	1
Gregory Avenue to Percy Street	373	2
Percy Street to Pakington Street	40	3
Watsons Place to Moorabool Street	154	4
La Trobe Terrace to La Trobe Boulevard	124	5
Hopkins Street to Watsons Place	74	6

Segment	Length	Priority
Moorabool Street to Yarra Street	219	7
Yarra Street to Bellerine Street	229	8
Shannon Avenue to Frank Street	257	9

APPENDIX H

ONGOING PIPE MAINTAINENCE



In the 2018 drainage report, a CCTV assessment carried out on 11 main drain alignments within the study area which found poor ratings for several pipes along Bellerine Street and Latrobe Boulevard. Further investigation into the condition of these pipes appears warranted to ensure the integrity of the assets is not compromised. Furthermore, additional CCTV assessments are likely to be required on the upstream sections of Latrobe Terrace and the Pakington Street Main Drain to investigate potential flood mitigation/drainage capacity works. Consideration should be given to a renewal plan for many of the older brick lined trunk drains in this area given the risk of failure and the likely forecast cost of replacement. The inclusion of open blue stone drains at Bellerine and Bridge Streets in a maintenance plan should be adopted. It may also be necessary to consider upgrading these to piped sections to reduce safety risk and erosion potential which was identified within the study.

APPENDIX I
WEST FYANS STREET MIXED USE
REZONED AREA



Council advised that since the 2025 South Geelong flood model was developed at the commencement of this 2026 report update, it is understood that minor road regrading has been carried out at the low point of the intersection of Belfast Street and West Fyans Street. This regrading is likely to result in minor changes to overland runoff from Belfast Street, some of which flows across West Fyans Street into properties located on the southern side.

Under the ultimate developed scenario, the proposed rezoning at this location is the most significantly affected by these changes. A mitigation is proposed at this location, involving pit and pipe augmentation and raised kerb along the southern side of West Fyans Street. These additional pipes would collect some of the overland flow runoff and divert it west into the existing stormwater network along Bridge Street.

While the road grades along West Fyans Street indicate that surface runoff generally flows to the east, augmenting the stormwater infrastructure to direct flows eastward may decrease pressures on the existing downstream stormwater network near Friers Reserve, which is already operating above capacity. Redirecting some flows westward instead may therefore alleviate pressure on the constrained trunk network. Re-grading the pipe alignment to slope west rather than east may also allow sufficient cover to accommodate pipe upgrades, subject to confirmation that there are no conflicts with existing underground services.

APPENDIX J

WSUD ENHANCEMENT OPPORTUNITIES



The Fyans-West Fyans Precinct presents various opportunities for distributed, 'at source' water quality treatment and volume management through a range of lot scale and streetscape water sensitive urban design. Assets can be retrofitted into existing streetscapes and Council owned areas. The proposed rezoning and subsequent development presents opportunities to deliver WSUD interventions as developers are required to meet planning requirements (such as VPP Clause 53.18) for stormwater management, with outcomes including liveability, biodiversity, resilience, greening and cooling.

Distributed WSUD provides a vital component of a resilient stormwater management system. Measures such as rainwater tanks reduce stormwater runoff, assist with flood mitigation and provide an alternative water supply to homes for non-potable uses such as toilet flushing, garden irrigation and laundry use, reducing the reliance on the valuable potable water supply network.

LaTrobe Boulevard is identified as a suitable location for streetscape enhancements and considered for potential enhancements in a detailed option assessment.

J-1 Latrobe Boulevard WSUD Enhancement

The streetscape of Latrobe Boulevard, south of Fyans St to the Barwon River, is identified as a significant opportunity and potential flagship street to incorporate streetscape water sensitive urban design elements. This street is currently a commercial industrial area with limited pedestrian use.

The properties fronting Latrobe Boulevard are nominated for redevelopment to Residential Growth Zone and will likely form a key public access connection between the landmark Kardinia Park complex to the north, and the Barwon River waterway corridor to the south. Such a change in the zoning will bring urban environment changes that necessitates careful planning, including increased emphasis on public amenity, aesthetics and liveability outcomes.

A WSUD approach to stormwater management in the new residential streetscape can support these and other outcomes that align with City of Greater Geelong strategic priorities. Some WSUD responses suitable for Latrobe Boulevard and their benefits are described in Table J-1.

Table J-1 WSUD elements nominated for Latrobe Boulevard

WSUD Type	Catchment	Benefits
Passively irrigated street trees	Public realm impervious surfaces – roads and footpaths	■ Improve greening and tree canopy cover ■ Urban heat mitigation ■ Enhance biodiversity ■ Improve soil moisture conditions ■ Water quality improvement ■ Stormwater volume reduction via infiltration and evapotranspiration ■ Flooding and climate change mitigation
Streetscape raingardens	Private property impervious surfaces – properties undergoing development / redevelopment	
End-of-line bioretention systems	Kardinia Park Main Drain	

The opportunities to incorporate WSUD elements into the Latrobe Blvd streetscape and Barwon River corridor is shown below in Table J-2.

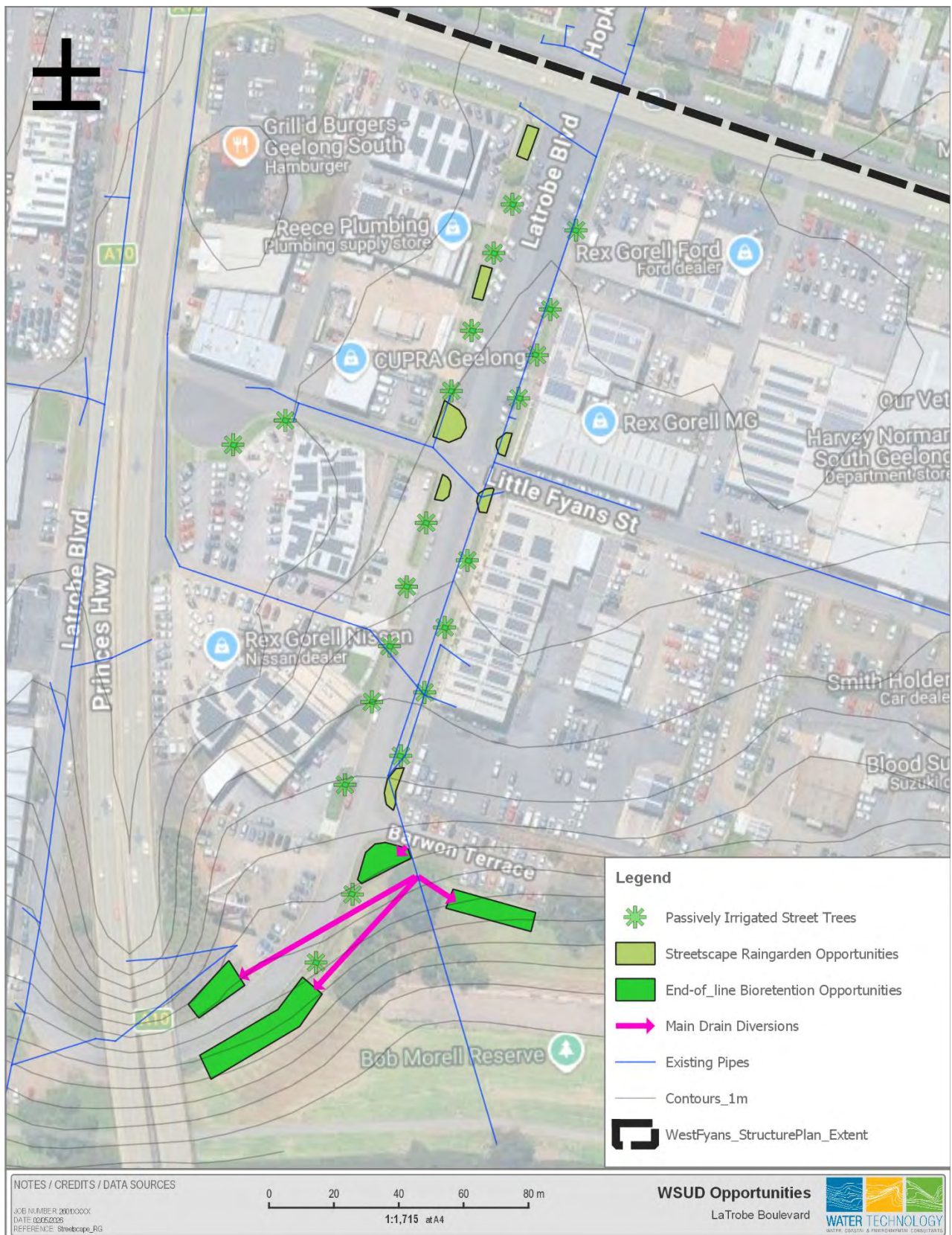


Figure J-1 LaTrobe Boulevard WSUD opportunities

J-2 Passively Irrigated Street Trees

J-2-1 Function

Passively irrigated street trees are trees which use gravity to direct stormwater from adjacent surfaces into the tree root zone as a water source. They are relatively similar to biofilters or raingardens but typically contain one or more trees and may or may not contain other vegetation.

Passively irrigated trees can provide effective treatment of stormwater through the tree root zone and increase retention of water within the landscape. Pollutants such as nutrients increase the risk of algal blooms for waterways but can be beneficial for plant and tree growth.

Using stormwater to passively irrigate street trees not only helps keep trees healthy but also delivers on a range of stormwater objectives that would otherwise need to be met using other infrastructure.

A passively irrigated tree pit typically consists of:

- A reservoir that stores water and allows it to infiltrate into the soil (such as extended detention volume on the surface, infiltration trench or leaky pipes within the soil profile).
- Adequate soil volume and quality (including filter media or other soils) providing suitable conditions for tree growth.

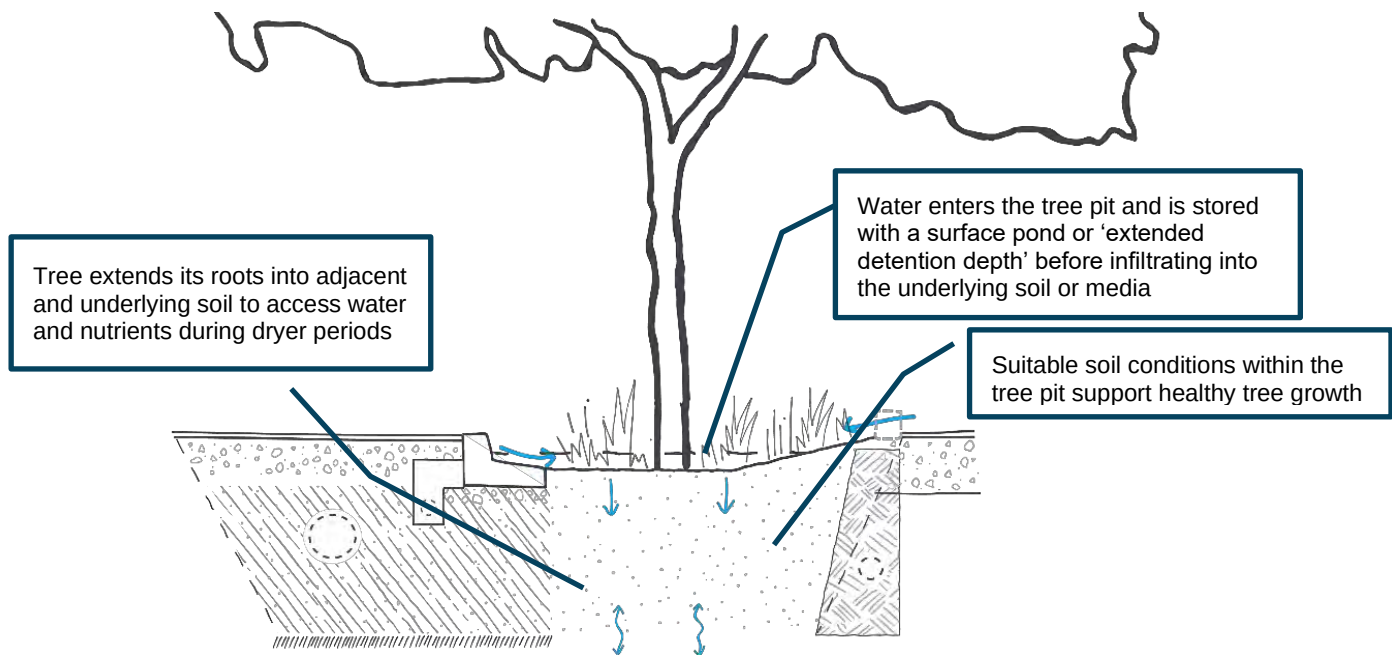


Figure J-2 Example of a passively irrigated street tree showing at-surface water storage and underlying soil volume

J-2-2 Adoption & Constraints

Preferred use typical road conditions:

- ✓ Wide verges
- ✓ Median strips
- ✓ Car parks
- ✓ Used as a key active transport route (walking and / or cycling)



- ✓ Public spaces
- ✓ Within the road to reduce service clashes (e.g. in kerb outstands, in line with parallel parking)
- ✓ Flat grade (<5%)
- ✓ Suitable catchment size to provide optimal soil moisture conditions

Non-preferred use typical road conditions:

- ✗ Heavily shaded
- ✗ Overhead infrastructure (e.g. powerlines, tram lines, street awnings)
- ✗ In verges with lots of underground services
- ✗ Steep site (e.g. >8%)
- ✗ Small catchment area available to supply stormwater
- ✗ High litter and leaf litter loads
- ✗ Minimise canopy growth into private realm
- ✗ Near to intersections where safe lines of sight might be compromised
- ✗ In location likely to become water-logged (e.g. shallow groundwater, street-low points)
- ✗ Sites with highly sodic soils

J-2-3 Design Considerations

Passively irrigated street trees can provide a range of benefits including shading, cooling, amenity, habitat and stormwater management. For the purposes of this guideline, the design considerations are focused on the stormwater management component.

There are a number of design guidelines that provide advice on the planning and design of passively irrigated street trees including:

- *Trees for Cooler and Greener Streetscapes Guidelines for Streetscape Planning and Design*, Victoria Government. Available at: <https://www.planning.vic.gov.au/guides-and-resources/guides/all-guides/trees-for-cooler-and-greener-streetscapes>
- *Designing for a cool city - Guidelines for passively irrigated landscapes*, CRC for Water Sensitive Cities. Available at: <https://watersensitivecities.org.au/content/new-passive-irrigation-guidelines-to-cool-our-cities/>
- *Embedding Green Infrastructure Design Guidelines*, City of Yarra. Available at: www.yarracity.vic.gov.au/about-us/council-taking-climate-action/embedding-green-infrastructure-toolkit#accordion-design-guidelines
- *Water Efficient Trees – Design matrix*, NSW Government. Available at: https://www.dpie.nsw.gov.au/_data/assets/pdf_file/0005/346658/Water-Efficient-Solutions-for-Trees.pdf and https://www.dpie.nsw.gov.au/_data/assets/pdf_file/0006/346659/Water-Efficiency-Study-Urban-Tree-Management-Report.pdf

To ensure passively irrigated street trees can support healthy trees and provide effective stormwater management, the following design principles need to be considered:

- Water treated – there is enough water enter the tree pit,
- Soil volume and quality – the media quality and volume can support tree growth and provide adequate stormwater treatment, and
- Soil moisture – the soil moisture conditions can support a healthy tree.
- Tree selection – a suitable tree species should be selected for the tree pit.
- Safety considerations – the location and design of the tree pit also needs to consider potential impacts on surrounding infrastructure and pedestrians.





There are a number of important design considerations which will influence the configuration, and components used in the passively irrigated tree pit design. These are summarised below with an example of a council's preferred design response.

Table J-2 Design considerations for an example council preferred design response

Design consideration	Example council preferred design response
Water treated	
Inlet designed to allow water to enter the tree pit with a reduced risk of clogging Storage reservoir designed to store the design volume of water and allow it to infiltrate into the tree pit Catchment area is large enough to generate the volume of water required: 80 – 120m² of impervious road surface Need to ensure there is a 'maintainable window' which is the interface between where the water enters the tree pit and then infiltrates into the soil, to ensure this can be maintained to ensure there is no future clogging / blockages.	Inlets: Preferred water supply is: ■ permeable surfaces / pavements. ■ Side kerb openings into tree pits within the road. Inlet configurations such as small kerb cut-outs or grated openings which require manual clearing or street sweeping are not preferred. Storage reservoirs / capture storages: ■ At-surface extended detention ■ Submerged / wicking zone ■ Infiltration well ■ Agi-pipe ■ Agi-pipe in gravel infiltration trench
Soil volume and quality	
Soil media specifications should balance the need for permeability, stormwater treatment and moisture holding capacity to support healthy vegetation and stormwater treatment Tree pit should be sized to provide stormwater treatment and sufficient soil or filter media volume to allow room for the tree to grow. Structural solutions to protect soil from compaction should be used where required	Soil media specifications: Soil specifications should be informed by the arborist to ensure optimal tree growth. Soil saturated hydraulic conductivity should be between 30-50 mm/hr for tree soils or alternately 100-200 mm/hr for biofilter media. Refer to the soil specification standards outlined in the appendix of the design guidelines in the Embedding Green Infrastructure Toolkit Yarra City Council Tree pit sizing: Depth should be at least 700mm (if the system is lined) Structural solution: Structural soils are preferred (ratio of 5:1 of aggregate to soil should be assumed and the effective soil volume should be calculated as 20% of the total volume of structural soil).
Soil moisture	



Design consideration	Example council preferred design response
Ensuring top 300mm (minimum) and 500 mm (preferred) of soil is free draining / has aerobic conditions. A subsoil drain will usually be required with invert at this depth to ensure this is achieved. If a subsoil drain is not possible, soil moisture modelling is required to check the tree will not become waterlogged. If the tree pit is lined, soil moisture modelling is also required as there is no connection to deep soil moisture.	Subsoil drain options: - Connection to existing subsoil drain - Aggie-pipe underdrainage - Slotted pipe underdrainage - Elevated outlet to create wicking zone Outlet / drainage: - Kerb overflow - Overflow pits - Inlet control Soil moisture: If the treatment to catchment area ratio is less than 2% or greater than 10% or if requested by Council, soil moisture modelling should be undertaken to ensure the following: Dry soil spell events greater than 35 days do not occur more than once per year. A dry spell event is defined as a period where soil moisture drops to wilting point, defined as a soil moisture saturation of 0.11 (11%). Wet soil spells don't exceed more than 5 days in duration within a 10-year period. A wet spell event is defined as a period where soil moisture is greater than or equal to a soil moisture saturation of 0.8 (80%)
Tree selection	
Tree height and diameter should be suitable for the location. Tree species should be suitable for the expected soil moisture conditions.	Tree species: Tree species should generally not be greater than 8m in diameter at full maturity unless it can be shown that there is sufficient soil volume and space above ground to support the tree. Tree species appropriate for the location should be chosen considering: - Potential conflicts with overhead infrastructure such as powerlines or awnings - Potential overhanging onto private property - Sight lines - Council arborists to review the design and tree species selection for suitability. - For a full list of environmental and management factors, as well as information on tree sourcing and placement, refer to the City of Yarra's Embedding Green Infrastructure guideline (City of Yarra, 2018)
Safety considerations	



Design consideration	Example council preferred design response
Tree pits need to be designed to mitigate potential impacts to surrounding infrastructure (e.g. underground services, roads, pathways and buildings) from root intrusion and saturation of soils Pedestrian safety also needs to be considered in the placement and design of tree pits to ensure there is adequate space, sightlines and there are no trip or fall hazards. It is the full responsibility of the designer to ensure that all safety risks have been considered and addressed.	Service clashes: Review underground service locations including site survey and service proving and confirm clearance requirements. Structural stability: Review required offsets from buildings and roads. The tree pit may require to be designed with structural soils at an angle of repose for the zone of influence of a building, road or structure to satisfy structural requirements. Impermeable liners may be required on the side of the tree pit adjacent to the structure to reduce risk of root penetration and soil saturation. Pedestrian safety Review traffic and pedestrian management requirements, Disability Discrimination Action (DDA) compliance, footpath and bicycle clearance requirements. Locate and plant passively irrigated street trees to ensure they have no impact on sightlines, especially near intersections. Use covered tree pits (grated or permeable paving) or tree pits that use underground storage (e.g. infiltration trenches) where needed to reduce trip and fall hazards.

There are many different passively irrigated street tree configurations as described. An example Council's preferred passively irrigated street tree designs and locations are summarised below.

Table J-3 Typical tree pit designs

Typical design	Description	Preferred location conditions
Sunken tree pit – open 	The surface is set down below level of surrounding pavement, allowing water to pond and infiltrate into the soil. Typically includes underdrainage connected to the local stormwater network allowing the system to freely drain and mitigate risk of water logging.	In location where surface level can be lowered to allow extended detention Typically combined with additional planting Can be located in areas with poorly draining soils if underdrainage is used Ideally installed in kerb outstands to achieve larger offsets to services and buildings in the streetscape



Typical design	Description	Preferred location conditions
Sunken tree pit – grated 	The surface of tree pit is set below surrounds, allowing water to pond. The pit is covered by a grate and water enters via kerb openings or pipes.	Typically used in high pedestrian traffic areas where shade is required as this can be a more expensive option, especially if structural cells or soils are also required. Can be located in areas with poorly draining soils if underdrainage is used
Leaky pipe around tree 	Slotted pipes placed around trees and connected to the kerb via openings, allowing for stormwater to enter the pipe and infiltrate into the soils.	Freely draining soils or ability to connect to drainage outlet to reduce risk of waterlogging due to absence of underdrainage Location where retaining the surface level is preferred
Below ground infiltration trench or pit 	Infiltration trench or pit adjoined to the tree connected to stormwater runoff via kerb opening. The trench fills with stormwater and exfiltrates to surrounding soils, providing a water source after rain stops.	Freely draining soils or ability to connect to drainage outlet to reduce risk of waterlogging due to absence of underdrainage Location where retaining the surface level is preferred



J-2-4 Option Performance

A total of 21 passively irrigated street trees are nominated to be retrofitted into the streetscape along LaTrobe Boulevard when urban redevelopment occurs. Ideally, each tree should aim to collect stormwater runoff from approximately 120m² of impervious road surface and provide around 100 litres of capture storage.

A nominal 100 trees is modelled in MUSIC and results are scaled to determine performance of a single tree and the 21 proposed trees in removing stormwater excess volume and pollutants. The model setup is shown in and node parameters (for 100 trees) are summarised below.

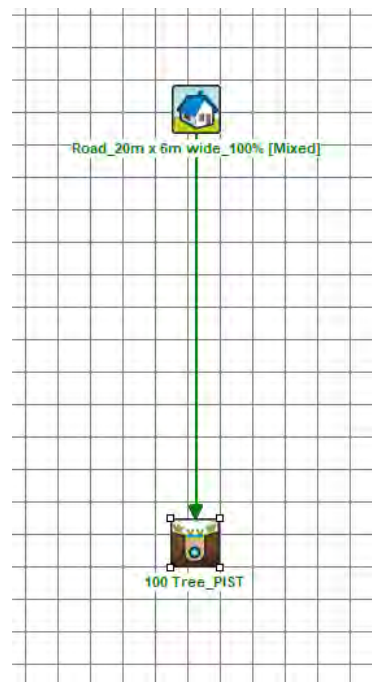


Figure J-3 MUSIC model setup

J-3 Streetscape Raingardens and Bioretention Systems

J-3-1 Function

Biofilters, often called raingardens or bioretention, receive stormwater flows and allow them to be absorbed into and infiltrate through a filter media. Biofilters can act as both filters and sponges for water.

The media works in combination with vegetation and microbes within the biofilter to naturally filter the water, removing sediment, pollutants and litter from runoff. The pollutants which are trapped within the soil via physical, chemical and biological processes are often then used by the plants as nutrients. Water is then usually directed via an underdrain and conveyed into the underground drainage system. Biofilters allow water to be returned to the atmosphere via evaporation and plant transpiration (evapotranspiration). They are usually not lined and allow water to infiltrate into the underlying soil, recharging groundwater and reducing stormwater excess runoff to downstream receiving waters. The reductions in volume and frequency as well as attenuation allow biofilters to more closely represent the natural environment prior to development in terms of stormwater flows.

Biofilters can be used in a range of sizes and locations, such as above ground planter boxes or as part of streetscape landscaping within median strips or adjacent to footpaths. Given their use throughout urban



environments, they can provide habitat and shelter for various plants and animal species, promoting biodiversity and enhancing ecological connectivity. Depending on the size of vegetation used, they can also provide shade and promote cooling through evapotranspiration.

Biofilters typically consist of:

- Extended detention (ponding) with the level of the overflow or bypass above the filter media surface
- Filter media which encourages plant growth as well as filtration of pollutants
- Dense planting throughout the filter media
- Transition and drainage layers which collect filtered water
- An underdrain which provides connection into the drainage network
- High flow bypass structure

Additional features that may be included:

- Sediment control such as a forebay or gross pollutant trap
- Submerged zone: This provides a store of water to help plants survive dry periods and improves overall treatment performance.



Figure A10-4 Streetscape Raingarden (sourced from WSUD Engineering Procedures: Stormwater, Melbourne Water)

J-3-2 Adoption & Constraints

Preferred use typical conditions:

- ✓ Carparks
- ✓ Adjacent to footpaths
- ✓ In urban plazas
- ✓ Within streetscapes where space allows
- ✓ At the end of gutters or swales
- ✓ In urban environments where space for water treatment is limited
- ✓ In locations where some pre-treatment has occurred (such as a swale or gross pollutant trap)
- ✓ End-of-line treatment (although preferably not within retarding basins)
- ✓ Median strips
- ✓ Within individual allotments or subdivisions

Non-preferred use typical conditions:

- ✗ In close proximity to driveways
- ✗ Where there is conflict with underground services
- ✗ When grades dictate that a tiered or cascading system is required
- ✗ In high traffic management zones requiring road or lane closures for maintenance
- ✗ In locations where they cause a hazard for parking
- ✗ Locations which obstruct sight lines for driveways
- ✗ Where grades and/or pedestrian traffic levels result in a high trip hazard
- ✗ Where deep outlet/overflow pits requiring confined space entry are required
- ✗ Insufficient head to outfall discharge



- ✗ Within road reserves not owned by council (i.e. VicRoads road corridors)
- ✗ Sites that are too wet (causing clogging) or too dry (causing plant death)
- ✗ Within retarding basins where they are online to all flows without bypassing of higher flows to protect from excessive sediment loads
- ✗ Catchments that have high sediment loads (such as open industry or construction areas)

J-3-3 Design Considerations

Biofilters provide a landscape amenity, flow attenuation, pollutant removal, opportunities for enhanced community engagement and increased biodiversity. For the purposes of this guideline, the design considerations are focused on stormwater quality and management.

Design guidelines which provide information regarding planning, design and implementation of swales include:

- *Biofiltration systems in Development Services Schemes: Guideline*, Melbourne Water. 2020. Available at: <https://www.melbournewater.com.au/building-and-works/developer-guides-and-resources/standards-and-specifications/biofiltration>
- *Adoption guidelines for stormwater biofiltration systems*, CRC for Water Sensitive Cities. 2015. Available at: <https://watersensitivecities.org.au/content/stormwater-biofilter-design/>
- *WSUD engineering procedures: stormwater*, Melbourne Water. 2005. Available at: <https://www.publish.csiro.au/book/4974/>
- *Designing for a cool city - Guidelines for passively irrigated landscapes*, CRC for Water Sensitive Cities. Available at: <https://watersensitivecities.org.au/content/new-passive-irrigation-guidelines-to-cool-our-cities/>

Other guidelines that may be of interest

- *Specifications for bioretention filter media*, Water by Design. 2023. Available at <https://waterbydesign.com.au/download/specifications-for-bioretention-filter-media>
- *District of Columbia; Stormwater management guidebook*, Department of Energy and Environment. 2020. Available at: <https://doee.dc.gov/swguidebook>

To enable a biofilter to perform effectively and efficiently, the following asset features need to be considered:

1. Inlet – Allows flows to enter the asset safely and efficiently.
2. Extended detention depth - Sufficiently designed for both flow attenuation and infiltration promotion.
3. Filter media – the filtration media can support vegetation growth and provide appropriate pollutant removal.
4. Vegetation – vegetation is selected to tolerate wetting and drying cycles and provide nutrient removal benefits.
5. Outlet and underdrainage – excess and infiltrated flows are able to safely be conveyed downstream.
6. Overflow and/or high flow bypass – protects asset from damaging flow velocities.

There are a number of important design considerations which will influence the configuration, and components used in the biofilter design. These are summarised below with an example council's preferred design response.



Table J-4 Design considerations and preferred design responses

Design consideration	Example Council preferred design response
Inlet	
For streetscape biofilters: Inlets should consider compatibility with street sweeping, pedestrian safety and providing an inflow capacity compatible with the scale of raingarden. For large scale biofilters: For a piped inlet, design ensures erosion and scour are minimised. Flow distribution	For streetscape biofilters: Inlet trays are provided for sediment and debris Kerb grooves are utilised to allow inflows If an at-grade biofilters is used in nature strips and inflows enter directly from adjacent surfaces, clear edge definition is required so residents maintaining nearby turf can differentiate the asset For large scale biofilters: Inlet scour velocities are checked to reduce erosion risk Make provision for achieving a reasonably even flow distribution to assist towards uniform soil moisture
Sediment and litter control	
Sediment and litter control are managed to prevent clogging of the asset and allow easy maintenance.	For streetscape biofilters: Inlet trays or sediment forebay may be provided for sediment and debris For large scale biofilters: Appropriate pre-treatment such as a gross pollutant trap, sediment forebay, or sediment basin is provided if required due to catchment size or characteristics
Extended detention depth	
Inlets, surface and overflow are designed such that water can spread and pond evenly across the surface of the biofilter Catchment area is sufficient to ensure flow volumes and frequencies will support healthy plant growth Extended detention depth is adequate to attenuate flows and promote infiltration without resulting in excessive periods of ponding	Incoming catchment can be increased via a side entry pit bypass General range for extended detention depth is 0.1-0.3m A typical preferred range for biofilters is between 1-10% of upstream impervious catchment with 1-3% being typical and larger sizes being for stormwater volume reductions and/or passive irrigation
Filtration media	



Design consideration	Example Council preferred design response
Soil media specifications balance the need for permeability and moisture holding capacity to support healthy vegetation and stormwater treatment Filtration media depth is appropriate for both stormwater treatment and plant growth Surface of the filter media is to be flat, except for limited batter areas where required A transition layer must be provided in between the filter media and the drainage layer	Rock mulch is not to be used Hydraulic conductivity of the filter media should be between 100 – 300mm/hour Filter media depth should be a minimum of 400 mm (500mm preferred) Filter media surface may need to be re-levelled after the first few rainfall events and natural compaction has taken place Large filter media footprints (>100m²) require water distribution channels to allow even spreading of inflows Transition layers should consist of clean, well-graded sand Filter media specifications can be found in Adoption guidelines for stormwater biofiltration systems, CRC for Water Sensitive Cities. Alternate filter media specifications that may be considered by Council can be found in Specifications for bioretention filter media, Water by Design.
Vegetation type	
Vegetation must be appropriate for the incoming flow volumes and velocities The vegetation must be able to withstand periods of both wetting and drying Native species are preferable, and the design should be resistant to invasive plant species Plants with strong root systems and high capacity to take up nutrients should be used, as this both stabilises the soil and filters stormwater Vegetation may be able to provide habitat benefits for local fauna Vegetation which requires minimal pruning will increase maintenance efficiencies Consultation with landscape architects will enable enhanced amenity	Vegetation type is to be selected in accordance with planting patterns At least 50% of plant cover should comprise plant species known to be effective for nutrient removal or of similar speciation, form including dense roots, vigorous growth and tolerances. Preferred batter species should be used on any batter slopes within the asset Lists of recommended plant species and typical characteristics which provide effective nutrient removal can be found in Adoption guidelines for stormwater biofiltration systems, CRC for Water Sensitive Cities. Biofiltration systems in Development Services Schemes Guideline, Melbourne Water
Outlet and underdrainage	



Design consideration	Example Council preferred design response
A drainage layer and under-drainage is usually required Flows collected via the underdrain should be safely conveyed downstream, via connection into a downstream drainage network An overflow pit is provided to allow for connection into the underground drainage network	Drainage layer should be 100-200mm deep and consist of fine aggregate Underdrains should be slotted pipes or aggie-pipes Only straight drainage lines are to be used for underdrainage, no curves are to be designed or installed Underdrains should have inspection openings with end caps to be secured with extra stainless-steel screws Underdrain capacity should be equal to or greater than the filtration capacity of the soil media Overflow capacity should be equal to or greater than the inflow capacity of the biofilter Overflow pits should be designed in accordance with Council drainage standards and specifications. The outlet must be accessible for regular inspection and maintenance

J-3-4 Option Performance

Spatial analysis of properties subject to rezoning to Residential Growth Zone (RGZ) along LaTrobe Boulevard indicates a potential future catchment area of 2.5ha can be directed to streetscape raingardens for stormwater management. Spatial analysis of the existing LaTrobe Blvd indicates that up to 270 m² of raingardens could be fitted into the streetscape to treat runoff from the identified properties. The properties and potential treatment areas are shown in.

MUSIC modelling indicates that the raingarden treatment area (filter area) required to treat a 2.5ha residential catchment to Best Practice is 75m². Therefore, there is ample opportunity to incorporate streetscape raingarden assets into LaTrobe Boulevard to meet the treatment requirements of development along this street.

Opportunities to incorporate bioretention systems along the southern end of LaTrobe Boulevard and Barwon Terrace within the Barwon River corridor are also identified in . These 'end-of-line' systems could treat flows from the larger upstream catchment by intercepting and diverting flows from the existing outfall main. This main 900mm diameter pipe currently discharges untreated urban flows from the Kardinia Park (west) catchment. The catchment is approximately 42 hectares and 51% impervious.

Spatial analysis has identified opportunities to incorporate approximate 750m² of bioretention basin assets into the waterway corridor and streetscape; MUSIC modelling shows this is adequate to meet Best Practice water quality outcomes for the catchment. Consideration for existing public use of the area for events may limit the extent of assets possible within the Barwon River corridor at these locations.

- A summary of the modelling parameters and results for streetscape raingardens are shown in and respectively. Model parameters and results for the end of line bioretention basins are provided in and respectively.

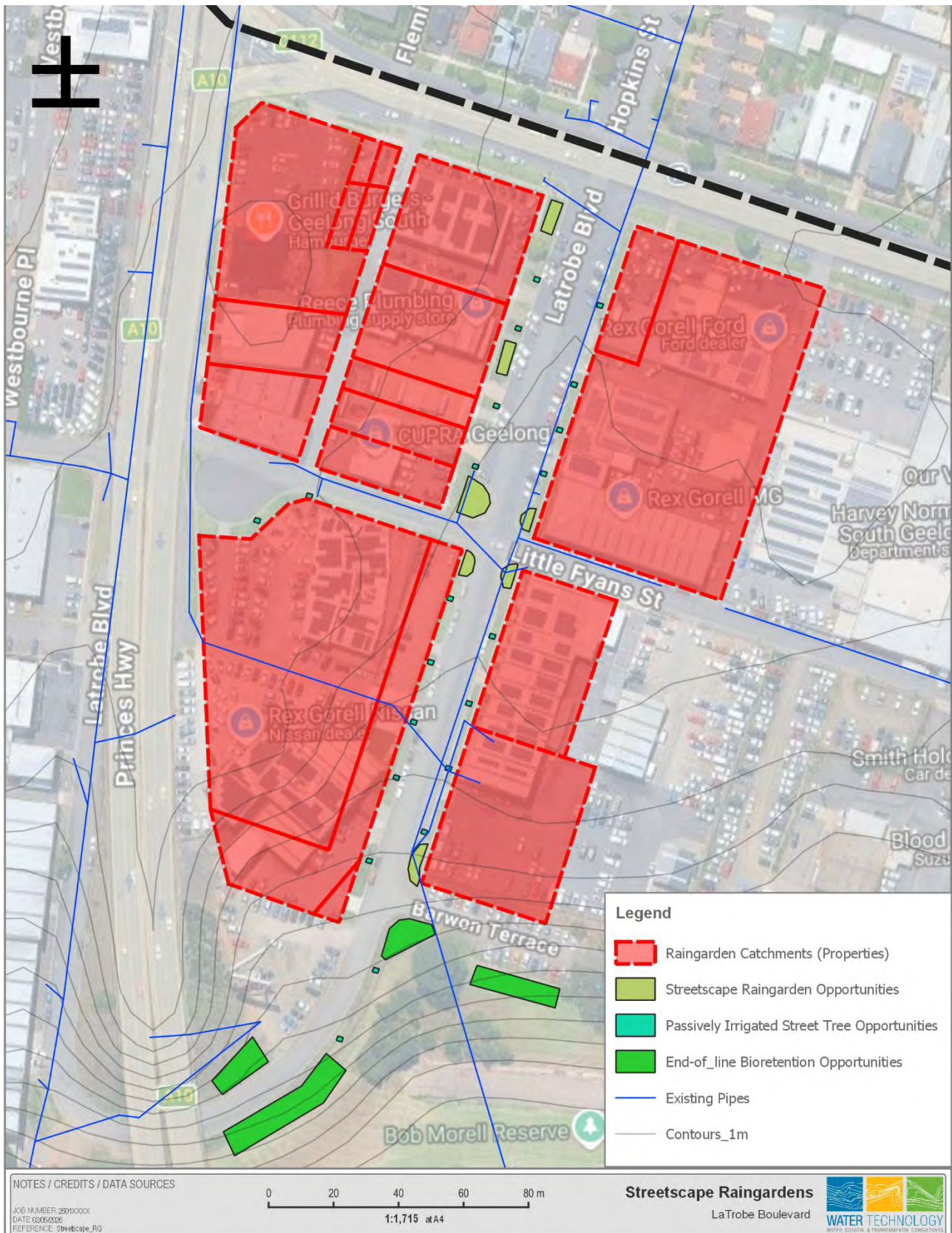


Figure J-4 WSUD enhancement of Latrobe Boulevard: potential streetscape raingarden catchments and WSUD asset locations

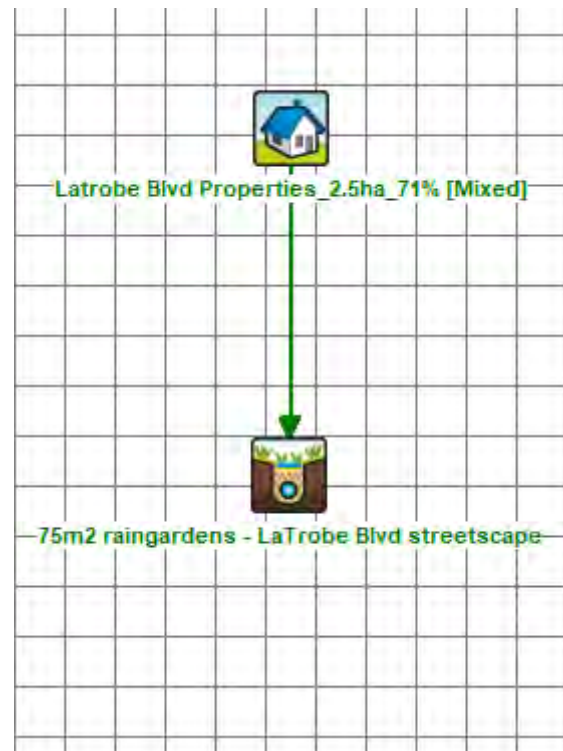


Figure J-5 Model schematic for streetscape raingardens to meet BPEM for local catchment

J-3-5 Parameters – raingardens for local catchment

Source node:

- Catchment area: 2.511 ha
- fraction impervious: 71%

Treatment node:

- Type: bioretention node
- Surface /filter area 75m² test
- Extended detention depth: 0.2m
- Unlined media perimeter: 14m
- Saturated hydraulic conductivity: 200mm/hr
- Filter depth: 0.5m
- Exfiltration rate: 0mm/hr
- Base: lined
- Effective nutrient removal plants
 - Underdrain present, and



- No submerged zone

Table J-5 Performance of 750m² of bioretention basins in Barwon River corridor

	Load reduction: 750m ² Bioretention	%reduction (from inflows)
Volume reduction		
Infiltration	0 kl/y	0%
Evapotranspiration	1,530 kl/y	1.5%
Total losses	1,530 kl/y	1.5%
Nutrient reduction		
TSS	14,870 kg/y	77%
TP	21.4 kg/y	54%
TN	134.8 kg/y	47%



APPENDIX K PRIMARY TREATMENT OF EXISTING BARWON RIVER OUTFALLS VIA NEW GROSS POLLUTANT TRAPS







Sixteen (16) existing outfalls in the precinct currently discharge stormwater to the Barwon River untreated. This concept proposes proprietary gross pollutant traps to intercept untreated flows and improve the quality of stormwater entering the river.

The outfall locations and reference are shown in Figure 8.2, including upstream catchments and existing land use. Table 8-2 details the analysis undertaken to prioritise the rollout of treatment devices, including an estimate of costs and benefits for each identified outfall location. The prioritisation of outfalls is undertaken based on the predicted performance of suitable GPT product over a 50-year operating life considered alongside the present value whole of life cycle cost to purchase, install and maintain the device over the 50 years. The top five (5) prioritised GPT locations include the following:

1. Southern end of Bridge Street downstream of Riversdale Road, Newtown (161)
2. Western side of Settlement Road bridge, South Geelong (162)
3. Eastern side of Barwon Bridge, South Geelong (165)
4. Wills Place, South Geelong (163)
5. Bellerine Street, South Geelong (167b)

The following assumptions have been made in the analysis:

- Reference product is nominated as the Holcim HumeGard for comparative analysis purposes only. We recognise that various products are available on the market that could fulfill the outcomes and therefore advise the City to consider these options alongside the nominated HumeGard product. Note that suitable product models, performance, supply and installation costs, and maintenance requirements and costs will vary across suppliers.
- Product selection and the respective cost (capital and operating), and treatment performance is based on direct advice and published materials from the supplier.
- The fractions impervious adopted for the various land use types include:
 - Roof areas: 100%
 - Road pavements: 100%
 - Other areas: 50%
- Table 8-2 identifies the Bridge Street main drain as the highest priority untreated open channel outfall (pipe size of 0) in the precinct. Other opportunities to improve stormwater quality for this catchment include the Balyang Golf Course treatment and harvesting (Appendix L) and the Pakington Street diversion and constructed wetland (Appendix M) options, whose construction will remove or divert gross pollutants away from this outfall and thus, affect the cost feasibility of GPT installation at this location.

Installation of an end of line gross pollutant trap on this outfall will likely require interception and diversion of low flows from the channel to an 'offline' device adjacent to the outfall channel.



Table 8-2 Outfall treatment prioritisation for Fyans-West Fyans Precinct

Priority	Catchment Ref	Council Pipe Ref	Upstream Area	Upstream Impevious	Fraction Impervious	Pipe size	Land use type_1	Land use type_2	Product Ref (or equiv)	Annual GP removed (0.4m3)	Supply Only Delivered Price (ex GST)	Annual Maintenance Cost (ex GST)	Cleans per year	Total NPV Cost (50 years)	NPV Cost Efficiency
	Ref.	PIPEDAT_ID	ha	ha	%	dia. mm			HumeGard	kg/y	\$	\$	No.	\$, 2025	\$, 2025/ kg GP
1	161	1019461	122.8	87.4	71%	0	Residential	Industrial	HG45	34.96	\$ 79,000	\$ 22,000	2	\$455,916	\$ 261
2	162	1045937	54.5	40.5	74%	1200	Residential	Industrial	HG45	16.20	\$ 79,000	\$ 11,000	1	\$265,577	\$ 328
3	165	524721	27.2	21.0	77%	825	Commercial	Residential	HG30	8.40	\$ 53,000	\$ 5,300	1	\$142,185	\$ 339
4	163	1022046	42.1	29.6	70%	1125	Commercial	Pervious	HG40	11.84	\$ 69,000	\$ 8,500	1	\$212,794	\$ 359
5	167b	1021241	25.2	19.5	77%	900	Industrial	Residential	HG30	7.80	\$ 53,000	\$ 5,300	1	\$142,185	\$ 365
6	166	610586	22.5	18.3	81%	750	Commercial	Residential	HG30	7.32	\$ 53,000	\$ 5,300	1	\$142,185	\$ 388
7	181c	502156	5.6	5.1	92%	450	Industrial	Industrial	HG15	2.04	\$ 17,000	\$ 2,800	1	\$64,640	\$ 634
8	181a	572794	5.4	4.6	85%	450	Industrial	Residential	HG15	1.84	\$ 17,000	\$ 2,800	1	\$64,640	\$ 703
9	181b	1015055	3.5	3.3	93%	300	Industrial	Commercial	HG12	1.32	\$ 16,500	\$ 2,800	1	\$64,164	\$ 972
10	178b	1024490	4.0	3.1	78%	450	Commercial	Commercial	HG15	1.24	\$ 17,000	\$ 2,800	1	\$64,640	\$ 1,043
11	164	1000198	14.7	10.4	70%	1350	Commercial	Industrial	HG45	4.16	\$ 79,000	\$ 11,000	1	\$265,577	\$ 1,277
12	167a	1005349	2.3	1.7	72%	225	Industrial	Commercial	HG12	0.67	\$ 16,500	\$ 2,800	1	\$64,164	\$ 1,909
13	178a	632202	2.7	1.6	58%	375	Pervious	Commercial	HG12A	0.64	\$ 16,500	\$ 2,800	1	\$64,164	\$ 2,007
14	181e	1031227	0.8	0.8	94%	150	Commercial	Pervious	HG12	0.31	\$ 16,500	\$ 2,800	1	\$64,164	\$ 4,175
15	181d	1020018	0.4	0.4	94%	225	Industrial	Industrial	HG12	0.14	\$ 16,500	\$ 2,800	1	\$64,164	\$ 9,050

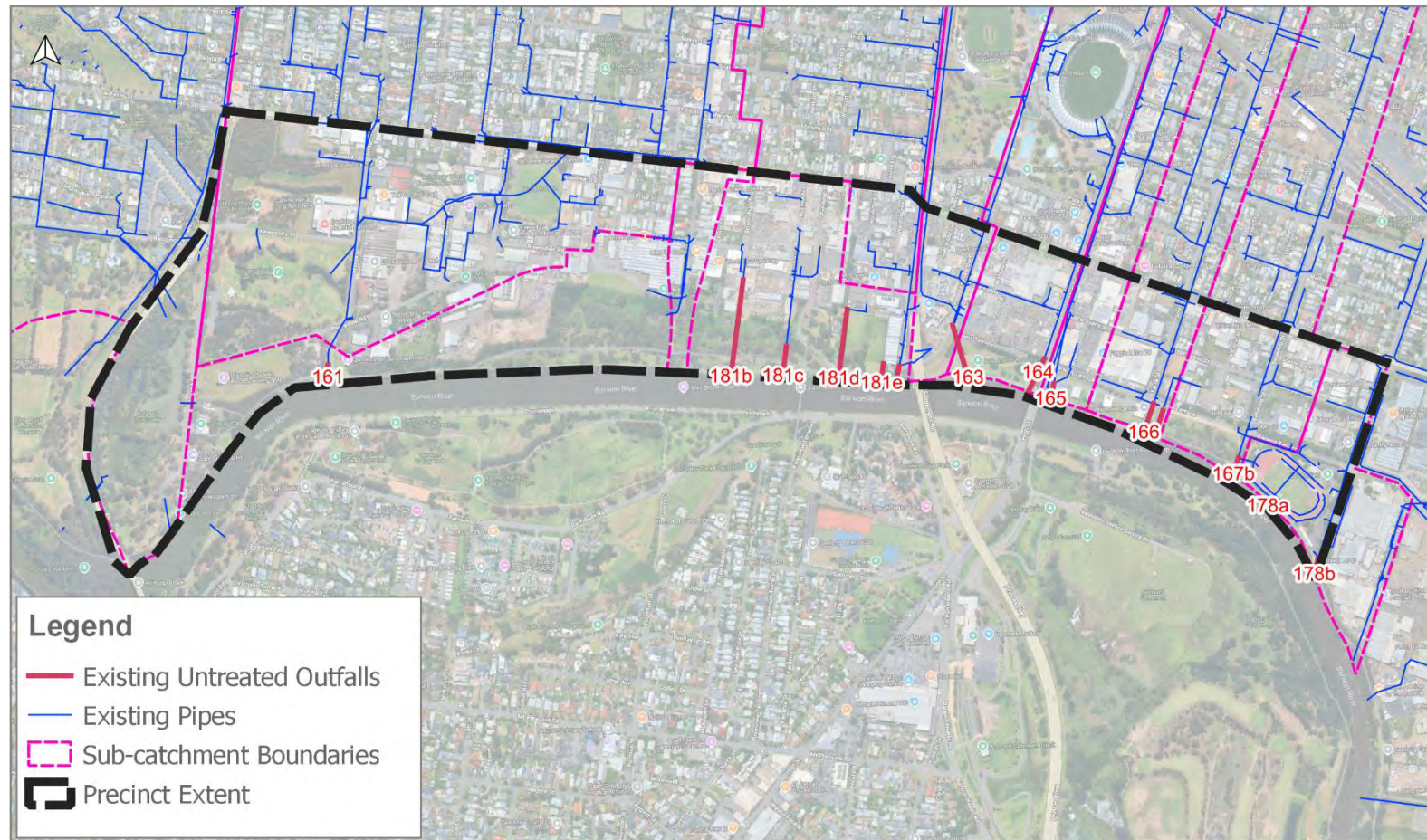


Figure 8.2 Proposed GPT locations





APPENDIX L BALYANG GOLF COURSE STORMWATER TREATMENT AND HARVESTING SCHEME



L-1 Description

The Balyang Par 3 Golf Course is a public golf course operated by the City of Greater Geelong, on a site of about 6.4 ha and contains three existing ponds, as shown in Figure 8.3. Stormwater is diverted from Bridge Street on the eastern boundary via a small pipe to the easternmost pond, and from Newcastle Street on the northern boundary into the westernmost pond. Water use data provided by the City indicates that approximately 4.4 ML/y of potable water is used to irrigate the Golf Course.



Figure 8.3 Location of ponds on the Balyang Par 3 Golf Course

The upstream catchment, known as the Bridge Road drain, is 119 ha of established urban development, one quarter of which is industrial land. The catchment has a directly connected imperviousness (DCI) of approximately 50%. The golf course sits on the Barwon River floodplain, and the ponds are inundated by riverine flooding in the approximately 10% AEP event, and additional low-lying areas of the golf course are inundated by the larger 1% AEP event (Water Technology, 2018). The land immediately to the east of the golf course was historically used as a landfill and therefore soil contamination is an identified risk for the site.



L-2 Proposed works

Minor modifications could be made to the ponds to create constructed wetlands to enhance water quality treatment within the ponds (Figure 8.4). The treated water could then be harvested and reused to provide a more reliable alternative water supply for irrigation of the golf course. This would have the multiple benefits of:

- Providing safe, secure and affordable water supply from an alternative water source; reducing the use of potable water for irrigation and providing an alternative water supply through the beneficial use of stormwater.
- Improving waterway health by reducing pollutant loads to the receiving environment, and reducing the volume of urban excess runoff discharged to the Barwon River.
- Providing healthy and valued landscapes with the additional irrigation maximising the greening, cooling, aesthetic and recreational values of the landscapes.

Further treatment of diverted stormwater runoff is proposed by discharging treated stormwater from the constructed wetland to the riparian woodland downstream. The riparian woodland is located between the southern boundary of the golf course and Riversdale Road, on land managed by the City. Here, stormwater would engage the floodplain, being treated within those ephemeral wetlands, and some water would infiltrate into the wetland soils to restore connection to groundwater and further reduce runoff volumes.

The proposed constructed wetland, harvesting and reuse system is described in Figure 8.4 and the proceeding numbered items.



Figure 8.4 Proposed constructed wetlands and stormwater harvesting concept

In reference to the numbered features in Figure 8.4:

- 1. Diversion** - Stormwater diverted from the open drain on Bridge Street via a pipe through the Balyang Golf Course. Only low flows are needed to provide a high reliability of supply i.e. $0.1 \text{ m}^3/\text{s}$.
- 2. Sedimentation basin** - The first cell of the constructed wetlands (eastern extent near Bridge Street) would be adapted to function as an inlet pond (sedimentation basin), so as to protect the remaining wetland cells from coarse sediment accumulation. High flows from the sedimentation basin would discharge to the Bridge Street drainage network.
- 3. Constructed wetlands** – The existing ponds would be modified to create higher performing constructed wetlands. This would require minor reshaping to create benches for planting aquatic macrophytes. Benches for planting deep marsh aquatic macrophytes would be set at 350 mm below the normal water level, so that deep marsh plants would not be subjected to water depths greater than 500 mm for long spells, as few species thrive in deeper environments.



- a. Large flow balancing pipes are required between wetland cells to convey incoming water through the 3 wetlands, minimising head loss during initial filling.
 - b. The water level (top of extended detention) of the constructed wetlands would be controlled by the high flow bypass from the sedimentation basin to the Bridge Street drain. This limit would prevent the wetland vegetation from being inundated by water depths that may be too deep to sustain healthy growth of emergent aquatic macrophytes. The extended detention is proposed to be set at 150 mm.
4. **Irrigation pumps** draw water for golf course irrigation as required. Water storage for irrigation supply would be limited to depth of 300 mm below the normal water level. This provides a storage of approximately 1500 kL, whilst leaving 50 mm of water to submerge the deep marsh aquatic macrophytes, and to thus protect plants from desiccation during prolonged dry spells. An irrigation pump would be connected to the existing irrigation tank. The pump rate would be designed to match the existing facilities' pumping requirements, presumably the rate of potable supply.
5. High topography within the golf course prevents the wetland draining by gravity and therefore pumping to riparian floodplain woodland is required. Once the wetlands have filled to top of extended detention, pumping would draw water down from top of extended detention to the design normal water level within 48 h, providing adequate residence time and optimal water quality treatment in the constructed wetland. An average pump rate of 12 l/s is assumed considering the wetland extended detention drawdown volume (1,500 KL) and a 0.7 scaling factor to incorporate the larger surface area of the water body when fully engaged. A 12-hour daily pump operation period and batter slopes of 1:3 are assumed. The elements must be confirmed in detailed design.
6. **Discharge to the riparian floodplain woodland:** Flow distribution could be achieved by small channels or French drains along paths. About half of the discharged water is expected to infiltrate into the floodplain soils, with the remainder discharging overland to the roadside drain on Riversdale Road.

L-3 Inundation considerations

The inundation of the riparian woodland would require minor earthworks such as bunding or shallow flow distribution channels to distribute and contain stormwater within the site. Natural undulations are likely to limit the even distribution of discharged water, and assumptions include only 50% of the identified area as being able to be regularly inundated. Assumed extended detention depth was 150 mm, a conservative parameter and shallow enough to allow ephemeral species to thrive i.e. *Carex appressa*. An infiltration rate of 1.0mm/h was assumed for the soils of the riparian floodplain woodland. This was considered conservatively low for the purposes of estimating performance since well vegetated soils typically have macropore flow that facilitates infiltration.

Wet and dry spells are assessed for the wetlands and riparian floodplain woodland using time-series data for 10 years that included the irrigation of the golf course at reported rates.

The constructed wetlands are expected to be drawn down weeks during the dry season to the depth of planting of the deep marsh macrophytes (350mm) every few years, and sometimes for periods of up to 4 weeks. It is recommended that deep marsh plants should not experience dry periods for more than 60 days.

The constructed wetlands would be inundated for long periods during the wet season. This is because the wetlands are undersized relative to the size of the contributing catchment. Long wet spells occur in the wet season (winter) lasting up to 120 days, even with a reduced 48-hour detention time. The extended detention depth has been limited to 150mm in response, to protect the plants from inundation depths that could limit plant growth.

In the riparian floodplain wetlands, wet spells of up to 120 days are also expected. Inundation spells were checked to identify if there is relief from flooding every year. With a detention time of 48 h (the same as the



upstream wetland), there are periods of relief from flooding that should be sufficient to allow tree and shrub seedlings to grow tall enough during the dry season (summer) to be able to survive the following wet season. Inundation depths should be limited to approximately 50mm to ensure that seedlings are not drowned. It is assumed that the natural variability of the surface topography would provide some habitat for recruitment of tree seedlings in most years, allowing the forest floodplain community to persist. Some near-permanently ponded areas may transition to a shallow marsh community.

L-4 Key constraints and opportunities

The vegetation of the riparian woodland was considered in a review of the Department of Sustainability and Environment's [NatureKit Interactive Mapping \(DELWP 2017\)](#), which was undertaken by Water Technology in 2018, and this identified the vegetation type likely to be present at the study site, both prior to European settlement (pre-1750) and currently existing (2005). The search indicated that the site was likely to be occupied by Floodplain Riparian Woodland (EVC 56). This EVC would contain *Eucalyptus camaldulensis* (River Red Gum) and *Eucalyptus ovata* (Swamp Gum) and would tolerate periodic flooding and inundation. However, advice from specialists should be sought for the following:

- Ecology specialists to confirm the duration and extent of inundation for the target plant community. It may also be necessary to limit the operating window of the pump (e.g. winter only), to prevent adverse impact on tree health and seedling recruitment from prolonged inundation.
-  Groundwater impacts within the riparian woodland to be assessed as there is the potential for groundwater infiltration to mobilise potential soil contamination.

Other constraints or considerations include:

- Contamination assessment required. The golf course site is adjacent to an old landfill site (the 'old tip') immediately to the east, on the other side of Bridge Street. Therefore, expanding the footprint of the wetlands was considered to be an undesirable risk, and minimal changes to the total footprint are proposed. Any excavated soils would be re-distributed within the site and would not be considered prescribed waste, nor require disposal to landfill.
- Landuse - The City are currently undertaking a review the potential use of the golf course land. The high reliability of alternative water supplies is likely to be advantageous for some future proposals.
- Gross Pollutant Trap - Previous reporting (Water Technology 2018, Section 6 .2) indicates that there is a GPT associated with the Bridge Street drainage network, that could be connected back online. Removing gross pollutants such as litter and coarse sediments would protect the downstream assets from blockages.
- No information was available on the existing drainage structures within the wetlands during the review and this infrastructure and its function, performance and condition should be confirmed prior to developing designs further. Risk of blockage and potential for sedimentation should be assessed.
- The constructed wetlands and riparian floodplain woodland are both subject to occasional riverine flooding from the Barwon River. This is not expected to impact the hydrology of the wetlands but could impact access to irrigation infrastructure.

Opportunities that could be developed through design include:

- The constructed wetlands should incorporate deep open water zones (about 1.5 m deep). These provide resilience to the pond ecology as they assist in retaining water within the wetlands year-round, and allow for wicking of moisture from the pools through the wetland soils to keep the root zone of the aquatic macrophytes wet. They also provide for settling of fine sediments, and act as a refuge for aquatic species during dry periods, including providing habitat for fish, insects and mosquito predators.



- The high flow bypass to the Bridge Street drain should also include a variable outlet that can lower the water level to:
 - Normal Water Level, in case the pumps break down and the water level needs to be lowered to protect the health of the aquatic macrophytes
 - 350 mm+ below NWL (if possible) to facilitate drainage of the sediment basin and constructed wetlands for maintenance if required.
- A GPT on the Bridge Street drain could be designed to incorporate the low flow diversion to the golf course, to prevent litter and coarse sediments from entering the stormwater harvesting network. This would substantially decrease downstream maintenance.
- There is the potential for this stormwater harvesting scheme offer the opportunities to supply future additional nearby demands such as:
 - Irrigation supply for the Mountain Bike Park grounds (north of Newcastle Street)
 - Alternative water supply for future use at the Historic Wool Mill precinct.
- Large urban catchments often have a persistent baseflow as a result of catchment activities such as overspill from upstream irrigation. This could lead to a consistent supply of low flows for harvesting during dry periods. Conversely, persistent flows may be detrimental to the downstream floodplain riparian woodland if such flows deprive the woodland of a seasonal drying phase during summer, and may need to be seasonally bypassed. The pumping depths could be modified to optimise outcomes for either water storage for irrigation during dry periods (i.e. retaining part of the extended detention as a permanent pool) or protecting the macrophytes from frequent inundation (i.e. by pumping below the normal water level to provide relief from inundation).

Key parameters of the concept design and outcomes of the associated MUSIC modelling for treatment performance are presented in Table 8-3. Key outcomes include:

- 33% of catchment treated to best practice (based on TN reduction)
- Substantial water quality improvement for a large urbanised catchment including Best practice stormwater treatment targets exceeded for all diverted flows
- Water storage of 1500 kL created in wetlands achieves a very high supply reliability of 96%
- The riparian floodplain woodland functions as a vegetated sponge removing substantial flows and associated pollutants.

L-5 Concept design summary

Table 8-3 Balyang Golf Course concept design summary

Concept Summary	
Project	
Name	Balyang Par 3 Golf Course wetland enhancement and stormwater harvesting
Location	19-33 Marnock Rd, Newtown
Asset Type	
Treatment type	Wetland
Total area	5,084 m ²
Harvesting	Yes



Concept Summary	
Stormwater drain location	NE at corner of Bridge St and Newcastle St
Management	
Land owner	Council
Utility	Barwon Water
Diversion drain	Council
Catchment	
Name	Barwon River
Area	110 ha
% Directly Connected Imperviousness	50%
% Industrial	25%
% of catchment treated to best practice (based on TN reduction)	33 %
Treatment performance: including Riparian Floodplain Woodland*	
Flow reduction	31.5 ML/yr (33 %)
TSS reduction	12,120 kg/yr (80 %)
TP reduction	23.1 kg/yr (68 %)
TN reduction	130 kg/yr (50 %)
* Removal assuming that infiltrated flows into Riparian Floodplain Woodland are sequestered into the wetland soils and plants.	
Harvesting performance	
Irrigation Demand	Balyang Par 3 Golf Course
Total demand	4.4 ML/yr
Total reuse volume	4.23 ML/yr
Storage	1500 kL (in wetlands)
Supply reliability (augmented with potable water if required)	96 %
Submersible pump in constructed wetland to golf course tanks	12 L/s
Pump to floodplain riparian woodland	12 L/s
Equipment shed	10 m ²
Financial	
BCR (supplied re-use valued at \$2.67/kL ¹ and monetised value of nitrogen abatement of \$11,390/kg ²)	1.00
CAPEX (\$)	\$1,340,000
OPEX (\$/yr)	\$16,350
Total PV Cost (\$2025) (50 year period, 20 year design life)	\$1,356,350
Other	
Indicator Score - from (Water Technology, 2026)	23 (very high)





APPENDIX M PAKINGTON STREET DIVERSION PIPE AND CONSTRUCTED WETLANDS





M-1 Description

Options to reduce flooding in the Bridge Street Drain catchment and around the Friers Reserve facility has been investigated for various configurations in the 2018 Fyans-West Fyans Drainage Assessment (Water Technology, 2018). This option considers Option 1 from this study, comprising the Pakington Street diversion pipe in conjunction with stormwater treatment wetlands within the receiving Barwon River floodplain.

The pipe diversion was modelled for the suite of durations from 15 minute to 6 hours for the 1% AEP design storm. The filtered flood depth plot and change in flood levels are shown in Figure 8.5. There is a significant reduction in the depth of flooding between Hampton Street and Frier Reserve with a reduction of 10 cm through the industrial area around Bridge Street. The largest reduction, however, is upstream of the catchment from West-Fyans to Mervyn Street. The increase in flows reaching the floodplain below Pakington Street is a result of the diversion pipe. Water level increases are confined to the informal wetlands both sides of the pedestrian path from the Barwon River to Pakington Street. The design of a wetland incorporating a high flow bypass would be required to ensure no additional risk to public safety or assets along the Barwon River floodplain. This offers an additional benefit with the potential to treat a larger volume of water within the wetlands before entering the Barwon River.

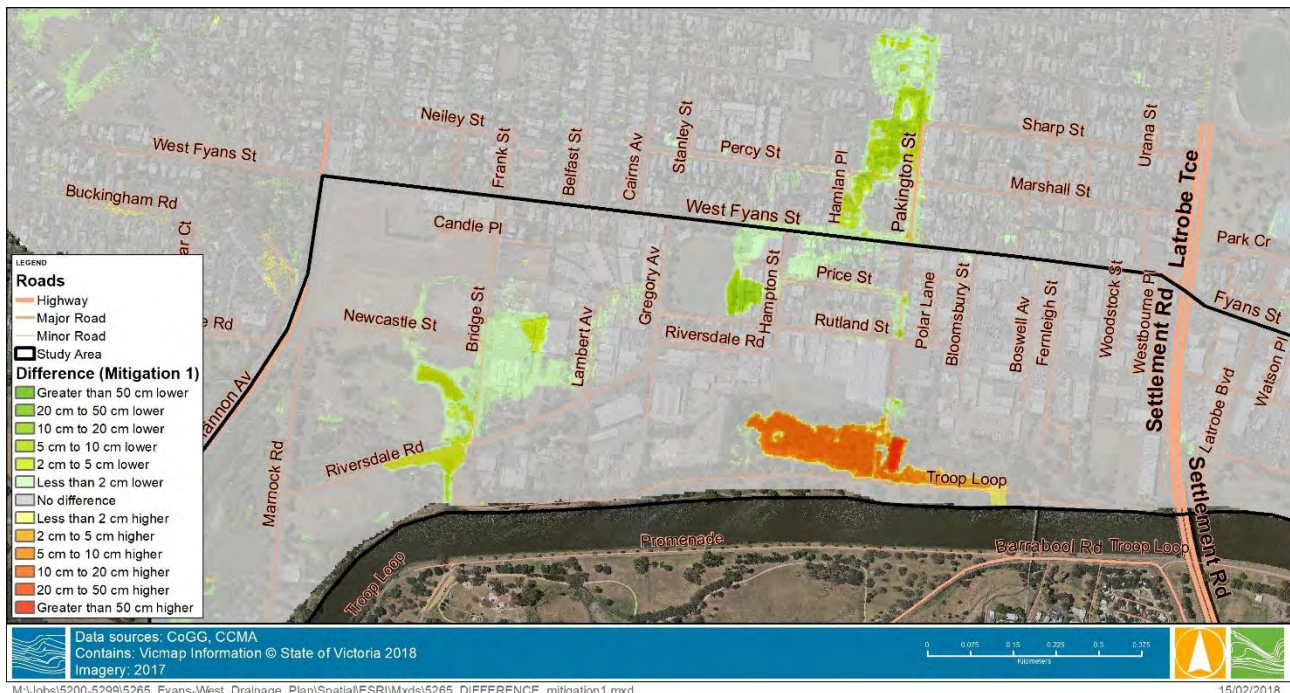


Figure 8.5 Mitigation Option 1 (Pakington Street Diversion Pipe) flood level difference plot

M-2 Proposed works

The Pakington Street diversion pipe option incorporates new pipe alignments along Pakington Street, south of Nicholas Street, that collects flows from underground drains in Nicholas, Mervyn and Percy Street's. The diversion pipe directs flows along Pakington Street South and outfalls to the Barwon River floodplain in the vicinity of the existing pipe outfall. While this option is likely to have a number of constraints relating to services and disruptions along Pakington Street, it offers additional opportunities to improve the quality of water flowing to the Barwon River. This improvement could be accomplished by formalising a constructed stormwater treatment wetland in the Barwon River floodplain at the location of the existing small informal wetland. This proposed constructed wetland can treat stormwater runoff beyond best practice prior to flows entering the



Barwon River, improving water quality in the receiving environment and resolving legacy catchment water quality issues for the diverted catchment.

The alignment modelled included additional reinforced concrete pipes (RCP) and pits along Nicholas Street (90 m RCP @ 450 mm diameter), Mervyn Street (80 m RCP @ 450 mm diameter) and Percy Street (80 m RCP @ 450 mm diameter) to remove flow from a significant overland flow path back to Pakington Street. The Pakington Street alignment includes 100 m of 600 mm diameter RCP from Nicholas to Mervyn Street, 150 m of 750 mm diameter RCP to Percy Street, 105 m of 900 mm diameter RCP to West Fyans Street and 320 m of 1200 mm diameter RCP to the outfall at the end of Pakington Street South.

A new constructed wetland is proposed within the Barwon River floodplain to treat the diverted Pakington Street catchment to Best Practice. The proposed wetland comprises an inlet pond to capture coarse sediments and an enhanced macrophyte zone to trap finer sediments and enable biological uptake of nutrients such as nitrogen and phosphorus. Ensuring a residence time in the order of 72 hours will enable sufficient time for biological uptake to occur along with evapotranspiration losses from the standing water bodies contributing to flow volume reduction losses. When the wetland extended detention is full, flows can be directed to bypass the macrophyte zone via overtopping of the inlet pond directly to the Barwon River, protecting the sensitive macrophytes from high velocities and extended inundation periods.

The concept design of the Pakington Street pipe diversion and constructed wetlands options is shown in Figure 8.6 below.

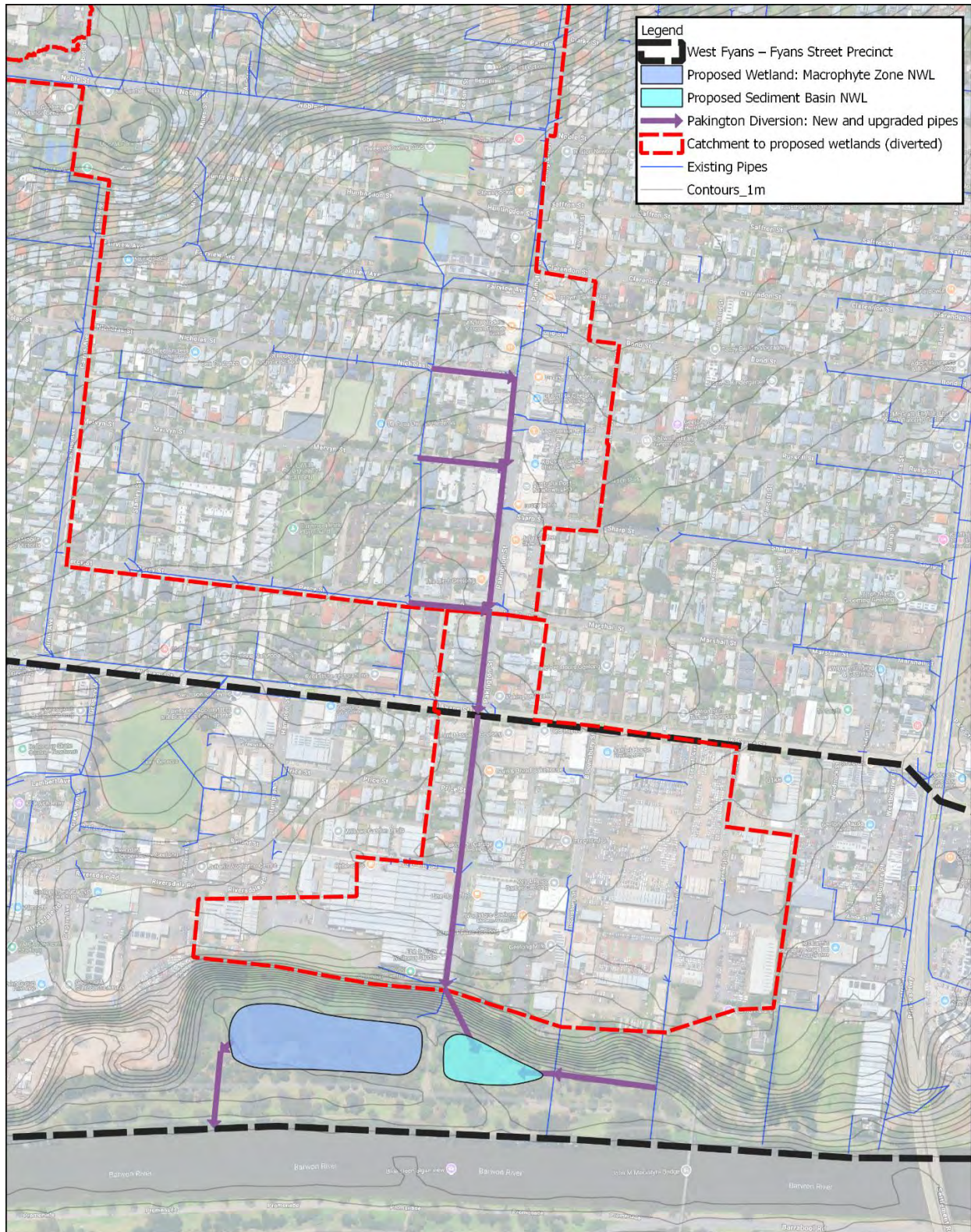


Figure 8.6 Pakington Street diversion pipe and constructed wetlands concept



M-3 Constraints and opportunities

Various organisations and community stakeholders will have interest in the proposed constructed wetlands, including:

- **Corangamite CMA (CCMA):** Being located within the Barwon River floodplain, the land is managed by CCMA.
-  **City of Greater Geelong (CoGG):** The location is zoned for PCRZ: Public Conservation and Resource Zone in the Greater Geelong Planning Scheme. The proposed assets will likely be owned and maintained by CoGG and will need to be designed and constructed to the relevant CoGG standards.
- **Environmental Protection Authority (EPA):** The presence and any proposed removal of values and/or protected native vegetation or fauna species may trigger restrictions or obligations under relevant environmental protection legislation.

 A range of funding options can be pursued to support construction, operation and maintenance of the Pakington Street pipe diversion and stormwater treatment wetlands. This could include (but not limited to):

- **Developers** of rezoned precincts can contribute to a water quality offset scheme, such as described in Section 2.7. This would require The City to establish the voluntary contribution Scheme and to collect sufficient contributions from developers to support design, construction, operation and maintenance of the proposed works.
- **State Government** agencies, departments or specific programs, such as DEECA or the Integrated Water Management Forums, may provide funding grants to support improved flooding and water quality outcomes in high value catchments and receiving environments. This option presents a compelling case for grant funding due to the high value catchment and high priority waterway status, including RAMSAR listed Lake Connemara being a receiving environment.

M-4 Concept design summary

Table 8-4 Balyang Golf Course concept design summary

Concept Summary	
Project	
Name	Pakington Street wetland enhancement
Location	Rear/403 Pakington St Newtown
Asset Type	
Treatment type	Wetland
Macrophyte zone area	12,300 m ² at NWL
Inlet pond volume	3,750 m ³
Asset Footprint	1.93 ha (treatment area +20%)
Management	
Land owner	City of Greater Geelong
Utility	Barwon Water
Diversion drain	City of Geelong
Catchment	
Name	Pakington Street Diversion (proposed)



Concept Summary	
Area	56 ha
% Directly Connected Imperviousness	64%
% Industrial (future)	0%
% of catchment treated to best practice (based on TN reduction)	100 %
Treatment performance:	
Flow reduction	17 ML/yr (10%) (evapotranspiration)
TSS reduction	28,485 kg/yr (87%)
TP reduction	50 kg/yr (76%)
TN reduction	257 kg/yr (55%)
Financial	
BCR (monetised value of nitrogen abatement of \$11,390/kg)	0.85
CAPEX (\$)	\$3,100,000 - \$1,300,000 for diversion pipes / pits - \$1,800,000 for wetlands
OPEX (\$/yr)	\$24,200 /yr - \$5,000 /yr for diversion pipes / pits - \$19,200 /yr for wetlands
Total PV Cost (\$2025) (50-year period)	\$3,450,000

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South Brisbane QLD 4101

Sydney

Suite 3, Level 1, 20 Wentworth Street
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Adelaide

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Wayville SA 5034

New Zealand

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Ponsonby New Zealand 1021

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Newtown VIC 3220

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Varsity Lakes QLD 4227

Sunshine Coast

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Birtinya QLD 4575

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Perth

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Fremantle WA 6160

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