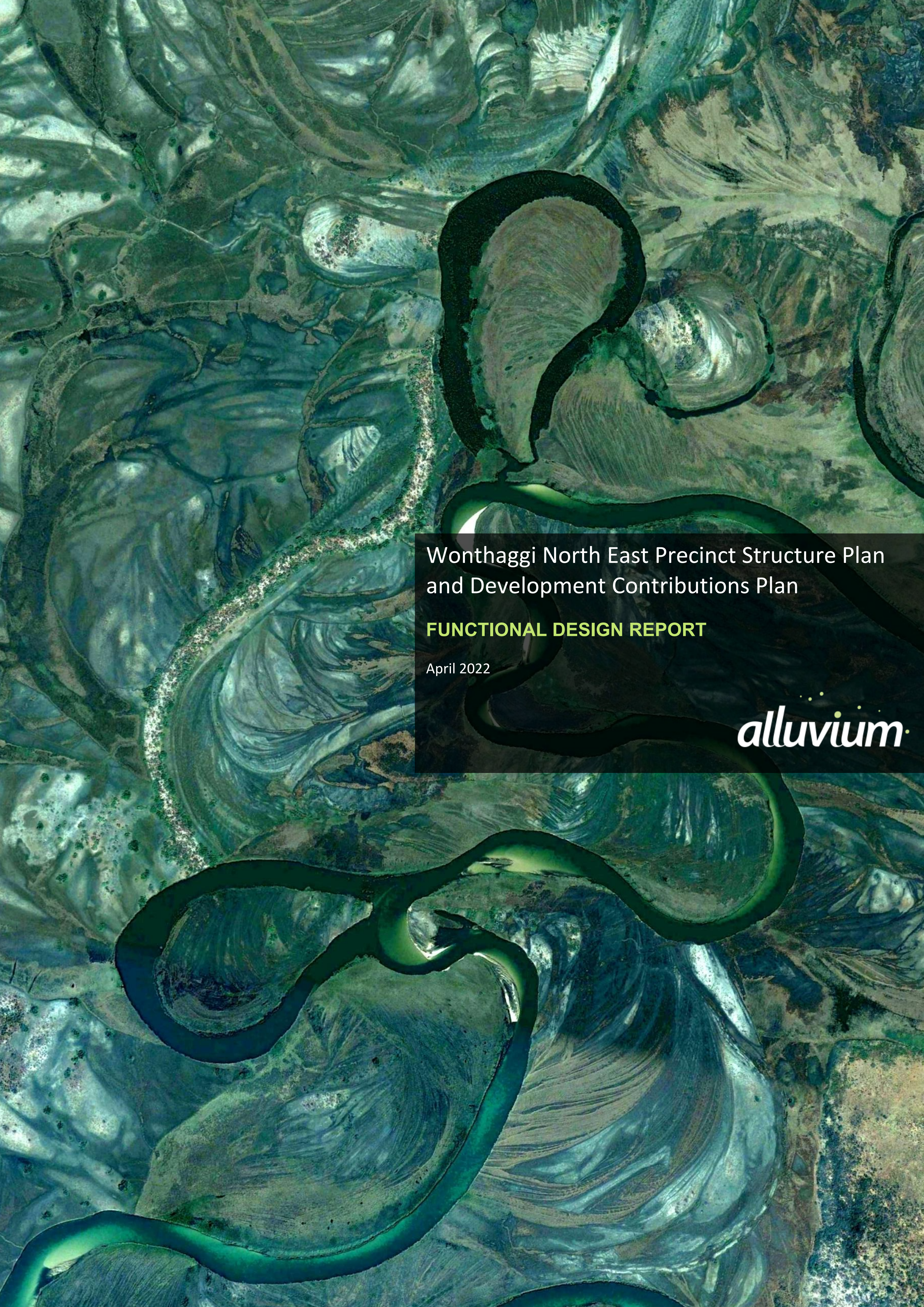

Wonthaggi North East Precinct Structure Plan and Development Contributions Plan

FUNCTIONAL DESIGN REPORT

April 2022

alluvium

Alluvium recognises and acknowledges the unique relationship and deep connection to Country shared by Aboriginal and Torres Strait Islander people, as First Peoples and Traditional Owners of Australia. We pay our respects to their Cultures, Country and Elders past and present.

Artwork by Vicki Golding. This piece was commissioned by Alluvium and has told our story of water across Country, from catchment to coast, with people from all cultures learning, understanding, sharing stories, walking to, and talking at the meeting places as one nation.

This report has been prepared by Alluvium Consulting Australia Pty Ltd for the Victorian Planning Authority under the contract titled 'D/21/3212 – WONTHAGGI NORTH EAST PRECINCT STRUCTURE PLAN AND DEVELOPMENT CONTRIBUTIONS PLAN – STORMWATER DRAINAGE FUNCTIONAL DESIGNS AND COSTINGS'.

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	06 Revised Functional Design Report (new modelling & redesigns, April 2022)
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Contents

Figures

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Abbreviations

Alluvium	Alluvium Consulting Australia Pty Ltd
BCSC	Bass Coast Shire Council
BPEMG	Best Practice Environmental Management Guidelines
CRZ	Core Riparian Zone (waterways)
DCP	Development Contributions Plan
DETV	Department of Education and Training, Victoria
Engeny	Engeny Water Management Pty Ltd
PoC	Alluvium Proof of Concept Report
PSP	Precinct Structure Plan
TSS	Total Suspended Solids
TP	Total Phosphorus
TN	Total Nitrogen
VB	Vegetated Buffer (waterway)
VPA	Victorian Planning Authority
WGCMA	West Gippsland Catchment Management Authority
WNEP	Wonthaggi North East Precinct
VPA	Victorian Planning Authority

1 Introduction

Alluvium Consulting Australia Pty Ltd (Alluvium) has been engaged by the Victorian Planning Authority (VPA) in partnership with Bass Coast Shire Council (BCSC) to undertake a suite of stormwater drainage functional designs and associated cost estimates based on previous concept work undertaken (by others) for the Wonthaggi North East Precinct Structure Plan (PSP) and Development Contributions Plan (DCP).

This project has been delivered by Alluvium in parallel to the refinement and finalisation of the Stormwater Management Plan ('drainage strategy') for the Wonthaggi NE PSP and the respective concept layout designs undertaken by Engeny Water Management.

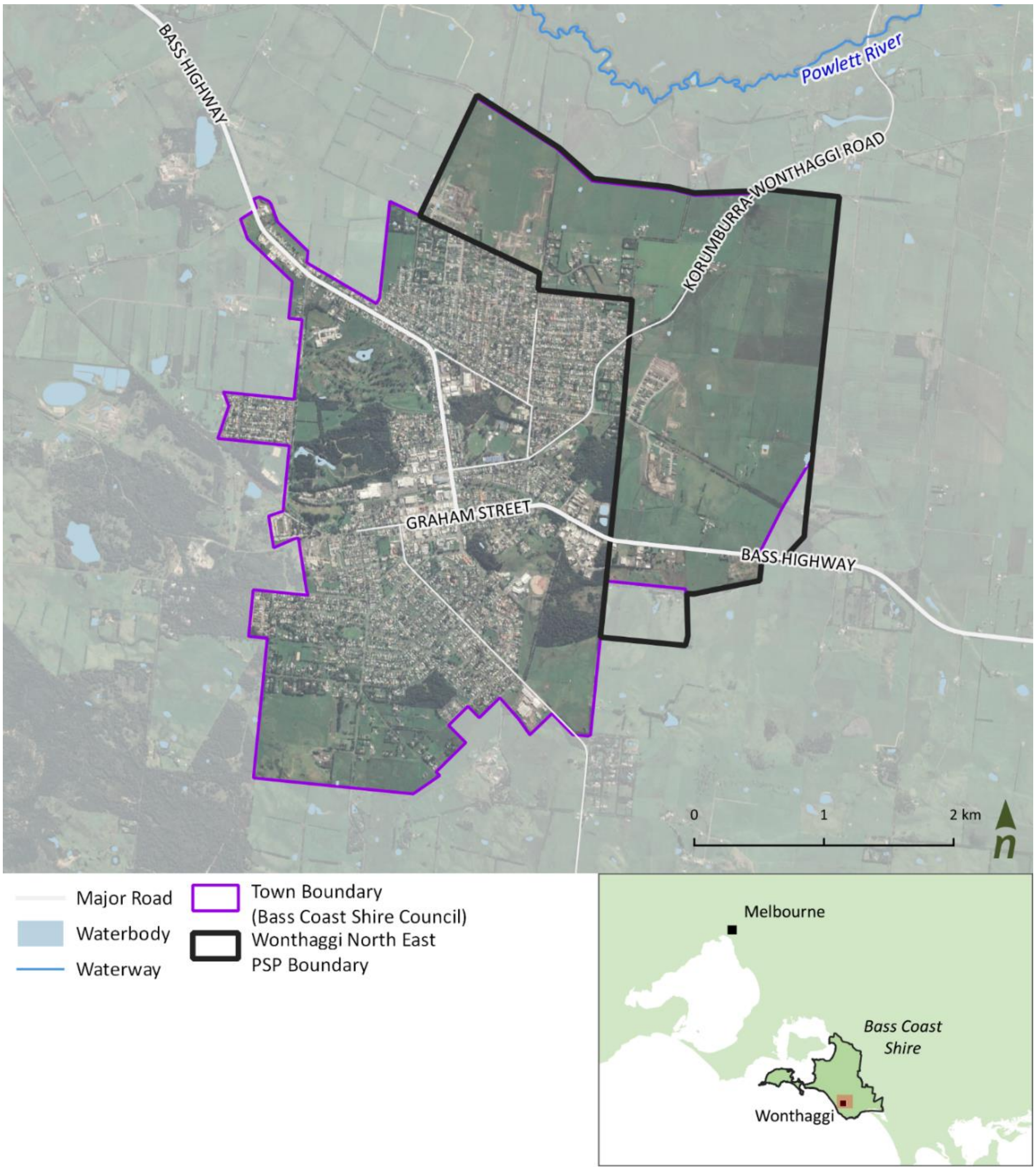


Figure 1. *Site location*

2 Project Background

2.1 Engeny Strategy & Concept Designs (October 2019 – September 2021)

Engeny Consultants were engaged by the Bass Coast Shire Council (2019) to undertake modelling, stormwater drainage investigations, and the development of the Stormwater Management Plan for the Wonthaggi North East PSP – *Stormwater Management Plan* (October 2019). Following the June 2020 planning scheme amendment process for the PSP (Amendment C152), Engeny were re-engaged to prove PSP concepts further, specifically in relation to the proposed wetland-retarding basin (WLRB1; DCP ref WL-01) and the ultimate outfall from the precinct to the downstream at Powlett River - *Impact and Proposed Mitigation Works Strategies* (March 2021).

On behalf of the Bass Coast Shire Council, Engeny was engaged by the VPA to revise the 2019 Stormwater Management Plan (the strategy) following feedback during the amendment process. The strategy was completed and provided to Alluvium in August 2021 and a later revised final version September 2021. This latest strategy provided further refinement of the proposed stormwater drainage infrastructure for the Wonthaggi North East PSP.

At the time of Alluvium's engagement by the VPA (July 2021) a further three iterations of the Strategy were produced as Engeny's revised modelling work further informed the concepts for the proposed precinct assets. Alluvium has reviewed all versions of the Strategy (October 2019 through to September 2021) including revised modelling outputs and changes to the concept designs (received July to September 2021).

The Engeny work developed the proposed assets to a conceptual level with associated high level cost estimates. The associated DCP (VPA, Nov 2020) identified 29 functional water assets for capture, conveyance and management of stormwater quantity and quality across the precinct, which included:

- Two (2) 'internal' constructed waterways (a west and east alignment)
- Four (4) treatment wetlands, two (2) of which to be integrated with retarding function (RBs)
- 11 sediment basins (SBs)
- and 12 culverts (CUs)
- and potential for additional (e.g. main outfall to Powlett River - MOP).

Several changes have occurred in the Strategy since its earlier direction to present time, particularly to the wetland/retarding basin assets where all four wetlands are now also retarding systems; the number of sediment basins increased to a total of 16; some culverts were later found to be existing assets; and new assets added that are associated with the precinct's ultimate outfall to the Powlett River. It should be noted that the Engeny final concepts end within the private land parcel (the subject property) to the north of the PSP where the outfall connects to an existing open farm channel, not the Powlett River.

The existing farm channels run adjacent to the river and ultimately outfall to an existing point on the Powlett River, downstream of Pinkerton Rd. No design changes have been made or suggested in relation to the Powlett River in this study. The MOP design extends from the PSP to the Pinkerton Rd existing culverts (upstream extent). This is addressed further in Section 4.

Figure 2 below shows the comparative change between the assets proposed for the PSP under the Development Contributions Plan (DCP) process and the various iterations of the Engeny 'drainage strategy' through to the final strategy (September 2021) and the proposed PSP assets.

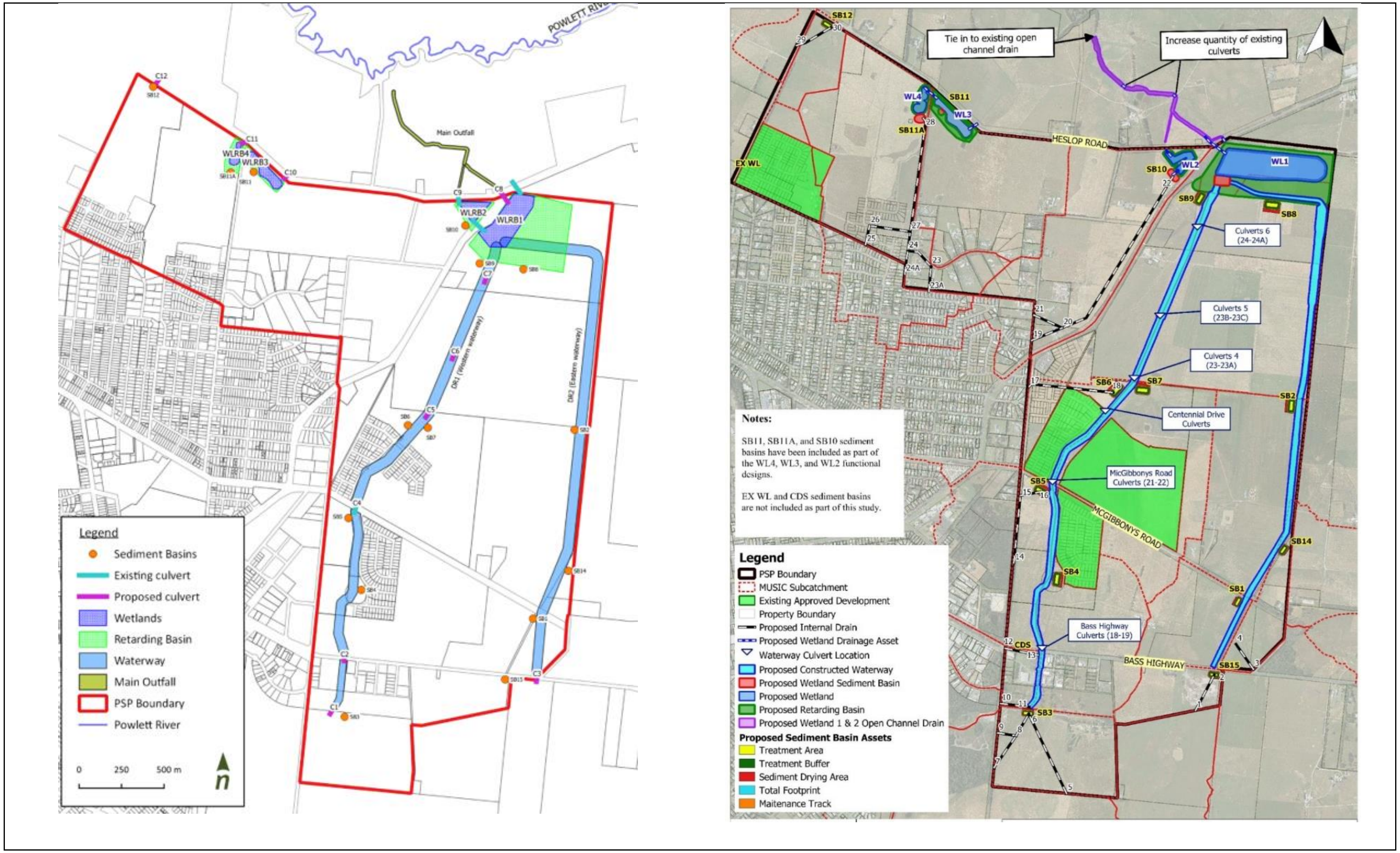


Figure 2. *Showing comparative changes in proposed assets for the PSP from October 2019 to September 2021 (Engeny)*

2.2 Alluvium Proof of Concept Report (September 2021)

Alluvium was engaged by the VPA (July 2021) to progress Engeny's work from concepts to a functional design stage. This work allows the VPA and stakeholders to gain confidence that the system can adequately function as intended for the PSP, as well as more accurately identifying the required infrastructure, land take, capital investment costs, maintenance requirements and associated costs for the DCP. Ultimately, this project will allow for the finalisation of the Precinct Structure Plan (PSP) and inform the Development Contributions Plan (DCP) assets and costings for the Wonthaggi North East Precinct.

The intent of this study (Alluvium) is to:

- review previous strategies and background information
- analyse previous modelling and concepts, and undertake refined modelling
- confirm the required stormwater management assets (location, type, footprints) in an integrated manner (Proof of Concept Report)
- and ultimately develop the concept designs into a functional design set for the PSP (Functional Designs, refined Costings and Report package).

Building on this existing work, Alluvium recommended an alternative concept / modified design approach for the Wonthaggi North East PSP for the VPA and Council consideration as part of our Proof of Concept (PoC) Report (September 2021). The recommendations were based on potential efficiencies in land take, asset performance and long term protection, capital costs and lifecycle management costs – all particularly important to allow development to proceed viably and sustainably.

Alluvium's PoC Report highlighted a total of 23 functional designs were required for the PSP which includes an additional design for the precinct's Main Outfall to the Powlett (MOP) River. While this appears as a loss of assets / designs, several previously identified and independent assets (e.g. 16 x sediment basins) were integrated into the designs of other systems (e.g. 4 x wetlands) while some were made redundant due to small contributing catchments, or existing/pending GPT.

Therefore, the total number of individual assets for functional design (x23) are as follows:

- **2/2** constructed waterways – remains the same as per DCP and Engeny concepts
- **4/4** wetland-retarding basins – all 4 wetlands found to be acting as RBs therefore 2 additional WLs to be designed as integrated RB systems
- **7/16** sediment basins – of the revised total of 16 SBs recommended, these assets were reconciled following further modelling and analysis:
    - 7 independent SB assets to be designed as separate structures (DCP SBs 2, 3, 4, 6, 7, 12, 15).
    - 5 of the 16 SBs have been integrated as part of the four WLRBs (DCP SBs 8, 9, 10, 11, 11A) **Note:** WLRB1 (DCP ref WL-01) has been split into 2 systems to account for the large catchments (WLRB-1A & WLRB-1B) and each has its own sediment basin as per design requirements.
    - 4 SBs were deemed to have limited contribution / effectiveness for the PSP and made redundant – DCP SB1 (catchment too small to warrant); DCP SB5 (removed from Engeny final strategy), DCP SB13 (removed from Engeny final strategy) & DCP SB14 (catchment too small to warrant).
- **9/12** culverts **–** of the 12 CUs recommended, these assets were reconciled following further modelling and analysis:
    - 2 Remain - DCP CU1 and DCP CU3 are critical assets for the two constructed waterways and remain.

    - 3 Remain – DCP CU5 to DCP CU7 were renamed in the final Engeny strategy to CU4 to CU6 respectively and remain.
    - 3 Remain – DCP CU8, DCP CU10 and DCP CU11 were missing from the Engeny strategy layout, however, Alluvium recommends these are critical assets for the WLRBs (i.e. outfalls) and remain.
    - 1 Remains – DCP CU12 remains (north-west corner of precinct).
    - 3 Existing – DCP CU2, DCP CU4 and DCP CU9 were removed from Engeny's final strategy as 'existing' assets (i.e. Bass Highway culverts and McGibbonys Rd culvert respectively).
- 1 main outfall (and associated infrastructure) – this PSP asset is an additional (anticipated) asset for functional design.

The above details are summarised in

#	ALLUVIUM ASSET ID FUNCTIONAL DESIGNS	DCP REFERENCE	ASSET FOOTPRINT	REFER TO REPORT SECTION (PER ASSET)
1	W-WW	DR-01	60m corridor	Section 9
2	E-WW	DR-02	60m corridor	Section 10
3	MOP	DR-03	-	Section 11
4A	WLRB1A (east)	WL-01	23.00 ha^	Section 13
4B	WLRB1B (west)	WL-01	(incl. above)*	Section 14
5	WLRB2	WL-02	1.51 ha^	Section 15
6	WLRB3	WL-03	1.10 ha^	Section 16
7	WLRB4	WL-04	2.23 ha^	Section 17
8	SB1	SB-01	0.43 ha^	Section 18
9	SB2	-	not required	GPT recommended in lieu of SB – catchment too small to warrant SB cost. GPT now installed as per developer works (Council advice Oct 2021)
10	SB3	-	not required	GPT recommended in lieu of SB – catchment too small to warrant SB cost.
11	SB4	SB-02	0.47 ha^	Relocated north into downstream property (council reserve) Section 19
12	SB5	SB-03	0.34 ha^	Section 20
13	SB6	SB-04	0.18 ha^	Section 21
14	SB7	SB-05	0.22 ha^	Section 22
-	-	-	-	High flow outlet from SB-01
15	CU3	CU-02	-	Section 9.3
16	CU1	CU-03	-	Section 10.3
-	-	CU-04	-	Currently under construction
17	CU4	-	-	Section 9.3
18	CU5	-	-	Section 9.3
19	CU6	-	-	Section 9.3
20	CU8	CU-08	-	Section 13
-	-	CU-09	-	Existing asset
21	CU9	CU-010	-	Section 16
-	-	CU-011	-	Removed
22	CU7	CU-012	-	Section 22

23	CU2	-	-	Missing from Engeny final layout but critical to PSP - see Section 10.3
-	-	CU-014	-	New crossing over DR-03
-	-	CU-015	-	New crossing over DR-03
-	-	CU-016	-	New crossing over DR-03
TOTAL	23 functional designs			

which represents the proposed / recommended / and agreed assets for the PSP (x23 asset designs). Following Alluvium's submission of the PoC Report, stakeholder reviews and comments from the VPA and BCSC were addressed and informed the next stage of the project – Functional designs (x23) of the approved stormwater management infrastructure for the Wonthaggi North East PSP. Stakeholders requested a revisit of two sediment basins' merit to the PSP (DCP SB4 & DCP SB6) given late alterations to their ultimate location and relative catchments.

2.3 Alluvium Functional Design Report (V06)

The Functional Design Report (**this report**) accompanies the Functional Design Package of works and documents the agreed design layout for the precinct. The agreed functional designs are based on achieving potential efficiencies in land take, accounting for size of contributing catchments, asset performance and long-term protection, capital costs and lifecycle management costs. All are particularly important to allow development to proceed viably and sustainably without compromising site values or creating subsequent implications for Bass Coast Shire - the ultimate asset owner.

The scope of this study was to develop feasible and cost-effective functional designs for the PSP based on the proposed concepts and flood modelling undertaken previously by others.

The following report documents the site context for the proposed development precinct; previous drainage investigations and modelling reviewed; background and site investigations undertaken which influence the proposed stormwater drainage system for the study area; and the subsequent functional design package as proposed and agreed, for the Wonthaggi NE PSP. Stakeholder feedback on previous work has also been considered.

Ultimately, this project will allow for the finalisation of the Precinct Structure Plan (PSP) and the Development Contributions Plan (DCP) for the Wonthaggi North East Precinct.

This Functional Design Report sets out:

- The agreed strategy and approach following the Proof of Concept (Alluvium) document
- Functional design documentation of the stormwater management assets as required for the PSP
- Construction estimates and costings for each of the functional design assets included within the PSP.

This Report accounts for all work undertaken to date. This Design Report and development of the Functional Designs has considered:

- specific site conditions – existing, proposed, constraints, values, and opportunities
- analysis of all data, GIS, topography, flood models, MUSIC models and concepts
- updated strategies, modelling outputs and development planning decisions/approvals by others
- project objectives and stakeholder inputs, including core and added value / future opportunities

- recommendations presented in our Proof of Concept Report (September 2021) which focused on the most cost-effective approach to ensure –
    - asset intended functionality and constructability
    - best practice integrated management of stormwater is achieved for the precinct / district
    - capital cost and ongoing maintenance implications are minimised through asset integration and consolidation
    - development viability and land availability without compromising stormwater function, environmental, social, cultural heritage, or landscape amenity values
    - and broader outcomes of liveability for the current and future communities.

Underlying our approach to the functional designs is the desire to provide robust, sustainable assets which adequately:

- capture, retard, detain, treat, and convey stormwater safely through the precinct and beyond
- protect and further enhance receiving environments and local biodiversity
- deliver improved landscape and neighbourhood amenity outcomes
- provide future community services related to community connectivity, comfort, health and wellbeing and broader liveability outcomes.

Any proposed land use changes should provide for multiple benefits and multiple community-based outcomes, beyond just stormwater management and function alone. This consideration, amongst others, are foundational principles that have been applied to the development of the functional design package for the Wonthaggi North East PSP and DCP. A summary of the proposed PSP land use is provided in Figure 3.

2.4 Functional Design Report – Revised (April 2022)

Wonthaggi NE PSP was a VPA 'fast track' PSP process. Alluvium was engaged to undertake 30+ functional designs for the PSP based on previous modelling, strategies and concepts undertaken by others. Further changes to the strategy and modelling occurred during the functional design process (as outlined above) and these were addressed progressively.

Alluvium submitted the final design report (V03) and drawings package in November 2021, and Addendum design (Main Outfall to Powlett River) in December 2021. Subsequently, VPA arranged for an independent peer review to be undertaken by Neil M Craigie Pty Ltd (Neil Craigie and Graham Daff) in December 2021.

While many of the recommendations were supported by Alluvium as having merit and benefit to the PSP, a number were not able to be accommodated without agreement for new modelling to be undertaken.

Subsequently, Engeny was re-engaged by the VPA to test design changes by Alluvium and recommendations of the Preliminary Drainage Review to determine if:

- PSP asset functionality can be maintained
- flood conditions are not made worse (upstream/downstream)
- retarding basin storages are sufficient to meet flood protection requirements
- treatment compliance to BPEM is met
- clearance requirements for other authority assets can be ensured
- and ultimately, cost savings may be realised for the overall DCP.

This report now includes revisions to capture the new approved modelling and redesign work (see Section 2.5).

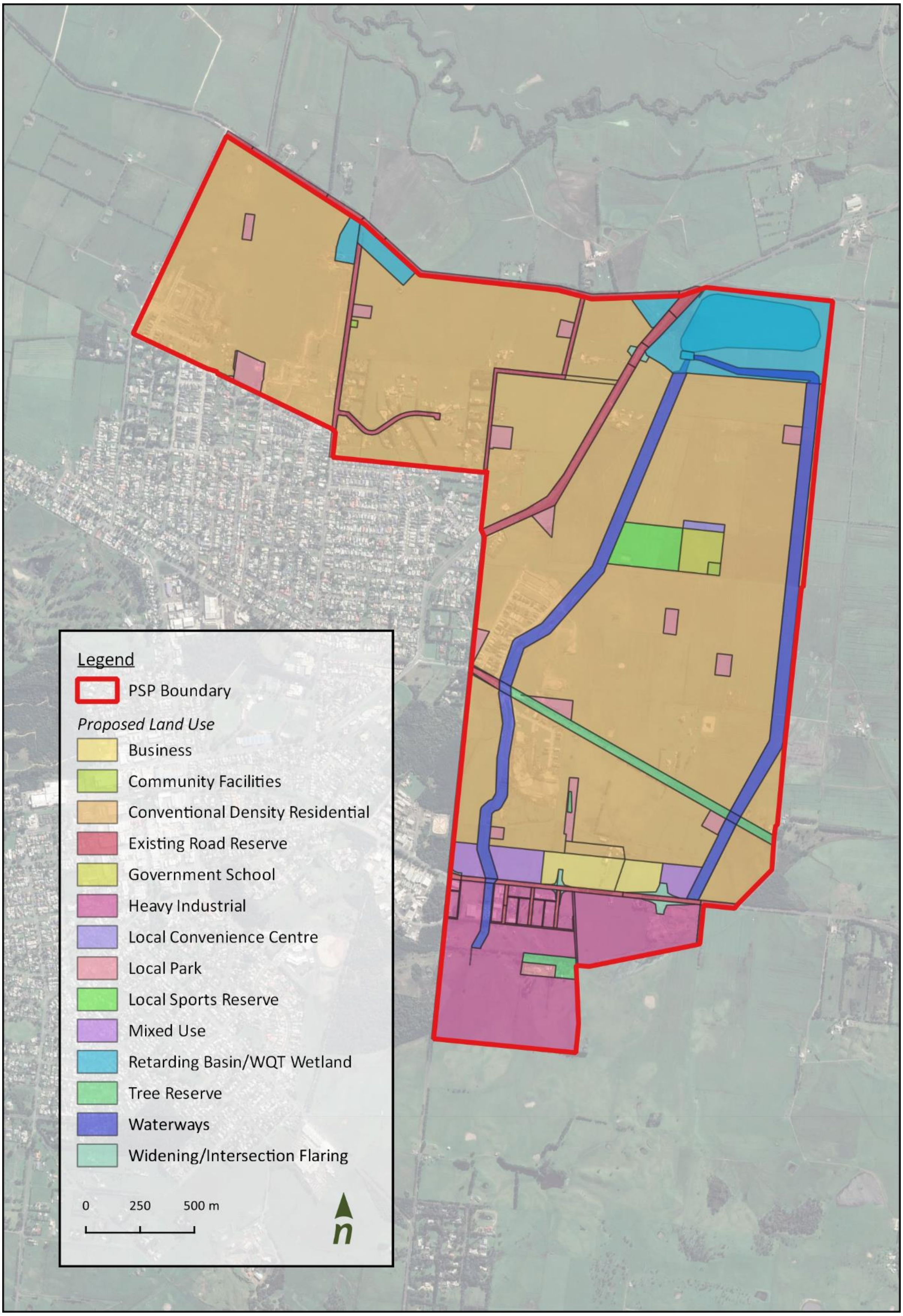


Figure 3. *Site Overview - project PSP area and proposed land use (source: modified from GIS proposed land use data, VPA).*

2.5 Wonthaggi NE PSP - Preliminary Drainage Review (Neil M Craigie Pty Ltd, 2021)

Following Alluvium's submission of the final deliverables - functional design package and functional design report for the Wonthaggi NE PSP, the VPA undertook an independent peer review - Preliminary Drainage Review (Craigie et al., 2021) to determine further opportunities to refine the design and achieve a favourable DCP outcome.

The Preliminary Drainage Review provided opportunity to test and challenge the design suite for the PSP and further investigate the costings to seek further refinement and DCP savings where appropriate. It should be noted that the cost comparisons undertaken in the peer review were based on a comparison of Engeny's original high level concept design estimates (and drainage strategy) of October 2019. These cost estimates were not revised between the original concepts and estimates (Oct 2019), and the subsequent finalisation of the drainage strategy, nor the new modelling findings (Engeny, Aug 2021).

Alluvium's cost estimates and design solutions were based on the latest modelling provided (Engeny, Aug 2021) which resulted in changes to all treatment wetlands now required to perform flood retardation functionality (not known at concepts stage); and WLRB1 to accommodate a higher than anticipated flood storage. The Alluvium cost estimates are in line with more recent industry rates (2021) and detailed to a functional design level.

The Preliminary Drainage Review proposed a suite of recommendations. VPA engaged Alluvium to provide a formal response to the recommendations with an explanation as to merit or otherwise; approach and limiting factors; and where Alluvium supports the recommendations; with justifications and guidance on PSP impacts.

While many of the recommendations were supported by Alluvium as having benefit to the PSP, a number were not able to be accommodated without agreement for new modelling to be undertaken. Subsequently, Engeny was re-engaged by the VPA to test design changes by Alluvium, ensuring PSP asset functionality is maintained, flood conditions are not made worse, retarding basin storages are sufficient to meet flood protection requirements, treatment compliance to BPEM is maintained, clearance requirements for other authority assets can be ensured, and ultimately cost savings may be realised for the overall DCP.

Most of the recommendations were focused on WLRB1 (a & b) and the two constructed waterways (E-WW and W-WW). The suggested recommendations supported by Alluvium to have value in reducing overall PSP costs and addressed within this revised Functional Design Report and drawings package relate to:

- The reduction in overall treatment areas (i.e. macrophyte zones) of the wetland/retarding basin assets, using modelling techniques and overall design outcomes as suggested (Craigie and Daff). This excluded WLRB4 previously approved through subdivisions process by BCSC (no design change from Nov 2021).
- Raising the normal water level (NWL) of WLRB1(a & b) to reduce overall excavation costs, without compromising flood storage requirements (downstream protection) and water quality treatment compliance.
- Subsequently raising the invert (bed) of the two PSP constructed waterways (E-WW, W-WW) to reduce overall excavation quantities associated with the development of the PSP and DCP, without losing flood conveyance and capacity (wider channel benches to cater for the shallower waterway to ensure full conveyance of the 1% AEP flow).
- Relocate sediment basins (SB 4 & SB6), which outfall to W-WW and E-WW, respectively, into the proposed waterway corridors. These SBs have been integrated into the waterway 'floodplains' to reduce overall land take, and shift assets from the developable land areas to the proposed waterway corridors.
- Shifting the E-WW as close to the eastern boundary of the PSP as possible to free up further developable land to the west, while still maintaining a total 19m minimum offset for bushfire protection through the waterway corridor/interface with developed areas, and streamside protection on the eastern flank.

- Updated costing rates and items using region-specific costing estimates (based on extensive knowledge of the construction and implementation of stormwater management assets within the greater Victorian region, 2021 rates).

This revised integrated stormwater management (drainage) strategy and functional design documentation includes the updated design recommendations (based on the new flood modelling by Engeny, April 2021) as indicated above.

Refer to Appendix D for a summary of the agreed redesign recommendations adopted within the Wonthaggi NE PSP.

3 Project Context

Wonthaggi North East PSP covers approximately 632 hectares of land located to the north-east of the existing Wonthaggi township, just south of the Powlett River, and intersected with most of the land north of Bass Highway and west of Kirrak Road. The proposed precinct boundary is provided in Figure 3. The precinct is potentially to provide up to 5,000 new homes, to respond to population growth predictions for the town from 8,000 to 20,000 residents over the next 30 to 50 years. The Wonthaggi North East PSP represents 40% of the Wonthaggi township.

The PSP is divided into three distinct catchments (North West Catchment, South West Catchment and East Catchment – see Figure 14) and has three major outfalls, two of which outfall north into the Powlett River, and one that outfalls towards the west and away from the PSP assets. The topography of the PSP area is generally flat and ranges in elevation from 13m AHD on the northern Heslop Road boundary to 32m AHD at a central highpoint in the precinct at the southern boundary.

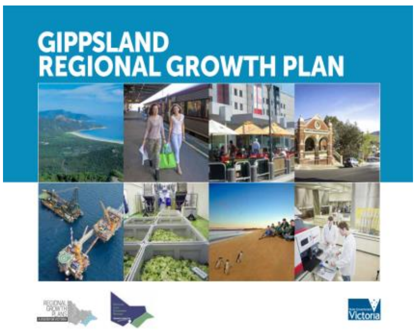
Bass Coast Shire Council is the local drainage authority for all urban land in the region, while West Gippsland Catchment Management Authority (WGCMA) is the rural drainage and floodplains manager. Together, with Traditional Owners, local landowners, and the broader community, they represent the key stakeholders to this project.

3.1 Strategic drivers

Planning for growth in Wonthaggi has been driven by the VPA's work in regional city growth plans. The sustainable management and use of surface waters (runoff) in the landscape, and the appropriate guidance for urban development adjacent to riverine floodplains, are vital to the continued growth and water resilience of the region.

Similarly, the IWM Forum vision for the West Gippsland Strategic Directions Statement has a focus on *Working together through sustainable water management to enhance urban landscapes and maximise amenity, environment, and economic outcomes for our communities.* In our experience with other IWM plans, stormwater drainage strategies, PSPs and DCPs, a clear and shared vision is critical in setting the focus and achieving intended outcomes.

The following summarises key strategic documents that are directly relevant to, will influence, and/or align with key outcomes of this project and the vision for the Wonthaggi North East PSP and DCP.

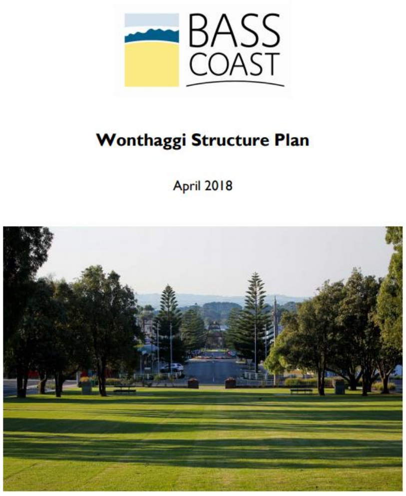


Gippsland Regional Growth Plan (VPA, 2014)

This plan addresses a wide range of challenges by recognising Gippsland's assets of regional significance and putting an integrated planning framework in place to direct and manage sustainable growth across the region.

It establishes regional policy to guide the use and preservation of these assets and provides a higher level of certainty and direction for investors, infrastructure and service providers, the community and decision makers.

Gippsland is forecast to become a fast-growing part of Victoria as more people relocate to the region from Melbourne. This plan considers the implications of growing the region to a population of 386,000 by 2041, an increase of 116,000 people.



Wonthaggi Structure Plan (BCSC, 2018)

The Plan recognises and responds to the significant growth and change in the Wonthaggi area which is emerging as a major centre in the West Gippsland region. Emerging issues to be addressed by the plan include:

- potential economic and social impacts on local townships
- population growth
- role of Wonthaggi as a regional centre
- opportunities for the preservation of remnant vegetation and environmental areas.

The 2018 Wonthaggi Structure Plan has incorporated key recommendations identified by the Future Wonthaggi Focus Group. The group produced a report (Future Wonthaggi Focus Group Workshop – Community Representative Report, 2016) which identified six key themes to enhance liveability in Wonthaggi:

- A safe town to walk and move around
- Create an interest and understanding of the community
- Focus on our infrastructure
- Deliver strong tourism services
- Wonthaggi a model town
- Stimulate job growth.

IWM Forum – Gippsland Strategic Directions Statement (DELWP, 2018)

The Strategic Directions Statement (SDS) has a region-specific vision, outcomes, objectives, and priority actions. Collaboration between Traditional Owners, Councils, Water Corps, CMAs, and DEWLP, with representatives from a cross section of these institutions has led to shared ideas, buy-in, and momentum.

Opportunities identified through this project will demonstrably align with the following outcomes and their associated objectives:

1. Safe secure and affordable supplies
2. Effective and affordable wastewater systems
3. Reduced flood risks
4. Healthy and valued waterways, and Gippsland Lakes
5. Healthy and valued urban landscapes
6. Community values are reflected in place-based planning
7. Jobs, economic bene fits and innovation.

4 Existing Conditions

4.1 Site visit

A site visit was conducted on the 14th July 2021 by the Alluvium project team with representatives from Bass Coast Shire Council and the Victorian Planning Authority in attendance. The site visit commenced at McGibbonys Road, near the developing Powlett Ridge subdivision to the south and Parklands residential estate to the north and progressed around the precinct (see Figure 4) identifying key sites that have since informed the functional design package. Proposed locations for key stormwater assets as identified in the Engeny stormwater strategy concepts were visited to better understand the landscape, surrounding features and connections, challenges, issues, and constraints, as well as opportunities. Sites included the Powlett Ridge subdivision (currently under construction), existing Parklands Estate and the proposed industrial area on Carneys Road.

It is noted that the land area southwest of the McGibbonys Road and Connection Road intersection has recently been sold to the Department of Education and Training Victoria for the provision of a local school.

A summary of our key findings from the site visit was presented in the Proof of Concept Report. It has been reproduced below with updated information received through stakeholder feedback and more recent review of land development plans and drawings received from council.

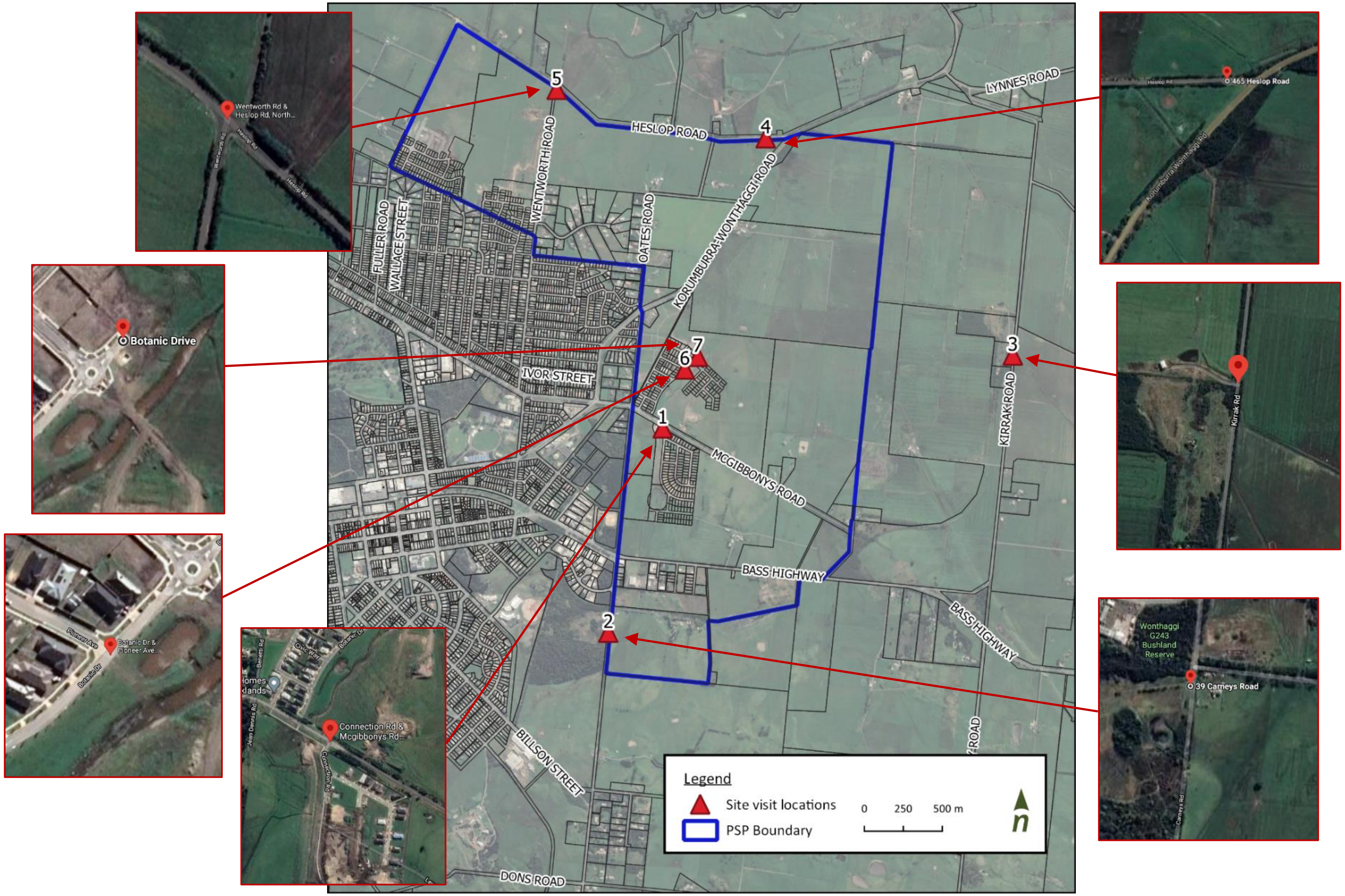


***Figure 4**. Site visit locations with georeferenced site photos (July 2021)*

Site 1 – McGibbonys Road and Connection Road – Powlett Ridge Estate

The Powlett Ridge estate is located south of McGibbonys Road and is currently under development, with several houses and internal roads already constructed. The estate is adjacent and east of the proposed constructed waterway 'west' alignment. West of the constructed waterway corridor (and south of McGibbonys Road) land has been purchased by the Department of Education and Training Victoria (DETV) for a proposed local school.

DETV has undertaken some site drainage works with pipe outfalls into the newly constructed western waterway. It was noted on site, that these pipe outfalls have been poorly constructed, placed and finished and is already resulting in headward and rill erosion to embankments, with no end wall treatments, or rock armouring to dissipate erosive impacts of stormwater discharges. It was evident that the combined sediment loading to the newly constructed waterway (from both the DETV land and Powlett Ridge subdivision under construction) will require removal of this build up and re-shaping/reinstatement of the waterway floor/banks.

The section of waterway adjacent to the Powlett Ridge Estate is generally in poor condition. Vegetation along the waterway bed (floor) has not established, and only a sparse non-indigenous grassed layer exists along the banks, resulting in erosional scour of banks where stormwater outfalls, and is resulting in sediment deposition to the waterway floor. This low flow channel (western waterway) lacks natural sinuosity along its length, and lack of rock armouring at critical locations (pipe outfalls) and ongoing erosion impacts are highly likely. This is important to address as this area and waterway ultimately discharge into PSP assets (WLRB-1B) and will affect asset integrity and add to maintenance implications.

Powlett Ridge Estate temporary sediment basin, looking upstream of constructed waterway 'west' alignment.

Existing headward and gully erosion along the newly constructed waterway banks from DETV land

Existing outfall drain from Powlett Ridge estate into constructed waterway 'west' alignment.

Constructed waterway 'west' alignment, looking upstream

Figure 5. *Site investigation photos of constructed waterway 'west' alignment (as proposed in Engeny concepts)*

Site 2 - Proposed Industrial Area (Carneys Road)

The proposed industrial area (Figure 6) is located at the southern boundary of the Wonthaggi North East precinct (WNEP). An undeveloped greenfield, external catchment falls through the industrial area from the south. The external catchment sheet flows across this relatively flat landscape. To the west of this industrial zone is the Wonthaggi Bushland Reserve and Wetlands (ID - G244).

It is noted that the existing industrial buildings / warehouses at this location, currently do not have any stormwater treatment infrastructure installed, prior to the area out-falling into one of the two proposed 'internal' constructed waterways (the west alignment in this instance), therefore exposing these assets to potentially hazardous pollutants. Ideally, Council should negotiate some form of proprietary intervention to protect the PSP waterways and downstream retarding basin/wetland systems. While this study is not to resolve this land use issue or design and cost a solution to this area of the PSP, it is provided as guidance to council to ensure this is not an ongoing concern and risk to the PSP water assets.

As advised by Council, permit conditions for the industrial area did make allowance for a 40m wide waterway reserve (the western waterway) which is critical in the ability to design and construct this waterway with reasonable space allowed for waterway stability and urban buffering. The reach of the waterway will therefore be narrowest at this location but widens to a 60m wide waterway corridor further downstream.

The urban pollutant loads of this area have been considered in the MUSIC modelling (i.e. industrial node selection) to inform the water quality treatment requirements for the design of the precinct assets.

Upstream of the proposed industrial area of Wonthaggi NE PSP, looking south at the future extension of Carneys Road.

Kirrak coal mine site (ruins) has been derelict for 100+ years and likely to be heritage protected. The land is owned by the State (Council).

Undulations and 'hills' are representative of coal mine spoil piles, otherwise the area is relatively flat.

West side of Carneys Rd (looking west) across the Wonthaggi Bushland Reserve and Wetlands (ID - G244). The site is outside the PSP area and opposite the proposed industrial zone (within the precinct/PSP area).

The developed catchment upstream of this wetland system, outfalls to this wetland (refer Figure 15 below).

Figure 6. *Proposed industrial precinct at southern extent (Carneys Rd) of PSP and surrounding landscape features.*

Site 3 – Kirrak Road

Kirrak Road runs north-south on the eastern side of the PSP area just outside the official PSP boundary. The landscape to the east of Kirrak Rd is relatively flat and surface runoff falls gently to an existing swale. Kirrak Road is proposed to be a future 40m wide bypass road (advice from BCSC). Flows from this external catchment are not entering the precinct / study area.

Site 4 – Wetlands 1 & 2

Wetland-Retarding Basin 1 (WLRB1A & 1B; DCP ref WL-01)

The Engeny stormwater strategy proposed an integrated wetland and retarding basin (DCP WL-01) at the downstream extent of the precinct, off the Korumburra-Wonthaggi Road. The site was inaccessible at the time of the site visit due to constrained timelines, where access to private property was not able to be arranged. As a result, the analysis of WLRB1 (DPC ref WL-01) was completed, based on a desktop analysis, using NearMap and Google maps.

WLRB1 (DPC ref WL-01) is located within the natural depression of the property, close to the Korumburra-Wonthaggi Road property boundary. The location selected is based on existing flood overlays and the Engeny flood modelling undertaken to date, indicating that this location is subject to flooding. Engeny's subsequent re-modelling of this wetland changed the concept layout considerably and identified this system would be performing significant retardation function with an excess water depth of 319mm above NWL (normal water level).

Alluvium's analysis of the concept and our own modelling work during Proof of Concept determined that the size of this WLRB needed to be increased based on the contributing catchment size, the increased retarding function expected, and land use nature upstream (that is 720ha of agricultural and proposed urban catchments external to the PSP boundary draining to this point). Therefore, this asset is now a split system - WLRB1A and WLRB1B to account for these issues.

Figure 7. Looking east along Heslop Rd to site for WLRB1A & WLRB1B (DCP ref WL-01) *(beyond tree line) on Korumburra-Wonthaggi Rd*

Wetland 2 (WLRB2; DCP ref WL-02)

This asset was previously identified to be a treatment-only wetland, located at the corner of Korumburra-Wonthaggi Road and Heslop Road. However, subsequent Engeny modelling and Alluvium's own for the Proof of Concept Report (September 2021) identified that this wetland is performing a retarding function and therefore should be an integrated WLRB2 (DCP ref WL-02) system. This is the case found for all precinct wetlands – all systems will be required to perform treatment and retardation function.

The site has a natural depression near the downstream corner of the site with an open cut drainage channel through the proposed WLRB2 (DCP ref WL-02) location, which then outfalls through existing culverts under Heslop Road (image left) and flows northwards across a private farm (referred to as the 'subject property' hereon, image right) to its ultimate outfall into the Powlett River.

Negotiations with the property owner of the subject property are underway with BCSC to address drainage issues and provide an ultimate outfall alignment from the WNEP to the River. This main precinct outfall forms part of this functional design package (additional design) by Alluvium.

Existing outfall from proposed WLRB2(DCP ref WL-02) site to culvert on Heslop Road (looking west).

Existing open channel outfall to Powlett River (looking north from Heslop Road) across subject property (private farm).

Figure 8. *Site investigation photos of the proposed WLRB2 (DCP ref WL-02) landscape and ultimate outfall to Powlett River (tree line in the north of image right).*

Site 5 – Wetlands 3 & 4

As has been demonstrated in the final Engeny Strategy and Alluvium's Proof of Concept Report, all wetlands for the PSP will be integrated WLRBs as all are performing a retarding and treatment function.

Wetland 3 (WLRB3; DCP ref WL-03)

The asset is located at the northern extent of the precinct, south of Heslop Road and on the east side of Wentworth Road, at their intersection. The landscape at this location generally falls to the east, towards the location of the WLRB3 (DCP ref WL-03) area. Based on all modelling undertaken to date, the functional design for this asset is for an integrated wetland-retarding basin.

It is noted, based on Council advice under the proposed development, the Wentworth Road extension will not be progressing (discontinued) for the PSP.

Wetland 4 (WLRB4; DCP ref WL-04)

This wetland is located at the north-western extent of the precinct, just south of Heslop Road and on the west side of the 'discontinued' Wentworth Road alignment. The system is 'perched' within the landscape (sits significantly higher than WL-03) and found to perform a retarding function. It is the smallest of all 4 retarding/treatment systems in the precinct. During the site visit, discussion was had around potential for merging WLRBs 3 and 4 into one consolidated asset.

However, as advised by Council, this system has been approved as part of a Development Plan (2011) and planning permit process to allow for the construction of the residential subdivision east of Fuller Road and to the west side of the Wentworth Road alignment. These approvals were completed prior to investigations into the Wonthaggi North East PSP process.

The approved / allowable area set aside for WLRB4 (DCP ref WL-04) through the planning approvals process has since been accommodated (updated since the PoC Report and council feedback) in this functional design stage.

Alluvium discussed the possibility with stakeholders to merge these WLRBs (3 & 4) as part of a future asset renewal program (some 30-50yrs) if found to be value-adding (e.g. to overall landscape amenity, community use, or contributes positively to Council's future maintenance program). For the purposes of this study and as agreed at Proof of Concept, these assets have been functionally designed as two separate structures.

WLRB 3 site, looking east along Heslop Road

Intersection of Wentworth Road alignment and Heslop Road, looking west across WLRB3 and WLRB4 (DCP ref WL-03 and 04) (foreground) sites

Figure 9. *Site investigation photos for WLRB3 and WLRB4 (DCP ref WL-03 and 04) proposed locations.*

Site 6 – Pipe Track at Pioneer Ave & Botanic Drive

An existing pipe track at this location offers an ideal opportunity to connect its alignment in both directions to better connect the PSP and future community with existing blue-green corridors and the existing community. Trail links could extend northwards from this point through to the functional water assets along the northern extent of the PSP. This northern extent provides a significant blue-green passive recreation corridor for the area. This trail link could then be connected to a future trail concept along the Powlett River where accessible to public (outside private land areas).

The existing pipe track at Pioneer Ave/Botanic Dve could also be enhanced by extending it southwards along the Carneys Road section of the PSP and/or through existing walks and trail links to the south of the precinct, thereby connecting current and future trails and communities along/to/from the PSP via a series of “living links”.

As can be seen in Figure 10 below, Wonthaggi township is well serviced with extensive walkable routes and key sites of ecological, historical, and social recreational value. There is an unusually high number of ‘destinations and trail links that could successfully be connected to the WNE PSP and further enhance community experiences, landscape values, and passive recreation opportunities.

Living Links - Potential community connections via existing walking trails (insets) with proposed trails from PSP (blue lines)

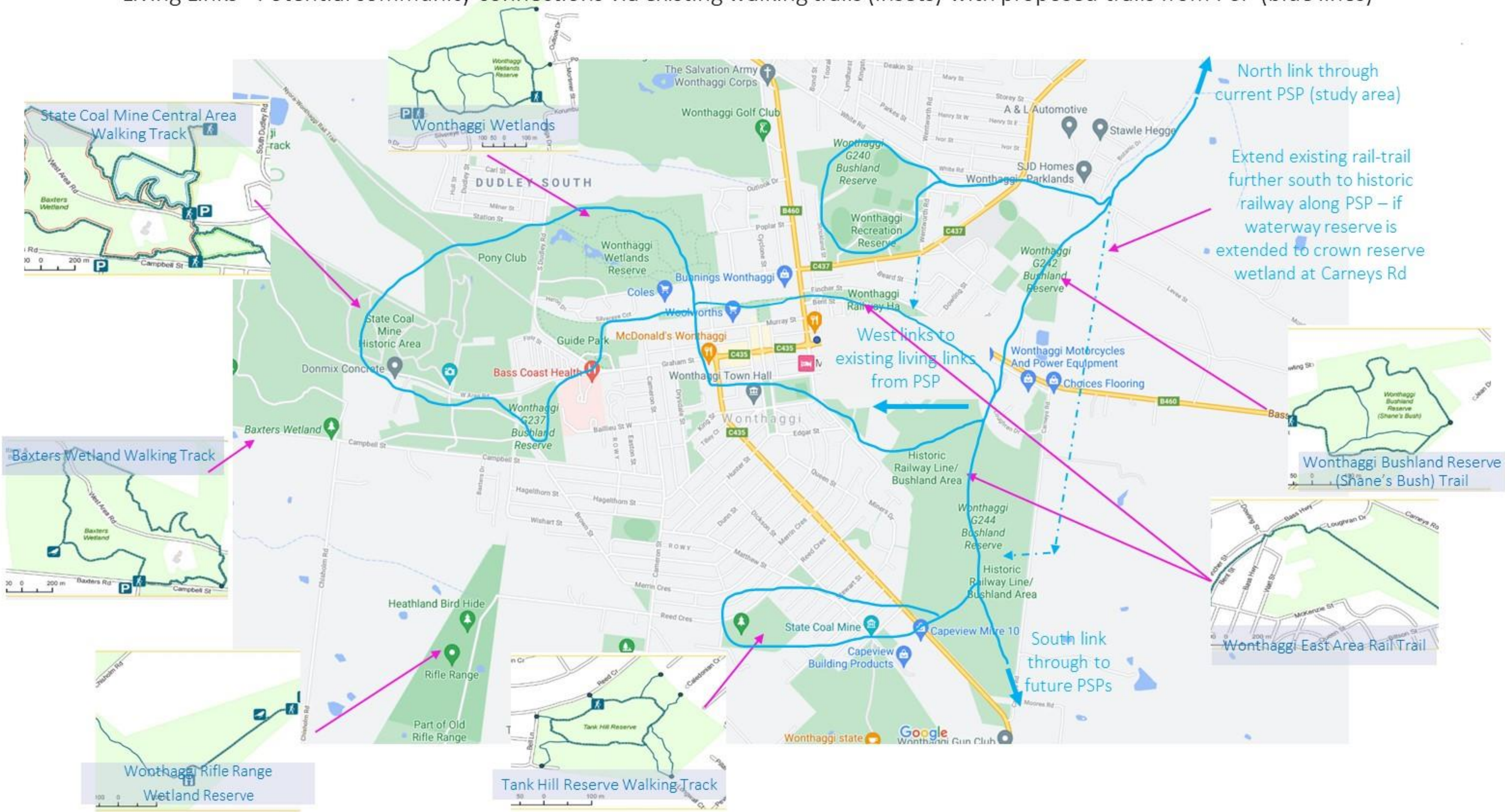


Figure 10. *Map of proposed trails from the Wonthaggi North East PSP to existing mapped trails as potential community connections along 'living links' (Updated Oct 2021).*

Site 7 - Parklands Estate Constructed Waterway (west alignment)

The Parklands estate is located north of McGibbonys Road and has been developed with all necessary stormwater drainage infrastructure completed within the road layouts of the estate. Adjacent to the estate is a section of the temporary open channels that align with the precinct's western waterway corridor (W-WW; DCP ref DR1). This section of open channels could be further enhanced as part of the W-WW works (DCP ref DR1) as they have stabilised well, and then connect to the upstream section, recently constructed as part of the Powlett Ridge Estate (refer Site 1 details above).

The Parklands estate outfalls into two interim / temporary sediment basins located adjacent to the open channel. The channel is generally in good condition with meanders present in the upstream section of this reach and has healthy aquatic vegetation established. The channel appears to back up just upstream of the culvert / road crossing likely due to a restricted outlet at the downstream section of the estate. This appears to have been retained in place as a form of interim stormwater *quantity* control so as not to impact downstream landowners during these temporary / interim drainage conditions that are in place.

It is possible to retain and further enhance this open channel section as part of the W-WW (DCP ref DR1).

Existing interim / temporary sediment basin

Existing waterway profile, looking upstream with good vegetation establishment

Existing temporary waterway outfall control for flood/drainage protection of downstream properties

Existing waterway profile, looking downstream

Figure 11. *Site investigation photos of the temporary open channel and ponds adjacent to Parklands estate, along the waterway 'west' alignment (W-WW; DCP ref DR1)) north of McGibbonys Road and east of Carneys/Korumburra-Wonthaggi roads.*

4.2 Topography

The precinct has a mostly flat topography ranging from 13m AHD on the northern Heslop Rd boundary to 32m AHD at a central highpoint at the southern boundary. The PSP is divided into three distinct catchments (North West Catchment, South West Catchment and East Catchment). The average slope (topography) of the precinct area means the site falls steadily towards the north, directing most of the flow to the Powlett River.

An overview of the topography is presented in Figure 12 below.

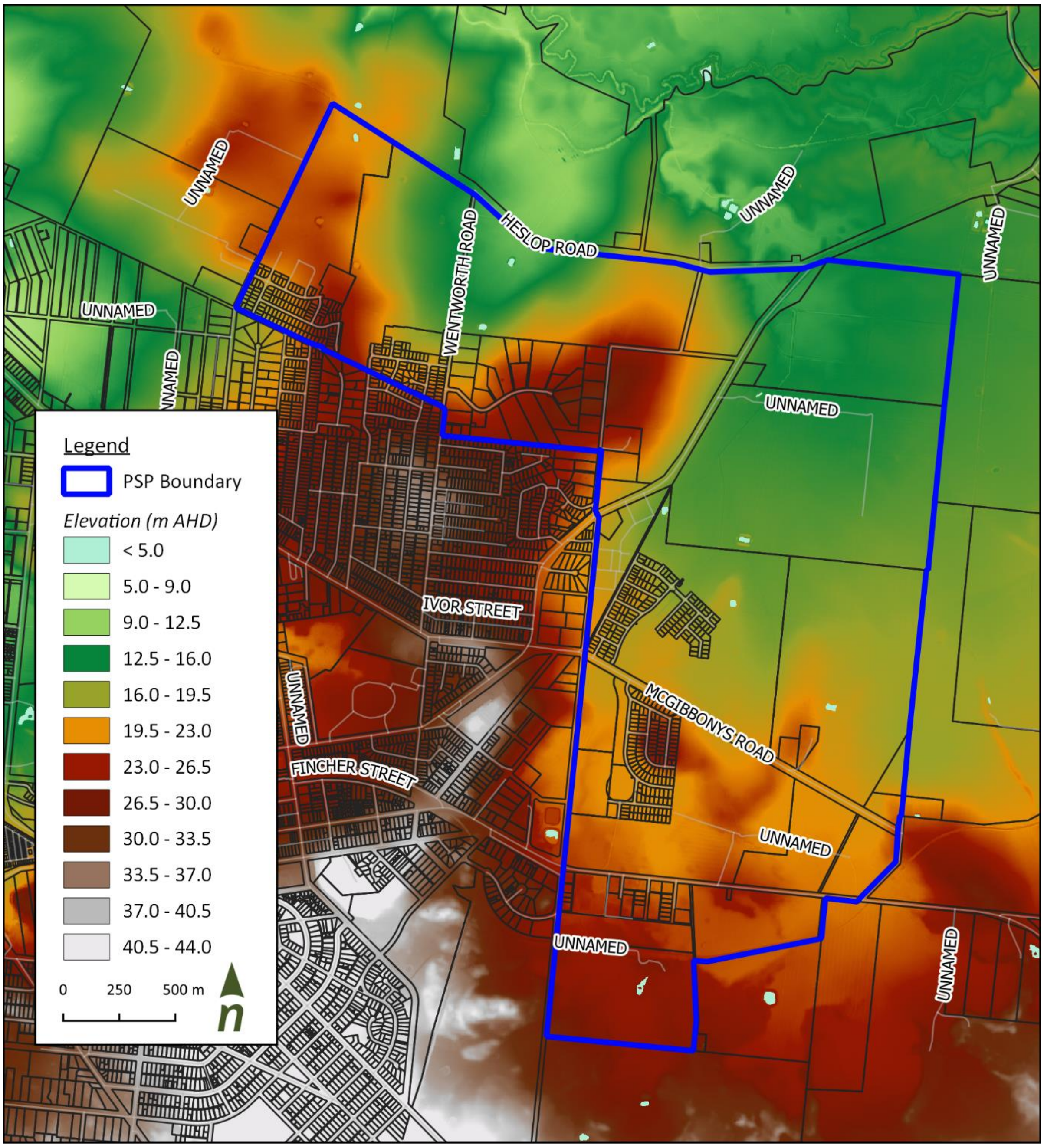


Figure 12. *Topography of PSP and surrounding area*

4.3 Existing services and infrastructure

The PSP area is intersected by major roads including the Korumburra-Wonthaggi Rd which runs north-east from Wonthaggi CBD, and the Bass Highway which runs east of the CBD. There are multiple existing culverts on the site (see Figure 13). Three culverts are used to convey the partially constructed west waterway (W-WW; DCP ref DR1) flows from McGibbonys Rd, under Korumburra-Wonthaggi Rd and out falling to the proposed wetland systems along Heslop Road at the northern extent of the PSP. One culvert conveys eastern catchment flows under the Korumburra-Wonthaggi Rd at Heslop Rd. Of the six culverts in the southern region of the PSP, four pass under Bass Highway and one was used to convey flows under a former railway line.

Although efforts were made to utilise the existing culverts, only the former railway line culvert, western McGibbonys Rd culvert and western Heslop Rd culvert were able to be incorporated into the Alluviums design solution (see Figure 13). The remaining culverts were either not in functional locations or insufficiently sized to for conveying the 1% AEP flow.

Another major infrastructure consideration is the water supply pipeline from the Victorian Desalination Plant. The pipeline runs from the plant (located west of Wonthaggi) along the north west edge of the PSP boundary, then runs east, parallel along Heslop Road and northwards towards the Powlett River. The pipeline location has particular significance in planning the main outfall for the PSP, as the outfall alignment is proposed to pass over the desal pipeline.

A transmission pressure gas pipeline runs along the north-eastern boundary of the PSP, immediately outside the precinct. The impact of this transmission pressure gas pipeline was investigated through a Safety Management Study undertaken by the VPA in 2021. WLRB1a and WLRB1b have been designed to fall within the pipeline measurement length, in accordance with the pipeline licensee's requirements.

Dial Before You Dig (DBYD) assessments undertaken at the concepts stage confirmed the water supply main and a gas transmission main. These alignments have been added to the map below using digitised information provided and have informed the asset layouts for the PSP and the functional design package.

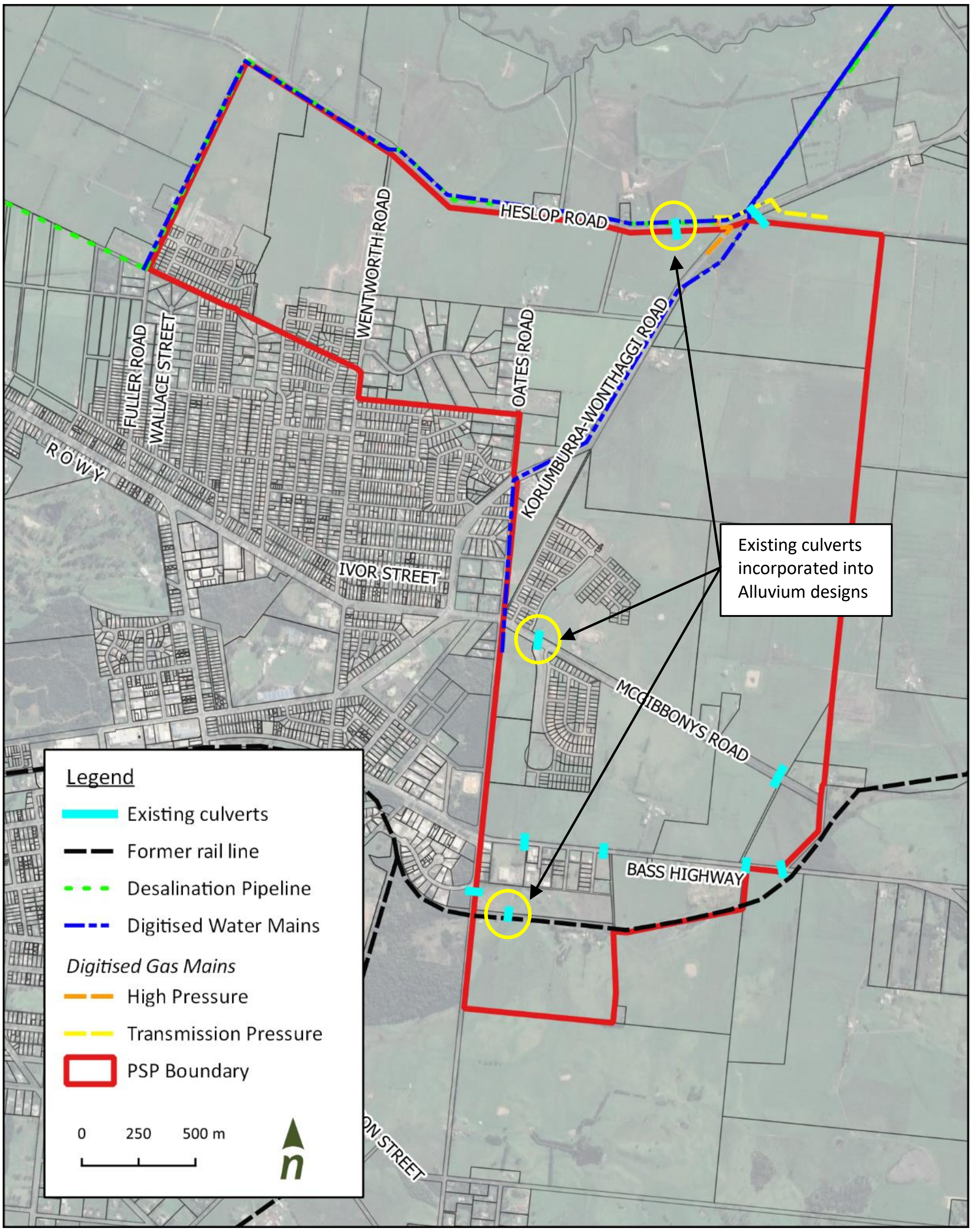


Figure 13. *Existing services and infrastructure in PSP area. Water mains digitised based on images by South Gippsland Water, gas mains digitised based on images by Multinet Gas - based on data provided 27/08/2021)*

4.4 Catchments & Sub-Catchments

There are three distinct catchments that cross the PSP study area (Figure 14); all stem from the local highpoint in the south-west extent of the precinct. The north-west catchment (green) is approx. 300 ha, and the eastern catchment (yellow) is approx. 1540 ha – together they cover most of the PSP area. These two catchments fall predominantly towards the north and ultimately outfall to the Powlett River via two outfall points across private land.

The eastern catchment extends south past the PSP area and further east until it intersects with Kirrak Rd. This large section of the eastern catchment (external to the PSP) has been accounted for in the functional design solutions. A grassy swale which runs along Kirrak Road captures and conveys flows from the undeveloped landscape further east and drains away from the PSP.

The south-west catchment (blue) falls south-westerly away from the PSP area and outfalls to the Powlett River. Due to the current development activity in this catchment, it is assumed that a drainage strategy for this area has already been established as part of the approved Development Plan (Council communication at site visit).

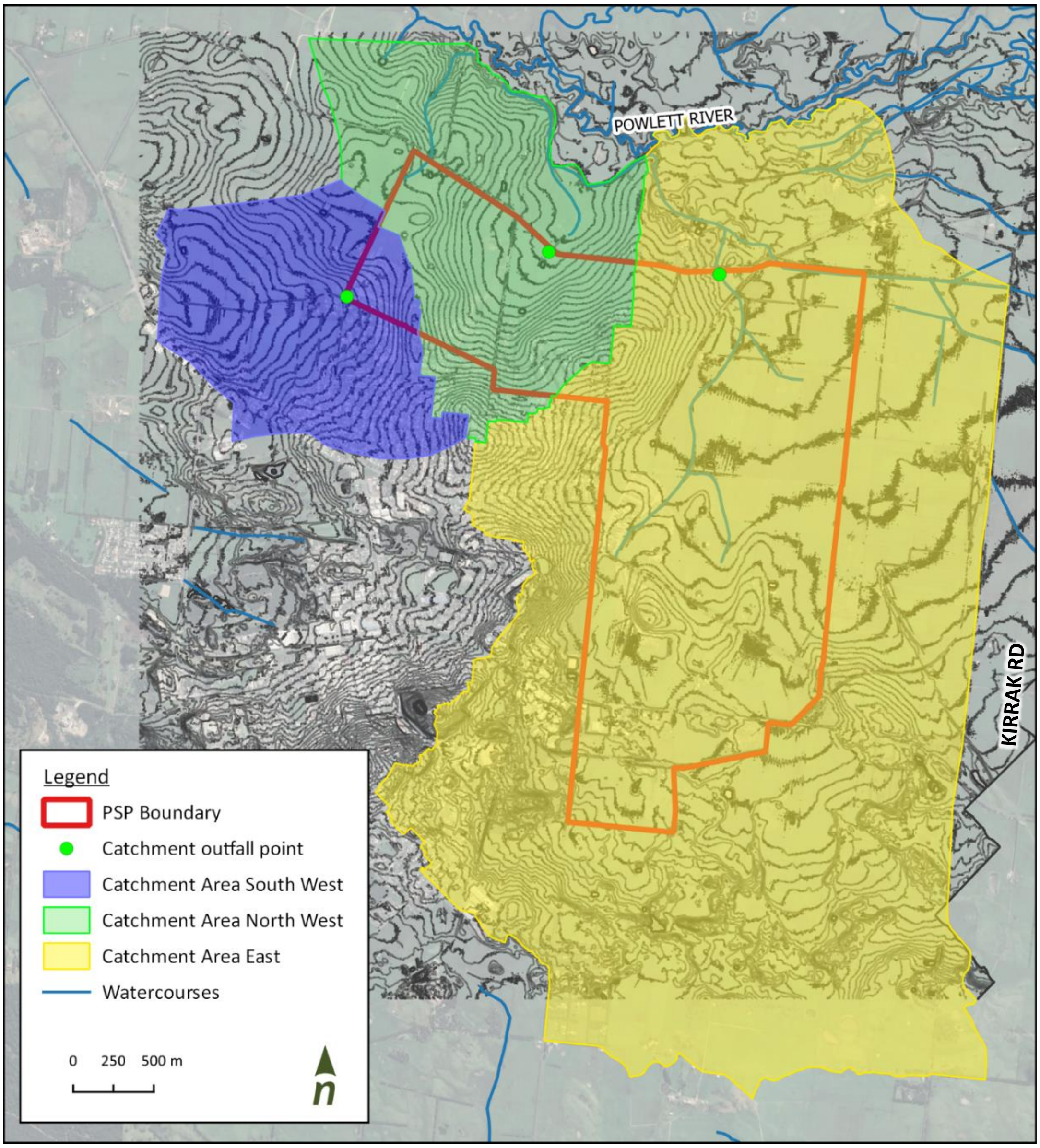


Figure 14. *Catchments across the PSP and broader area*

The proof of concept approach undertaken by Alluvium sought to better understand the impacts of these catchment areas (outside the PSP boundary) on the proposed waterways and WLRBs for the precinct. Figure 16 below highlights key locations across the sub-catchments that would be ideal locations for future stormwater management infrastructure (retardation and/or treatment) to meet best practice and ensure assets within the PSP are able to function as intended and for duration of their asset life (approx. industry standard for wetlands is 30-50yrs subject to design, catchment condition and maintenance regimes).

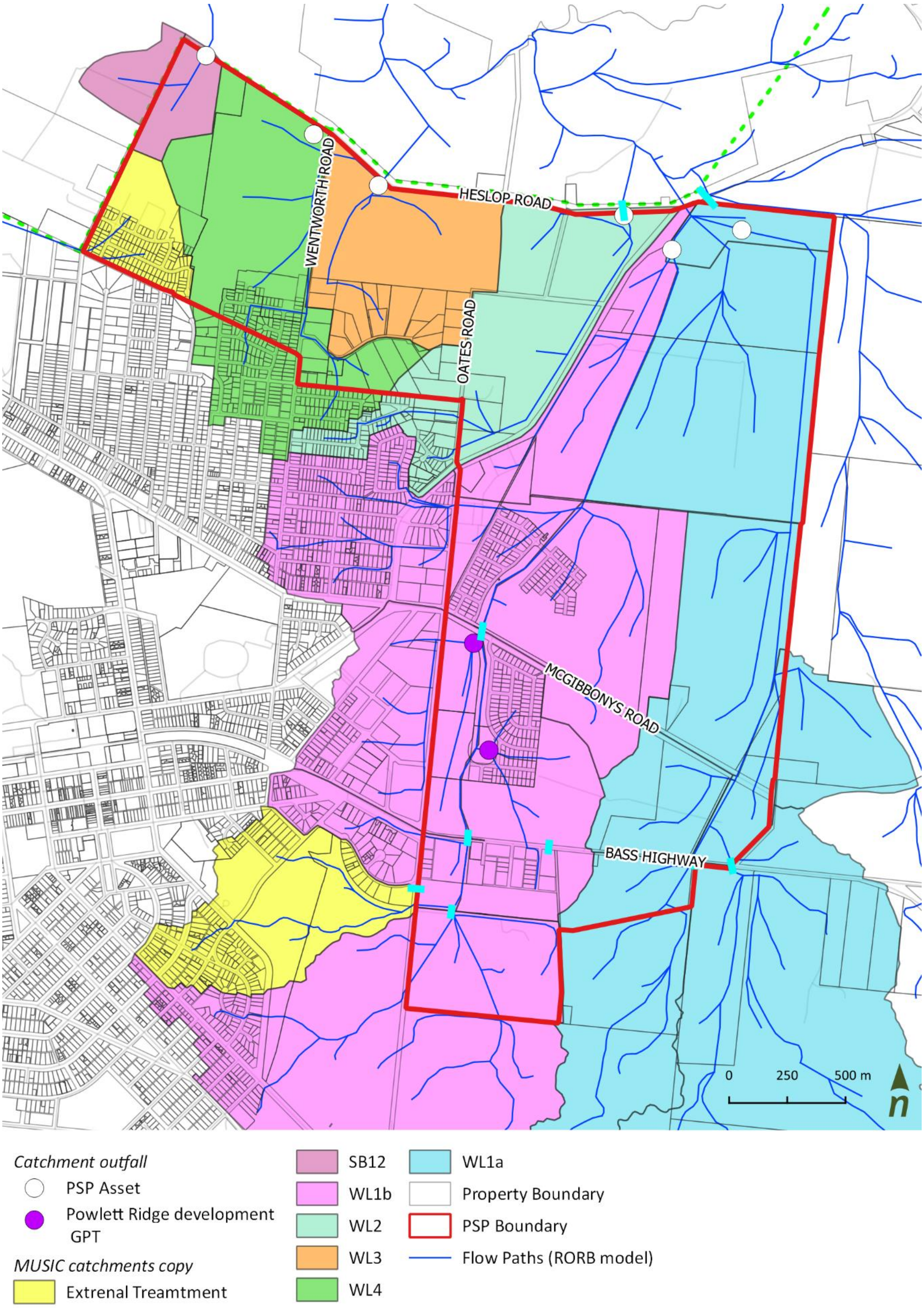


Figure 15. *Map of drainage catchments and respective outfalls indicating ideal treatment asset locations within/beyond PSP.*

As per the figure above, a breakdown of the contributing catchments with respect to the external agricultural land, the external urban land (i.e. the Wonthaggi township) and the future proposed developable area contributing to each outfall location within the PSP area is provided in the Table below.

Table 1. Catchment breakdowns within the PSP and external area

Asset	Area type	Area (ha)	% Area of each sub catchment	% Area of total catchment
WLRB 1A (DCP ref WL-01)	Existing External Agricultural	442	69%	31.9%
	PSP	199	31%	14.4%
	Total	641	100%	-
WLRB 1B (DCP ref WL-01)	Existing External Agricultural	137	27%	9.9%
	Existing External Urban	146	29%	10.5%
	PSP	225	44%	16.2%
	Total	508	100%	-
WLRB2 (DCP ref WL-02)	Existing External Urban	14	19%	1.0%
	PSP	59	81%	4.3%
	Total	73	100%	-
WLRB3 (DCP ref WL-03)	PSP	52	100%	3.8%
	Total	52	100%	-
WLRB4 (DCP ref WL-04)	Existing External Urban	23	23%	1.7%
	PSP	78	77%	5.6%
	Total	101	100%	-
SB7	PSP	11	100%	0.8%
	Total	11	100%	-
Total catchment area		1386	-	100%
Total external catchment area (mix)		762		
Existing Agricultural total		579		
Existing Urban total		183		
Total internal PSP catchment area		624		

A map of the contributing external catchments and 1% AEP flows to each of the WLRB assets is shown in Figure 16.

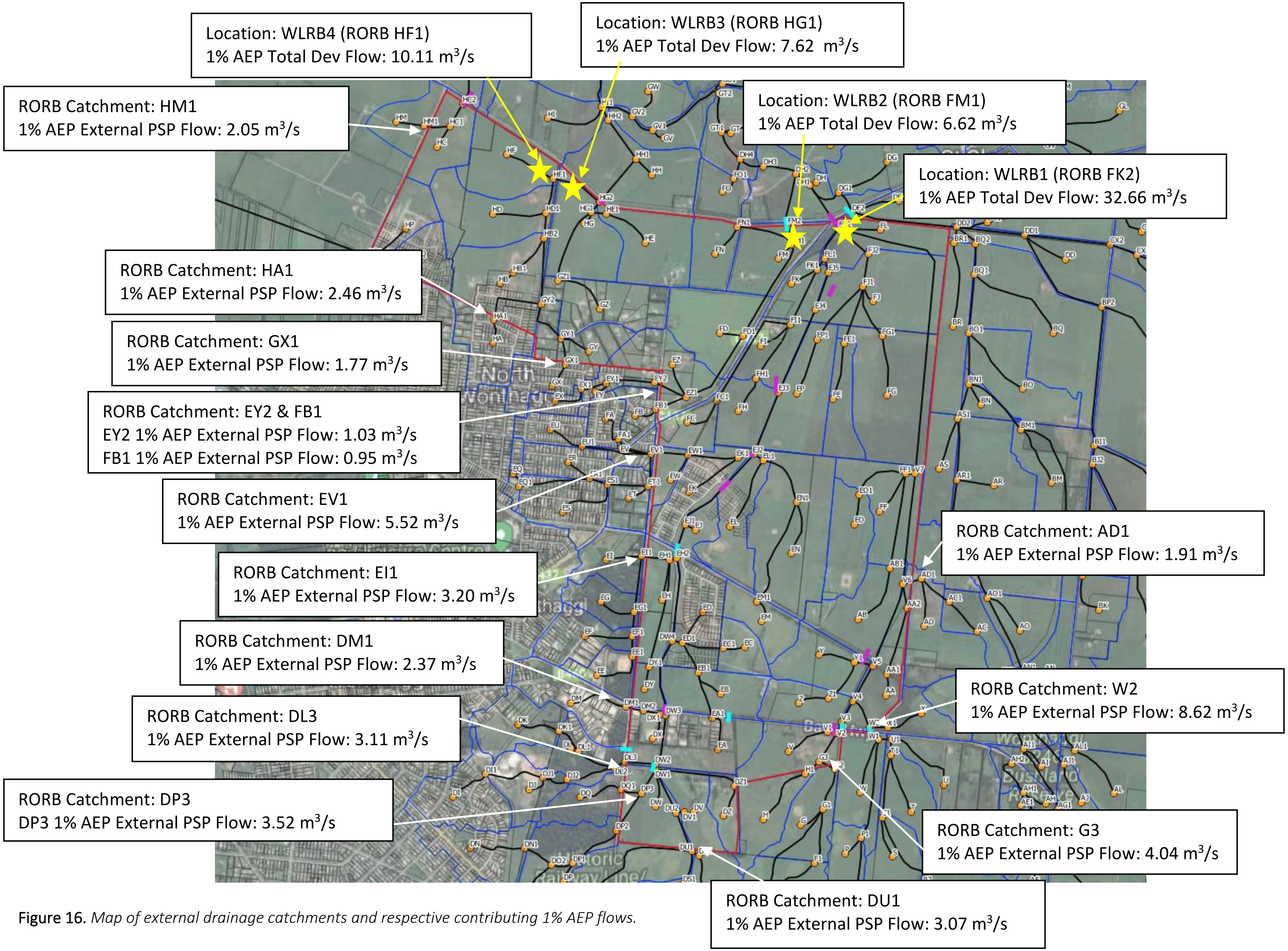


Figure 16. *Map of external drainage catchments and respective contributing 1% AEP flows.*

The three catchments that cross the PSP may be further broken down into smaller stormwater drainage sub-catchments (Figure 17). There are 3 large sub-catchments south of the WNE PSP that are currently agricultural land use which drain through the precinct. These external catchment inflows have been accounted for in the functional designs. These areas have been factored into the WLRB1A and 1B (DCP ref WL-01) functional design footprints.

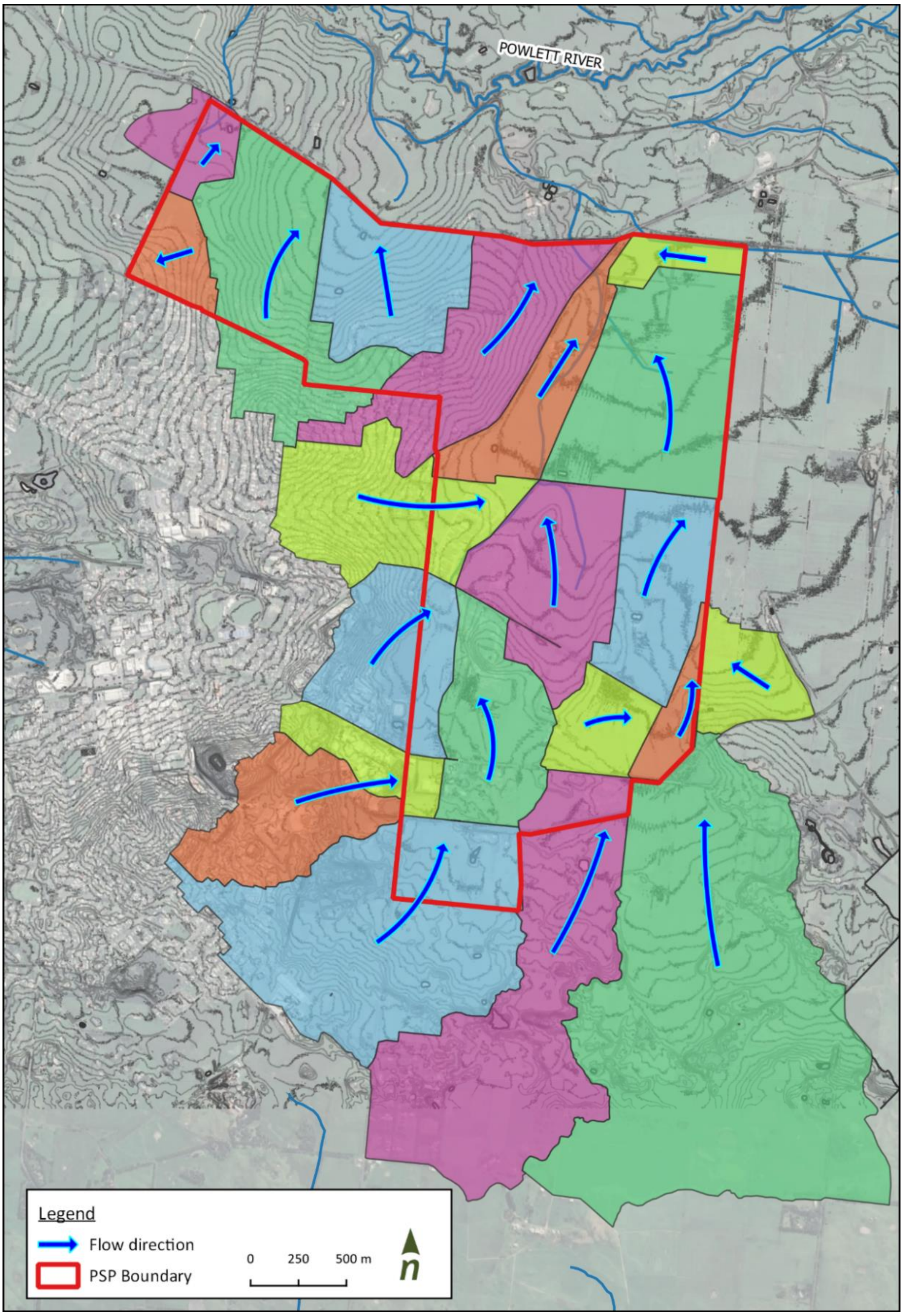


Figure 17. *Stormwater drainage sub-catchments across the PSP area (Engeny delineations, 2021)*

4.5 Flora and fauna values

As part of the precinct planning process, Nature Advisory were engaged by Council in 2020 to conduct a biodiversity assessment of the PSP area. The investigation provided information on the extent and conditions of native vegetation in the area according to *Victoria's Guidelines for the removal, destruction or lopping of native vegetation* to be used as input into the Native Vegetation Precinct Plan for the area. The study was conducted by a review of existing information on the region and two independent site visits.

- The site primarily comprised of agricultural lots which supported introduced pastures and/or used for cattle grazing
- The predominant native vegetation recorded throughout the PSP area includes:
  - Swamp Scrub (EVC 53), mainly around roadsides
  - Damp Sands Herb-rich Woodland (EVC 3)
  - Lowland Forest (EVC 16)
  - Grassy Woodland (EVC 175)
  - Tall Marsh (EVC 821)
  - Swampy Woodland (EVC 937)
- A total of 14 large native trees were recorded across the area. Nature Advisory noted under the DEWLP Native Vegetation Removal Report (May 2020), any approval for removal of native vegetation would have these offset requirements:
  - 1.744 general habitat units with a minimum strategic biodiversity value score (SBV) of 0.338
  - The protection of the 14 large trees.
- A large wetland exists near the intersection of Bass Hwy and Carneys Road, providing an aquatic habitat, and is heavily vegetated with Narrow-leaf Cumbungi (*Typha domingensis*)
- Based on the current development plan at the time of the Flora and Fauna study, no threatened ecological communities, flora, or fauna species were likely to be impacted
- A map of identified native vegetation is provided in Figure 18.

Additional to the general biodiversity assessment, Nature Advisory was also engaged by Council in 2020 to conduct targeted Growling Grass Frog, Swamp Skink and Latham's Snipe Surveys. The surveys consisted of three separate field trips to the PSP area including active searches for the target species and placement of cameras. The surveys concluded that the PSP development posed a low threat to the target species due to:

- the current considerations and PSP retain the main fauna habitat linkages
- a lack of presence of the target species in the PSP area
- the proposed PSP poses a low risk to the target species.

Based on the ecological studies undertaken for the PSP, Alluvium has considered the recommendations from the Flora and Fauna studies and considered:

- the presence of roadside native flora
- pre-existing wetland ecosystems that we have demonstrated could provide direct links and enhanced outcomes through connection with the PSP blue-green asset corridors
- existing flora values and how these may be enhanced to improve ecological outcomes through PSP waterways and wetland systems.

A 'map overlay' of the PSP asset footprints relative to identified environmental values of the PSP is shown in Figure 19 to demonstrate consideration of site values at the functional design stage. **Note:** this does not preclude requirements to assess native vegetation, determine vegetation offsets (where appropriate) and define tree protection zones (TPZ) at the detailed design and construction phase in the future.

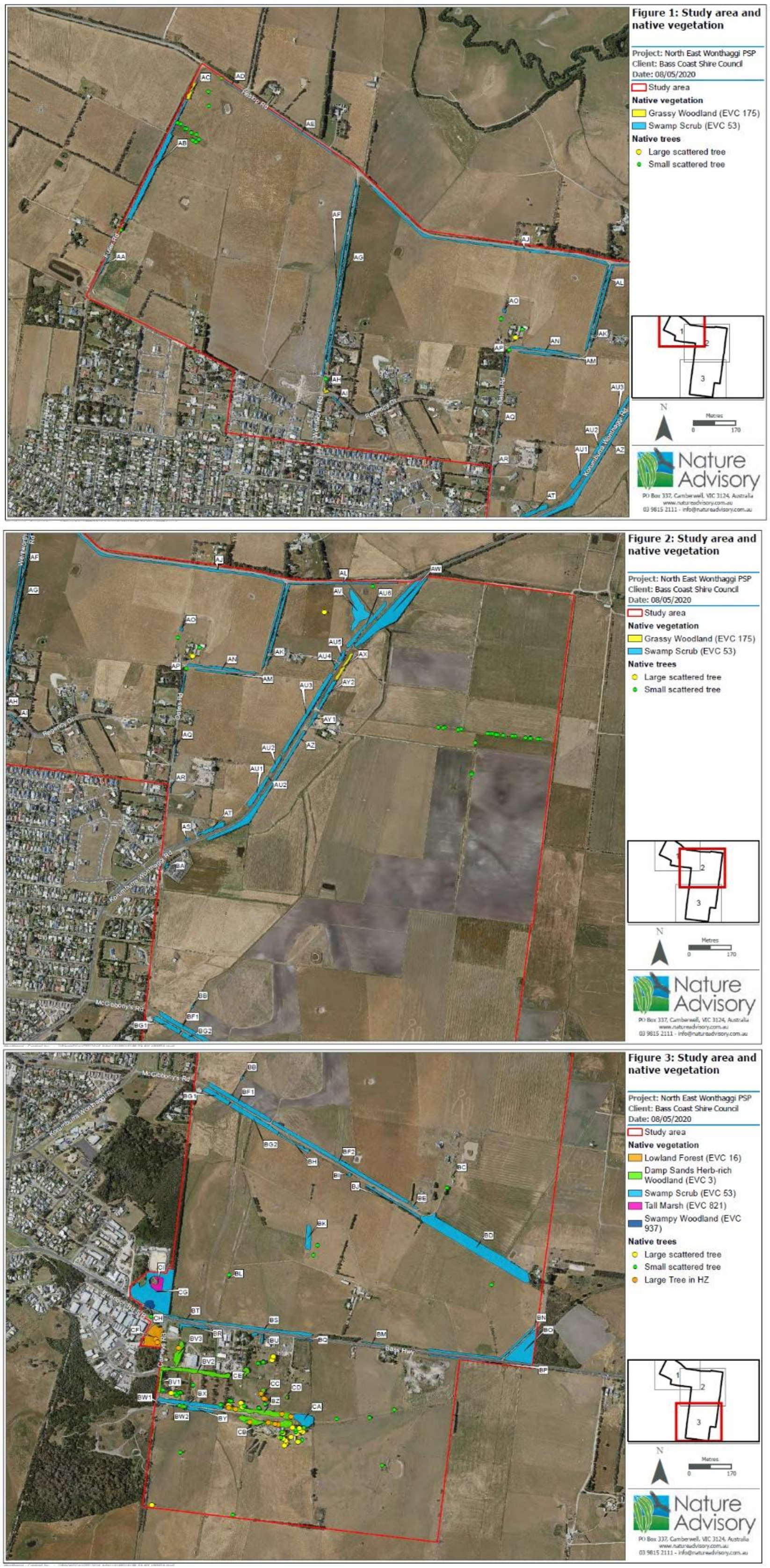


Figure 18. *Native vegetation in PSP area (source: Nature Advisory, May 2020)*

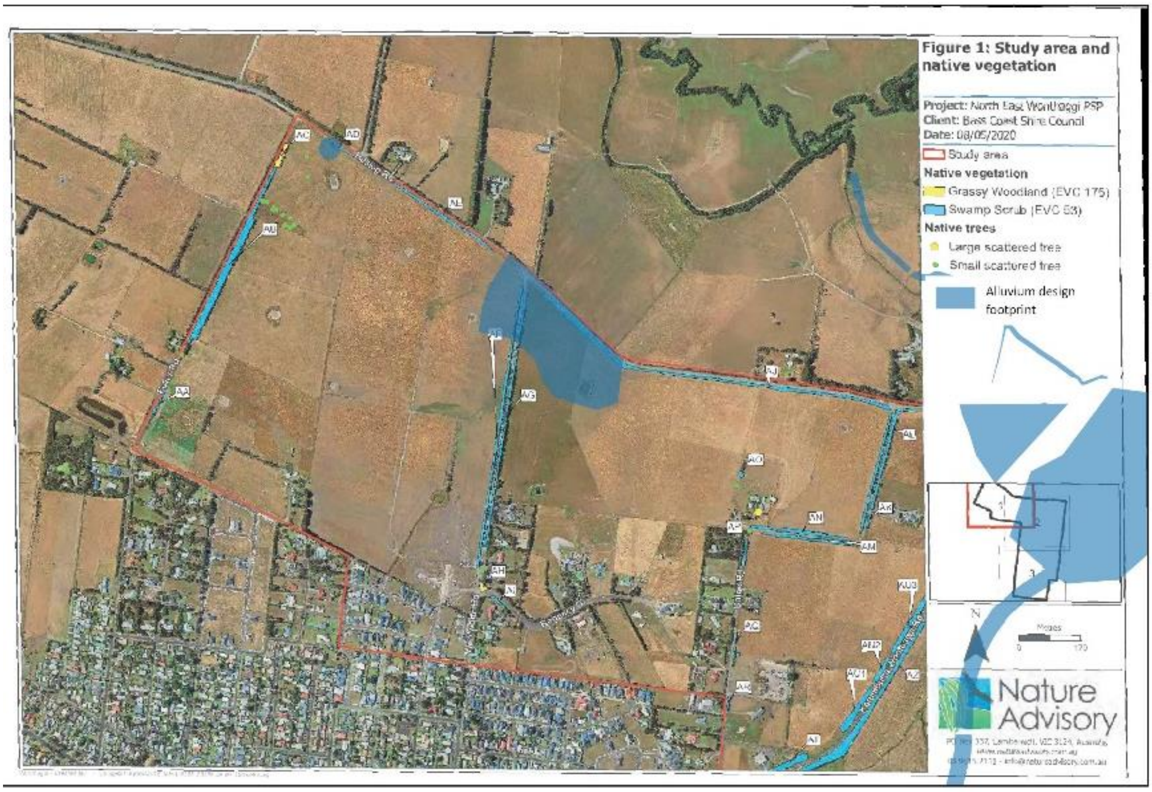


Figure 1: Study area and native vegetation
Project: North East Wonthaggi PSP
Client: Bass Coast Shire Council
Date: 08/05/2020
Study area
Native vegetation
Grassy Woodland (EVC 175)
Swamp Scrub (EVC 53)
Native trees
Large scattered tree
Small scattered tree
Alluvium design footprint
Nature Advisory

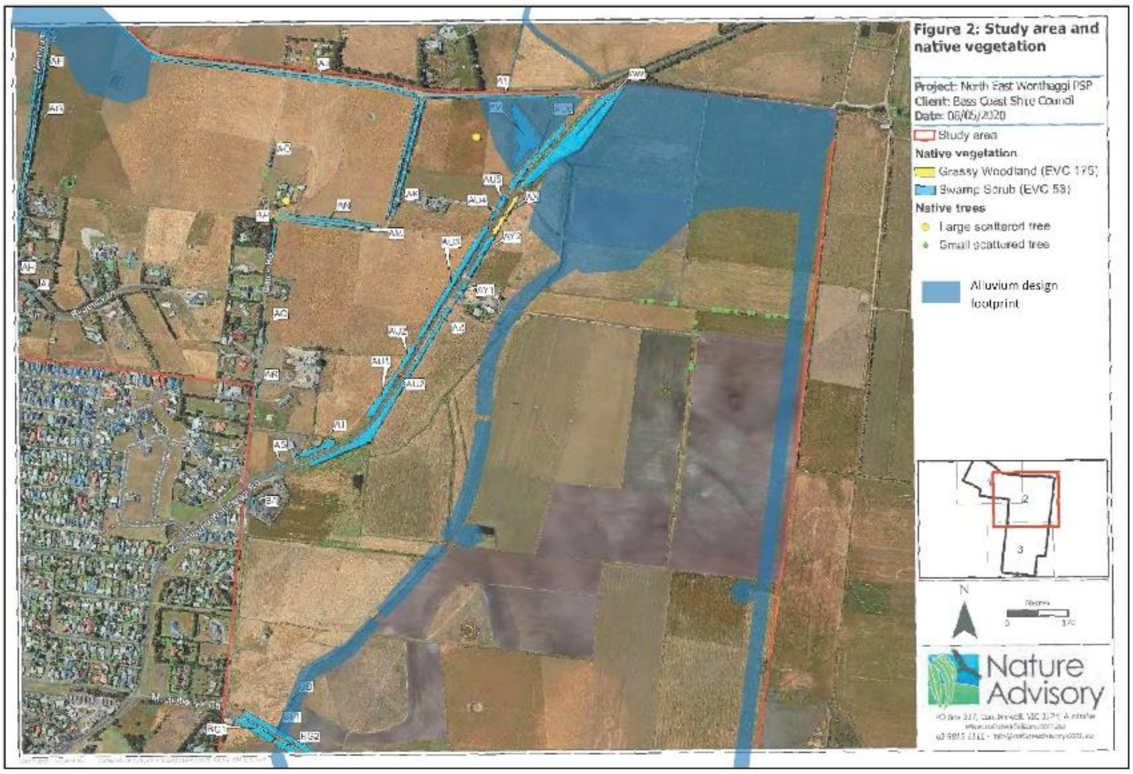


Figure 2: Study area and native vegetation
Project: North East Wonthaggi PSP
Client: Bass Coast Shire Council
Date: 08/05/2020
Study area
Native vegetation
Grassy Woodland (EVC 175)
Swamp Scrub (EVC 53)
Native trees
Large scattered tree
Small scattered tree
Alluvium design footprint
Nature Advisory

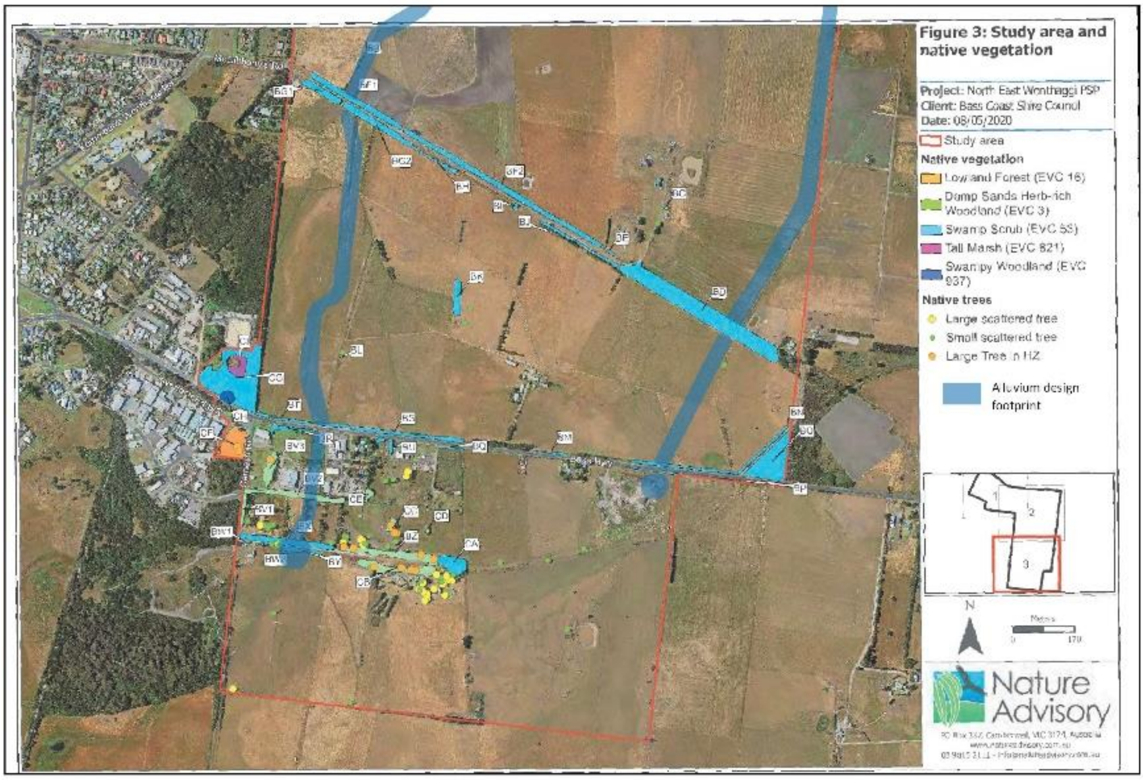


Figure 19. *Design footprint and native vegetation in PSP area (source: Nature Advisory, May 2020)*

4.6 Cultural heritage

The Yallock Bulluk clan (one of the largest clans of the Bunurong People) are the traditional owners of the region. The traditional land of Bunurong People (Figure 20) extends from the Werribee River in the north-west, down to Wilson's Promontory in the south east which includes the Powlett River catchment. The Bunurong people have a continuing connection to country, including the lands and water for which the precinct falls within.

Like many other Indigenous Peoples, the Yallock Bulluk People changed with the seasons. Their culture and lifestyle explored all elements of the diverse land around them - from hunting in the ocean for seals and mutton bird, to trading with other Bunurong clans or Koolin People in the Dandenong, Bass Valley and Upper Powlett River. The Boon Wurrung Foundation and Bunurong Land Council Aboriginal Corporation (BLCAC) are the current Traditional Owner Groups for the PSP area, with BLCAC being appointed as a registered Aboriginal Party in 2017. Their feedback and input to the development of this PSP is critical for inclusion of Traditional Owner values in the management of water and development of land in the region.

An Aboriginal Cultural Heritage Survey was completed by Triskel Heritage Consultants in 2017 as part of the Wonthaggi North East Growth Area (WNEGA) Precinct Structure Plan. This survey was contained within the PSP boundary and did not include areas external to the precinct. The study involved a desktop-based assessment of the PSP conducted in 2016 by Andrew Orr (Triskel) and a fieldwork component conducted in March 2017. The following provides a summary of the Aboriginal Cultural Heritage Survey:

- The survey comprised of visual (surface level only) inspection over most of the WNEGA
- Identified no new artifacts or archaeological features
- There are six approved Cultural Heritage Management Plans (CHMPs) within the current WNEGA boundaries
- Assessment of the CHMPs identified seven Aboriginal places all assessed as having low to moderate significance - no areas of high significance were found

- Dan Turnbull (Manager, Bunurong) emphasized the traditional cultural value of elevated land, while also expressing the importance of the whole area, especially considering the Yowengerra Clan (a relevant clan to the area) potentially having no living descendants.

Figure 20. *Bunurong Land Council Aboriginal Corporation (BLCAC) registered Aboriginal party (source: BLCAC website)*

While waterways (rivers and creeks) were typically travelling routes for Aboriginal peoples, there were often numerous landforms other than waterways, and elevated land areas that can pose a high potential to yield Aboriginal material culture. Any high impact activity (such as the proposed land development for the PSP) within defined areas of Aboriginal cultural sensitivity, requires a mandatory Cultural Heritage Management Plan (CHMP).

Key recommendations from the Triskel Heritage study were to produce voluntary CHMPs, especially in the high potential locations as shown in Figure 21, and continue to consult and engage relevant Traditional Owners through the current PSP process, in this instance, the BLCAC. It is noted that to date, while CHMPs have been undertaken for the PSP, none have been commissioned for areas of *high potential sensitivity*.

Key definitions of note for the protection of Aboriginal cultural values

High Impact Activity	Examples include the subdivision of land into three or more parcels/lots. (*Victorian Aboriginal Heritage Act 2006*, Regulation 46)
Areas of Cultural Sensitivity	Are determined using several spatial parameters intended to reflect where Aboriginal cultural heritage places are most commonly found; and land within 50m of these (R.25) and land within 200m of a waterway (R.26)
High Sensitivity (Most Likely potential)	As much as possible, these areas should be retained in their current form and, where applicable, be rehabilitated to further stabilise them (e.g. from erosion). This should be in the form of passive open space or other non-developable reserved land. Where lower impact works are proposed in these areas, such as pedestrian and/or bike paths, these works should be designed to minimise impacts and be placed largely on top of the surface, to avoid impacting below the ground surface where material culture is most likely.
Significant ground disturbance	Under the Aboriginal Heritage Regulations these areas are no longer areas of cultural heritage sensitivity as disturbance of the topsoil layer by machine excavation or grading (excluding ploughing) is defined as significant disturbance (R.5)
Registered Aboriginal Parties (RAP)	In this case, Bunurong Land Council Aboriginal Corporation (BLCAC) are given the responsibility for most Aboriginal heritage matters within their registered area, including being responsible for the evaluation of CHMPs (as per *Aboriginal Heritage Act 2006*).

The map below shows the predicted likelihood of Aboriginal cultural heritage occurring within the PSP area based on topographical conditions. Of note, is that the proposed locations for the functional stormwater assets to the north of the precinct do not conflict with areas of *High Potential* for Aboriginal cultural value (Figure 22).

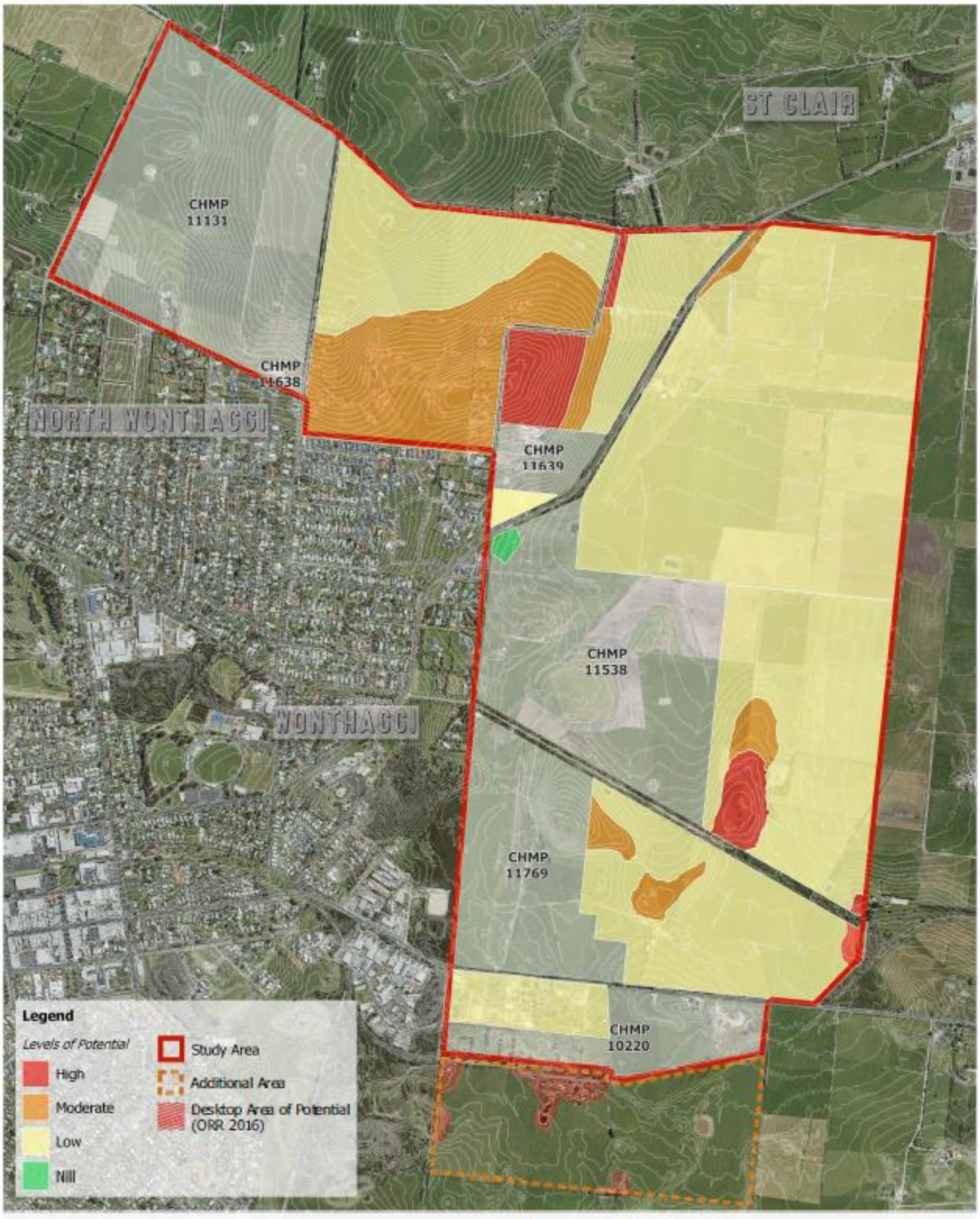


Figure 21. *Areas of potential Aboriginal cultural heritage values (source: Triskel, May 2017)*

In accordance with current regulations for the protection of Aboriginal culture, during the functional design stage we have ensured the alignment of E-WW (DCP ref DR2) does not conflict with the adjacent high value location at McGibbonys Road intersect and has ensured avoidance and preservation of existing.

A 'map overlay' of the PSP asset footprints relative to identified cultural heritage values of the PSP is shown in Figure 22 to demonstrate consideration of site values at the functional design stage. **Note:** this does not preclude requirements to ensure these areas of likely sensitivity are not impacted / clearly identified for protection at the detailed design and construction phase in the future.

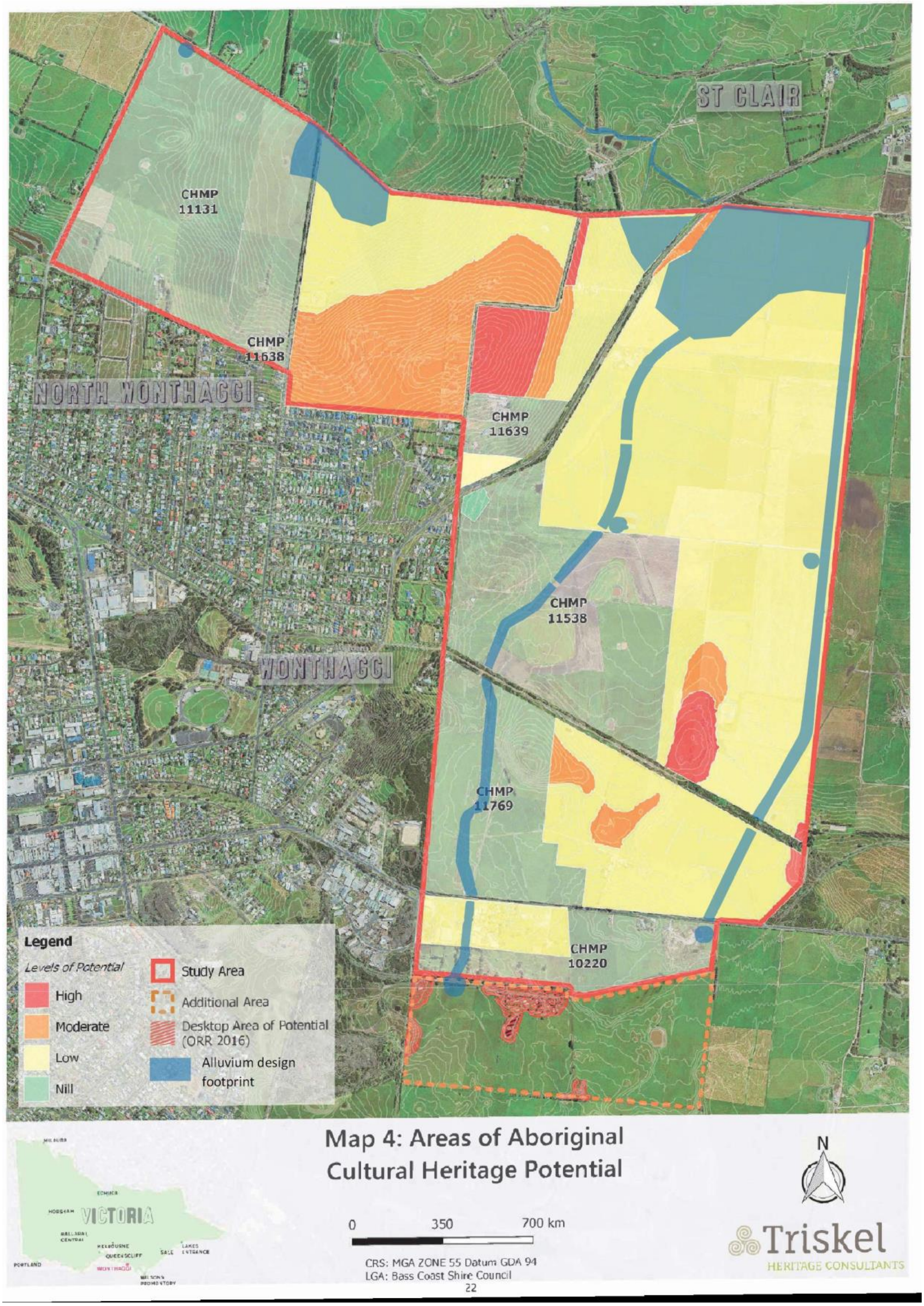


Figure 22. *Map overlay of PSP asset footprint relative to identified areas of Aboriginal culture / heritage values (source: Triskel 2017, modified by Alluvium 2021)*

4.7 Geology

A desktop survey was conducted to understand the geological conditions present in the PSP area. Based on publicly available State data, the predominant geological types in the PSP boundary are gravel/sand-silt layers and lithic volcanic sandstone.

It is assumed that further geotechnical investigations will be undertaken prior to the development of the Precinct, and ultimate implementation of the functionally designed assets for the PSP.

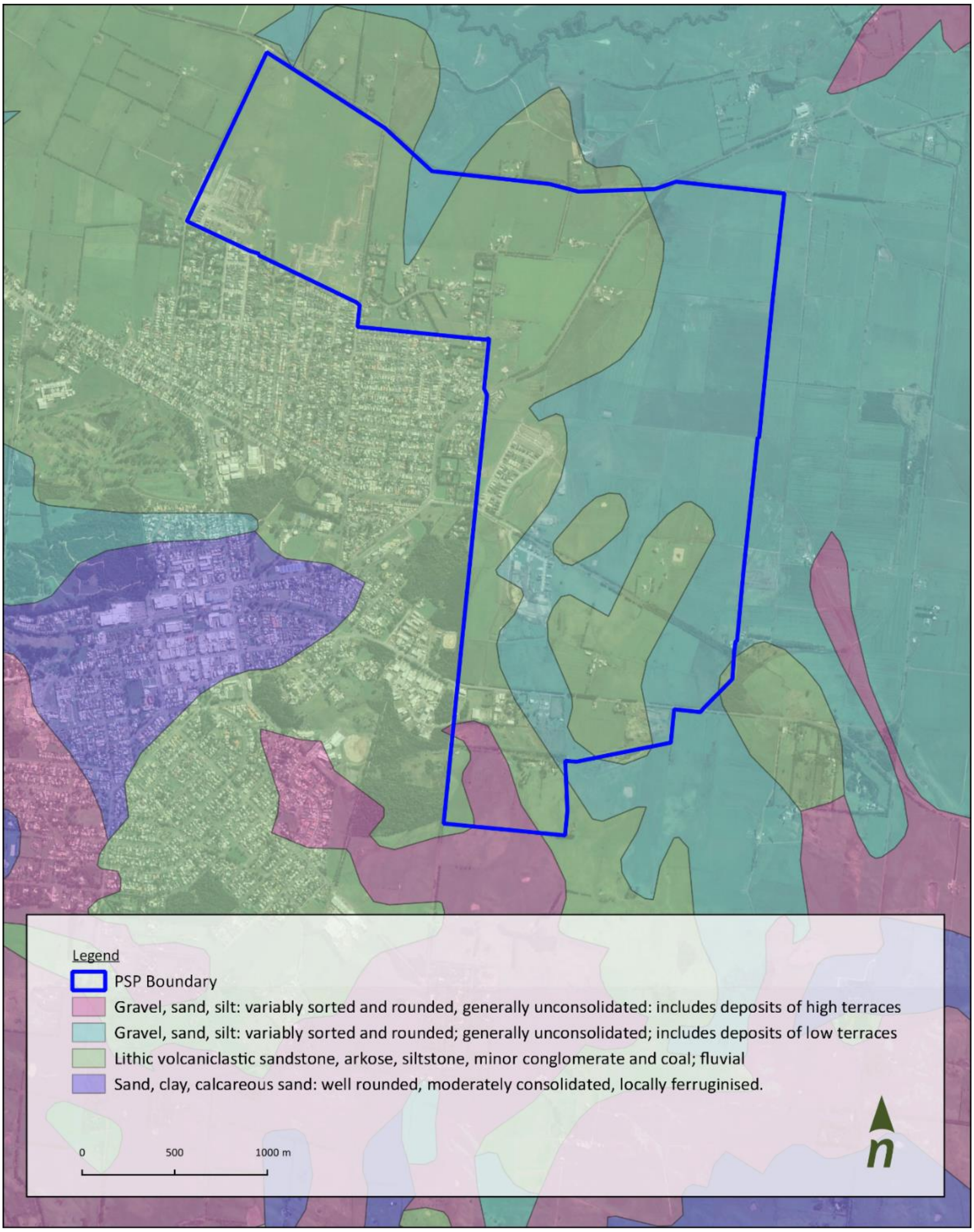


Figure 23. *Geological features of PSP and surrounding areas*

5 Proof of Concept Assessments

Alluvium has undertaken a thorough review and analysis of the work undertaken to date for the WNE PSP. In assessing concepts and modelling (undertaken by others) for the PSP assets. Below is a summary of Alluvium's assessment of the DCP / Engeny concepts that led to the recommended final concept layout (Figure 26) and the suite of functional designs approved by stakeholders. We have not reiterated all PSP assets only those that vary from what has been previously proposed. This variation in Alluvium's recommendations is to ensure all requirements, including best practice standards are being met, and that the design solutions lead to functionally sound assets.

5.1 Constructed wetland design principles

Constructed wetlands are man-made surface water management structures that aim to mimic natural wetland systems by filtering surface water flows through:

- Physical processes – a combination of wetland form and aquatic plant selection and placement
- Biological / chemical processes – nutrient cycling, chemical uptake, and contaminant removal (including heavy metals)
- Transformation processes – stabilising and 'fixing' contaminants like phosphorus and metals; converting pollutants such as ammonium and nitrogen into inert (non-reactive) gases (denitrification) released safely to the atmosphere; and providing some disinfection through ultraviolet (UV) exposure across open water areas.

Wetlands are a tertiary treatment component typically part of a 'treatment train' with an upstream primary treatment component such as a sediment basin or gross pollutant trap (GPT). Wetlands are shallow waterbodies with extensive vegetation coverage and long flow paths to reduce flow velocities and allow treatment action.

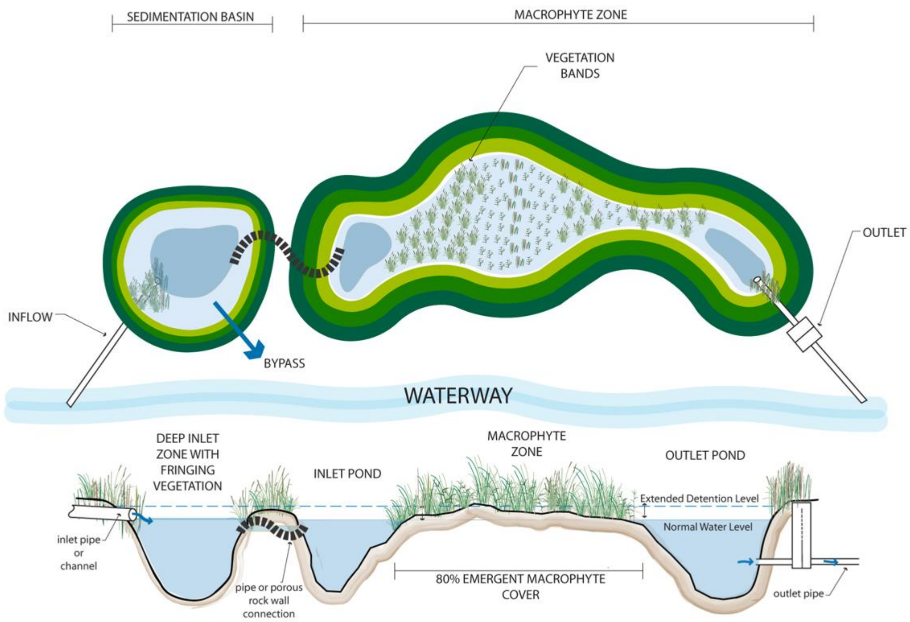


Figure 24. Typical concept layout of a treatment wetland (source: Constructed Wetlands Design Manual, Melbourne Water)

Constructed wetlands are comprised of three (3) main parts:

- **Inlet zone** – a sediment forebay or sediment basin that allows coarse sediment (> 125 micron) deposition (and litter) to protect the main body (integrity and lifespan) of the wetland. The sediment basin performs the primary treatment function in the treatment train and passes pre-treated flows into the inlet zone (first deep pool) of the wetland.

- **Macrophyte zone** (bounded by with inlet and outlet pools) – Pre-treated flows then move from the inlet zone (first wetland deep pool) and pass slowly over a 48-72hr period through a combination of shallow marsh and deep marsh zones (macrophyte zone) before entering the final deep pool (or outlet zone). A controlled outlet helps detain flows within the wetland for the treatment duration. The macrophyte zones are densely planted with specifically selected aquatic vegetation that filter flows and remove the pollutants from the water column.
    - Fine sediments and heavy metals which adhere to fines (e.g. clays) are trapped by the vegetation and 'locked' to the wetland floor (preventing their re-suspension).
    - Nutrient cycling of dissolved organics in the water column (e.g. phosphorus and nitrogen) is undertaken by the aquatic plants (for their growth and survival).
    - Micro-organisms (biofilms) growing on the surface of aquatic plants absorb pollutants and trap fine suspended particles through adhesion.
    - Stabilisation and 'fixing' of contaminants (e.g. phosphorus and metals) in the wetland soils through regular wetting and drying cycles of the designed wetland.
    - UV treatment in open water sections of the wetland provides a level of disinfection.
- **High-flow bypass channel** – allows excess flows to pass around (and not through) the wetland to protect wetland stability and plant survival (from bank, floor and vegetation scouring); and ensures further flows are bypassed when maximum extended detention depth (EDD) is reached within the wetland, allowing the system to effectively treat flows and achieve pollutant reduction targets as generated from the source catchment.

  Note: pollutant reduction targets are not about reducing by target percentages from the volume of water that enters the wetland, but a reduction in pollutants generated from the land area. Excess volume within the wetland reduces its design intent function in pollutant reductions.

During our proof of concept background analysis we identified the following.

Consideration: WLRB 3 & WLRB 4 (DCP ref WL-03 & WL-04)
These two assets are located at the north-west corner of the PSP at the intersection of the discontinued Wentworth Road and Heslop Road. The wetland concepts included:

- Inlet pond / sediment basin for each wetland
- Maintenance access ramps to the base of each sediment basin
- Sediment dry-out areas provided for each sediment basin
- Balance pipes between open water zones within the macrophyte zone
- Wetland vegetation zones provided in a banded manner
- Sediment basin transfer pits / pipes to outfall from the sediment basin to the macrophyte zone of wetlands
- Outlet from the wetlands through the downstream adjacent property to the north.

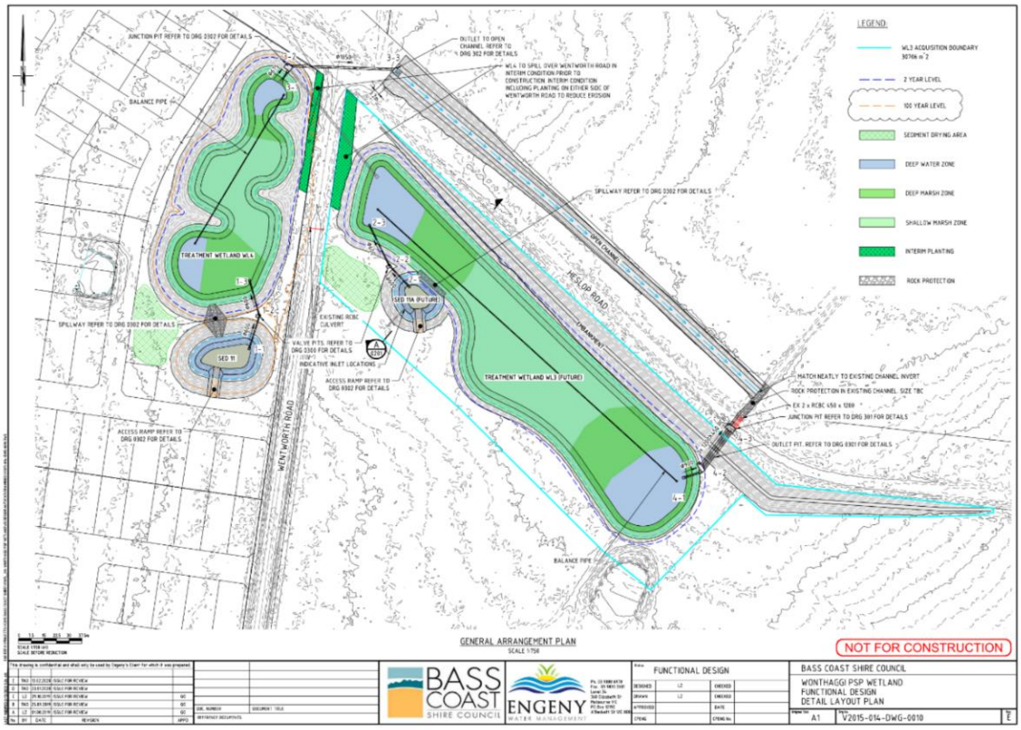


Figure 25. *Layout plans for wetlands (WLRB3 & WLRB4; DCP ref WL-03&04) at Wentworth/Heslop roads (Engeny, 2020)*

Summary of assessment - *Wetlands*

- No indicative inlet location was provided for DCP/Engeny sediment basin (SB11).
- Connection between SB11 and the macrophyte zone of WLRB4 (DCP ref WL-04) should be made into the open water zone, not the macrophyte zone. The concept designs show these flows out-falling from the SB into the deep marsh vegetated zone and will likely result in higher shear stresses and stripping vegetation. This also results in a 'short circuit' of the wetland where flows are bypassing the first deep pool or wetland inlet zone where velocities are mitigated, and first line of the treatment process begins.
- The width at NWL along the wetland macrophyte zone (WLRB4; DCP WL-04) is very constricted near the outlet pool, but within the deep marsh zone. Constricting the width at NWL too much at this point will likely result in increased velocities through this vegetated section of the wetland, and likely strip vegetation and resuspend sediments and trapped pollutants from the wetland floor.
- The wide meanders along WLRB4 (DCP ref WL-04) will likely result in areas of stagnation at the widest points or ineffective flow areas and reduce the overall treatment efficiency of the wetland.
- Sediment basins and wetland macrophyte zones have been set at the same NWL. For maintenance purposes it is best to have the sediment basin NWL set at least 100mm above the wetland macrophyte zone NWL, to allow for draining of the sediment basin for sediment clean outs.
- To protect the integrity of the wetland and vegetation drowning out from an increased inundation duration, it is recommended that a high flow bypass of the wetland asset be incorporated, for events greater than the 20% AEP. Further, if these high flows are not diverted around the wetland, the pollutant reduction performance of the wetland will drop significantly as it is unable to manage these high volumes and reduced pollutant concentrations (dilution is not an acceptable pollutant reduction approach to waterway protection).
- The 1% AEP gap flows (i.e. 1% AEP minus the 20% AEP flow) can be managed via overland flow paths and along road reserves.

Consideration: Bushfire Management

It should be noted that plant selections proposed for the treatment wetlands, constructed waterways and sediment basins are necessary for the function of each specific stormwater management (drainage) assets and note proposed as part of landscaping finishes for the PSP. Plants recommended for key water assets in the precinct meet the criteria for 'excluded vegetation under AS 3959-2018' as identified in the *Addendum* to the *Bushfire Development Report for the Wonthaggi North East Precinct Structure Plan* (VPA, 2021). Further, waterway corridor widths within the PSP have ensured a minimum bushfire protection buffer width of 19m to the proposed developed interface.

Plant recommendations are predominantly aquatic species requiring submersion or wet/dry conditions and are necessary for the design function of the wetland systems (i.e. stabilisation and pollutant filtration function). Species proposed for the sediment basins and constructed waterways are those requiring wet/moist conditions for bank stabilisation. No shrubs or trees have been specified, nor terrestrial plantings. All the plants are either related to the water asset function and/or bank stabilisation.

Consideration: Flood management at 465 Heslop Road (subject property)

In response to concerns raised in the C152 amendment of the PSP, Council engaged Engeny to produce an *Impact and Proposed Mitigation Works Report* (March 2021) to reduce flooding conditions to a dairy farm at 465 Heslop Road (directly north, and downstream, of the PSP boundary, hereafter referred to as the subject property). Concerns that increased runoff from the developed area would exacerbate flood conditions already existing on the property were raised by the landowner.

Engeny produced an impact assessment using a more complex and detailed software (TUFLOW), allowing for considerations to be made for the inflows (riverine flooding) from the Powlett River. The results indicated that although there is an increase in flows from the precinct to the subject property in the 1% AEP event, inundation within the property was dominated by inflows from rural catchments to the east of the property and outfalling into the Powlett River upstream, and not directly attributable to the PSP discharge.

The summary findings (below) were applied to the functional design process (for the subject property / main outfall to the river):

- An increase in flooding in the 50% AEP event of up to 60 mm (up to 100mm at some locations)
- An increase in flooding in the 20% AEP event of generally less than 40 mm
- An increase in flooding in the 1% AEP event of less than 30 mm with the PSP flows only. When the Powlett River flows are included, there is no increase in the peak flooding experienced on the subject property.

A series of non-structural (non-designed) levees exist along the Powlett River on the subject property side which is providing protection to the property from river flows during the smaller more frequent events, however, they may also prevent the large events from discharging to the river from the PSP and should be considered further in the main outfall design.

Consideration: Powlett Ridge Estate – Endorsed Plans (Sept 2021)

Powlett Ridge Estate is one of two main developments proposed for the Wonthaggi North East PSP. A review of endorsed plans (June 2019 – Sept 2021) was completed and found to be in line with Alluvium's prior understanding of the site. As such, no changes were required in our modelling and functional design approach in relation to this area.

Summary of assessment – *Powlett Ridge*

- Land take for proposed W-WW (DCP ref DR1) is accounted for as 'future reserve space' with provision for approx. 45m wide broadening to 60m downstream

- Development location aligns with DCP SB4 (Alluvium SB2). Detailed designs in development plan set did not specify construction of SB however, negotiations between council and the developer have resulted in a GPT being installed at this location (council update Oct 2021).

- North-western lot at McGibbonys Rd purchased by DETV proposed to include DCP SB5 - Alluvium recommends this SB be made redundant as catchment is catered for by downstream WLRBs. Engeny's final strategy concurs with this redundancy.
- Changes to the W-WW (DCP ref DR1) alignment at the upstream extent of works has resulted in a widening and straightening of the upstream section. No functional design required for this section however performance of this upstream section has been considered in the functional design of the downstream.
- Whalebone Boulevard is currently planned to pass over the waterway entrance to the future reserve (council advice Sep 2021), subsequent culverts should be sized appropriately to convey 1% AEP flows. As this section of W-WW (DCP ref DR1) is existing along Connection Road, and the waterway it has no direct impact on the functional design set.
- *Council update (Oct):* School site - flow from Jean Dennis Rd to discharge into waterway via GPT to be approved by the landowner and constructed by Powlett Ridge. Town drainage from the south to be redirected to a GPT in the drainage reserve in Powlett Ridge stage 6 (as per Council advice).

5.2 Engeny Drainage Strategy (August 2021)

Engeny was engaged by Bass Coast Shire Council to investigate the stormwater quantity and stormwater quality treatment requirements of the proposed Wonthaggi North East Development Precinct. This section relates to the review of the revised drainage strategy (August 2021) predominately, and review of the original strategy (October 2019) with respect to costings and the initial PSP/DCP layout.

A review of the subsequent reports and outputs (February 2020, March 2021) received to date has been included. It is noted, the initial cost estimates used to inform the initial PSP/DCP were based on the original Engeny Strategy (2019), no cost estimates were included as part of the Engeny revised strategy (2021), costs are likely to vary between the revised strategy and the original due to a redesign of proposed assets; and original costings based on concepts at a high level. Alluvium's review and analysis of the proposed approach for the PSP for surface water management is offered considering an understanding of existing values and constraints, background investigations, stakeholder input, and the PSP objectives.

The revised Engeny drainage strategy was undertaken in parallel with this study - Wonthaggi North East PSP functional designs (Alluvium study). Alluvium have revisited initial strategy iterations of the PoC report, to ensure steps going forward are consistent.

The proposed concept layout plan for the Engeny 'drainage strategy' received up to 13th August 2021 has been included in Figure 2 (above) alongside the latest concept layout plan received 25th August. Table 1 (in Section 1) attempts to draw correlations and conflicts / changes between these two key concept layouts to aide in reader tracking.

Summary

The following is based on all information provided up to and including the submission of the Engeny revised strategy (past strategy versions, reports, DCP and data received to date). A review has been completed to inform a base understanding of the PSP area and provides Alluvium with an initial understanding of the strategy intent and the proposed drainage interventions (assets). The strategy has assumed the following:

- Development density of 11 dwellings / or lots per hectare
- Fraction impervious for the residential development area of 0.65
- The development precinct is required to meet best practice treatment of stormwater prior to outfall into the Powlett River, which includes:
    - 70% removal of the total Gross Pollutant load
    - 80% removal of the total Suspended Solids (TSS)
    - 45% removal of the total Phosphorus (TP)
    - 45% removal of the total Nitrogen (TN).

- All drains outfalling into an existing or constructed waterway will receive primary sediment removal treatment through sediment basins
- Confirmed with the WGCMA there is no requirement to control peak flows to predevelopment peak flow rates for major storm events (i.e. 1% AEP), understanding the significant cost burden likely, however:
    - Increased runoff due to development in more frequent storm events means downstream land owners are subject to more frequent inundation, as a result more frequent events are to be controlled back to predevelopment peak flow rates.

High level cost estimates (Engeny 2019)
The Engeny Strategy estimated landscape and civil costs for the Wonthaggi North East Development Precinct, based on the original 2019 strategy concepts as follows:

- $25,284,000 for conveyance related drainage infrastructure:
    - $16,389,000 is estimated for constructed waterways
    - $4,438,000 is estimated for culvert structures
    - $4,457,000 is estimated for drainage pipelines.

- $10,070,000 for stormwater treatment infrastructure:
    - $3,439,000 is estimated for WLRB1
    - $1,017,000 is estimated for WL2
    - $1,935,000 Is estimated for WL3
    - $1,400,000 is estimated for WL4
    - $2,279,000 is estimated for stand-alone sediment basins.

- $4,328,000 for the retarding basin infrastructure at WLRB1.

The total cost of the Engeny strategy is equal to $39,682,000. This total infrastructure excludes the costs associated with land acquisition and inclusion of litter traps or high flow bypasses of the sediment basins. A 35% contingency was applied to the overall costs.

Review of revised strategy (Aug 2021)
A high-level review of the Engeny Revised Strategy (received 25 August) has been undertaken, based on an understanding of known values and constraints, and feedback from stakeholders. The Revised Strategy considerations:

Sediment Basins

- Includes 14 sediment basins, 8 of which outfall directly into the proposed waterway corridors. To reduce costs of excavation / land take, consolidation of some sediment basins provides an opportunity to reduce the overall Development Contributions Plan (DCP) rates.
- Each sediment basin will require safe batters, hardstand areas for maintenance access and dedicated area for sediment drying prior to disposal – all of which will impact overall asset footprints / land take / asset costs. These will be addressed as part of the future concept / functional design and ensure stormwater quality treatment to best practice reduction targets are achieved.
- The proposed sediment basins are to be sized using the Fair and Geyer equation, where sediment basins must meet the following criteria:
    - Capture 95% of coarse particles ≥ 125 µm diameter for the peak 4EY event.
    - It should be noted that several of the sediment basins have been significantly undersized and are currently not meeting the capture efficiency target highlighted above. This is likely to result in a high amount of sediment transferring from the sediment basins into the proposed waterway corridors, and subsequently, the proposed wetland assets.

- Sediment basins have been designed to include a clean out frequency of 3 years. A 5 year cleanout frequency may be more desirable (and is standard industry practice and recommendation) to reduce ongoing maintenance costs.
- Sediment basin design calculations / performance (based on Engeny revised strategy) are provided in Appendix B.

Wetlands

- WLRB1 has been designed as online to the constructed waterways, as it is expected to receive flows from the external rural catchment.
- Wetlands that are located online to a waterway generally experience increased durations of inundation and high velocities through the system, as a large volume of flow generated from the catchment is required to pass through an online wetland. This is likely to result in stripping of vegetation due to higher velocities and vegetation 'drowning' due to increased periods and depths of inundation.
- Due to a large contributing catchment to WLRB1, a large regular flow is expected to enter the system via the waterways. Currently, the proposed wetland designs do not meet velocity threshold limits of 0.05 m/s in the 4EY event, and 0.5 m/s in the 20% AEP event, whilst maintaining an appropriate length to width ratio of 4:1. Wetland velocity calculations / performance (based on the revised Engeny strategy) are provided in Appendix B. If wetland velocity thresholds are exceeded vegetation within the system is likely
- It is noted WLRB1 is also carrying 319mm of excess volume, above NWL and needs to be addressed through increasing the wetland size and macrophyte zone to safely distribute this volume and ensure wetland function. WLRB's 2, 3 & 4 also have increased water level exceedance, and are to be addressed as part of the functional design.
- Based on the proposed strategy, it is assumed any future development that occurs upstream of the PSP area is controlled back to predevelopment conditions, and stormwater treated to BPEM guidelines prior to outfalling into the PSP area.
- Following the analysis of the RORB and MUSIC modelling undertaken by Engeny.
    - WLRB1 contributing catchment: 1126.42 ha
    - WLRB2 contributing catchment: 73.03 ha
    - WLRB3 contributing catchment: 153.61 ha
    - WLRB4 contributing catchment: 101.34 ha.

Waterway Corridors

- The overall waterway corridor widths provided within the strategy appear adequate (40-60m). However, the lack of sinuosity (meandering) of the waterway layout is likely to lead to higher velocities, erosive capabilities, and in time compromise bed, bank, and associated vegetation.
- The proposed industrial area at the southern extent of the precinct on Carneys Road should require installation of a triple interceptor or similarly suitable product to manage quality of flows from this area discharging into the waterway.
- The E-WW (located along the eastern boundary of the PSP) includes a '90 degree' bend prior to outfall into the proposed WLRB1 asset. This is likely to result in localised high velocities / shear stresses, which will result in erosion along the banks and incision of the waterway over time, and potential short circuiting of the system. If a 90 degree bend along the waterway is to remain, substantial rock armouring / beaching will be required to ensure the waterway can be retained in this form (without short circuit/bank collapse).
- Combined with areas of deeper pools and rock riffle zones with meanders, will not only better stabilise and protect the system, but will encourage a biodiverse 'creek' environment allowing

macroinvertebrates to move in and breed, providing a reliable food supply for higher order species (birds, frogs, etc).

- Further, the landscape amenity, community enjoyment and appreciation of these constructed waterways will be further improved, increasing their value to the community and therefore their passive surveillance (through use / visitation) and protection.

Culverts

- Multiple outfall culverts from the PSP are proposed across Heslop Road, more specifically, two are proposed at the WLRB1/WLRB2 locations, and two are proposed at the WLRB3/WLRB4 locations. It may be more desirable to consolidate these culvert assets, designed appropriately and reduce number of assets for long term maintenance / asset renewal costs, and initial capital investment.

Retarding Basins

- Due to the tailwater effects of the Powlett River floodplain, retarding basins have been sized using TUFLOW. As such storage sizes of each retarding basin, and their respective outlets have been sized to reduce flows, and the downstream afflux flood depth (developed conditions flood depth minus the existing conditions flood depth).

- Each retarding basin has been designed to include a wetland located within the base of the system, which provides stormwater quality treatment for the Precinct.

- The TUFLOW model is required to be updated top include any changes to the retarding basin/wetland systems, as well as any changes to the constructed waterway systems.

6 Functional Design Approach

Following review of all previous studies, modelling and data, strategies, and stakeholder feedback, we have built on this knowledge and established a thorough understanding of the PSP landscape. We have considered future plans, current conditions and intended outcomes, and developed a revised stormwater management concept for the PSP (refer Figure 26).

The focus of the revised Alluvium Concept Layout for the PSP was to build on work done to date, and to focus on asset functionality and protection of downstream environs, while also seeking a more cost-effective outcome through asset integration and optimised functionality, including asset relocation, co-location and/or asset redundance to minimise developable land take (improve lot yield), and reduce overall development contribution cost for the precinct, without compromising values and outcomes.

Underlying this approach is the objective to design multi-outcome/multi-functional assets which not only manage flows and treat urban stormwater runoff, but provide for broader community benefits such as amenity, recreation, cooling, connectivity, health and wellbeing, biodiversity and cultural heritage preservation and potential enhancement. In considering all these objectives and outcomes, our functional design considerations are also mindful of a changing climate and the potential impacts this may have on asset performance, integrity, robustness, and endurance.

Climate change considerations

Victoria's climate is changing and will continue to change into the future. We understand that with continued increases in greenhouse gas concentrations, most climate models predict Victoria's climate will become hotter and drier. The latest research from the Victorian Climate Initiative (DELWP, 2016) has identified clear reductions in cool season (April to October) rainfall over recent decades. Compared to current conditions, median climate projections for 2065, expect that Victoria will experience a temperature increase of between 1.9 - 2.6°C and an increased rate of potential evapotranspiration of 6% - 8%. The greatest impacts from climate change are projected to occur in western Victoria.

Climate change is having an impact on Wonthaggi's water cycle – while overall annual rainfall and runoff will decrease, the intensity of storms is expected to increase and has bearing on how we build (design in) resilience into the PSP water infrastructure. A key component of treatment asset function and optimal performance is directly related to the selection, placement, densities, and survival of aquatic vegetation within these assets. Understanding the impacts of inundation frequencies, depths, and equally times of low rainfall and/or high evapotranspiration rates, all contributed to the functional design outcomes.

Further, well-designed assets should ensure these systems integrate seamlessly with the surrounding urban landscape, respond to the opportunities the 'location landscape' offers in the design outcomes, and considers how people may use the space in future.

Functional design considerations

Alluvium's Proof of Concept recommendations for the PSP have been incorporated (along with stakeholder feedback) into the functional design phase.

The following key considerations were addressed:

- all wetlands have a retarding function, subsequently adopting the naming convention WLRB.
- consider flow volumes modelled to pass through WLRB1 (DCP ref WL-01) - now 'split' into WLRB-1A and WLRB-1B with corresponding inlet zones (sediment basins integrated). This will improve overall treatment performance and asset integrity (given the size of the contributing catchments in play),

while ensuring overall land take (footprint) is confined to existing areas prone to inundation (non-developable lands).

- increase sinuosity of W-WW (DCP ref DR1) and E-WW (DCP ref DR2) to reduce instream flow velocities to protect waterway bed/banks and promote ecological health of waterways and associated riparian zones (i.e. vegetation buffer for bank protection/stabilisation, habitat creation and wildlife protection, landscape amenity, shade, and cooling).
- Alignment of E-WW and the waterway reserve is to remain within PSP boundary as defined (VPA advice) and to avoid isolating areas of developable land, therefore velocity management through this waterway to be sought in other ways.
- reduce the number of independent sediment basins by integrating them into WLRB assets or remove redundant/unnecessary assets. Of the proposed 31 assets for the PSP, these were reduced to 23 functional designs at Proof of Concept stage.
- A further two (2) SBs have now been made redundant as they service small catchments or have since had a GPT installed, freeing up additional developable area.

Alluvium's Concept Layout for the PSP is shown below.

A summary of the retarding basin areas vs wetland areas is provided below:

<u>Wetland / Retarding Basin 1 (a&b)</u>

- Wetland 1A: 3.03 ha
- Wetland 1B: 4.45 ha
- Retarding Basin 1: 23.0 ha

<u>Wetland / Retarding Basin 2</u>

- Wetland 2: 1.55 ha
- Retarding Basin 2: 2.10 ha

<u>Wetland / Retarding Basin 3</u>

- Wetland 3: 1.15 ha
- Retarding Basin 3: 3.94 ha*

<u>Wetland / Retarding Basin 4</u>

- Wetland 4: 2.50 ha
- Retarding Basin 4: 3.94 ha*

* Combined volumetric load based on the approved Engeny footprint, future design scenario (discontinuance of Wentworth Road extension and further upgrade works to consider volumetric storage required.

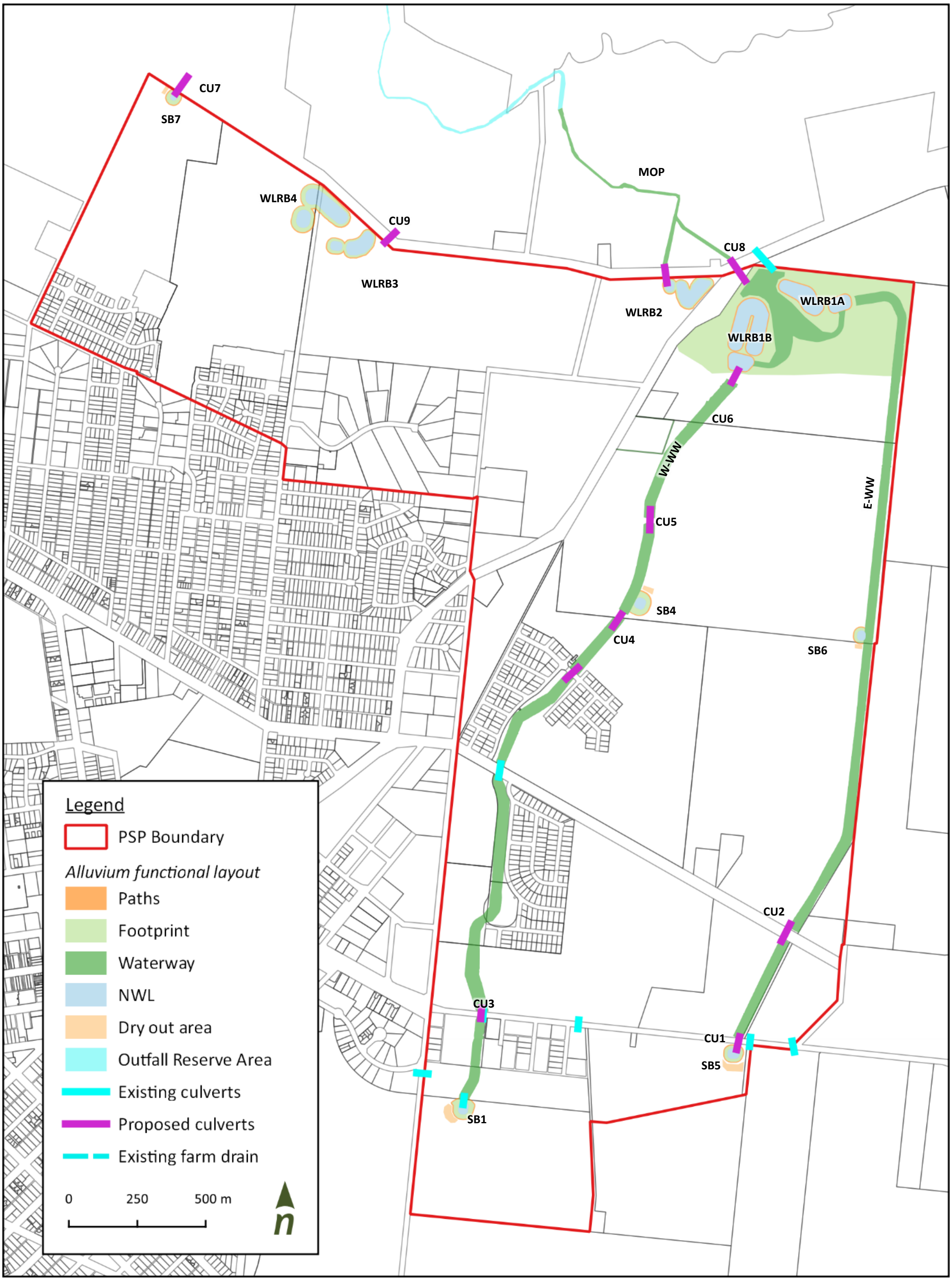


Figure 26. *Overall layout of stormwater assets for the PSP – Alluvium 2022*

Table 2. Assets considered for functional design – naming, footprints, and location links within this report

#	ALLUVIUM ASSET ID FUNCTIONAL DESIGNS	DCP REFERENCE	ASSET FOOTPRINT	REFER TO REPORT SECTION (PER ASSET)
1	W-WW	DR-01	60m corridor	Section 9
2	E-WW	DR-02	60m corridor	Section 10
3	MOP	DR-03	-	Section 11
4A	WLRB1A (east)	WL-01	23.00 ha^	Section 13
4B	WLRB1B (west)	WL-01	(incl. above)*	Section 14
5	WLRB2	WL-02	1.51 ha^	Section 15
6	WLRB3	WL-03	1.10 ha^	Section 16
7	WLRB4	WL-04	2.23 ha^	Section 17
8	SB1	SB-01	0.43 ha^	Section 18
9	SB2	-	not required	GPT recommended in lieu of SB – catchment too small to warrant SB cost. GPT now installed as per developer works (Council advice Oct 2021)
10	SB3	-	not required	GPT recommended in lieu of SB – catchment too small to warrant SB cost.
11	SB4	SB-02	0.47 ha^	Relocated north into downstream property (council reserve) Section 19
12	SB5	SB-03	0.34 ha^	Section 20
13	SB6	SB-04	0.18 ha^	Section 21
14	SB7	SB-05	0.22 ha^	Section 22
-	-	-	-	High flow outlet from SB-01
15	CU3	CU-02	-	Section 9.3
16	CU1	CU-03	-	Section 10.3
-	-	CU-04	-	Currently under construction
17	CU4	-	-	Section 9.3
18	CU5	-	-	Section 9.3
19	CU6	-	-	Section 9.3
20	CU8	CU-08	-	Section 13
-	-	CU-09	-	Existing asset
21	CU9	CU-010	-	Section 16
-	-	CU-011	-	Removed
22	CU7	CU-012	-	Section 22

23	CU2	-	-	Missing from Engeny final layout but critical to PSP - see Section 10.3
-	-	CU-014	-	New crossing over DR-03
-	-	CU-015	-	New crossing over DR-03
-	-	CU-016	-	New crossing over DR-03
TOTAL	23 functional designs			

* Total footprint of WLRB1A & WLRB1B (DCP ref WL-01) system is combined.

^Total asset footprint of these assets does not include the required sediment dry out area.

7 Stormwater Quantity Management – Storage Design

The hydrologic analysis of the Wonthaggi North East PSP was undertaken to determine the pre and post-development peak runoff flow rates (m^3/s) for various flood events throughout the catchment. The hydrologic analysis is used to determine the storage capacities of proposed retarding basins required to retard the fully developed peak stormwater runoff rates back to pre-developed conditions, and to determine the flows entering the stormwater quality treatment wetlands for the PSP. The hydrology results are also used as inputs for the flood modelling.

The aim of the RORB modelling is to establish critical peak flows and the storage requirements within the PSP. As identified by the WGCMA, development conditions peak runoff from the PSP area is to be controlled back to the equivalent 50% AEP predeveloped conditions peak flow. The supplied Engeny RORB and TUFLOW models were reviewed and further refined as part of the functional design process.

The hydrologic analysis was undertaken using RORB (v6.31), which is a runoff-routing software designed to simulate attenuation and time of concentrations to produce flood estimates at specified catchment locations to determine:

- Existing peak flows
- Impact of development on peak flows
- Reduction in peak flows that is possible using retarding basin storage etc.
- Impact of climate change on peak flows.

The RORB model was built by delineating the major catchments into sub-areas based on topography and potential road alignments. A layout of the RORB model is provided in Figure 27.

Given no gauge data was available for the RORB model validation, the RORB model was calibrated based on initial loss and continuing loss values provided from the ARR datahub, then modelled multiple kc scenarios based on the Pearse equation for Victorian Catchments ($kc = 1.25 \times d_{av}$), and parameters compared against the DNRE flood regression analysis and the RFFE model.

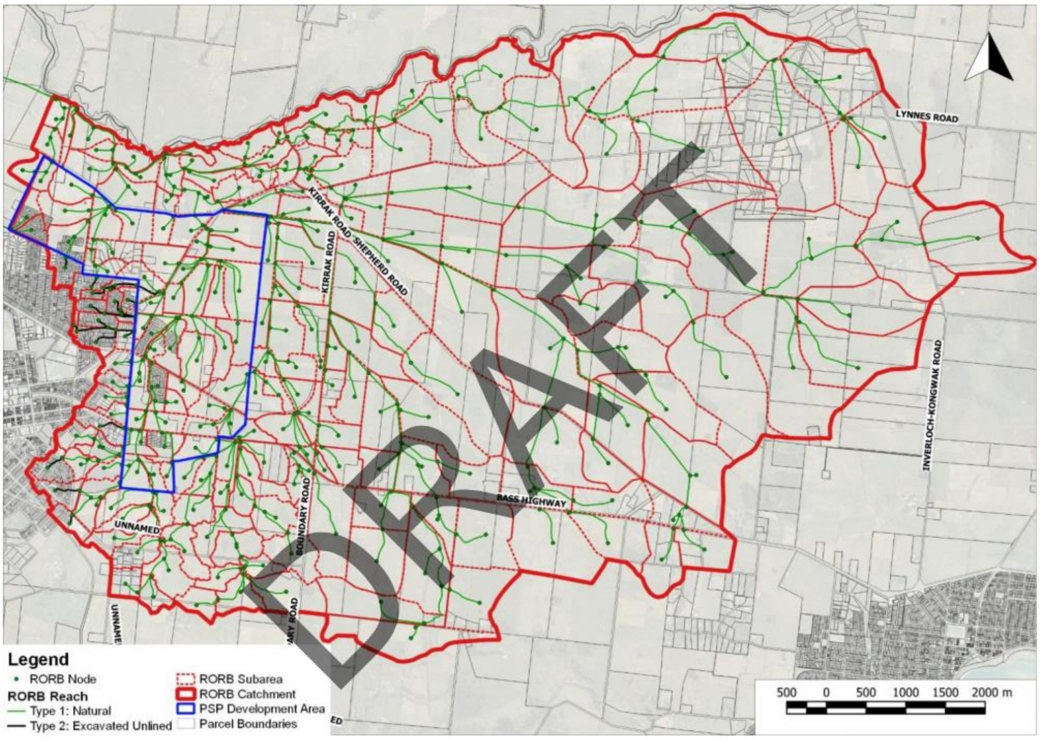


Figure 27. *RORB model layout for the Wonthaggi North East PSP (source: Engeny, Aug 2021)*

A summary of the Engeny RORB outputs, RFFE results, DNRE and Rational Method calculations are below.

Table 3. Predevelopment conditions RORB modelling results for the Wonthaggi North East PSP

Calibration	Total catchment Flow (1% AEP)	Total catchment Flow (50% AEP)
RFFE	108.0 m^3/s	21.3 m^3/s
RFFE 5% Limit	47.0 m^3/s	10.8 m^3/s
RFFE 95% Limit	248.0 m^3/s	42.1 m^3/s
DNRE	116.0 m^3/s	-
kc 10.48 (Pearse), IL 21mm, CL 4.6mm/hr	104.6 m^3/s	7.7 m^3/s
kc 10.48 IL 20mm, CL 3.8mm/hr	115.9 m^3/s	13.1 m^3/s
kc 13, IL 10mm, CL 3.8mm/hr	116.1 m^3/s	21.0 m^3/s
Rational Method	55.5 m^3/s	13.7 m^3/s

7.1 Wetland design

As shown above, adopting the Pearse kc value (10.48), whilst reducing the Initial Loss/Continuing Loss value results in flows that closely align with the RFFE and DNRE estimation tools, and correlate with rational method results whilst remaining within the RFFE 5% limit. It appears logical to lower the Initial Loss/Continuing Loss marginally, given typical values for Initial Losses and Continuing Losses modelled within Victorian catchments generally vary from 10-25mm and 1-3 mm/hr respectively.

The calibration method still holds true to the specified regional equation for Victorian catchments (Pearse) while determining peak flows generally in accordance with multiple estimation methods. Based on the supplied RORB model and input parameters, the RORB model was computed for the 1%, 10%, 20% and 50% AEP events for both pre and post developed scenarios and summarised below. The flows have been adopted for the design of the wetland treatments proposed within the PSP. Wetland design flows are required to compute the average velocity values with respect to velocity thresholds and minimum width requirements.

The incoming sediment basin inlet ponds, located immediately upstream of each wetland macrophyte area have been modelled within RORB to ensure appropriate flow regimes have been modelled for regular flow events (up to and including the 20% AEP event).

Table 4. RORB modelling results for the Wonthaggi North East catchment

Functional Design Report ref. DCP reference	WLRB1 (WL-01)	WLRB2 (WL-02)	WLRB3 (WL-03)	WLRB4 (WL-04)
Catchment area (ha)	1126.42	73.03	52.27	101.34
1% AEP Pre-developed critical flow rate (m^3/s)	15.54	15.84*	6.96^	6.96^
1% Developed critical flow rate (m^3/s)	32.66	6.62	7.62	10.11
10% AEP Pre-developed critical flow rate (m^3/s)	7.49	7.57*	4.12^	4.12^
10% Developed critical flow rate (m^3/s)	20.96	4.28	4.90	6.09

20% AEP Pre-developed critical flow rate (m^3/s)	5.40	5.46*	2.93^	2.93^
20% Developed critical flow rate (m^3/s)	15.56	3.59	3.80	5.08
50% AEP Pre-developed critical flow rate (m^3/s)	2.47	2.49*	1.25^	1.25^
50% Developed critical flow rate (m^3/s)	9.54	2.27	2.53	3.32
1EY developed flow rate (m^3/s)	6.63	1.80	1.46	1.96
4EY developed critical flow rate (m^3/s)	2.53	0.81	0.67	0.72

* Under existing conditions, runoff generated from WLRB1 (DCP ref WL-01) catchment outfalls through proposed location of WLRB2 (DCP ref WL-02), as proposed in the developed conditions, flow is to be diverted north under Korumburra-Wonthaggi Road.

^ Under existing conditions, WLRB3 & WLRB4 (DCP ref WL-03&04) catchments naturally fall to the same location, as part of the proposed developed conditions model, the catchments are controlled separately.

7.2 Retarding basin design

The retarding basins for this catchment have been modelled and sized to control the 50% AEP flow. The total required area for the assets has been calculated assuming a 1(V):6(H) batter to existing surface, and an allowance of 600mm of freeboard on top of the peak 1% AEP flood depth.

As per the Engeny strategy, retarding basins have been modelled using TUFLOW as the assets are proposed within the Powlett River floodplain and significant inundation occurs across the downstream adjacent property to the north. A summary of the extent of the Engeny TUFLOW model is shown below.

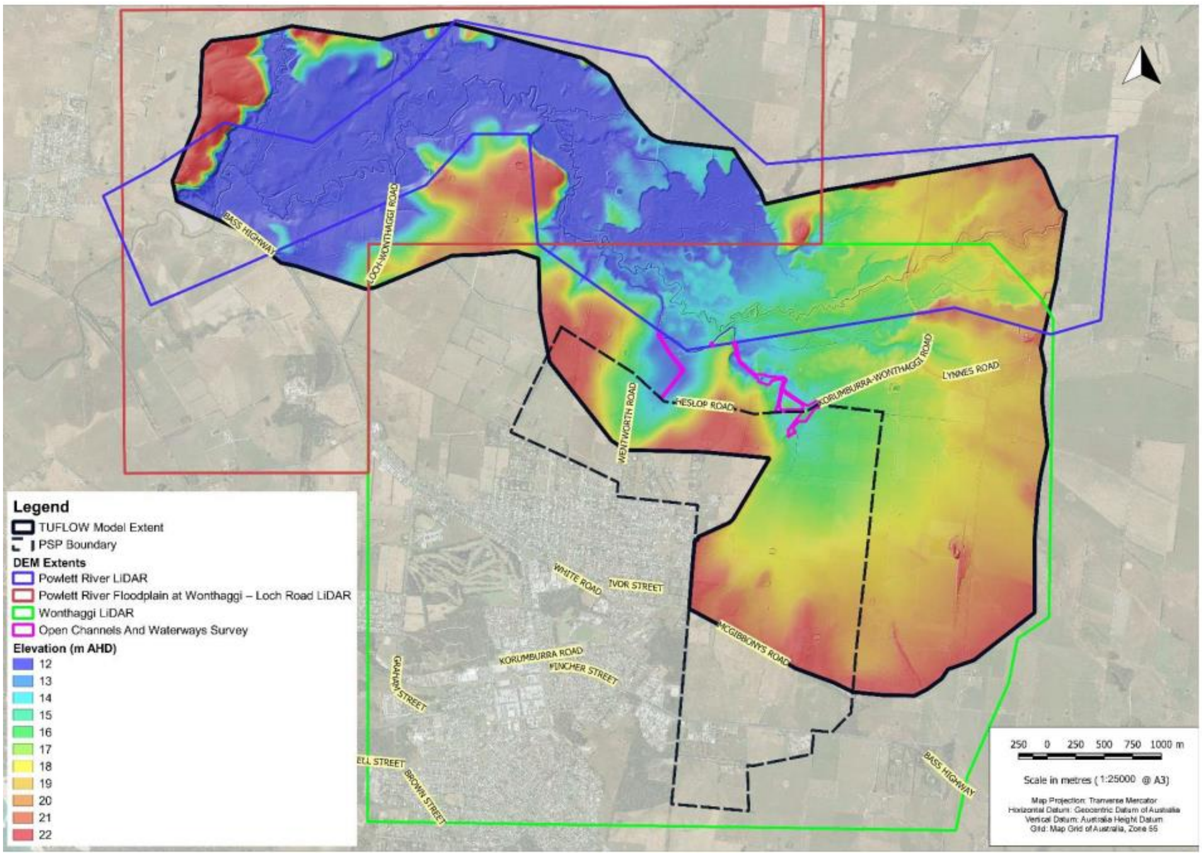


Figure 28. *TUFLOW model extent, DEM, and Topography data (Engeny, 2021)*

As per the WGCMA requirements, retarding basin storages are required to control the 50% AEP and the 1% AEP events back to predeveloped conditions. Based on the TUFLOW modelling for the retarding basin assets, outfall culverts and pipes form each of the assets were adjusted in an iterative process until outflows from the retarding basins were less than the predeveloped conditions flows and the flood levels through the downstream property were equal to or less than the predeveloped flood levels.

The TUFLOW model was computed for pre and post development scenarios, and the outflow culvert size / retarding basin storage areas adjusted to ensure the post development flood depths were no greater than the existing conditions flood depths (I.e., the afflux).

A summary of the outfall properties from each of the WLRB assets is provided in the Table below.

Table 5. Summary of key outfall culverts and pipelines from the proposed WLRB's

WLRB1	
Existing	3 x 1200mm(W) x 1200mm(H) Box culverts under Korumburra-Wonthaggi Road
Proposed	2 x 900mm(W) x 300mm(H) transitioning to 1 x 1200mm(W) x 600mm(H) WLRB1 low flow outfall culverts under Korumburra-Wonthaggi Road
Proposed	3 x 1200mm(W) x 900mm(H) WLRB1 high flow outlet culverts under Korumburra-Wonthaggi Road
WLRB2	
Existing	3 x 1650mm dia. pipe culverts under Heslop Road
Proposed	1 x 1200mm dia. pipe outfall from WL2
WLRB3	
Proposed	3 x 1200mm(W) x 450mm(H) box culverts under Heslop Road.
WLRB4	
Proposed	1 x 1050mm dia. WL4 transfer pipe to WLRB3 culvert outlet.

The system is designed to 'not be in fill', however as per the future development of the PSP, all lots must be filled to 600mm above the peak 1% AEP flood level.

Climate change

Climate change scenarios have been adopted within the hydrologic models built, not to design assets to these increased peaks, but to perform a sensitivity check on how increased peak flows will move through the systems designed and how the system will respond. For example, how an increased peak 1% AEP will sit within the provided freeboard in a proposed retarding basin.

Climate change scenarios have been modelled in line with guidance from ARR2019 (Book 1, Section 6.2), which suggests the use of Representative Concentration Pathways (RCP's) for low and high concentrations of RCP 4.5 and RCP 8.5. The approach adopted for establishing these scenarios has been:

- The use of Bureau of Meteorology (BoM) IFD curves derived for the site
- That the IFD curves are adjusted to reflect increased intensity arising from climate change
- ARR2019 recommends the adoption of a 5% increase in rainfall intensity per degree of global warming (Book 1, Chapter 6) for events up to the 1% AEP

- RCP 4.5 and RCP 8.5 were adopted for climate change. The catchment is located within the Southern Slopes cluster, which estimates the temperature increase in the RCP 4.5 scenario of 0.5 to 3 degrees during the year 2100 (midpoint of 1.75 degrees selected), and a temperature increase in the RCP 8.5 scenario of 3.6 degrees in the year 2100.
- This approach results in a 9% increase in rainfall intensity for the RCP 4.5 scenario for events up to the 1% AEP, and an increase of 19% in rainfall intensity for the RCP 8.5 scenario.

The Engeny strategy has considered a rainfall intensity increase of 18.4% for the year 2100 climate change scenario.

Tables below show the required capacity of the retarding basins (WLRBs), based on the RORB and TUFLOW modelling completed by Engeny.

A summary of the TUFLOW outputs is provided in Appendix E.

Table 6. WLRB1 (DCP ref WL-01) retarding basin requirements

Parameter	Retarding Basin WLRB1 (DCP ref WL-01)
Peak RB storage required (m^3) (50% AEP)	224000
Peak RB storage required (m^3) (1% AEP)	431000
1% AEP peak water level (m AHD)	16.51
Surface Area (ha)	23

Table 7. WLRB2 (DCP ref WL-02) retarding basin requirements

Parameter	Retarding Basin WLRB2 (DCP ref WL-02)
Peak RB storage required (m^3) (50% AEP)	10,600 (10.6 ML)
Peak RB storage required (m^3) (1% AEP)	31,400 (31.4 ML)
1% AEP peak water level (m AHD)	15.90
Surface Area (ha)	2.1 ha

Table 8. WLRB3 (DCP ref WL-03) retarding basin requirements

Parameter	Retarding Basin WLRB3 (DCP ref WL-03)
Peak RB storage required (m^3) (50% AEP)	34,100 (34.1 ML) *
Peak RB storage required (m^3) (1% AEP)	41,000 (41.0 ML) *
1% AEP peak water level (m AHD)	14.59
Surface Area (ha)	3.94 *

* Combined volumetric load based on the approved Engeny footprint, future design scenario (future removal of Wentworth Road and further upgrade works to consider volumetric storage required)

Table 9. WLRB4 (DCP ref WL-04) retarding basin requirements

Parameter	Retarding Basin WLRB4 (DCP ref WL-04)
Peak RB storage required (m^3) (50% AEP)	34,100 (34.1 ML) *
Peak RB storage required (m^3) (1% AEP)	41,000 (41.0 ML) *
1% AEP peak water level (m AHD)	14.55
Surface Area (ha)	3.94 *

* Combined volumetric load based on the approved Engeny footprint, future design scenario (future removal of Wentworth Road and further upgrade works to consider volumetric storage required)

TUFLOW Modelling (April 2022)

Modelling of the refined functional design arrangement was undertaken by Engeny to test the impact of the revised wetland-retarding footprints on flood behaviour (upstream and downstream). A summary of the outflow characteristics of the WLRB systems is provided in Table 10 below. Refer to Appendix E for TUFLOW modelling results.

Table 10. Outflows from WLRB 1 – 4 (based on Engeny TUFLOW modelling)

Asset	Location ID	Description	50% AEP Pre-Developed (m^3/s)	50% AEP Developed (m^3/s)	1% AEP Pre-Developed (m^3/s)	1% AEP Developed (m^3/s)
WLRB1	1	Existing box culverts under Korumburra-Wonthaggi Road – to be removed / abandoned (4 x 1260 mm)	0.46	-	0.9	-
	2	WLRB1 low flow outlet (2 x 300 x 900 RCB into 1 x 600 x 1200 RCB)	n/a	1.1	-	1.42
	3	WLRB1 high flow outlet (3 x 1200 mm box culverts)	n/a	5.4	-	13.56
	4	Overland flow d/s of WLRB1	5.1	10.3	52.6	63.80
WLRB2	5	Outfall Pipes from WLRB2 - Circular culverts under Heslop Road (3 x 1650 mm)	6.4	1.56	15.72	14.76
	7	Overland flow d/s of WLRB2	6.4	1.56	15.6	14.51
WLRB 1&2	6	Overland flow overtopping Korumburra-Wonthaggi and Heslop Road d/s of WLRBs 1 & 2	0	0	44.3	41.52
WLRB 3&4	8	Proposed WL4 to WL3 circular transfer pipe (1 x 1050 mm)	-	-0.89	-	-1.12
	9	Proposed WL3 low level outlet pipe 1 new culvert and extension to 2 existing culverts (3 x 1200 x 450)	-	1.26	-	4.33
	10	Overland flow d/s of WLRBs 3&4	2.4	1.3	4.9	4.44

8 Stormwater Quantity – Conveyance

The main considerations for waterways adjacent to and within a development precinct are the waterway corridors, constructed waterway designs (including waterway crossings), and flood levels. Proposed waterway corridors must demonstrate they are sufficient in terms of flow conveyance and providing river health and amenity opportunities in a future urbanised landscape.

A waterway corridor is defined as the waterway channel (bed to top of bank) and its associated riparian zones. The riparian zones consist of two parts:

- The vegetated buffer (VB) – protects riparian zone from urban zone 'edge' effects
- The core riparian zone (CRZ) – supports instream stability, ecology, food supply and habitats.

A typical waterway corridor section is shown below.

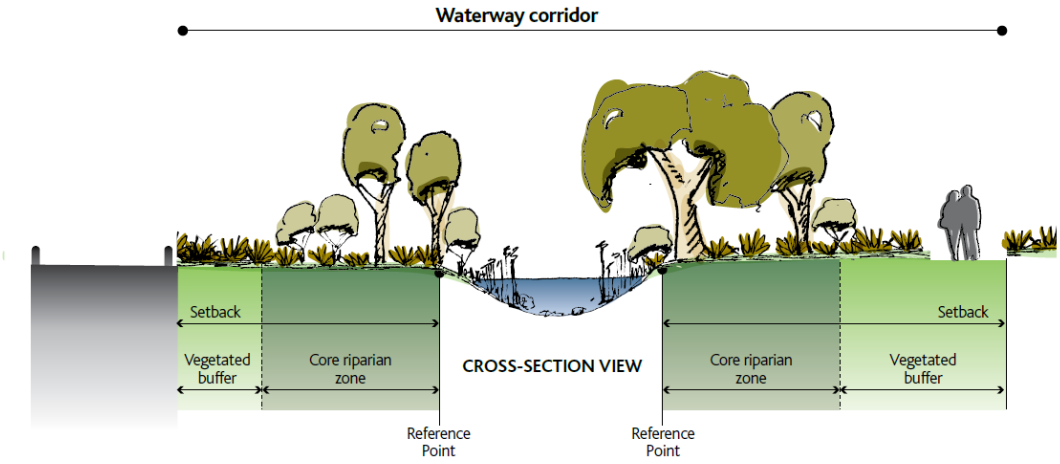


Figure 29. *Waterway corridor (source: Waterway Corridors, Guidelines for Greenfield Developments, Melbourne Water, 2019)*

Assigning a waterway corridor preserves areas of the riparian zone that protect or enhance native vegetation, instream health and biodiversity, and provides space for recreational infrastructure and activities (e.g. shared paths, furniture and (in some cases) stormwater treatment systems).

A fundamental principle is to provide continuity along the core riparian zone. Therefore, the strong preference is to locate shared paths and other infrastructure outside this zone. However, in some instances, stormwater treatment systems such as constructed wetlands and bio-retention systems may be located within the CRZ but should form a relatively small proportion of the area so as not to degrade its ecological function.

Therefore, constructed waterways (W-WW; DCP ref DR1 and E-WW; DCP ref DR2) have been functionally designed to carry developed flows through the waterway corridor, provide habitat, and improve channel stability and visual amenity.

There are four primary variables in HECRAS modelling:

- Channel geometry (constructed waterway design cross sections)
- Downstream boundary conditions (normal depth from gauge or slope / known flood level)
- Hydraulic roughness (Manning's n) and
- Flow (derived during hydrologic analysis).

The derived flows and downstream boundary conditions have been informed from Engeny's hydrologic and hydraulic modelling. The hydraulic roughness (Manning's n) for the model is provided below.

Table 11. Hydraulic parameters adopted for the HEC-RAS model

Hydraulic parameters	Description	Value
Manning's n	High flow channel –	0.055
	Low flow channel -	0.055

A summary of the HECRAS model layout is shown below. The functional design details of W-WW (DCP ref DR1) and E-WW (DCP ref DR2) are provided in Sections 9 and 10.

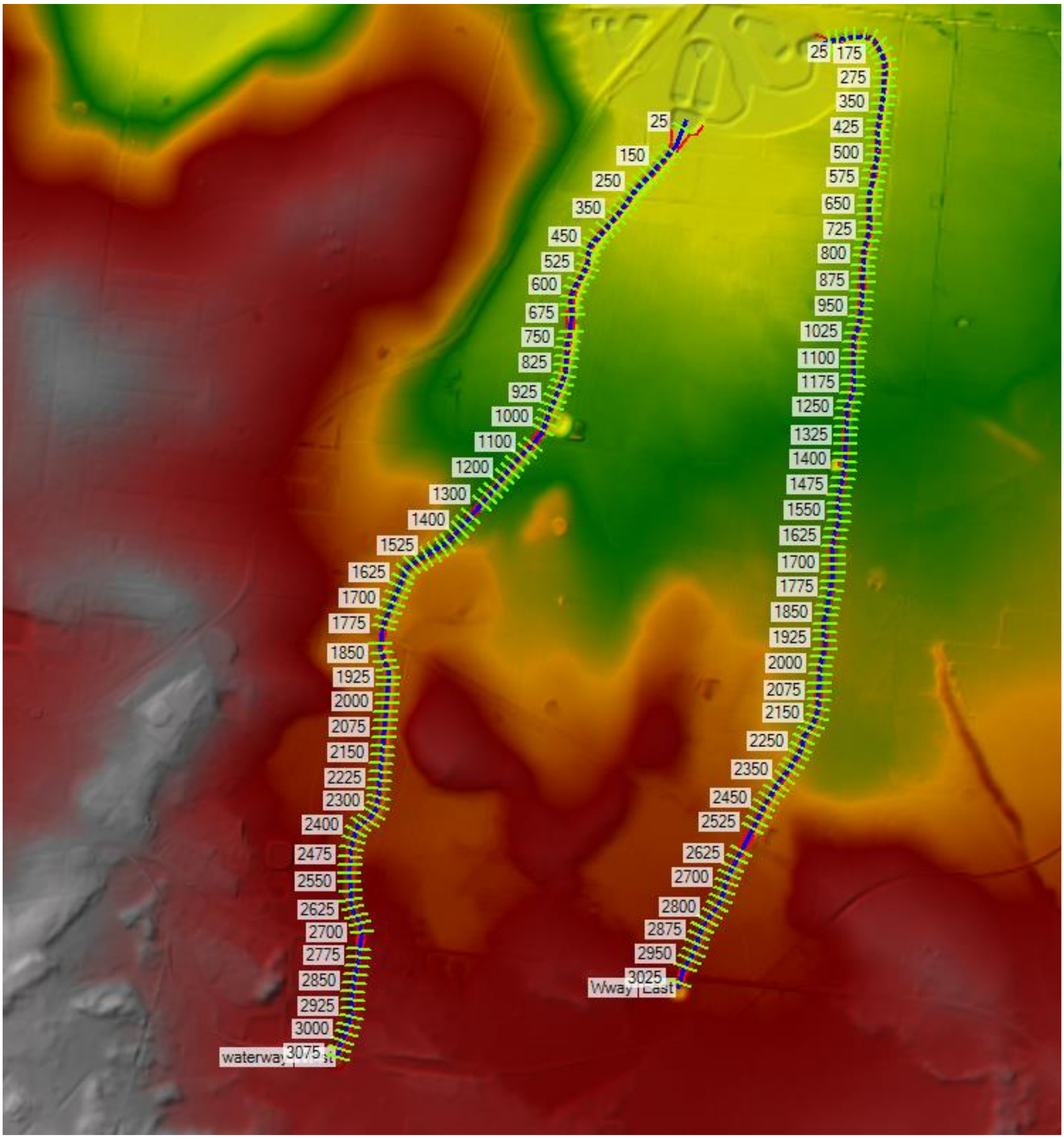


Figure 30. *HECRAS model layout*

9 Waterway Functional Design W-WW (DCP ref DR1)

9.1 Longitudinal slope

One of the key criteria for the waterway is to ensure that shear stress values are within an acceptable range. This is to ensure that the waterway is stable and to minimise the erosion potential. The shear stress threshold value is generally considered to be 45 N/m^2, which can increase by up to 10% during a 1% AEP flow event.

The longitudinal slope is dictated by invert controls at the downstream and upstream extents of the constructed waterway. The provided design features a change in slope along the alignment, discussed in Table 12. Note that this is the slope along the low flow channel, which will be slightly gentler than the high flow channel due to meanders designed into the low flow alignment.

These grades are suitable for facilitating stable channel design in accordance with industry best practice guidelines.

Table 12. Longitudinal slope along low flow channel

Reach	Upstream Boundary	Downstream Boundary	Upstream elevation (m AHD)	Downstream elevation (m AHD)	Average slope low flow (1 in x)
1	SB1 (DCP ref SB3) (stn 3075)	Bass Hwy (stn 2750)	24.0	23.2	406
2	Bass Hwy (stn 2700)	McGibbonys Rd (stn 1825)	22.7	19.6	282
3	McGibbonys Rd (stn 1775)	Centennial Dr (stn 1350)	19.2	17.2	212
4	Centennial Dr (stn 1300)	Culvert #4 (stn 1075)	16.8	16.4	562
5	Culvert #4 (stn 1025)	Culvert #5 (stn 700)	16.2	15.6	541
6	Culvert #5 (stn 675)	Culvert #6 (stn 75)	15.4	14.3	545

9.2 Cross-section geometry

The cross-sectional geometry should be designed to accommodate the 3-month to 1-year Average Recurrence Interval (ARI) flows in the low flow channel, and the 100-year ARI flows in the full compound channel. These flows are determined using RORB modelling as discussed in the flood modelling section. The proposed channel cross section has the dimensions given in Table 13. The alternate slope along the alignment leads to the differing channel capacities for the reach sections in Table 14.

Table 13. Channel cross-section geometry and design parameters

Parameter	Low flow channel	High flow channel
Base width	5.0	Varies from 16m to 20m wide
Depth	0.6	-
Side slope	1 in 3	Typically 1 in 6
Bench slope	-	1 in 40
Top width	8.6	
Manning's n (assumed)	0.05	0.05

Table 14. Channel design capacities

Reach	Low flow capacity (m^3/s)	High flow capacity (m^3/s)
1, 2, 3	2.2	27.4
4, 5, 6	2.7	31.4

9.3 Design flows

The drainage and hydrologic analysis of the site has been informed from hydrologic modelling that was completed for the drainage strategy (refer Table 15).

Table 15. Design flows contributing to W-WW

Location	4EY (m^3/s)	1EY (m^3/s)	10% AEP (m^3/s)	1% AEP (m^3/s)
Reach 1	0.95	1.67	7.08	11.22
Reach 4	2.59	6.13	16.41	26.27

The downstream boundary condition was set by the slope through the downstream section of the property, which will be the future waterway corridor outfall through the downstream property.

9.4 Culvert design

There are 6 culvert crossings through the proposed section of the West Waterway (W-WW (DCP ref DR1)). These crossings have been designed to convey the 1% AEP design flows with minimum head loss. To meet these criteria the typical culvert arrangement consists of the following:

- At Bass Hwy (proposed culvert #3): 4 culvert cells, each opening 1.5m diameter
- At McGibbonys Road (existing): 4 culvert cells, each opening 1.5m diameter
- At Centennial Dr (proposed): 2 culvert cells, each opening 3.6m wide by 1.5m high (not a PSP item)
- At culvert #4, #5, #6: 3 culvert cells with 2 link slabs, each opening 3.6m wide by 1.5m high.

The hydraulic model was run for two scenarios: culverts fully unimpeded and culverts 50% blocked.

The figures below show the culvert designs (looking downstream from the upstream side).

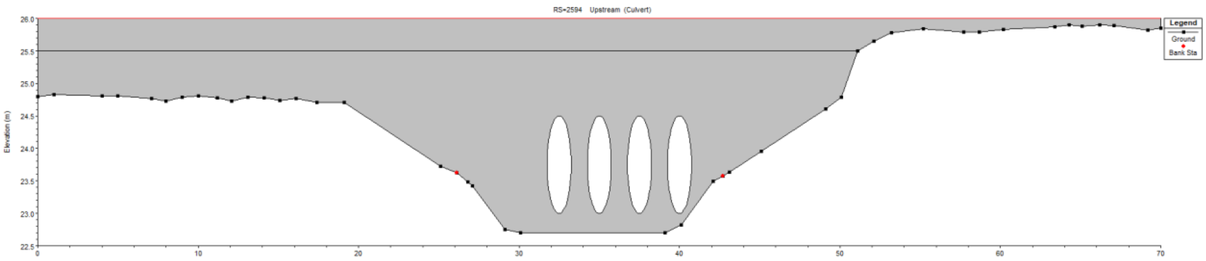


Figure 31. *Upstream Bass Hwy design cross section (looking downstream)*

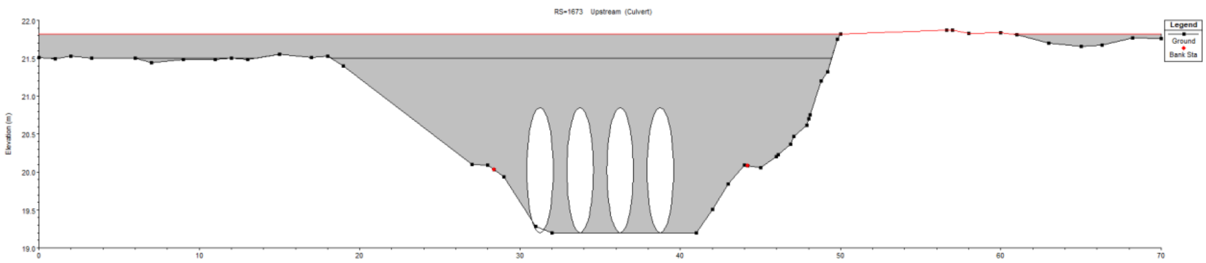


Figure 32. *Upstream McGibbonys Rd cross section (looking downstream)*

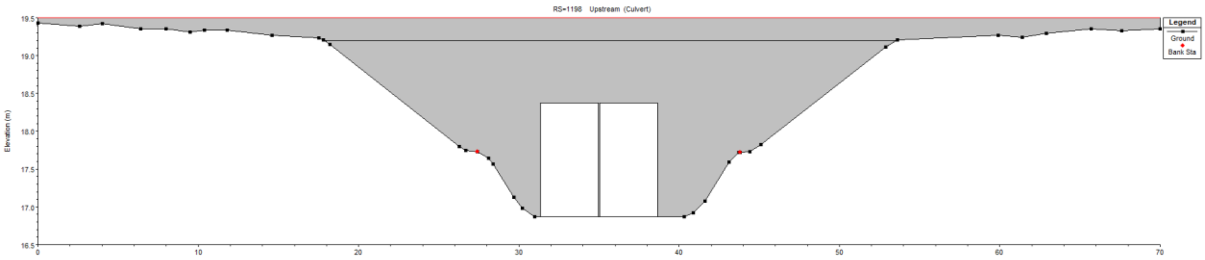


Figure 33. *Upstream Centennial Dr cross section (looking downstream)*

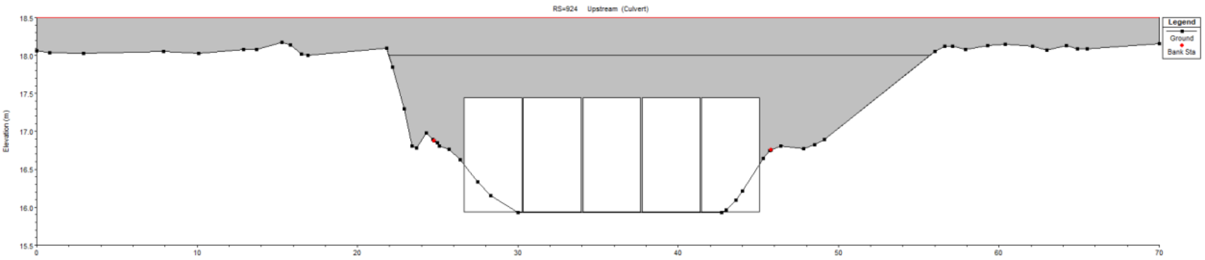


Figure 34. *Upstream culverts 4, 5, 6 cross-sections (looking downstream)*

9.5 Results (ultimate culvert designs)

The figures below show the longitudinal profile of the water surface for the 1% AEP flow for culverts open and blocked.

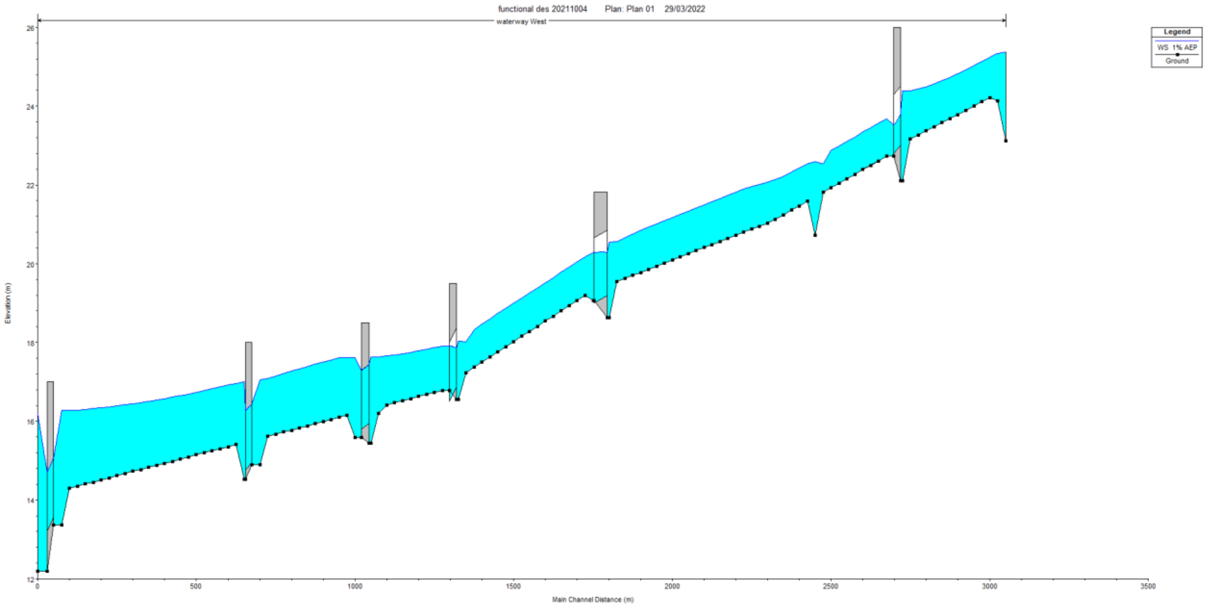


Figure 35. *1% AEP water surface elevation along the waterway alignment with culverts unimpeded*

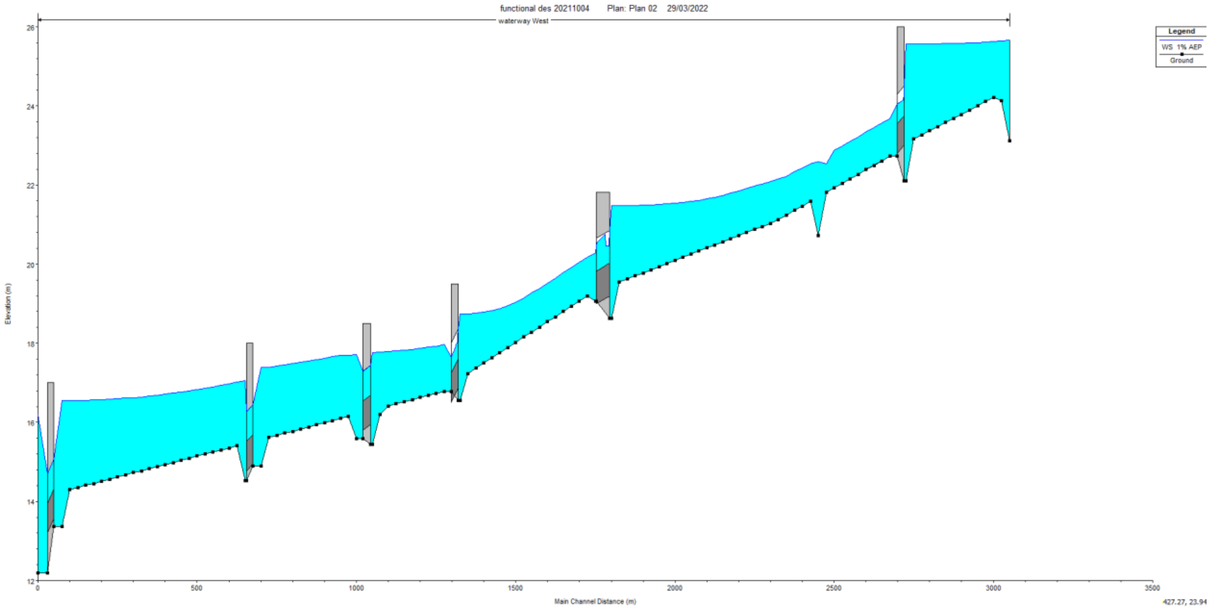


Figure 36. *1% AEP water surface elevation along the waterway alignment with culverts 50% blocked*

The figures below represent results for the 10% AEP flow unimpeded and blocked.

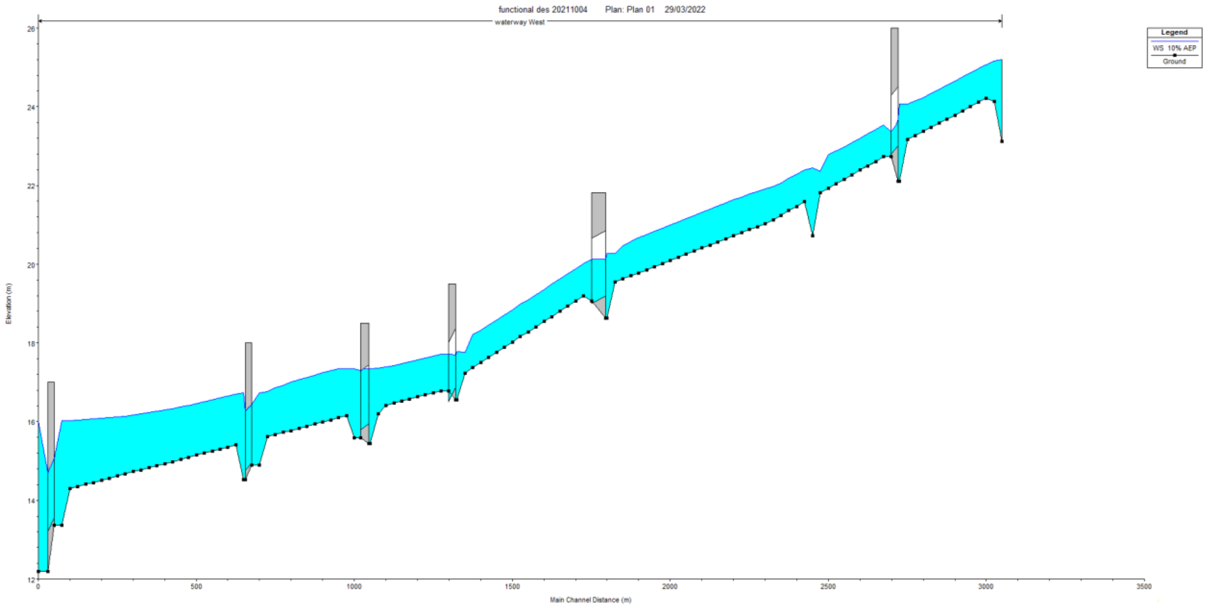


Figure 37. *10% AEP water surface elevation along the waterway alignment with culverts unimpeded*

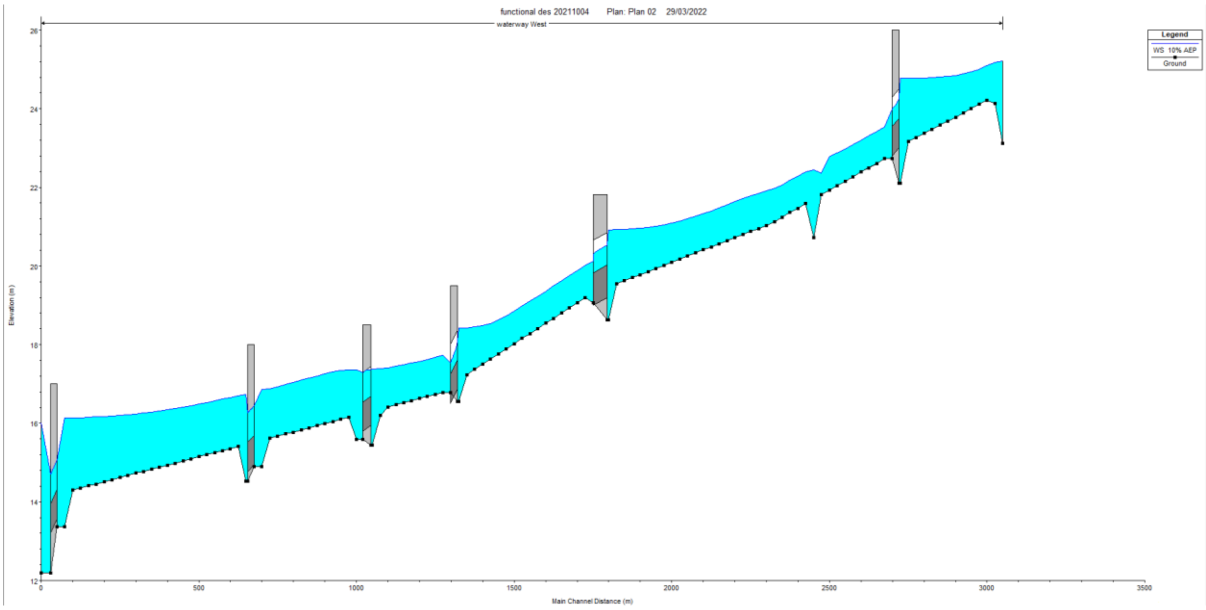


Figure 38. *10% AEP water surface elevation along the waterway alignment with culverts 50% blocked*

The table below shows the hydraulic results for the open and blocked scenarios for the 1% AEP flow.

Table 16. Hydraulic results through culverts for both scenarios for the 1% AEP flow

Culvert Crossing		Open culverts	Blocked culverts
Bass Hwy			
	Head loss (m)	0.72	1.88
	Freeboard to road (m)*	1.60	0.44
	Average velocity (m/s)	0.68	0.59
McGibbonys Rd			
	Head loss (m)	0.25	1.18
	Freeboard to road (m)*	1.28	0.35
	Average velocity (m/s)	0.78	0.63
Centennial Dr			
	Head loss (m)	0.12	0.77
	Freeboard to road (m)*	1.47	0.75
	Average velocity (m/s)	0.68	0.51
Culvert #4			
	Head loss (m)	0.01	0.06
	Freeboard to road (m)*	0.88	0.71
	Average velocity (m/s)	0.40	0.35
Culvert #5			
	Head loss (m)	0.06	0.34
	Freeboard to road (m)*	0.90	0.53
	Average velocity (m/s)	0.66	0.55
Culvert #6			
	Head loss (m)	0.08	0.35
	Freeboard to road (m)*	0.47	0.20
	Average velocity (m/s)	0.21	0.19

*Note: Road deck levels are assumed

The table below shows the hydraulic results for the open and blocked scenarios for the 10% AEP flow.

Table 17. Hydraulic results through culverts for both scenarios for the 10% AEP flow

Culvert Crossing		Open culverts	Blocked culverts
Bass Hwy			
	Head loss (m)	0.53	1.23
	Freeboard to road (m)*	1.93	1.23
	Average velocity (m/s)	0.59	0.53
McGibbonys Rd			
	Head loss (m)	0.14	0.79
	Freeboard to road (m)*	1.55	0.90
	Average velocity (m/s)	0.63	0.52
Centennial Dr			
	Head loss (m)	0.06	0.71
	Freeboard to road (m)*	1.72	1.07
	Average velocity (m/s)	0.59	0.47
Culvert #4			
	Head loss (m)	0.01	0.03
	Freeboard to road (m)*	1.16	1.13
	Average velocity (m/s)	0.33	0.33
Culvert #5			
	Head loss (m)	0.01	0.12
	Freeboard to road (m)*	1.26	1.14
	Average velocity (m/s)	0.55	0.51
Culvert #6			
	Head loss (m)	0.03	0.13
	Freeboard to road (m)*	0.97	0.87
	Average velocity (m/s)	0.18	0.17

* Road deck levels are assumed

Note: Appropriate rock beaching will be required at the outlet of the culverts as they transition to the waterway.

Fill Required

For residential allotments fill will be required to provide 600mm of freeboard above the 1% AEP flood level.

The HEC-RAS model indicates that the waterway corridor provides sufficient freeboard through the waterway corridor. There are no regions neighbouring the constructed waterway that are of concern. Table 18 provides the finished surface level, flood level and freeboard level.

Table 18. Constructed waterway design and 1% AEP flood levels

Chainage	River station	Flood level (m AHD)	Finished surface level (left) (m AHD)	Finished surface level (right) (m AHD)	Freeboard (m AHD)
3000	3000	25.13	27.28	26.85	1.72
2900	2900	24.73	26.7	26.35	1.62
2800	2800	24.44	25.86	25.3	0.86
2745	Bass Hwy culverts				
2700	2700	23.68	25.01	25.12	1.33
2600	2600	23.22	24.99	25.06	1.77
2500	2500	22.55	24.17	24.54	1.62
2400	2400	22.34	23.33	23.16	0.82
2300	2300	22.02	23.02	23.08	1.00

Chainage	River station	Flood level (m AHD)	Finished surface level (left) (m AHD)	Finished surface level (right) (m AHD)	Freeboard (m AHD)
2200	2200	21.73	23.11	23.11	1.38
2100	2100	21.42	23.29	23.54	1.87
2000	2000	21.1	22.79	22.78	1.68
1900	1900	20.76	22.16	22.35	1.40
1820	McGibbonys Road culverts				
1700	1700	19.91	21.04	21.16	1.13
1600	1600	19.39	20.96	21.02	1.57
1500	1500	18.87	20.87	20.65	1.78
1400	1400	18.33	19.7	19.53	1.20
1345	Centennial Dr culverts				
1300	1300	17.91	18.85	18.83	0.92
1200	1200	17.75	18.41	18.47	0.66
1100	1100	17.63	18.23	18.23	0.60
1070	Culvert #4				
1000	1000	17.62	18.22	18.22	0.60
900	900	17.46	18.06	18.06	0.60
800	800	17.24	17.84	17.84	0.60
700	Culvert #5				
600	600	16.93	17.53	17.53	0.60
500	500	16.79	17.39	17.39	0.60
400	400	16.67	17.27	17.27	0.60
300	300	16.59	17.19	17.19	0.60
200	200	16.55	17.15	17.15	0.60
100	100	16.53	17.13	17.13	0.60
75	Culvert #6				

9.6 Waterway shear stresses

Figure 39 shows the average shear stresses in the channel for the 1% AEP event calculated by HEC-RAS. There remain some isolated locations with higher shear stresses at pools along the alignment and transitions to culvert structures. Rock armouring will be provided within the design at locations of high local shear stresses.

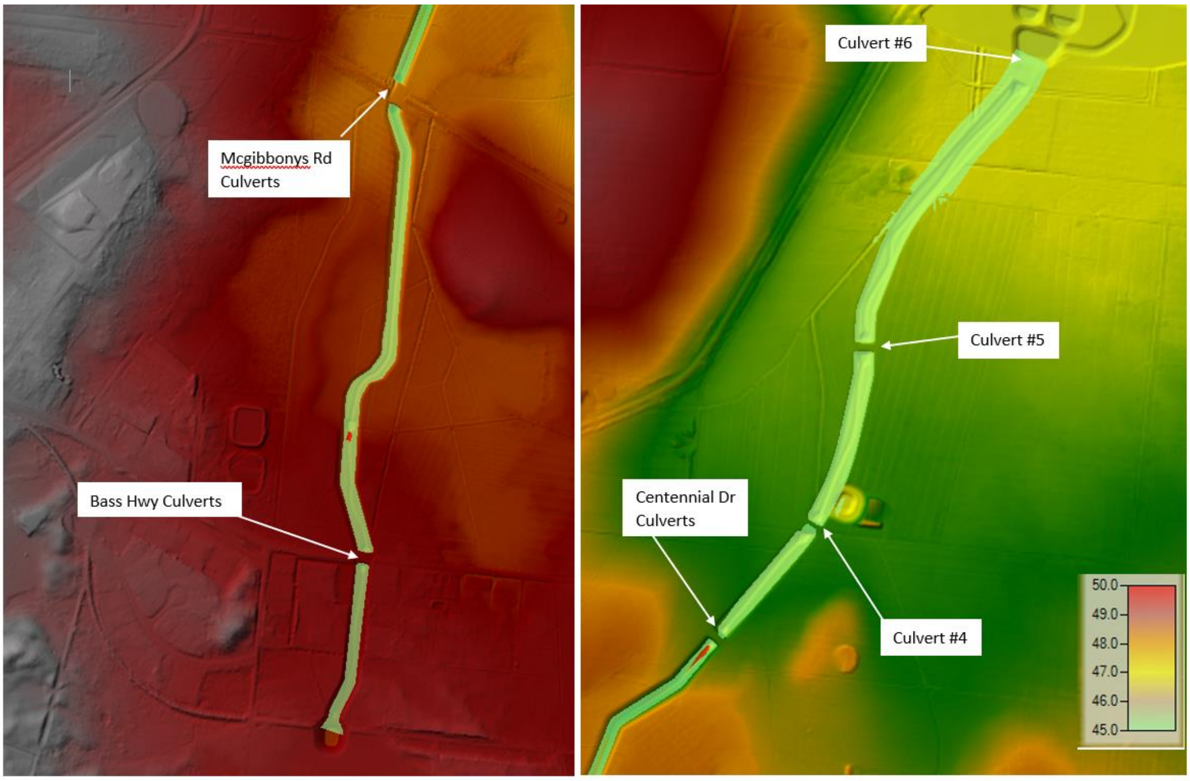


Figure 39. *Average shear stress map through constructed waterway (in N/m²)*

TUFLOW Modelling (April 2022)

Modelling of the refined functional design arrangement was undertaken by Engeny to test the impact of the revised Western Waterway on flood conveyance. The results shown in Appendix E, indicate that the Western Waterway has sufficient capacity to convey the 1% AEP flows with no breakout occurring.

10 Waterway Functional Design E-WW (DCP ref DR2)

10.1 Longitudinal slope

One of the key criteria for the waterway is to ensure that shear stress values are within an acceptable range. This is to ensure that the waterway is stable and to minimise the erosion potential. The shear stress threshold value is generally considered to be 45 N/m^2, which can increase by up to 10% during a 1% AEP flow event.

The longitudinal slope is dictated by invert controls at the downstream and upstream extents of the constructed waterway. The provided design features change in slope along the alignment, discussed in the table below. Note that this is the slope along the low flow channel, which will be slightly gentler than the high flow channel due to meanders designed into the low flow alignment.

These grades are suitable for facilitating stable channel design in accordance with industry best practice guidelines.

Table 19. Longitudinal slope along low flow channel

Reach	Upstream Boundary	Downstream Boundary	Upstream elevation (m AHD)	Downstream elevation (m AHD)	Average slope low flow (1 in x)
1	Bass Hwy (stn 3025)	McGibbonys Rd (stn 2625)	21.6	20.7	444
2	McGibbonys Rd (stn 2500)	WLRB1A (DCP ref WL-01) (stn 25)	19.9	14.0	419

10.2 Cross-section geometry

The cross-sectional geometry should be designed to accommodate the 3-month to 1-year Average Recurrence Interval (ARI) flows in the low flow channel and the 100-year ARI flows in the full compound channel. These flows are determined using RORB modelling as discussed in the flood modelling section. The proposed channel cross section dimensions are given in Table 20. The alternate slope along the alignment leads to the differing channel capacities for the reach sections outlined in Table 21.

Table 20. Channel cross-section geometry and design parameters

Parameter	Low flow channel	High flow channel
Base width	3.0	20m
Depth	0.6	0.7
Side slope	1 in 3	Typically 1 in 6
Bench slope	-	1 in 40
Top width	7.0	34.0
Manning's n (assumed)	0.05	0.05

Table 21. Channel design capacities

Reach	Low flow capacity (m^3/s)	High flow capacity (m^3/s)
1, 2	1.6	17.5

10.3 Design flows

The drainage and hydrologic analysis of the site has been informed from hydrologic modelling that was completed for the drainage strategy. Table 15

Table 22. Design flows contributing to E-WW

Location	4EY (m^3/s)	1EY (m^3/s)	10% AEP (m^3/s)	1% AEP (m^3/s)
Reach 1	0.34	0.69	2.50	4.87
Reach 2	1.14	2.21	5.68	16.02

The downstream boundary condition was set by the slope through the downstream section of the property, which will be the future waterway corridor outfall through the downstream property.

10.4 Culvert design

There are 2 culvert crossings through the section of the East Waterway (E-WW; DCP ref DR2). These crossings have been designed to convey the 1% AEP design flows with minimum head loss. To meet these criteria the typical culvert arrangement will consist of the following:

- At Bass Hwy (proposed culvert #1): 3 culvert cells, each opening 1.5m diameter.
- At McGibbonys Rd (proposed culvert #2): 3 culvert cells, each opening 1.5m diameter.

The figures below show the culvert designs (looking downstream from the upstream side).

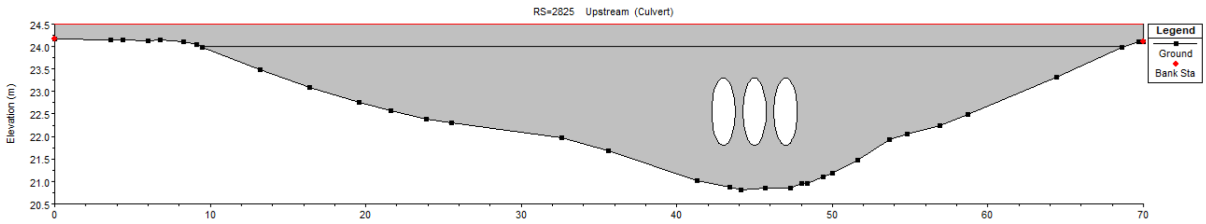


Figure 40. *Upstream Bass Hwy design cross section (looking downstream)*

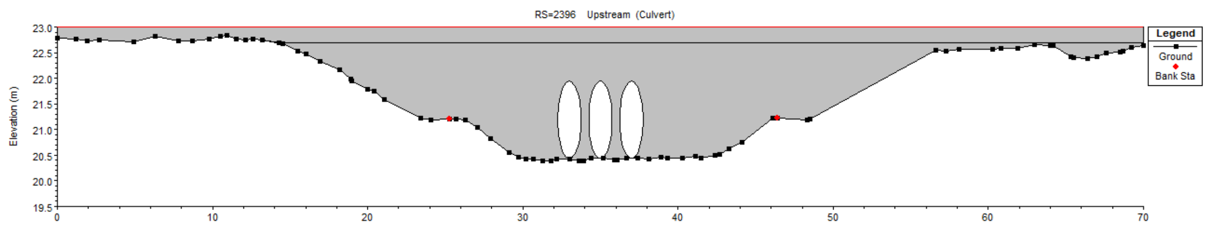


Figure 41. *Upstream McGibbonys Rd design cross section (looking downstream)*

10.5 Results (ultimate culvert designs)

The hydraulic model was run for two scenarios: culverts fully unimpeded and culverts 50% blocked.

The figures below show the longitudinal profile of the water surface for the 1% AEP flow for culverts open and blocked.

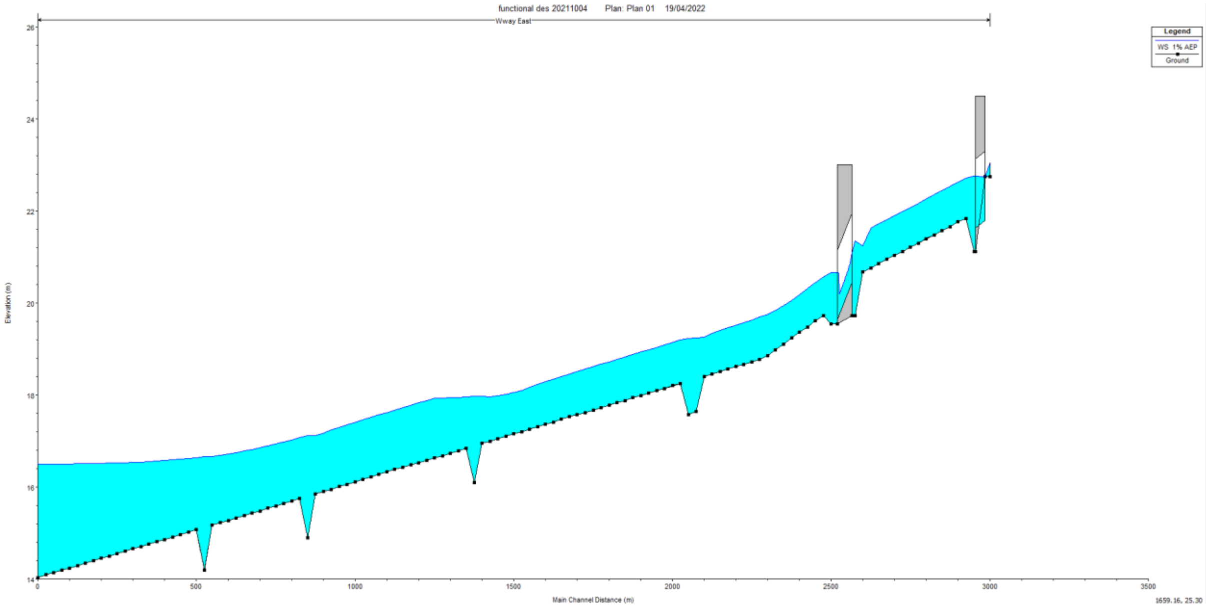


Figure 42. *1% AEP water surface elevation along the waterway alignment with culverts unimpeded*

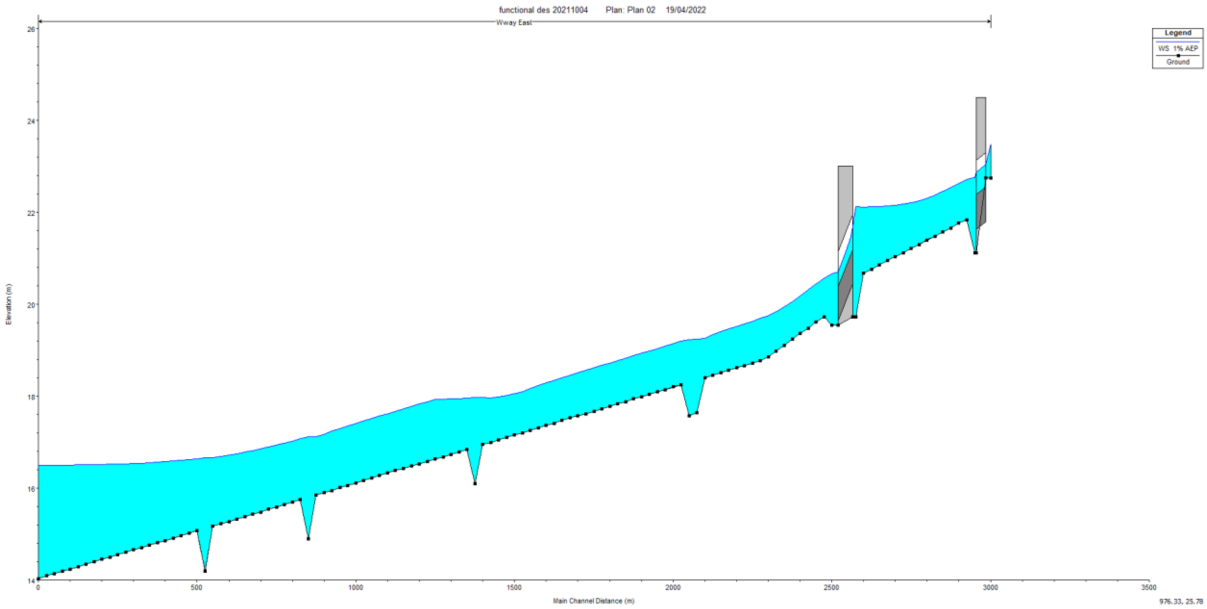


Figure 43. *1% AEP water surface elevation along the waterway alignment with culverts 50% blocked*

The figures below show results for the 10% AEP flow for unimpeded and blocked.

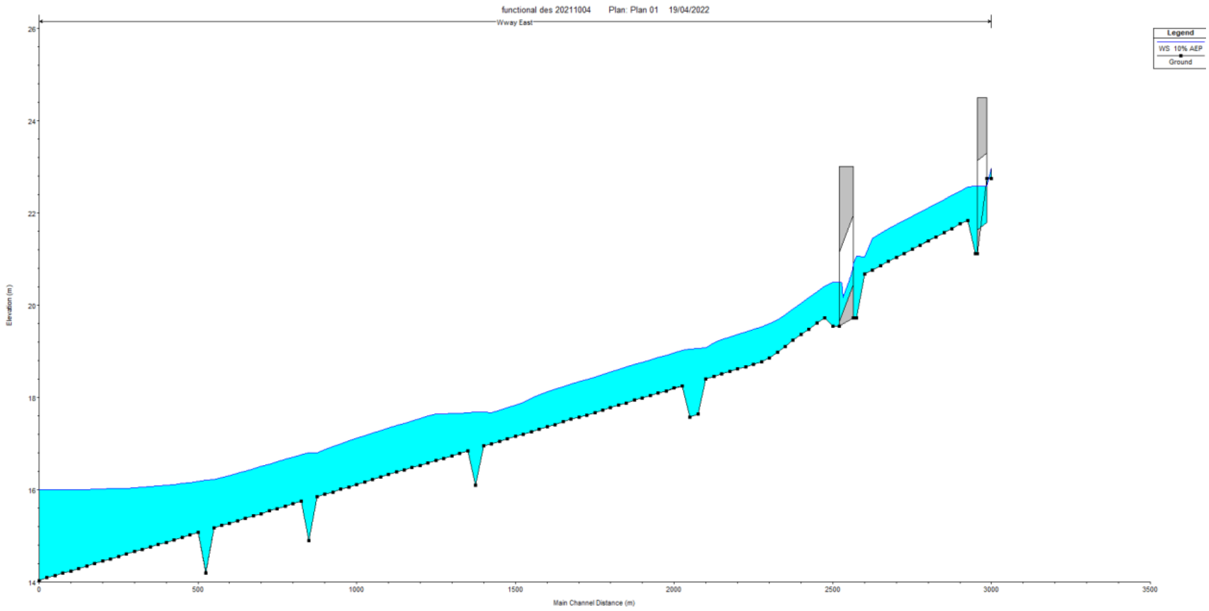


Figure 44. *10% AEP water surface elevation along the waterway alignment with culverts unimpeded*

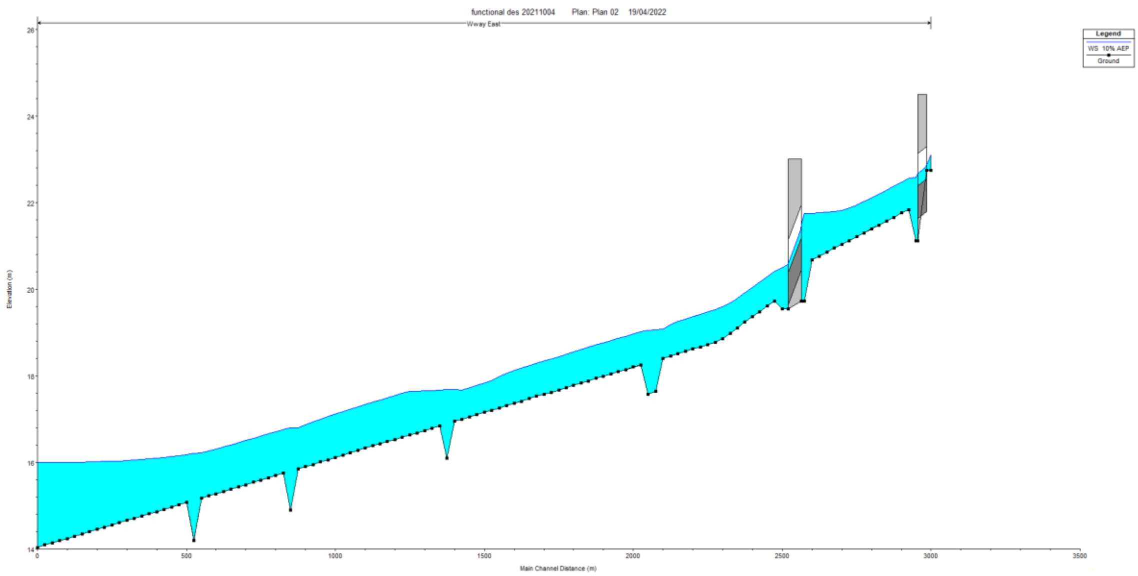


Figure 45. *10% AEP water surface elevation along the waterway alignment with culverts 50% blocked*

The hydraulic results for the open and blocked scenarios for the 1% AEP flow are outlined in the table below.

Table 23. Hydraulic results through culverts for both scenarios for the 1% AEP flow

Culvert Crossing		Open culverts	Blocked culverts
Bass Hwy			
	Head loss (m)	0.30	0.72
	Freeboard to road (m)*	1.45	1.03
	Average velocity (m/s)	0.82	0.32
McGibbonys Rd			
	Head loss (m)	0.69	1.46
	Freeboard to road (m)*	1.65	0.88

	Average velocity (m/s)	0.43	0.39

*Note: Road deck levels are assumed

The hydraulic results for the open and blocked scenarios for the 10% AEP flow are outlined below.

Table 24. Hydraulic results through culverts for both scenarios for the 10% AEP flow

Culvert Crossing		Open culverts	Blocked culverts
Bass Hwy			
	Head loss (m)	0.38	0.52
	Freeboard to road (m)*	1.54	1.40
	Average velocity (m/s)	0.66	0.36
McGibbonys Rd			
	Head loss (m)	0.56	1.26
	Freeboard to road (m)*	1.94	1.24
	Average velocity (m/s)	0.31	0.28

* Road deck levels are assumed

Note: Appropriate rock beaching will be required at the outlet of the culverts as they transition to the waterway.

Fill Required

It is required that residential allotments are provided 600mm freeboard above the 1% AEP flood level. The HEC-RAS model indicates that the waterway corridor provides sufficient freeboard through the waterway corridor. There are no regions neighbouring the constructed waterway that are of concern. Table 25 provides the finished surface level, flood level and freeboard level.

Table 25. Constructed Waterway Design and 1% AEP Flood levels

Chainage	River station	Flood level (m AHD)	Finished surface level (left) (m AHD)	Finished surface level (right) (m AHD)	Freeboard (m AHD)
3010	Bass Hwy Culverts				
2900	2900	22.54	23.79	23.93	1.25
2800	2800	22.17	23.37	23.51	1.20
2700	2700	21.81	23.27	22.93	1.12
2600	2600	21.35	22.74	22.74	1.39
2590	McGibbonys Rd Culverts				
2500	2500	20.56	22.13	22.36	1.57
2400	2400	20.06	21.29	21.29	1.23
2300	2300	19.69	20.18	20.46	0.49
2200	2200	19.47	19.84	19.95	0.37
2100	2100	19.24	19.77	19.85	0.53
2000	2000	19.09	19.79	19.82	0.70
1900	1900	18.88	19.84	19.81	0.93
1800	1800	18.67	19.62	19.69	0.95
1700	1700	18.46	19.55	19.67	1.09
1600	1600	18.23	19.24	19.23	1.00
1500	1500	18.02	19.02	18.97	0.95
1400	1400	17.97	18.62	18.62	0.65
1300	1300	17.94	18.45	18.50	0.51
1200	1200	17.78	18.23	18.14	0.36
1100	1100	17.57	17.93	17.95	0.36

1000	1000	17.35	17.74	17.76	0.39
900	900	17.12	17.60	17.60	0.48
800	800	16.98	17.43	17.30	0.32
700	700	16.82	17.23	17.09	0.27
600	600	16.69	16.98	16.91	0.22
500	500	16.62	17.03	16.84	0.22
400	400	16.56	17.26	16.98	0.42
300	300	16.53	16.53	16.72	0.19
200	200	16.51	16.51	16.69	0.18
100	100	16.50	16.50	16.50	0.00

10.6 Waterway shear stresses

Figure 46 shows the average shear stresses in the channel for the 1% AEP event calculated by HEC-RAS. There remain some isolated locations with higher shear stresses at pools along the alignment and transitions to culvert structures. Rock armouring will be provided within the design at locations of high local shear stresses.

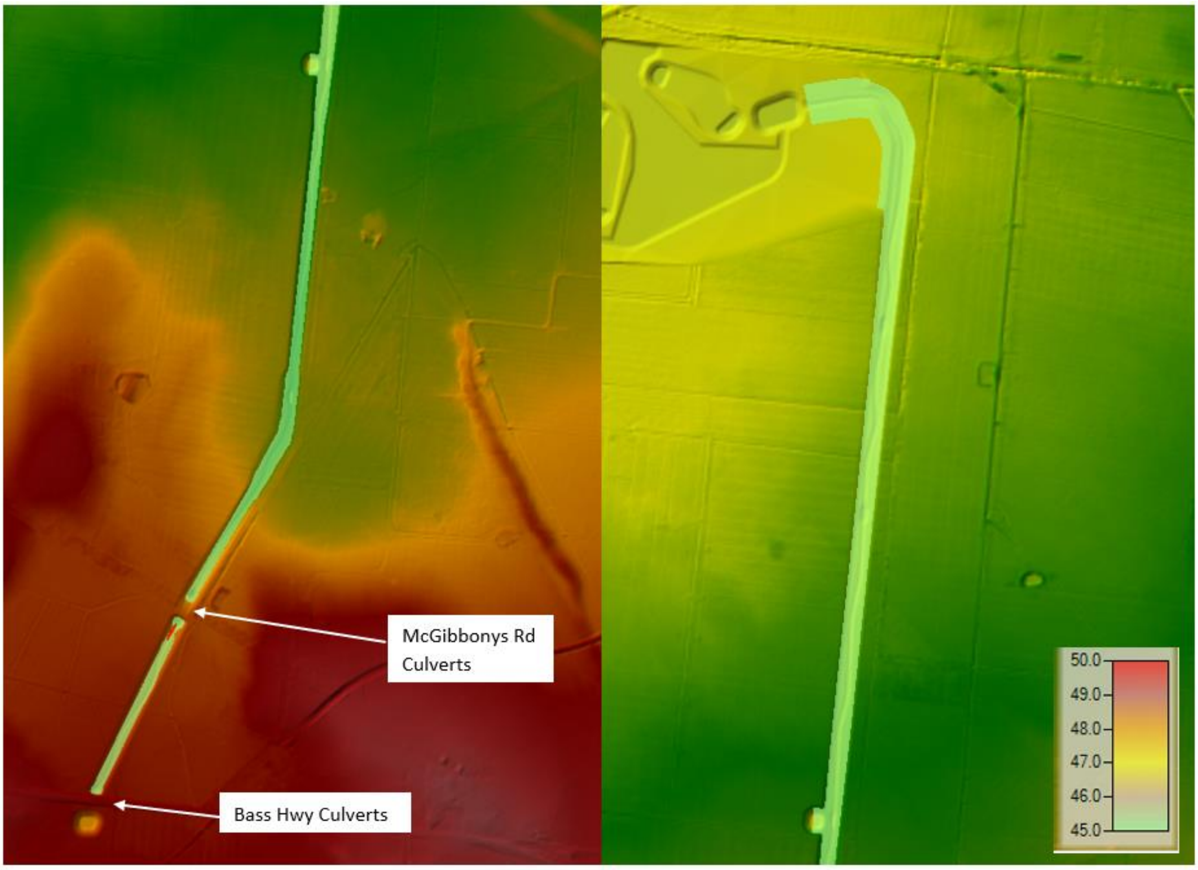


Figure 46. *Average shear stress map through constructed waterway (in N/m²)*

TUFLOW Modelling (April 2022)

Modelling of the refined functional design arrangement was undertaken by Engeny to test the impact of the revised Eastern Waterway on flood conveyance. The results shown in Appendix E, indicate that the Eastern Waterway has sufficient capacity to convey the 1% AEP flows with no breakout occurring.

11 MOP – Main Outfall to Powlett River

The main outfall from the PSP area has been designed to carry the 50% AEP flow from the WLRB1 (A and B; DCP ref WL-01) and WLRB2 (DCP ref WL-02) outflow location. The main outfall alignment remains similar to the concept design proposed by Engeny (using the existing farm channel alignments) and extends to the Pinkerton Rd culvert (upstream) before flows continue to the existing main outfall drain to the Powlett River. This is due to design constraints associated with crossing existing infrastructure along Korumburra-Wonthaggi Road (gas transmission main, desalination water supply main, and mains water supply line) and the need to ensure flows are transitioned through to Powlett River.

A summary of the proposed alignment and the existing infrastructure is shown below.

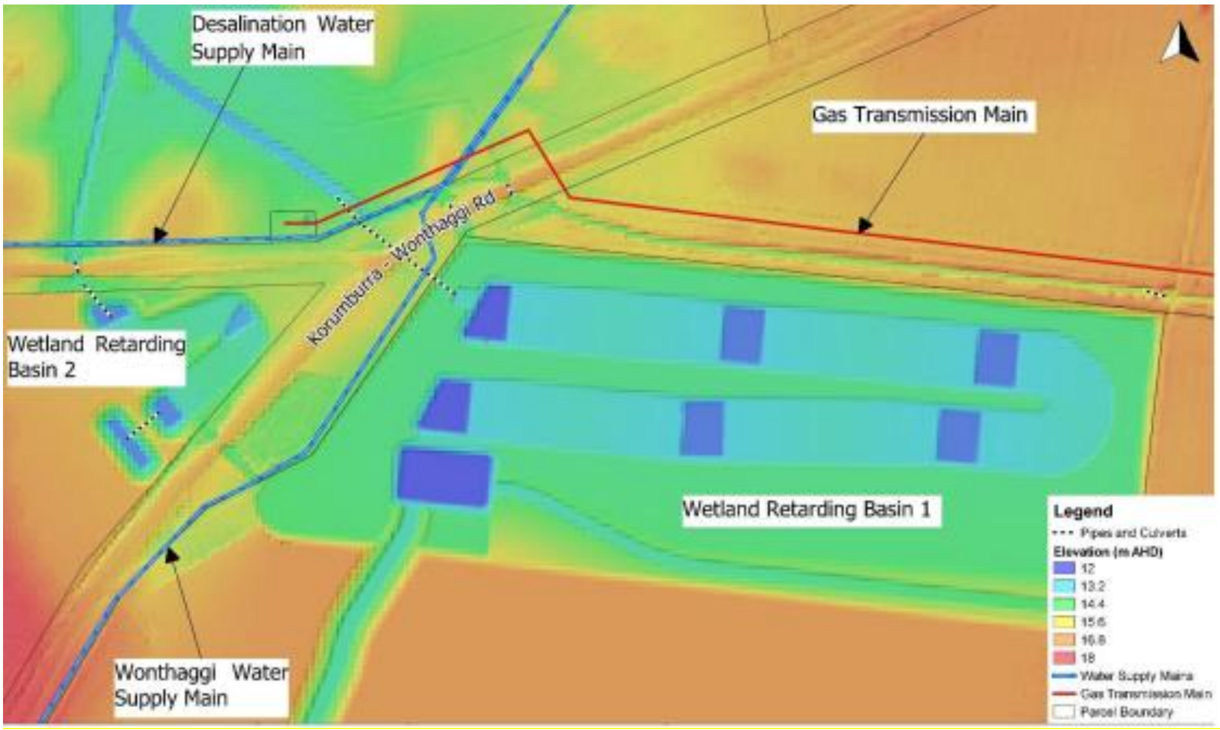


Figure 47. *Existing gas and water service pipelines (Engeny, August 2021)*

Service Crossings

As per the Engeny concepts and strategy development for the Wonthaggi North East PSP, Multinet and South Gippsland Water were contacted to confirm locations and levels of the gas and water mains, as well as the clearances and offsets required for each of these assets when a crossing is proposed.

Multinet require a 500mm vertical clearance to services and drains crossing the gas transmission main. As per discussions between Multinet and Engeny, the gas main is relatively new and specific legislative controls designed to protect the pipeline and areas around the pipeline, are in place. Therefore, potential relocation of the gas main should be considered as a last resort and should be avoided where possible.

South Gippsland Water requires 300mm vertical clearance for drainage pipes crossing over water mains and 150mm vertical clearance for drainage pipes passing under water mains. As per discussions between South Gippsland Water and Engeny, crossing the mains (desalination pipeline or potable water main) would carry significant risks for both.

Any potential relocation of the desalination pipeline would be limited to winter months, due to operational demand requirements through the summer period. Further, as advised, the line has limited flushing points, therefore requiring large volumes of water to clean the line following relocation works, to ensure public health and safety.

The potable water supply main is the main supply for the Wonthaggi township. The storages within the township have a limited water reserve, and significant risk mitigation planning would be required to maintain town services, particularly if any potential relocation works did not proceed as scheduled.

Following a review of the proposed outfall crossing of Korumburra-Wonthaggi Rd by Craigie et.al (2021) a proposed 'alternate' outfall design was considered for the low flow outlet crossing from WLRB1.

The updated design considered 3 x 900mm (W) x 300mm (H) box culverts, which would transition to a single 1200mm (W) x 600mm (H) box culvert midway through the road crossing, once the existing services requiring appropriate cover was passed.

The proposed outfall arrangement is considered a more feasible and effective approach in comparison to a 10 x 300mm HDPE pipe arrangement (Engeny, 2021) given the propensity to blockages.

A summary of the layout is provided below.

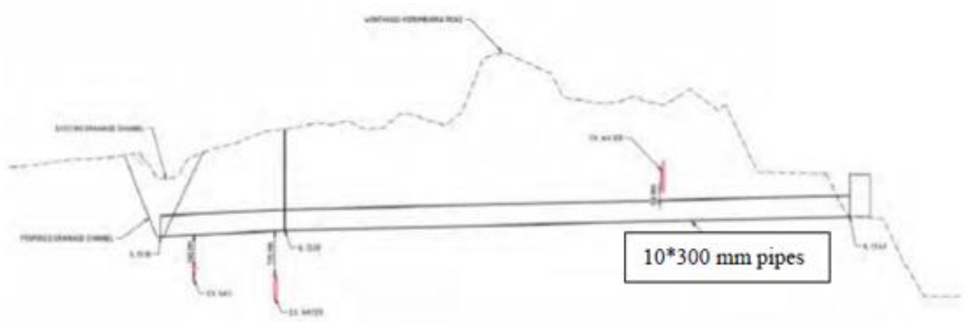


Figure 1 **Engeny/Alluvium Proposal for WLRB1 lowflow outlet**

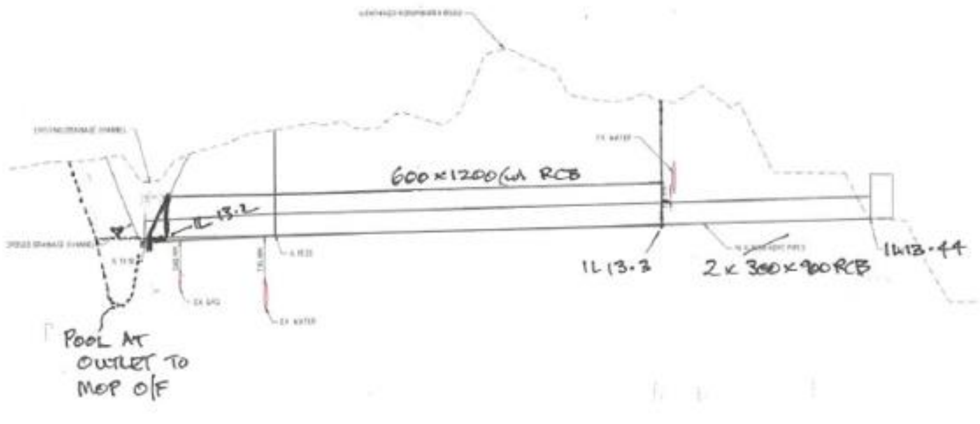


Figure 2 **Suggested Alternative for WLRB1 lowflow outlet**

Figure 48. *Alternative low flow outlet arrangement (Neil Craigie, 2022)*

A high flow channel is proposed at the location of the gas main crossing (downstream of Korumburra-Wonthaggi Road), the high flow channel is designed to carry the high flow outfall (HFO) from the WLRB1 asset.

The HFO channel crossing the gas pipeline (Multinet) requires a vertical separation of 700mm between the top of the gas main and the invert of the channel, with allowance for a 200mm thick concrete slab to protect the pipe from erosion.

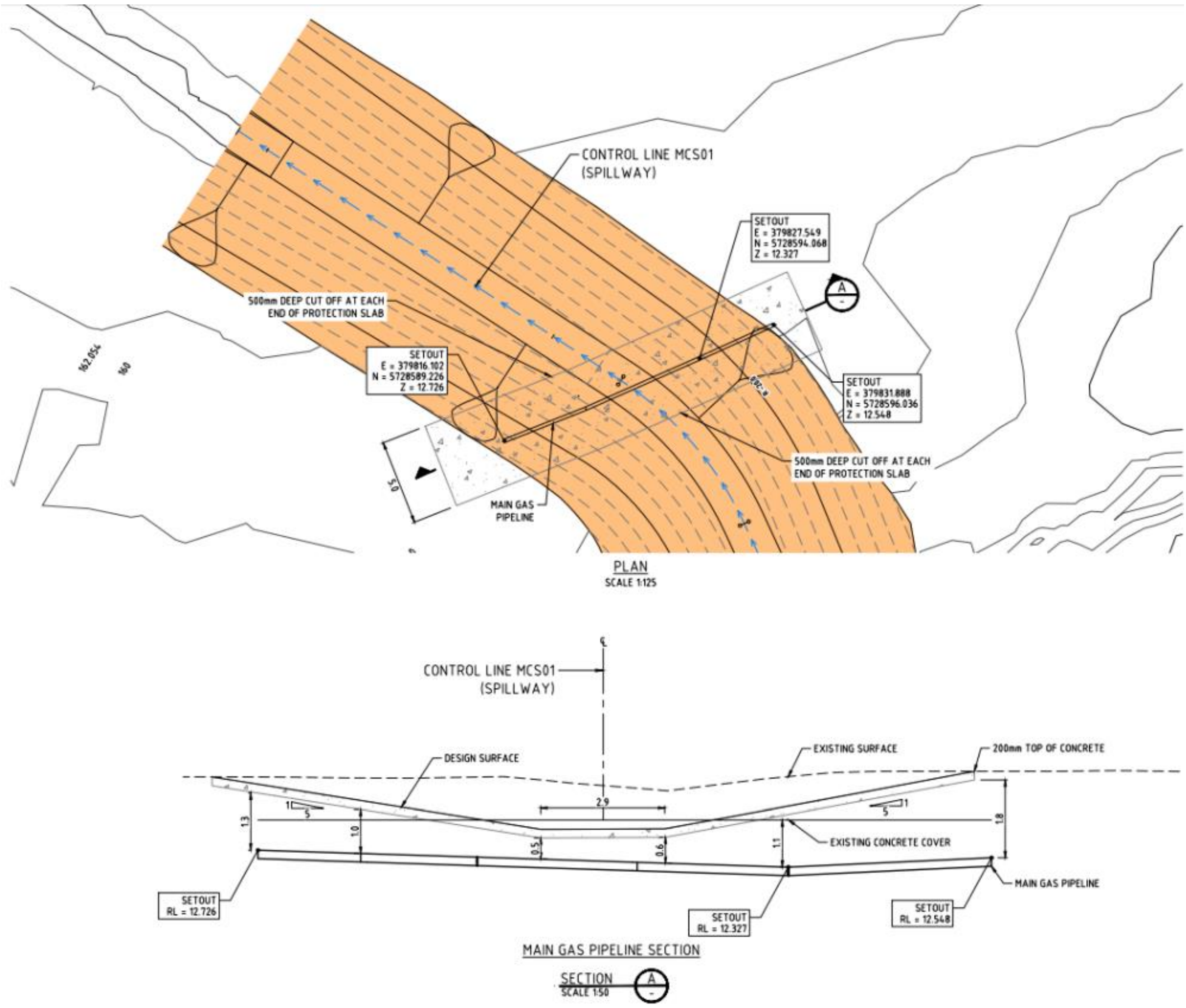


Figure 49. *Proposed channel crossing of the gas transmission main (Engeny, Aug 2021)*

Outfall to Powlett River

The outfall connection to the Powlett River required further investigation to ensure concentrated retarding basin outflows from the Wonthaggi North East PSP do not impact on downstream landowners, prior to its ultimate outfall into the Powlett River. The original concepts (Engeny) and subsequent functional design (Alluvium) connected the PSP outfall to existing open farm channels located on the subject property at 465 Heslop Road, north of the precinct.

The existing channel alignment runs parallel to the Powlett River towards the west, before connecting into the river approximately 2km further downstream. The existing farm channel is undersized with respect to conveying the 50% AEP flow for the precinct as identified by Engeny and Alluvium (September 2021). An overview of the study area is shown in the figure below.

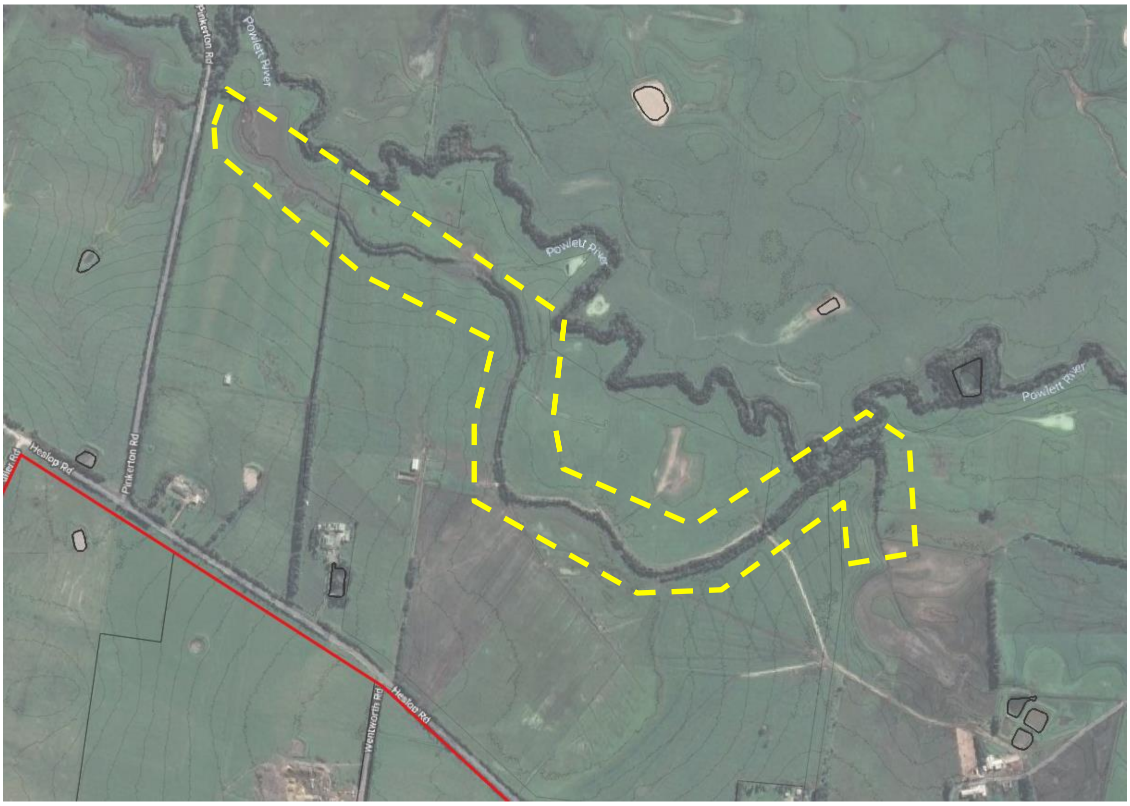


Figure 50. *Extent of study area (yellow dash) for the ultimate outfall to Powlett River.*

The capacity of the existing farm channels to receive PSP outfall discharges has been considered to resolve the ultimate outfall design of the PSP. The ultimate outfall design alignment passes through the downstream property and ensures no further flooding is experienced on the subject property as a result of the PSP (as per requirements). The outfall design also considered how flood conditions could be improved downstream (wherever possible) and considered potential erosion to the outfall channel from PSP discharges. The design ensures the protection of the existing riparian vegetation to maintain bank stability. The proposed outfall connection has been designed with respect to the following:

- Confirmation of design invert levels from the end of the current design to the outfall to the Powlett River
- Confirmation of the current capacity of the existing farm channels in the 50% AEP event
- Hydraulic modelling (HEC-RAS) to confirm flood levels and sheer stresses through the system.

It is noted that the proposed main outfall design matches the existing farm drain invert level upstream of the Pinkerton Road bridge, to ensure the PSP area can freely drain to Powlett River. As part of the TUFLOW modelling completed for the PSP, flood levels along the Powlett River floodplain have shown no net increase in flood levels as per the CMA requirement, ensuring there is no impact on the Pinkerton Road Bridge from the proposed developable area.

The main outfall design discharges through the existing farm drain alignment (not the river), as a result no works are proposed within the Powlett River and no new drainage connections to the Powlett River have been proposed.

Following the TUFLOW modelling completed by Engeny, it was determined that the downstream outfall to Powlett reach was to remain in its current form. The drain alignment is too sensitive to change, and any alterations made to the existing outfall alignment downstream of the original Engeny channel results in increased flood levels further downstream within the Powlett River flood plain (refer Appendix E).

11.1 Longitudinal slope

One of the key criteria for the MOP design is to ensure shear stress values are within an acceptable range to achieve waterway stability and to minimise the erosion potential. The shear stress threshold value is generally considered to be 45 N/m^2.

The longitudinal slope is dictated by invert controls at the downstream and upstream extents of the constructed waterway. The provided design features change in slope along the alignment as shown in the table below. These grades are suitable for facilitating stable channel design and are in accordance with industry guidelines.

Table 26. Longitudinal slope along low flow channel

Reach	Upstream Boundary	Downstream Boundary	Upstream elevation (m AHD)	Downstream elevation (m AHD)	Average slope (1 in x)
1	WLRB1 (DCP ref WL-01) Out (stn 2975)	Culvert 1 (stn 2600)	14.43	12.52	214
2	Culvert 1 (stn 2550)	Culvert 2 (stn 2300)	12.47	11.95	500
3	Culvert 2 (stn 2250)	Outlet (stn 1975)	11.89	11.30	508
4	Outlet (stn 1950)	Pinkerton Rd (stn 0)	11.30	10.90	7300

11.2 Cross-section geometry

The cross-sectional geometry should be designed to accommodate the 50% AEP flow, as required through the 'subject property' (465 Heslop Rd) to convey the developed conditions outflow from the PSP to the Powlett River. These flows are determined using RORB modelling. The proposed channel cross section dimensions are provided in Table 27 below. The alternate slope along the alignment leads to the differing channel capacities for the reach sections as shown in Table 28.

Table 27. Channel cross-section geometry and design parameters

Parameter	Channel
Base width	8 – 12 m
Depth	0.5 – 3 m
Side slope	1 in 3
Manning's n (assumed)	0.035

Table 28. Channel design capacities

Reach	Capacity (m^3/s)
1, 2, 3, 4	3.0

11.3 Design flows

The drainage and hydrologic analysis of the site has been informed from hydrologic modelling that was completed for the drainage strategy.

Table 29. Design flows contributing to MOP

Location	4EY (m^3/s)	1EY (m^3/s)	10% AEP (m^3/s)	1% AEP (m^3/s)
Reach 1	0.49	1.50	7.49	15.54

The downstream boundary condition was set by the slope through the downstream section of the property, which will be the future waterway corridor outfall through the downstream property.

11.4 Hydraulic modelling

A hydraulic model (HECRAS) was created for the existing farm channel, through the downstream property towards the west, and the proposed design surface alignment. The existing conditions analysis checked the overall capacity of the outfall drain with respect to runoff generated from the upstream Wonthaggi NE PSP area.

There are four primary variables in HEC-RAS modelling:

- Channel geometry (survey data)
- Downstream boundary conditions (rating curve from gauge or slope)
- Hydraulic roughness (Manning's n)
- Flow (derived from hydrologic analysis)

The hydraulic roughness (Manning's n), boundary conditions, and flows adopted for the model are provided below (Table 30).

Table 30. Hydraulic parameters adopted for the HEC-RAS model

Hydraulic parameters	Description	Value
Manning's n	Channel	0.035
	Floodplain/pasture short grass	0.035
Boundary conditions	Downstream slope	0.002 m/m
Flow	1% AEP 50% AEP	15.54 m^3/s 2.47 m^3/s

Culvert design (WLRB1 to Culvert 2)

The are 2 culvert crossings through the proposed outfall alignment. These crossings have been designed to convey the 50% AEP design flows with minimum head loss. To meet these criteria the typical culvert arrangement will consist of the following:

- Culvert #1: 5 culvert cells, each opening 1.5m diameter.
- Culvert #2: 5 culvert cells, each opening 1.35m diameter.

The figures below show culvert designs (looking downstream from the upstream side).

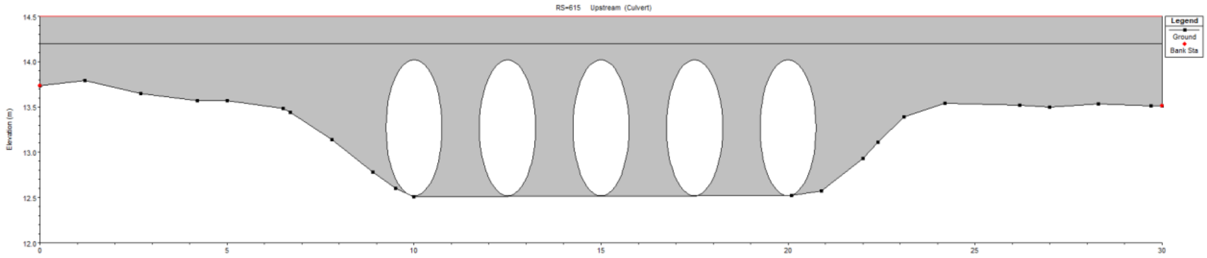


Figure 51. *Upstream Culvert 1 cross section (looking downstream)*

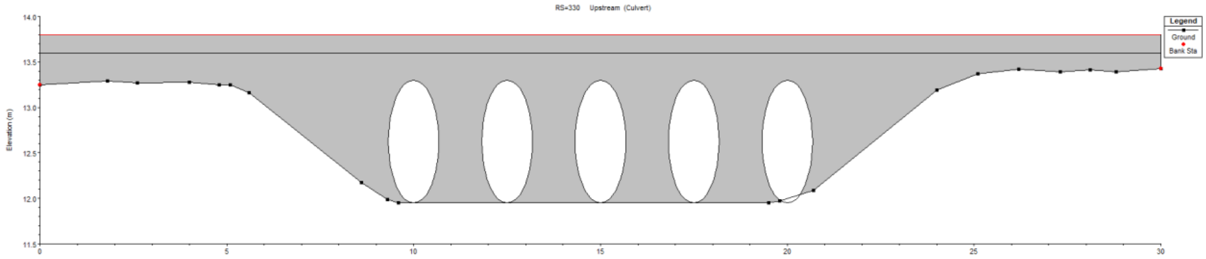


Figure 52. *Upstream Culvert 2 cross section (looking downstream)*

Results (ultimate culvert designs - WLRB1 to Culvert 2)

The hydraulic model was run for two scenarios: culverts fully unimpeded and culverts 50% blocked. The figures below show the longitudinal profile of the water surface for the 50% AEP flow for culverts open (unimpeded) and blocked.

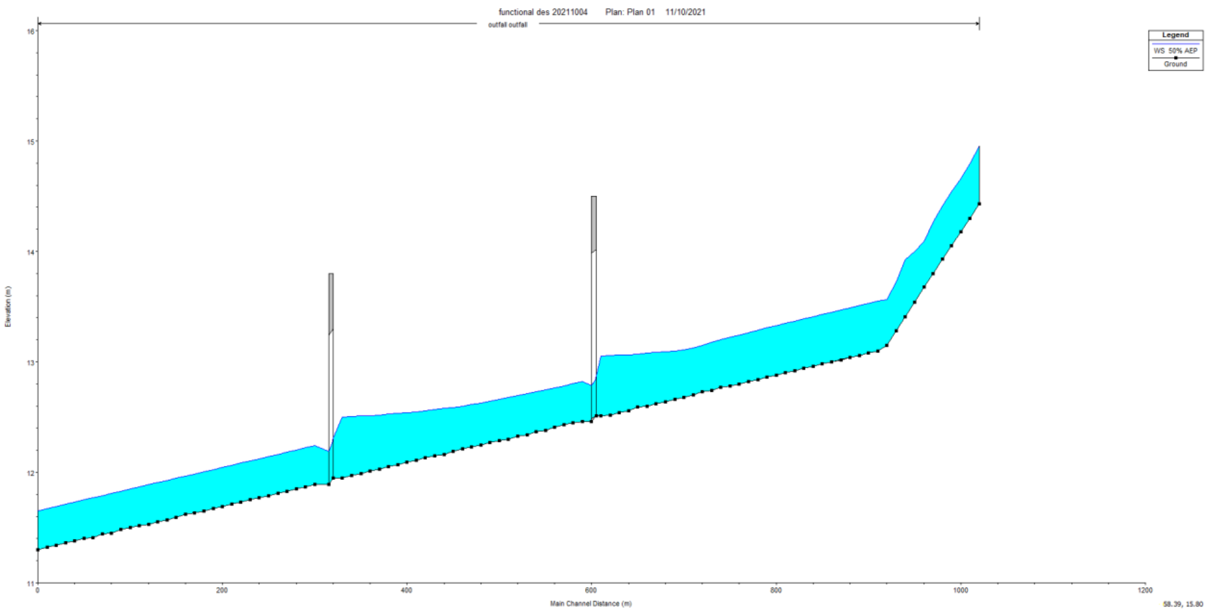


Figure 53. *50% AEP water surface elevation along the waterway alignment with culverts unimpeded*

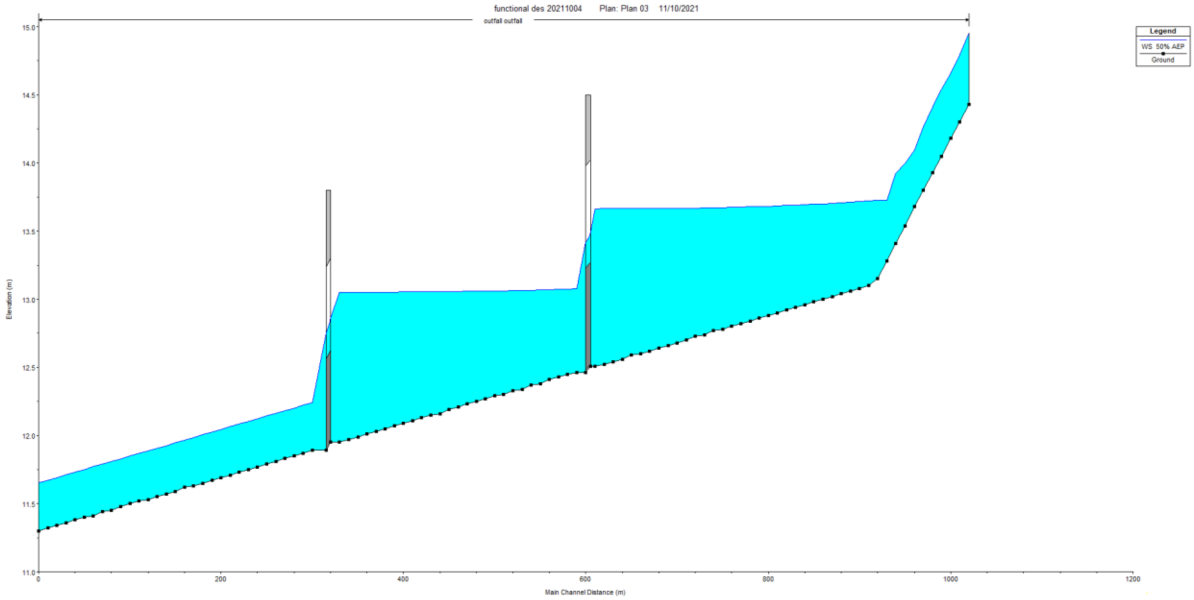


Figure 54. *50% AEP water surface elevation along the waterway alignment with culverts blocked*

The hydraulic results for the open and blocked scenarios for the 1% AEP flow are outlined below.

Table 31. Hydraulic results through culverts for both scenarios for the 1% AEP flow

Culvert Crossing		Open culverts	Blocked culverts
Culvert 1			
	Head loss (m)	0.23	0.58
	Average velocity (m/s)	0.45	0.22
Culvert 2			
	Head loss (m)	0.26	0.81
	Average velocity (m/s)	0.47	0.38

Waterway shear stresses

Figure 55 shows the average shear stresses in the channel for the 1% AEP event calculated by HEC-RAS. There remain some isolated locations with higher shear stresses at pools along the alignment and transitions to culvert structures. Rock armouring has been provided within the functional design at key locations of high local shear stresses.

Figure 55. *Average shear stress map through constructed waterway (in N/m²) – note red grading near WLRB1 (DCP ref WL-01) outfall to MOP.*

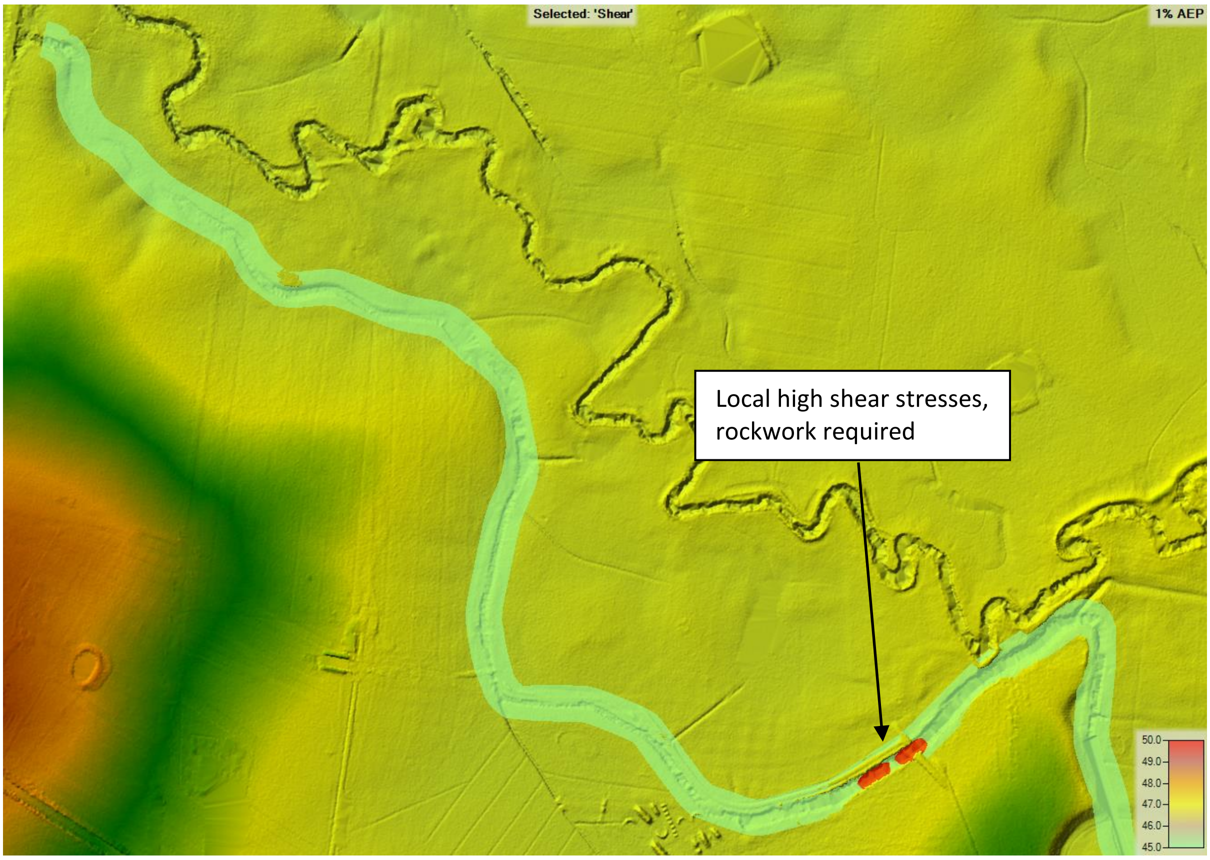


Figure 56. *Average shear stress map through constructed waterway (in N/m^2) – design conditions*

TUFLOW Modelling (April 2022)

Modelling of the refined functional design arrangement was undertaken by Engeny to test the impact of the revised MOP outfall channel on flood behaviour and conveyance. The results shown in Appendix E, indicate that the channel downstream of the PSP through the subject property (465 Heslop Rd) constriction is very sensitive to changes in cross sectional flow area. Any change (either bigger or smaller) is altering how the floodplain behaves.

Therefore, the design extends from the PSP WLRB1 outfall to the existing choke point on the subject property. Minor rock stabilisation works may be required for the channel sections further downstream, between the choke point and Pinkerton Rd culverts, however this is to be tested at the detailed design stage. The previous Addendum design for the MOP has now been superseded.

Given flood behaviour sensitivity to any modifications to the downstream channel sections, at future detailed design phases during the permit stage, detailed feature level survey of the downstream farm channel (along the MOP outfall to Powlett River) should be undertaken to refine the final design. At the time of this study, no feature level survey was available nor time to undertake this work to better inform the new modelling and redesign works.

12 Stormwater Quality Treatment

A key principle for the development of the Wonthaggi North East PSP is that all stormwater is to be treated to BPEM Guidelines before being discharged from the precinct to the receiving waterway environment (Powlett River). The following BPEM targets have been adopted:

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

Table 32 shows the multiple sub-catchments (as previously shown in Figure 17 above) that fall within, and external to the PSP, indicating contributing catchment areas (hectares) discharging to the proposed treatment assets for the WNE PSP.

Table 32. Contributing catchments (sources) and receiving treatment asset

Asset	Area type	Area (ha)	Asset Size - NWL (m^2)	
			Inlet pond	Macrophyte Zone
WLRB 1A (DCP ref WL-01)	Existing External Agricultural	442	4,000	10,000
	PSP	199		
	Total	**641**		
WLRB 1B (DCP ref WL-01)	Existing External Agricultural	137	5,000	20,000
	External Urban	146		
	PSP	225		
	Total	**508**		
WLRB2 (DCP ref WL-02)	Existing External Urban	14	1,150	7,500
	PSP	59		
	Total	**73**		
WLRB3 (DCP ref WL-03)	PSP	52	1,350	5,500
	Total	**52**		
WLRB4 (DCP ref WL-04)	Existing External Urban	23	2,850	9,000
	PSP	78		
	Total	**101**		
SB7	PSP	11	500	
	Total	**11**		
Total catchment area		1386		

A MUSIC *(Model for Urban Stormwater Improvement Conceptualisation)* model was developed by Engeny to estimate the pollutant loads generated from the developed conditions scenario. This was used to define the target pollutant load reduction, and therefore test the sizing and treatment capacity of assets required to meet the best practice targets. The modelling and asset sizing does not seek to treat existing residential areas upstream to best practice, only future residential areas proposed within the Precinct.

The catchment nodes used in the east catchment model have been calculated based on the areas, land uses, and associated fraction impervious values used in the RORB modelling. The MUSIC model layout is shown in Figure 57 below.

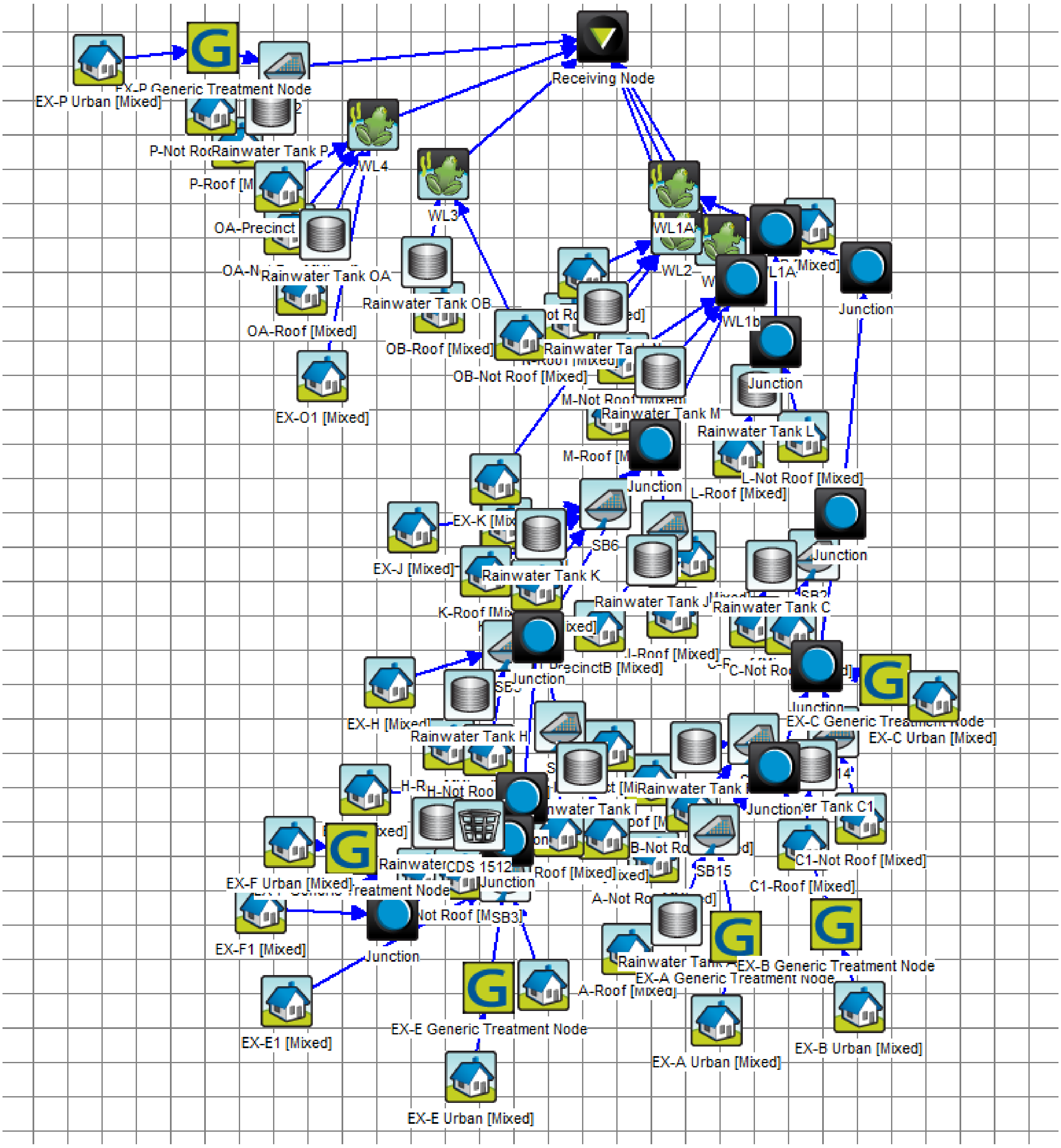


Figure 57. *MUSIC model for the Wonthaggi North East PSP (Alluvium, Aug 2021)*

MUSIC modelling treatment asset summary

The MUSIC modelling determined the sizing required for the four wetland assets located at each of the catchment low points, and the sediment basins located throughout the PSP area. The details of the required wetland treatment systems and sediment basins are provided in Table 33 and Table 34 below.

Given the increased wetland size required to meet velocity threshold limits, the retarding basin / wetland assets have been redesigned within the land subject to inundation extent, to maximise the area for stormwater quantity and quality drainage works. The stormwater drainage reserve areas for these assets are as per Alluvium's revised Proof of Concept shown in

Figure 26 (above). A close-up of the wetlands with the inundation extent has been provide below (Figure 58).

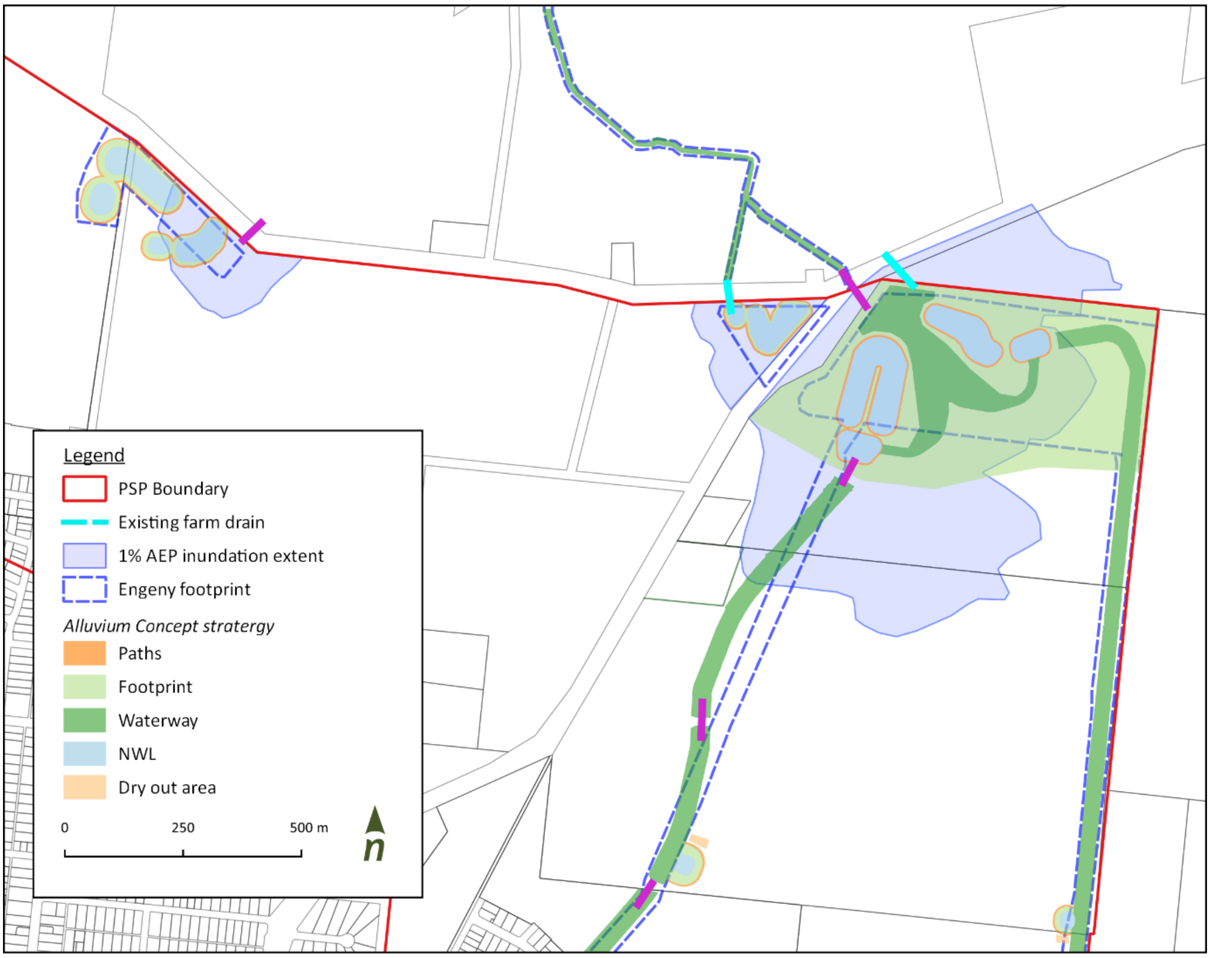


Figure 58. *Wetland assets and inundation extents*

The land within the inundation extent falls within the LSIO. The Engeny asset footprint does not include the land areas within this flood extent. However, for development to occur within this area, land would need to be filled 600mm above the 1% AEP flood level to protect any development from future flooding. A more cost-effective approach would be to co-locate stormwater assets within this inundation extent (maximise the use of this land for stormwater drainage purposes), and potentially freeing up developable land areas upstream in the PSP. A summary of the proposed treatment assets is provided below.

Table 33. Wetland treatment asset parameters for the Wonthaggi North East PSP

	WLRB1A	WLRB1B	WLRB2	WLRB3	WLRB4
DCP reference	WL-01	WL-01	WL-02	WL-03	WL-04
NWL area, m^2	10,000	20,000	7,500	5,500	9,000
Inlet pond area, m^2	4,000	5,000	1,150	1,350	2,850
Inlet pond volume m^3	2,800	3,500	805	945	1,995
Ave. depth wetland, m	0.40	0.40	0.40	0.40	0.40
Extended detention, m	0.35	0.35	0.35	0.35	0.35
Extended detention time, hr	72.0	72.0	72.0	72.0	72.0

Table 34. Sediment basin treatment asset parameters for the Wonthaggi North East PSP

DCP reference	*SB1* (*SB3)*	*SB4* (*SB7)*	*SB5* (*SB15)*	*SB6*	*SB7*
NWL area, m^2	1,500	1,400	1,500	1,000	500
Average depth, m	0.80	0.80	0.80	0.80	0.80
Extended detention, m	0.35	0.35	0.35	0.35	0.35

Overall treatment performance

The modelling has assumed the upstream external catchment to the south remains as agricultural land, which has no prior treatment or control before directly out falling through the Wonthaggi North East PSP area.

Note: While it is noted that more recently (Sept 2021) Council advises they are in a negotiating process for a Development Plan for this upstream area, however, at the time of this study, the process was only in its early stages and could not inform this work.

The wetlands (WLRBs) for the PSP have been redesigned and 'upsized' in comparison to earlier concepts to meet velocity threshold requirements. The sediment basins have been upsized using the Fair and Geyer equation, where sediment basins are required to meet a 95% sediment capture efficiency of coarse particles ≥ 125 µm diameter for the peak 4EY (4 Exceedances per Year) event. Overall treatment performance has only considered meeting BPEM for the PSP area only. As a result, source loads generated from external catchments are not considered in the overall reduction results.

The results of the MUSIC modelling analysis demonstrates that BPEM targets are met with the performance of the wetland and sediment basin assets, as shown below.

Table 35. Total model inflow, PSP and external load, removal target

	Removal target	Total model load	External load	PSP load	Removal target
TSS (kg/yr)	80%	694,080	197,000	694,080	555,260
TP (kg/yr)	45%	1,470	810	1,470	660
TN (kg/yr)	45%	10,740	10,400	10,740	4,830
GP (kg/yr)	75%	141,500	0	141,500	106,120

Table 36. Overall MUSIC modelling results

	Total model load	PSP load	Residual load	% Reduction Total model	Kg/yr removed	% Reduction PSP load only
TSS (kg/yr)	900,000	694,080	207,000	77%	691,000	100%
TP (kg/yr)	2,070	1,470	787	62%	1,283	87%
TN (kg/yr)	15,500	10,740	10,700	31%	4,800	45%
GP (kg/yr)	176,000	141,500	0	100%	176,000	124%

Functional design details of the Wetland and Sediment basin assets are provided in Sections 13 – 22 following.

13 Wetland Functional Design (WLRB-1A; WL-01)

This section outlines the design calculations that have been undertaken to ensure the performance of the treatment system WLRB1A (DCP ref WL-01) complies with the appropriate guidelines. A plan view of the designed wetland system is shown below (see Appendix B for further design details and cross sections). The Wetland Normal Water Level (NWL) is set at **14.00m AHD**, and the Top of Extended Detention (TED) is set at **14.35m AHD**.

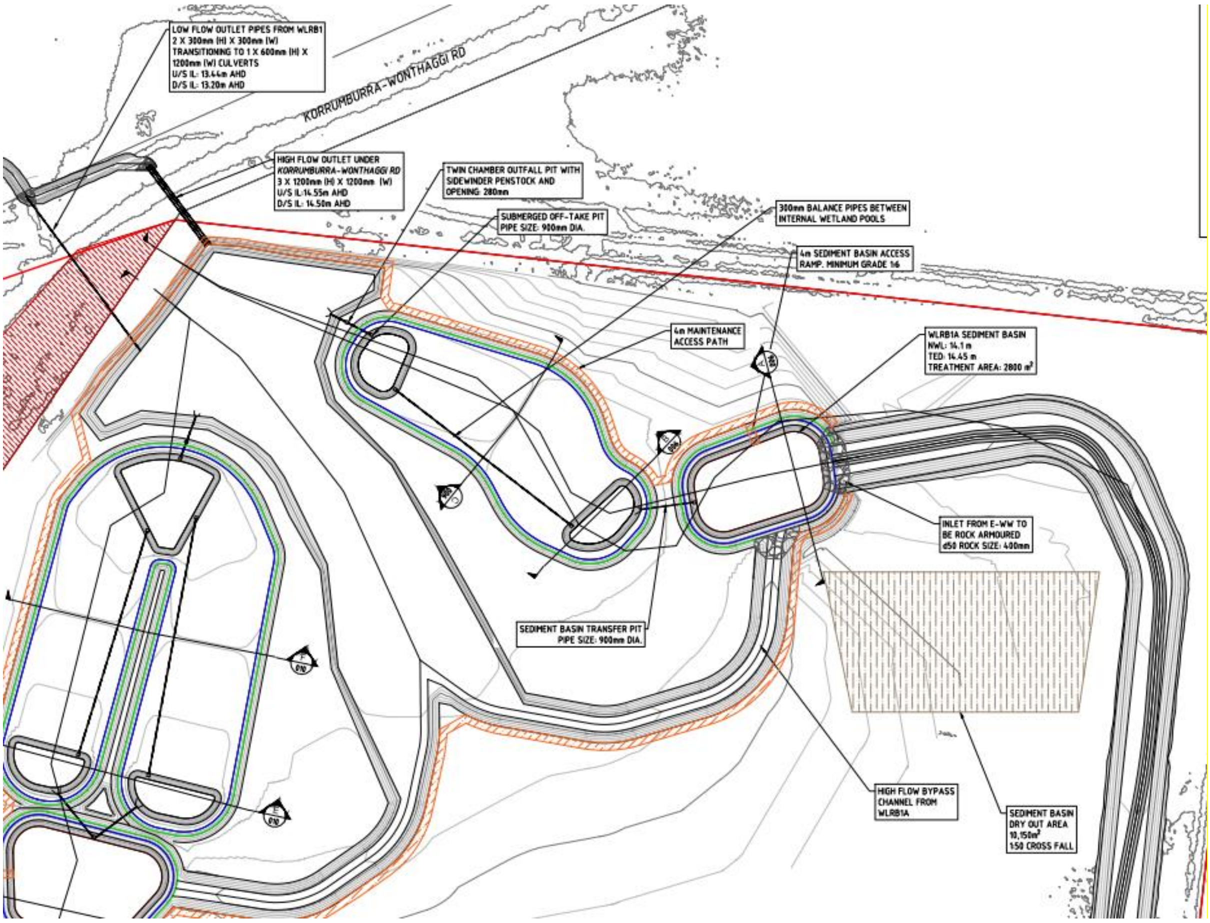


Figure 59. *Plan view of the designed wetland structure WLRB1A (DCP ref* WL-01*) (east)*

13.1 Velocities

WLRB1A (DCP ref WL-01) is designed to treat the approx. 600 ha catchment out falling through the W-WW (DCP ref DR1).

The area of the WLRB1A (DCP ref WL-01) macrophyte zone is proposed at 10,000 m^2 and 4,000 m^2 at the inlet pond, as established in the MUSIC modelling. Therefore a width of 47m is the maximum average width possible in the macrophyte zone to ensure an adequate width to length ratio.

The velocity through each treatment asset is considered here. A flow depth of 0.35m, which is the extended detention depth (EDD), has been assumed for 4EY and 20% AEP events.

For WLRB1A the minimum design width is 45m in the macrophyte zone and 35m in the inlet pond to meet velocity threshold requirements. The table below provides details on the minimum widths and velocities determined.

Table 37. System velocity calculations and design checks – WLRB1A (DCP ref WL-01)

	Parameter	4EY	20% AEP
Flow Conditions	Design flow (m^3/s)	0.82	5.67
	Flow depth (m)	0.35	0.35
Inlet pond	Width at NWL (m)	35	35
	Width at EDD (m)	39.2	39.2
	Average Width (m)	37.1	37.1
	Flow area (m^2)	13.0	13.0
	Flow velocity (m/s)	0.06	0.44
	Check	<0.5 OK	<0.5 OK
Macrophyte zone	Width at NWL (m)	45	45
	Width at EDD (m)	49.2	49.2
	Average Width (m)	47.1	47.1
	Flow area (m^2)	16.0	16.0
	Flow velocity (m/s)	0.05	0.34
	Check	<0.05 OK	<0.5 OK

13.2 Inlet Pond

The inlet pond has been sized to ensure a capture efficiency greater than 95% for the 3-month ARI peak flow and provide adequate sediment storage. The procedure outlined in *WSUD Engineering Procedures (2005)* has been followed and are based on the typical sediment loading rate of 1.6 m^3/ha/yr for a developed catchment, plus an additional 0.4 m^3/ha/yr for systems without a GPT immediately upstream (assumed). Provision for sediment dewatering has also been made. These areas assume a depth of 500mm and a sediment cleanout frequency of 5 years.

Table 38. Inlet Pond design parameters and checks

	Parameter	Proposed design
Conditions	Contributing Catchment (ha)	552
	Area of Basin (m^2)	4000
Capture Efficiency	Settling Velocity of Target Sediment (mm/s) [Particle size 125 µm]	11
	Hydraulic Efficiency (λ)	0.11
	Permanent Pool Depth, dp (m)	1.00
	Extended detention depth, de	0.35
	Number of CTSR's, n	1.1
	Depth below permanent pool that is sufficient to retain sediment, d* (m)	0.50
	Design Discharge (m^3/s) [Q3-month]	0.82
	Capture Efficiency	98.7%
	Check (>95%)	OK
Sediment Storage	Sediment Loading rate, Lo (m^3/ha/yr)	2.0
	Desired clean-out frequency, Fr	5
	Storage volume required, St	2468
	Available sediment storage volume	2800
	Check (Available storage > required storage)	OK
Sediment dewatering	Depth for dewatering area (m)	0.5
	Area required for dewatering (m^2)	4937

13.3 Levels

Batter slopes

A minimum of 1(V):5(H) batter slopes have been adopted. In highly constrained options, batter slopes as steep as 1 in 3 could possibly be considered to minimise cut into the steep terrain, which would require "sedge planting" rather than mow-able grass. Another option would be to use benching and retaining walls.

These alternative approaches to managing the slope would require discussion and agreement with Council; therefore this report has adopted batter slopes of 1(V):6(H) to try and minimise a potentially very large asset footprint. Below the NWL, all batters up to -0.35m must be at least 1(V):8(H), after which they can steepen to 1(V):3(H).

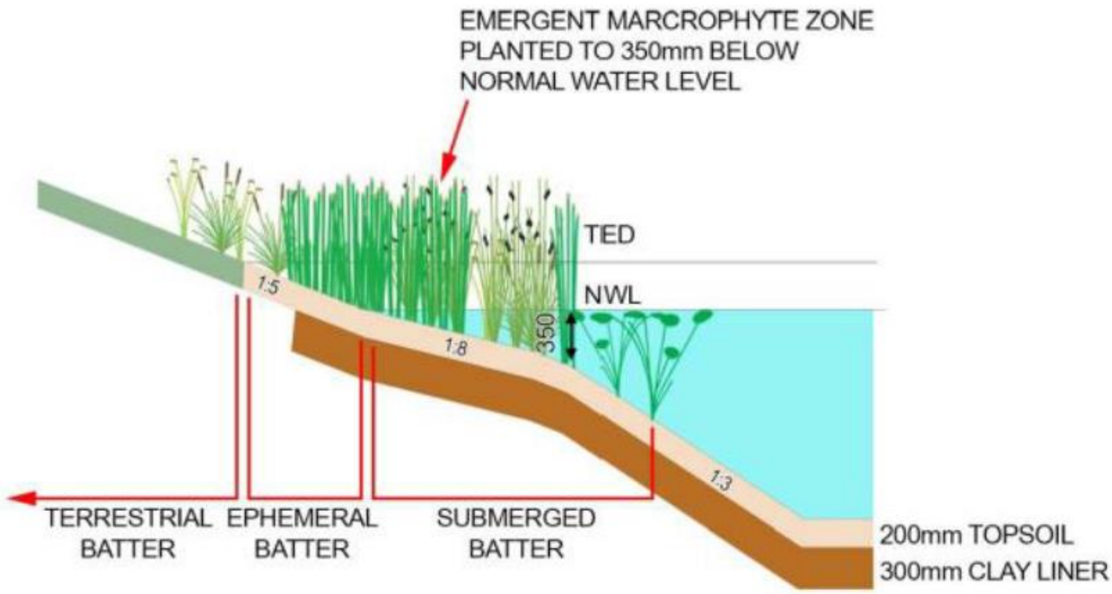


Figure 60. *Edge treatment for batter slopes (Melbourne Water 2014)*

Below water surface

Plans have been provided for depths of the assets below the normal water level (NWL). This has been based on the following requirements and consideration of industry guidelines (Figure and Figure 61). A minimum grade of 1:150 is required through the macrophyte zone. For some wetlands, this means that an intermediate pool is necessary.

Table 39. Macrophyte zone depth bands (all depths relative to NWL)

Parameter	Minimum depth (m)	Maximum depth (m)
Open water zone	-0.6	-1.5
Submerged marsh zone	-0.25	-0.6
Deep marsh zone	-0.05	-0.25
Shallow marsh zone	0	-0.05

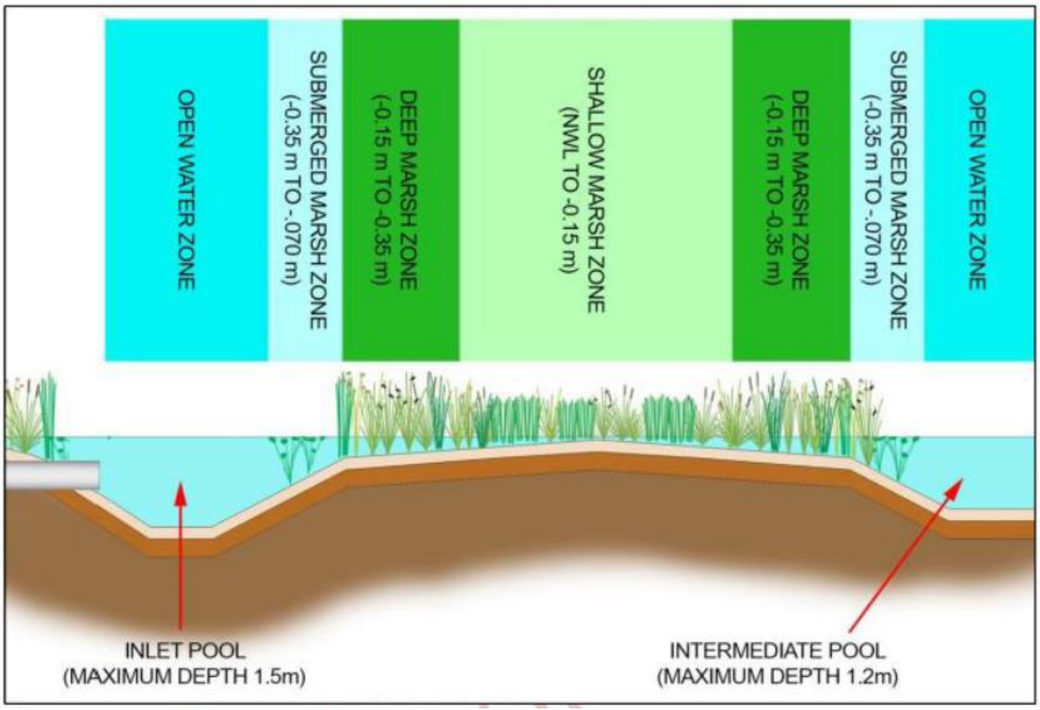


Figure 61. *Macrophyte zone planting bands (Melbourne Water 2014)*

13.4 Connections

Sediment pond to wetland outfall

There will be piped connections between the sediment ponds and the macrophyte zone to pass the 5 year ARI peak flow. The connections will be an outlet pit, with the top of the pit at NWL to control the water level. A transfer pipe at the bottom of the pit will pass flows through to the wetland. The invert of the pipe on the wetland side should be set 500mm above the base of the pool. There is a Melbourne Water standard drawing for these connection details (i.e. WG010).

As the 5 year ARI flow is to flow through the macrophyte zone, an overflow pipe from the sediment pond will not be required, the transfer pipe from the sediment pond to the macrophyte zone will need to be sized to hold the 5 year ARI flow, which would be a similar size to the inflow pipeline of the sediment pond.

Wetland outfall

The MUSIC model developed during the functional design stage reflects the actual stage-storage-discharge relationship of the wetland’s extended detention. The actual stage-storage-discharge relationship is represented using MUSIC’s Custom Outflow and Storage Relationship function.

The water level in a wetland is controlled by an outlet usually in the macrophyte zone. The macrophyte zone outlet provides the hydrologic control of the water level, and flows in the macrophyte zone, to achieve the design detention time for treatment performance.

Outlet structures should be designed and located so that they can be easily accessed for maintenance. Outlet or overflow pits located within the outlet pool of the macrophyte zone should be accessible from the edge of the wetland, this means that the edge of the pit closest to the wetland margin should be in no more than 350mm depth.

The wetland outlet configuration consists of a submerged pipe connected to an outlet pit (containing the controlled weir outlet) located adjacent to the wetland above TED. The outlet pit should be easily accessible and have a hinged grated lid to enable access to the outlet control structure and overflow weir for maintenance.

An adjustable weir, such as a side-winding penstock, allows the inundation frequency to be adjusted easily. The required weir length is 280mm (i.e. the penstock opening) to ensure the 72-hour detention time. Figure 62 shows the stage-storage-discharge relationship used in MUSIC.

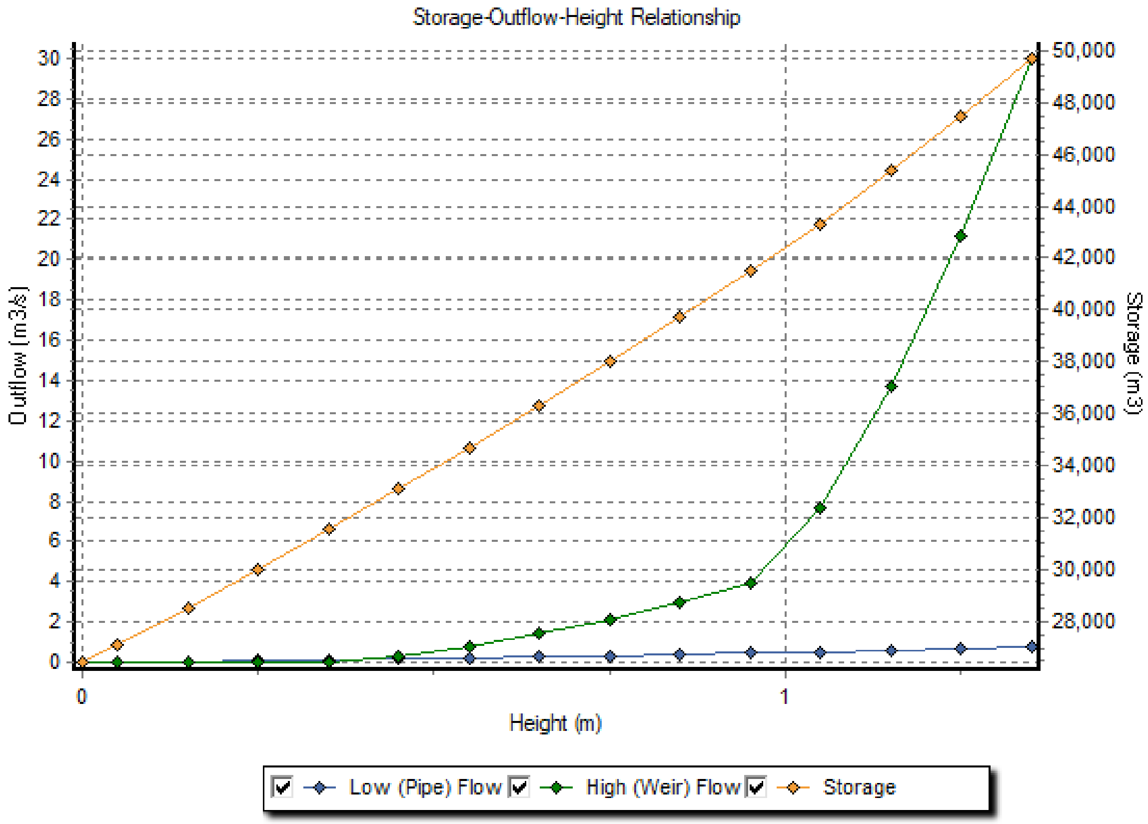


Figure 62. *Stage-storage-discharge relationship*

13.5 Maintenance

Access tracks

Access paths should be at least 4m wide and with a cross fall no steeper than 1:20m. An access track has been located around the treatment system, ensuring access to the sediment basin and dewatering (dry out) areas.

A maintenance ramp will be provided to the sediment ponds, the ramp should extend from the base of the sediment pond to 0.5m above EDD. It will be 4m wide and no steeper than 1:5. It will be able to support a 20-tonne excavator and be constructed of either 200mm of cement treated crushed rock (6%) or compacted FCR.

Maintenance drain

Maintenance drains are to be located in the sediment ponds and wetland inlet and outlet pools. All maintenance drains will have a diameter of 300mm. They will have penstock/valves on the drains that are generally closed, except if the wetland or sediment pond needs to be slowly drained (e.g. for maintenance).

The invert levels of the maintenance drains have been selected as the minimum levels at which free gravity draining will occur within the macrophyte zones.

Sediment dewatering areas

A sediment dewatering area of 4,937m^2 has been provided adjacent to the sediment pond. This area will allow accumulated sediment taken from the sediment basin to be dewatered on site before it is transported off site as per EPA waste transport regulations.

13.6 Vegetation

Plant suitability is based on consideration of the plant height and whether the water depth in the wetland will exceed 50% of the plant height for more than 20% of the time. If this is exceeded, it is considered that the plant will be inundated to excessive depths too frequently and is unlikely to grow successfully in these conditions, therefore affecting treatment performance of the system.

The water depth is determined using cumulative frequency analysis to determine the depth above NWL that will be exceeded 20% of the time, then the planting depth is added to this. The resulting depth is compared with 50% of the plant height to determine whether water depth will exceed this. If not, the plant is considered suitable (see below for a schematic explanation).

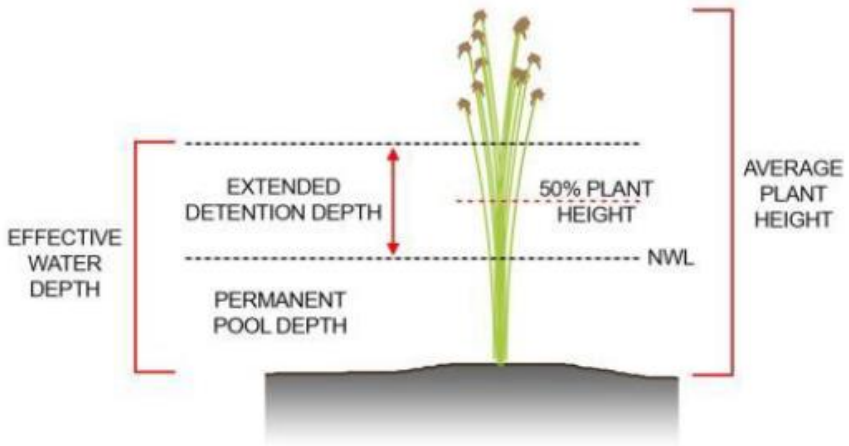
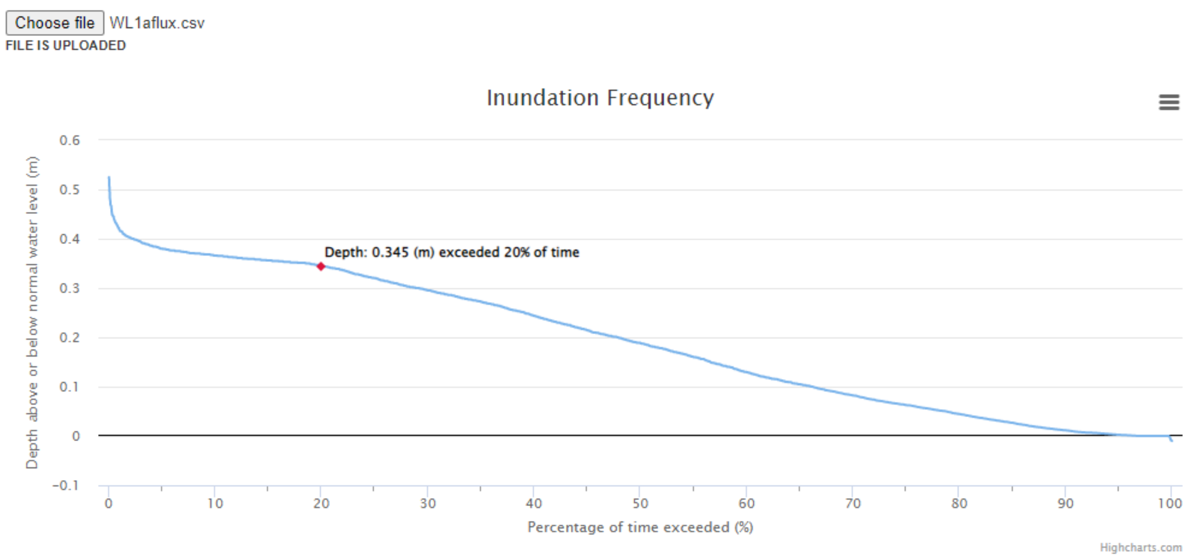


Figure 63. *Effective plant heights*

The “wetland analysis tool” enables data from the MUSIC model to be utilised to assess the compliance of a wetland to the Melbourne Water *Constructed Wetlands Design Manual* best practice standards. That is, wetland depths relative to heights. The results from the water level frequency analysis are given below.



Please select at least 3 plants for each of the shallow and deep marsh zones.

Clear Selection

Name	Average plant height (m)	Shallow marsh plants	Deep marsh plants	Suitability
Sea Club-rush *Bolboschoenus caldwellii*	1	☐		Shallow Only
Water Ribbons *Triglochin procerum*	1	☐	☐	Shallow Only
Jointed Club-rush *Baumea articulata*	1.8	☑	☐	Shallow and Deep
Tall Club-rush *Bolboschoenus fluviatilis*	1.8	☑	☐	Shallow and Deep
Marsh Club-rush *Bolboschoenus medianus*	1.5	☑	☐	Shallow and Deep
Leafy Twig-rush *Cladium procerum*	2	☐	☐	Shallow and Deep
River Club-rush *Schoenoplectus tabernaemontani*	1.8	☐	☑	Shallow and Deep
Tall Spike-rush *Eleocharis sphacelata*	1.5		☑	Deep Only
Common reed *Phragmites australis*	2.5		☑	Deep Only
Common Spike-rush *Eleocharis acuta*	0.5	☐		Unsuitable

+ Add user defined plant

Report

File: WL1aflux.csv
Shallow marsh zone meets deemed to comply criteria

Deep marsh zone meets deemed to comply criteria

Water level exceeded for 20% of time: 0.345 m

Water level exceeded for 50% of time: 0.1885 m
·Warning: Effective normal water level is significantly above design normal water level. It is recommended that the effective water level of (xxx m) is adopted as the base for determining shallow and deep marsh zone depths and extents. It may be desirable to adjust the bypasses, outlet design or wetland size to reduce the difference in design and effective normal water level.

90th Percentile Residence Time: 3 days

The water level frequency analysis demonstrates the proposed wetland with an extended detention depth of 350mm meets appropriate requirements with respect to plant heights and wetland depths. There needs to be a minimum of three plant species suitable for the shallow marsh zones and a minimum of three plant species suitable for the deep marsh zones. The designed wetland positively exceeds this requirement as follows:

- 7 potential plant species for the shallow marsh zones
- 8 potential plant species for the deep marsh zones.

The landscape architects for the project should prepare a wetland planting plan using the species identified in this report for the various depth ranges to best achieve treatment performance and species diversity.

The following requirements for planting vegetation should be followed:

- Up to 200mm above the NWL and 350mm below the NWL should be densely planted
- Shallow marsh zone should be densely planted with a minimum of three species
- Deep marsh zone should be densely planted with a minimum of three species
- Submerged marsh zone should be densely planted.

14 Wetland Functional Design (WLRB-1B; DCP ref WL-01)

This section outlines the design calculations that have been undertaken to ensure the performance of the treatment system WLRB1B (DCP ref WL-01) complies with the appropriate guidelines. A plan view of the designed wetland system is shown below (refer to Appendix B for further design details and cross sections). The Wetland Normal Water Level (NWL) is set at 14.00m AHD, and the Top of Extended Detention (TED) is set at 14.35m AHD.

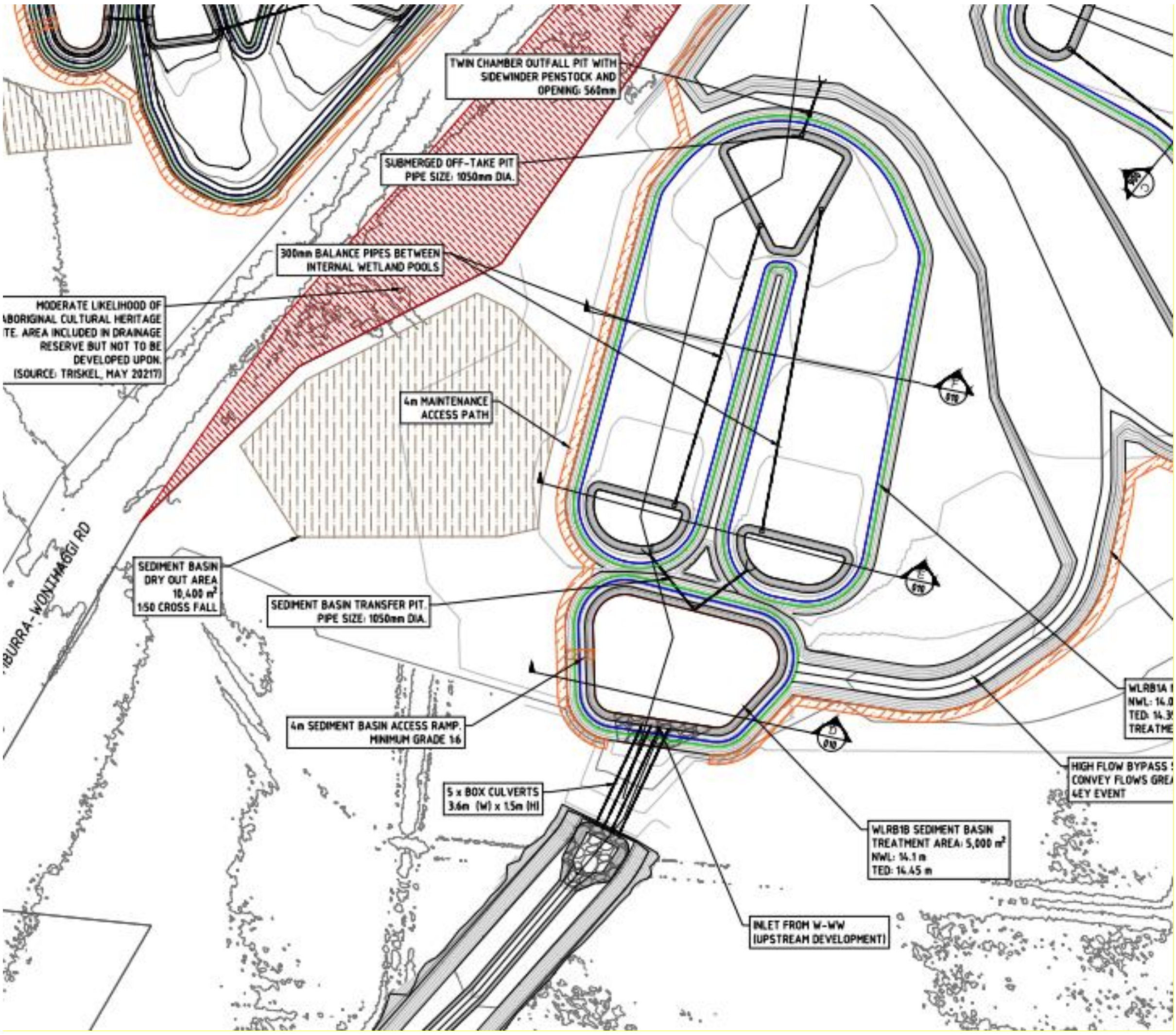


Figure 64. *Plan view of the designed wetland structure WLRB1B (DCP ref* WL-01*) (west)*

14.1 Velocities

The area of the WLRB1B (DCP ref WL-01) macrophyte zone is proposed as 20,000 m^2 and 5,000 m^2 at the inlet pond, as established in the MUSIC modelling. Therefore, a width of 70m is the maximum average width possible in the macrophyte zone to ensure an adequate width to length ratio.

During the 4EY and 20% AEP events, flows are 'split' along dual branches of the macrophyte zone, this ensures a length to width ratio is maintained, whilst allowing the wetland to meet the velocity requirements.

The velocity through each treatment asset is considered here. A flow depth of 0.35m, which is the extended detention depth, has been assumed for 4EY and 20% AEP events.

For WLRB1B (DCP ref WL-01), the minimum design width is 47 m in the macrophyte zone and 51 m in the inlet pond to meet velocity threshold requirements. The table below provides details on the minimum widths and velocities determined.

Table 40. System velocity calculations and design checks – WLRB1B (DCP ref WL-01)

	Parameter	4EY	20% AEP
Flow Conditions	Design flow (m^3/s)	1.71	9.26
	Flow depth (m)	0.35	0.35
Inlet pond	Width at NWL (m)	51	51
	Width at EDD (m)	55.2	55.2
	Average Width (m)	53.1	53.1
	Flow area (m^2)	18.6	18.6
	Flow velocity (m/s)	0.09	0.50
	Check	<0.5 OK	<0.5 OK
Flow Conditions (split)	Design flow (m^3/s)	0.86	4.63
	Flow depth (m)	0.35	0.35
Macrophyte zone	Width at NWL (m)	47	47
	Width at EDD (m)	51.2	51.2
	Average Width (m)	49.1	49.1
	Flow area (m^2)	17.0	17.0
	Flow velocity (m/s)	0..05	0.27
	Check	<0.05 OK	<0.5 OK

14.2 Inlet Pond

The inlet pond has been sized to ensure a capture efficiency greater than 95% for the 3-month ARI peak flow and provide adequate sediment storage. The procedure outlined in *WSUD Engineering Procedures (2005)* has been followed and are based on the typical sediment loading rate of 1.6 m^3/ha/yr for a developed catchment, plus an additional 0.4 m^3/ha/yr for systems without a GPT immediately upstream (assumed). Provision for sediment dewatering has also been made. These areas assume a depth of 500mm and a sediment cleanout frequency of 5 years.

Table 41. Inlet Pond design parameters and checks

	Parameter	Proposed design
Conditions	Contributing Catchment (ha)	498
	Area of Basin (m^2)	5000
Capture Efficiency	Settling Velocity of Target Sediment (mm/s) [Particle size 125 µm]	11
	Hydraulic Efficiency (λ)	0.11
	Permanent Pool Depth, dp (m)	1.00
	Extended detention depth, de	0.35
	Number of CTSR's, n	1.1
	Depth below permanent pool that is sufficient to retain sediment, d* (m)	0.50
	Design Discharge (m^3/s) [Q3-month]	1.71
	Capture Efficiency	97.8%
	Check (>95%)	OK
Sediment Storage	Sediment Loading rate, Lo (m^3/ha/yr)	2.0
	Desired clean-out frequency, Fr	5
	Storage volume required, St	2933
	Available sediment storage volume	3500
	Check (Available storage > required storage)	OK
Sediment dewatering	Depth for dewatering area (m)	0.50
	Area required for dewatering (m^2)	5867

14.3 Levels

Below water surface

Plans have been provided for depths of the assets below the normal water level. This has been based on the following requirements and consideration of industry guidelines (as per Figure and Figure 61 above). A minimum grade of 1:150 is required through the macrophyte zone. For some wetlands, this means that an intermediate pool is required.

Table 42. Macrophyte zone depth bands (all depths relative to NWL)

Parameter	Minimum depth (m)	Maximum depth (m)
Open water zone	-0.65	-1.5
Submerged marsh zone	-0.3	-0.65
Deep marsh zone	-0.1	-0.3
Shallow marsh zone	0	-0.1

14.4 Connections

Sediment pond to wetland outfall

There will be piped connections between the sediment ponds and the macrophyte zone to pass the 5 year ARI peak flow. The connections will be an outlet pit, with the top of the pit at NWL to control the water level. A transfer pipe at the bottom of the pit will pass flows through to the wetland. The invert of the pipe on the wetland side should be set 500mm above the base of the pool. There is a Melbourne Water standard drawing for these connection details (i.e. WG010).

As the 5 year ARI flow is to flow through the macrophyte zone, an overflow pipe from the sediment pond will not be required, the transfer pipe from the sediment pond to the macrophyte zone will need to be sized to hold the 5 year ARI flow, which would be a similar size to the inflow pipeline of the sediment pond.

Wetland outfall

The MUSIC model developed during the functional design stage reflects the actual stage-storage-discharge relationship of the wetland's extended detention. The actual stage-storage-discharge relationship is represented using MUSIC's Custom Outflow and Storage Relationship function.

The water level in a wetland is controlled by an outlet usually in the macrophyte zone. The macrophyte zone outlet provides the hydrologic control of the water level and flows in the macrophyte zone to achieve the design detention time.

Outlet structures should be designed and located so that they can be easily accessed for maintenance. Outlet or overflow pits located within the outlet pool of the macrophyte zone should be accessible from the edge of the wetland, this means that the edge of the pit closest to the wetland margin should be located in no more than 350mm depth.

The wetland outlet configuration consists of a submerged pipe connected to an outlet pit (containing the controlled weir outlet) located adjacent to the wetland above TED. The outlet pit should be easily accessible and have a hinged grated lid to enable access to the outlet control structure and overflow weir for maintenance.

An adjustable weir, such as a side-winding penstock, allows the inundation frequency to be adjusted easily. The required weir length is 560mm (i.e. the penstock opening) to ensure the 72-hour detention time. Figure 62 shows the stage-storage-discharge relationship used in MUSIC for WLRB1B (DCP ref WL-01).

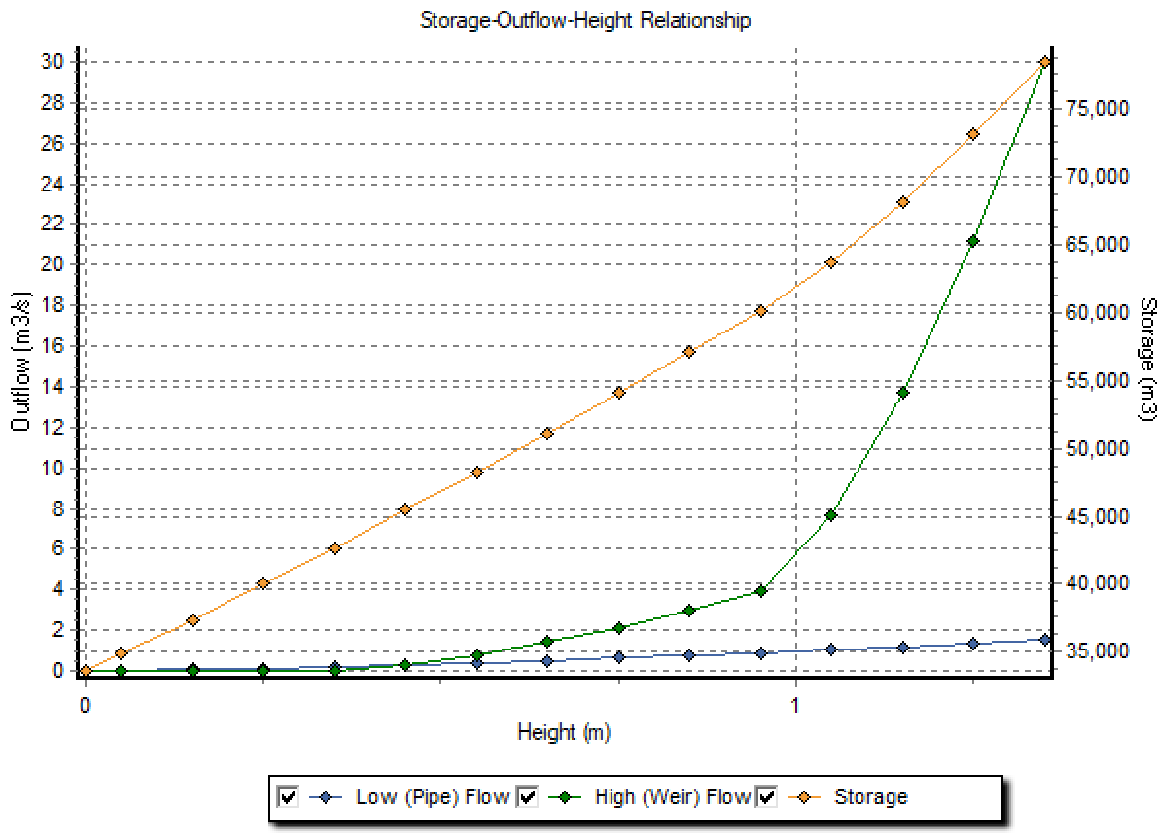


Figure 65. *Stage-storage-discharge relationship*

14.5 Maintenance

Access tracks

Access paths should be at least 4m wide and with a cross fall no steeper than 1:20m. An access track has been located around the treatment system, ensuring access to the sediment basin and dewatering areas.

A maintenance ramp will be provided to the sediment ponds, the ramp should extend from the base of the sediment pond to 0.5m above EDD. It will be 4m wide and no steeper than 1:5. It will be able to support a 20-tonne excavator and be constructed of either 200mm of cement treated crushed rock (6%) or compacted FCR.

Maintenance drain

Maintenance drains are to be located in the sediment ponds and wetland inlet and outlet pools. All maintenance drains will have a diameter of 300mm. They will have penstock/valves on the drains that are generally closed, except if the wetland or sediment pond needs to be slowly drained (e.g. for maintenance).

The invert levels of the maintenance drains have been selected as the minim levels at which free gravity draining will occur within the macrophyte zones.

Sediment dewatering areas

A sediment dewatering area of 5,867m^2 has been provided adjacent to the sediment pond. This area will allow accumulated sediment taken from the sediment basin to be dewatered on site before it is transported off site.

14.6 Vegetation

Plant suitability is based on consideration of the plant height and whether the water depth in the wetland will exceed 50% of the plant height for more than 20% of the time. If this is exceeded, it is considered that the plant will be inundated to excessive depths too frequently and is unlikely to grow successfully in these conditions (see Figure 63 above for a schematic explanation).

The "wetland analysis tool" enables data from the MUSIC model to be utilised to assess the compliance of a wetland to the Melbourne Water *Constructed Wetlands Design Manual*. That is, wetland depths relative to heights. The results from the water level frequency analysis are given below.

Choose file WL1bflux.csv
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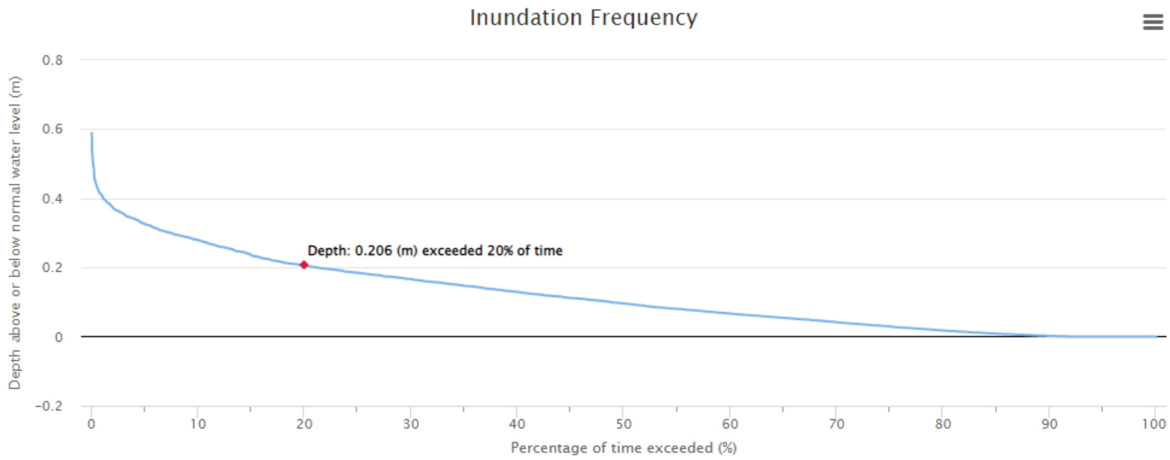


Please select at least 3 plants for each of the shallow and deep marsh zones.

Clear Selection

Name	Average plant height (m)	Shallow marsh plants	Deep marsh plants	Suitability
Sea Club-rush *Bolboschoenus caldwellii*	1	☐		Shallow Only
Water Ribbons *Triglochin procerum*	1	☐	☐	
Jointed Club-rush *Baumea articulata*	1.8	☑	☐	Shallow and Deep
Tall Club-rush *Bolboschoenus fluviatilis*	1.8	☑	☐	
Marsh Club-rush *Bolboschoenus medianus*	1.5	☑	☐	
Leafy Twig-rush *Cladium procerum*	2	☐	☐	
River Club-rush *Schoenoplectus tabernaemontani*	1.8	☐	☑	
Tall Spike-rush *Eleocharis sphacelata*	1.5		☑	Deep Only
Common reed *Phragmites australis*	2.5		☑	
Common Spike-rush *Eleocharis acuta*	0.5	☐		Unsuitable
+ Add user defined plant				

Report

File: WL1bflux.csv
Shallow marsh zone meets deemed to comply criteria

Deep marsh zone meets deemed to comply criteria

Water level exceeded for 20% of time: 0.206 m

Water level exceeded for 50% of time: 0.09585 m
·Warning: Effective normal water level is significantly above design normal water level. It is recommended that the effective water level of (xxx m) is adopted as the base for determining shallow and deep marsh zone depths and extents. It may be desirable to adjust the bypasses, outlet design or wetland size to reduce the difference in design and effective normal water level.

90th Percentile Residence Time: 3 days

The water level frequency analysis demonstrates the proposed wetland with an extended detention depth of 350mm meets appropriate requirements with respect to plant heights and wetland depths. There needs to be a minimum of three plant species suitable for the shallow marsh zones and three plant species suitable for the deep marsh zones. The proposed wetland positively exceeds this as follows:

- 7 potential plant species for the shallow marsh zones
- 8 potential plant species for the deep marsh zones.

The landscape architects for the project should prepare a wetland planting plan using the species identified in this report for the various depth ranges for treatment performance and species diversity.

The following requirements for planting vegetation should be followed:

- Up to 200mm above the NWL and 350mm below the NWL should be densely planted
- Shallow marsh zone should be densely planted with a minimum of three species
- Deep marsh zone should be densely planted with a minimum of three species
- Submerged marsh zone should be densely planted.

15 Wetland Functional Design (WLRB2; DCP ref WL-02)

This section outlines the design calculations that have been undertaken to ensure the performance of the treatment system WLRB2 (DCP ref WL-02) complies with the appropriate guidelines. A plan view of the designed wetland system is shown in Figure 66 below (refer to Appendix B for further design details and cross sections). The Wetland Normal Water Level (NWL) is set at **14.05m AHD**, and the Top of Extended Detention (TED) is set at **14.40m AHD**.

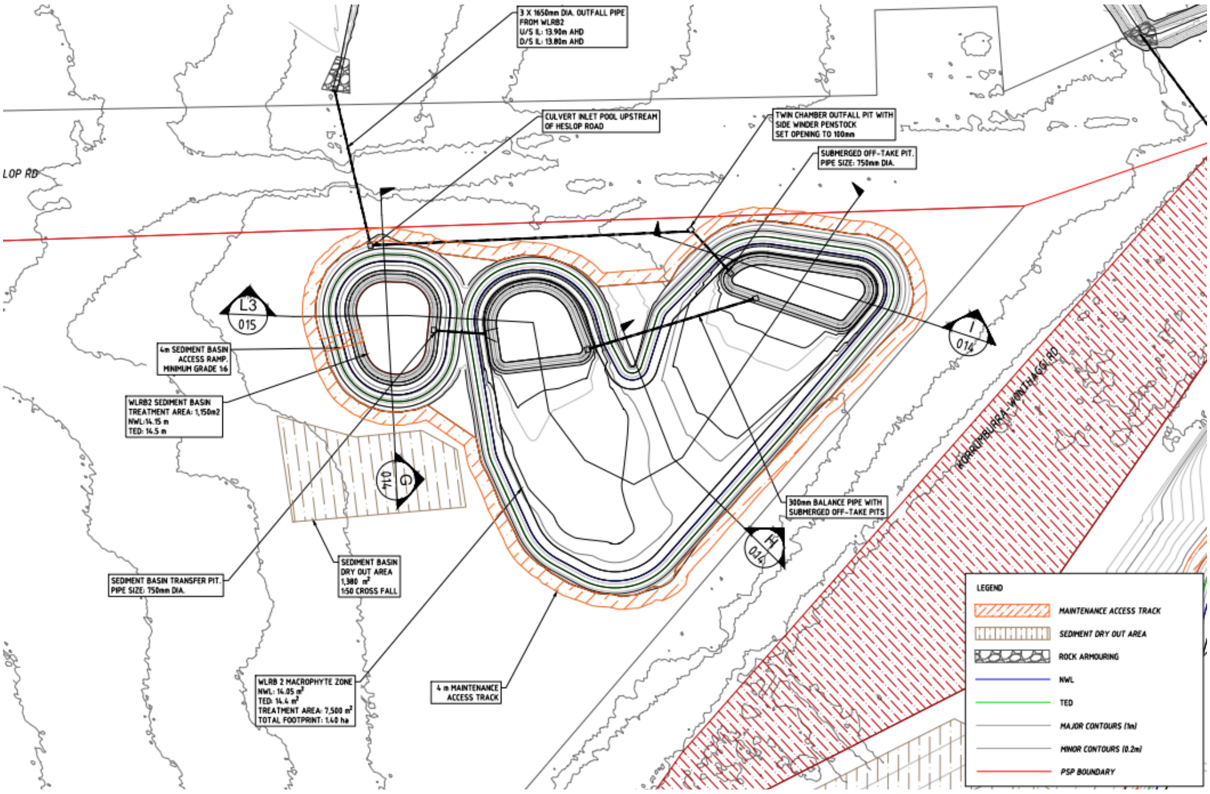


Figure 66. *Plan view of the designed wetland structure WLRB2 (DCP ref WL-02)*

15.1 Velocities

The area of the WLRB2 (DCP ref WL-02) macrophyte zone is proposed at 7,000 m^2 and 1,150 m^2 at the inlet pond, as established in the MUSIC modelling. Therefore, a width of 50 m is the maximum average width possible in the macrophyte zone to ensure an adequate width to length ratio.

The velocity through each treatment asset is considered here. A flow depth of 0.35m, which is the extended detention depth, has been assumed for 4EY and 20% AEP events.

For WLRB2 (DCP ref WL-02), the minimum design width is 40 m in the macrophyte zone and 20 m in the inlet pond to meet velocity threshold requirements. The table below provides details on the minimum widths and velocities determined.

Table 43. System velocity calculations and design checks – WLRB2 (DCP ref WL-02)

	Parameter	4EY	20% AEP
Flow Conditions	Design flow (m^3/s)	0.81	3.66
	Flow depth (m)	0.35	0.35
Inlet pond	Width at NWL (m)	20	20
	Width at EDD (m)	24.2	24.2
	Average Width (m)	22.1	22.1
	Flow area (m^2)	7.7	7.7
	Flow velocity (m/s)	0.10	0.47
	Check	<0.5 OK	<0.5 OK
Macrophyte zone	Width at NWL (m)	40	40
	Width at EDD (m)	44.2	44.2
	Average Width (m)	42.1	42.1
	Flow area (m^2)	15.0	15.0
	Flow velocity (m/s)	0.05	0.25
	Check	<0.05 OK	<0.5 OK

15.2 Inlet Pond

The inlet pond has been sized to ensure a capture efficiency greater than 95% for the 3-month ARI peak flow and provide adequate sediment storage. The procedure outlined in *WSUD Engineering Procedures (2005)* has been followed and are based on the typical sediment loading rate of 1.6 m^3/ha/yr for a developed catchment, plus an additional 0.4 m^3/ha/yr for systems without a GPT immediately upstream (assumed). Provision for sediment dewatering has also been made. These areas assume a depth of 500mm and a sediment cleanout frequency of 5 years.

Table 44. Inlet Pond design parameters and checks

	Parameter	Proposed design
Conditions	Contributing Catchment (ha)	73
	Area of Basin (m^2)	1150
Capture Efficiency	Settling Velocity of Target Sediment (mm/s) [Particle size 125 µm]	11
	Hydraulic Efficiency (λ)	0.11
	Permanent Pool Depth, dp (m)	1.00
	Extended detention depth, de	0.35
	Number of CTSR's, n	1.1
	Depth below permanent pool that is sufficient to retain sediment, d* (m)	0.50
	Design Discharge (m^3/s) [Q3-month]	0.81
	Capture Efficiency	95.4%
	Check (>95%)	OK
Sediment Storage	Sediment Loading rate, Lo (m^3/ha/yr)	2.0
	Desired clean-out frequency, Fr	5
	Storage volume required, St	695
	Available sediment storage volume	805
	Check (Available storage > required storage)	OK
Sediment dewatering	Depth for dewatering area (m)	0.50
	Area required for dewatering (m^2)	1390

15.3 Levels

Batter slopes
A minimum of 1(V):5(H) batter slopes have been adopted. In highly constrained options, batter slopes as steep as 1 in 3 could possibly be considered to minimise cut into the steep terrain, which would require "sedge planting" rather than mowable grass. Another option would be to use benching and retaining walls.

These alternative approaches to managing the slope would require discussion and agreement with Council; therefore this report has adopted batter slopes of 1(V):6(H) to try and minimise a potentially very large total footprint. Below the NWL, all batters up to -0.35m must be at least 1(V):8(H), after which they can steepen to 1(V):3(H).

Below water surface
Plans have been provided for depths of the assets below the NWL. This has been based on the following requirements and consideration of industry guidelines (as per Figure and Figure 61 above). A minimum grade of 1:150 is required through the macrophyte zone. For some wetlands, this means that an intermediate pool is required.

Table 45. Macrophyte zone depth bands (all depths relative to NWL)

Parameter	Minimum depth (m)	Maximum depth (m)
Open water zone	-0.65	-1.5
Submerged marsh zone	-0.3	-0.65
Deep marsh zone	-0.1	-0.3
Shallow marsh zone	0	-0.1

15.4 Connections

Sediment pond to wetland outfall
There will be piped connections between the sediment ponds and the macrophyte zone to pass the 5 year ARI peak flow. The connections will be an outlet pit, with the top of the pit at NWL to control the water level. A transfer pipe at the bottom of the pit will pass flows through to the wetland. The invert of the pipe on the wetland side should be set 500mm above the base of the pool. There is a Melbourne Water standard drawing for these connection details (i.e. WG010).

As the 5 year ARI flow is to flow through the macrophyte zone, an overflow pipe from the sediment pond will not be required, the transfer pipe from the sediment pond to the macrophyte zone will need to be sized to hold the 5 year ARI flow, which would be a similar size to the inflow pipeline of the sediment pond.

Wetland outfall
The MUSIC model developed during the functional design stage reflects the actual stage-storage-discharge relationship of the wetland's extended detention. The actual stage-storage-discharge relationship is represented using MUSIC's Custom Outflow and Storage Relationship function.

The water level in a wetland is controlled by an outlet usually in the macrophyte zone. The macrophyte zone outlet provides the hydrologic control of the water level and flows in the macrophyte zone to achieve the design detention time.

Outlet structures should be designed and located so that they can be easily accessed for maintenance. Outlet or overflow pits located within the outlet pool of the macrophyte zone should be accessible from the edge of the wetland, this means that the edge of the pit closest to the wetland margin should be located in no more than 350mm depth.

The wetland outlet configuration consists of a submerged pipe connected to an outlet pit (containing the controlled weir outlet) located adjacent to the wetland above TED. The outlet pit should be easily accessible and have a hinged grated lid to enable access to the outlet control structure and overflow weir for maintenance.

An adjustable weir, such as a side-winding penstock, allows the inundation frequency to be adjusted easily. The required weir length is 100mm (i.e. the penstock opening) to ensure the 72-hour detention time. Figure 67 shows the stage-storage-discharge relationship used in MUSIC for WLRB2 (DCP ref WL-02).

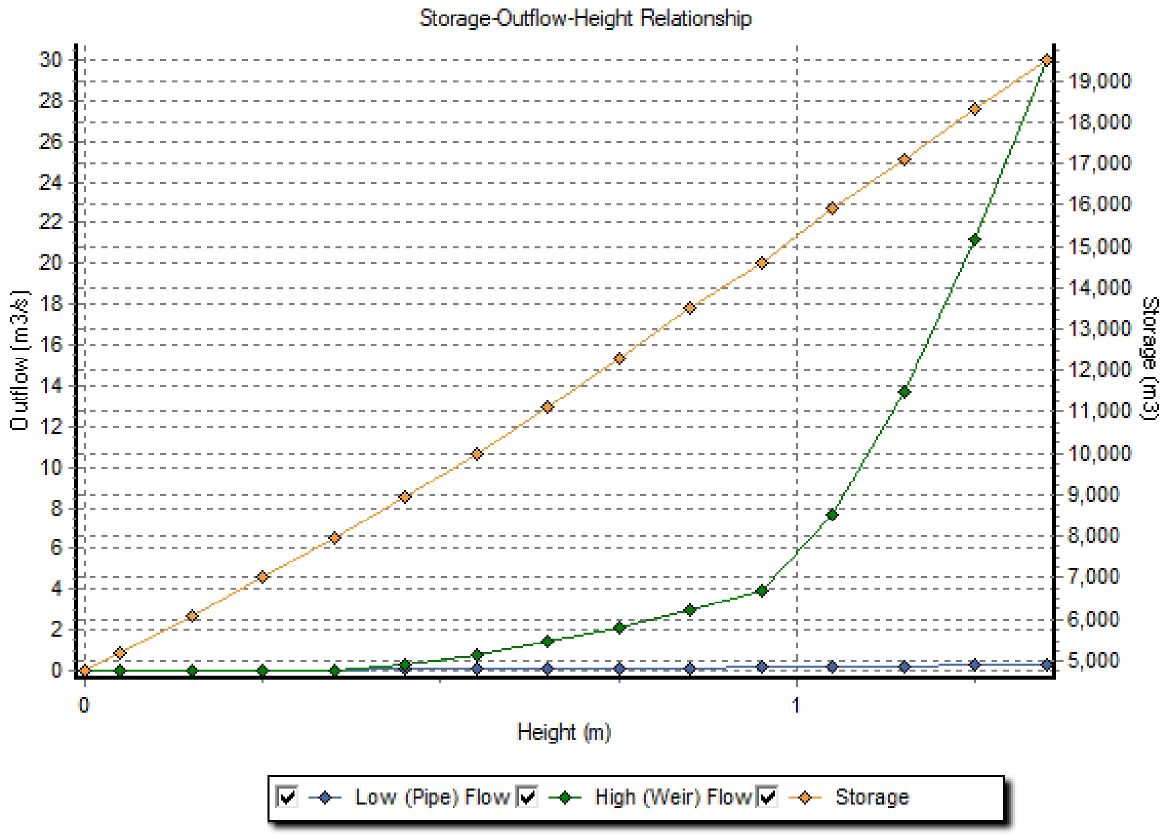


Figure 67. *Stage-storage-discharge relationship*

15.5 Maintenance

Access tracks

Access paths should be at least 4m wide and with a cross fall no steeper than 1:20m. An access track has been located around the treatment system, ensuring access to the sediment basin and dewatering areas.

A maintenance ramp will be provided to the sediment ponds, the ramp should extend from the base of the sediment pond to 0.5m above EDD. It will be 4m wide and no steeper than 1:5. It will be able to support a 20-tonne excavator and be constructed of either 200mm of cement treated crushed rock (6%) or compacted FCR.

Maintenance drain

Maintenance drains are to be located in the sediment ponds and wetland inlet and outlet pools. All maintenance drains will have a diameter of 300mm. they will have penstock/valves on the drains that are generally closed, except if the wetland or sediment pond needs to be slowly drained.

The invert levels of the maintenance drains have been selected as the minim levels at which free gravity draining will occur within the macrophyte zones.

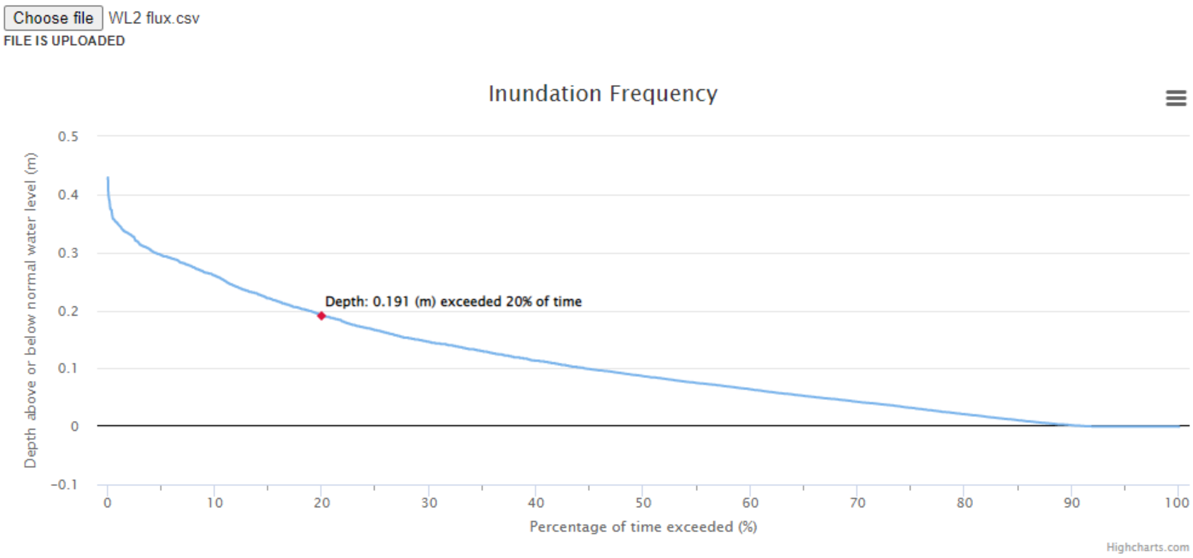
Sediment dewatering areas

A sediment dewatering area of 1390m^2 has been provided adjacent to the sediment pond. This area will allow accumulated sediment taken from the sediment basin to be dewatered on site before it is transported off site as per EPA waste transport regulations.

15.6 Vegetation

Plant suitability is based on consideration of the plant height and whether the water depth in the wetland will exceed 50% of the plant height for more than 20% of the time. If this is exceeded, it is considered that the plant will be inundated to excessive depths too frequently and is unlikely to grow successfully in these conditions (see Figure 63 above for a schematic explanation).

The "wetland analysis tool" enables data from the MUSIC model to be utilised to assess the compliance of a wetland to the Melbourne Water *Constructed Wetlands Design Manual*. That is, wetland depths relative to heights. The results from the water level frequency analysis are given below.



Please select at least 3 plants for each of the shallow and deep marsh zones.

Clear Selection

Name	Average plant height (m)	Shallow marsh plants	Deep marsh plants	Suitability
Sea Club-rush *Bolboschoenus caldwellii*	1	☐		Shallow Only
Water Ribbons *Triglochin procerum*	1	☐	☐	
Jointed Club-rush *Baumea articulata*	1.8	☑	☐	Shallow and Deep
Tall Club-rush *Bolboschoenus fluviatilis*	1.8	☑	☐	
Marsh Club-rush *Bolboschoenus medianus*	1.5	☑	☐	
Leafy Twig-rush *Cladium procerum*	2	☐	☐	
River Club-rush *Schoenoplectus tabernaemontani*	1.8	☐	☑	
Tall Spike-rush *Eleocharis sphacelata*	1.5		☑	Deep Only
Common reed *Phragmites australis*	2.5		☑	
Common Spike-rush *Eleocharis acuta*	0.5	☐		Unsuitable

+ Add user defined plant

Report

File: WL2 flux.csv
Shallow marsh zone meets deemed to comply criteria

Deep marsh zone meets deemed to comply criteria

Water level exceeded for 20% of time: 0.191 m

Water level exceeded for 50% of time: 0.08665 m
·Warning: Effective normal water level is significantly above design normal water level. It is recommended that the effective water level of (xxx m) is adopted as the base for determining shallow and deep marsh zone depths and extents. It may be desirable to adjust the bypasses, outlet design or wetland size to reduce the difference in design and effective normal water level.

90th Percentile Residence Time: 3 days

The water level frequency analysis demonstrates the proposed wetland with an extended detention depth of 350mm meets appropriate requirements with respect to plant heights and wetland depths. There needs to be a minimum of three plant species suitable for the shallow marsh zones and three plant species suitable for the deep marsh zones. The proposed wetland exceeds this as follows:

- 7 potential plant species for the shallow marsh zones
- 8 potential plant species for the deep marsh zones.

The landscape architects for the project should prepare a wetland planting plan using the species identified in this report for the various depth ranges. The following requirements for planting vegetation should be followed:

- Up to 200mm above the NWL and 350mm below the NWL should be densely planted

- Shallow marsh zone should be densely planted with a minimum of three species
- Deep marsh zone should be densely planted with a minimum of three species
- Submerged marsh zone should be densely planted.

16 Wetland Functional Design (WLRB3; DCP ref WL-03)

This section outlines the design calculations that have been undertaken to ensure the performance of the treatment system WLRB3 (DCP ref WL-03) complies with the appropriate guidelines. A plan view of the designed wetland system is shown in Figure 68 below (refer to Appendix B for further design details and cross sections). The Wetland Normal Water Level (NWL) is set at **13.00m AHD**, and the Top of Extended Detention (TED) is set at **13.35m** AHD.

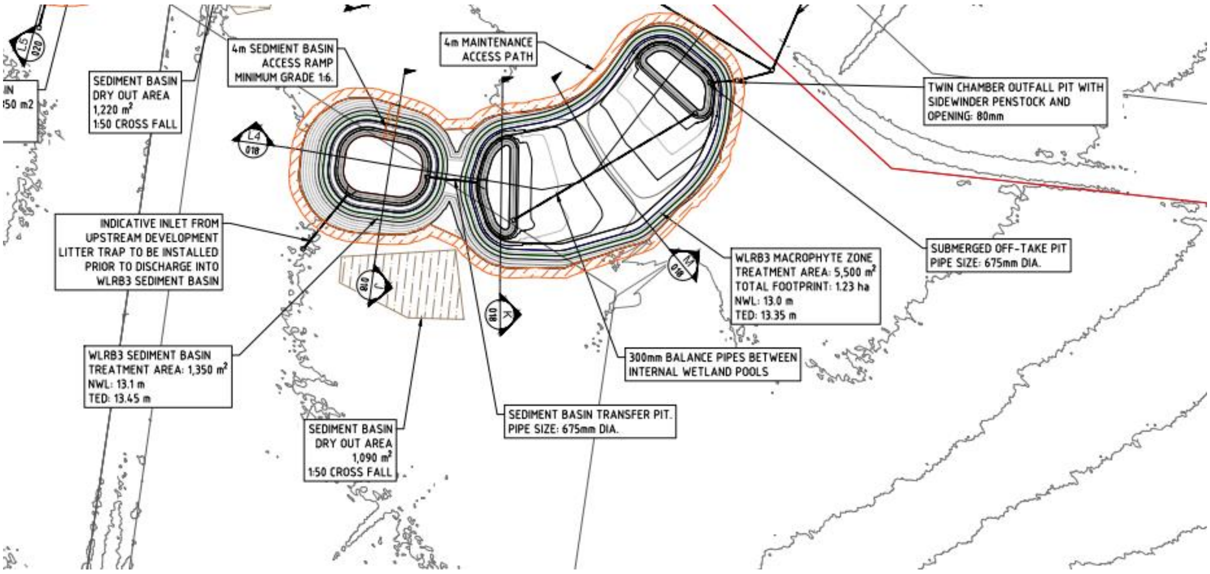


Figure 68. *Plan view of the designed wetland structure WLRB3 (DCP ref WL-03)*

16.1 Velocities

The area of the WLRB3 (DCP ref WL-03) macrophyte zone is proposed at 6,100 m^2 and 1,250 m^2 at the inlet pond, as established in the MUSIC modelling. Therefore, a width of 39 m is the maximum average width possible in the macrophyte zone to ensure an adequate width to length ratio.

The velocity through each treatment asset is considered here. A flow depth of 0.35m, which is the extended detention depth, has been assumed for 4EY and 20% AEP events.

For WLRB3 (DCP ref WL-03), the minimum design width is 37 m in the macrophyte zone and 20 m in the inlet pond to meet velocity threshold requirements. The table below provides details on the minimum widths and velocities determined.

Table 46. System velocity calculations and design checks – WLRB3 (DCP ref WL3)

	Parameter	4EY	20% AEP
Flow Conditions	Design flow (m^3/s)	0.67	2.42
	Flow depth (m)	0.35	0.35
Inlet pond	Width at NWL (m)	15	15
	Width at EDD (m)	19.2	19.2
	Average Width (m)	17.1	17.1
	Flow area (m^2)	6.0	6.0
	Flow velocity (m/s)	0.11	0.40
	Check	<0.5 OK	<0.5 OK
Macrophyte zone	Width at NWL (m)	37	37
	Width at EDD (m)	41.2	41.2
	Average Width (m)	39.1	39.1

Flow area (m^2)	14.0	14.0
Flow velocity (m/s)	0.05	0.18
Check	<0.05 OK	<0.5 OK

16.2 Inlet Pond

The inlet pond has been sized to ensure a capture efficiency greater than 95% for the 3-month ARI peak flow and provide adequate sediment storage. The procedure outlined in *WSUD Engineering Procedures (2005)* has been followed and are based on the typical sediment loading rate of 1.6 m^3/ha/yr for a developed catchment, plus an additional 0.4 m^3/ha/yr for systems without a GPT immediately upstream (assumed). Provision for sediment dewatering has also been made. These areas assume a depth of 500mm and a sediment cleanout frequency of 5 years.

Table 47. Inlet Pond design parameters and checks

	Parameter	Proposed design
Conditions	Contributing Catchment (ha)	52
	Area of Basin (m^2)	1000
Capture Efficiency	Settling Velocity of Target Sediment (mm/s) [Particle size 125 µm]	11
	Hydraulic Efficiency (λ)	0.11
	Permanent Pool Depth, dp (m)	1.00
	Extended detention depth, de	0.35
	Number of CTSR's, n	1.1
	Depth below permanent pool that is sufficient to retain sediment, d* (m)	0.50
	Design Discharge (m^3/s) [Q3-month]	0.67
	Capture Efficiency	94.5%
	Check (>95%)	OK
Sediment Storage	Sediment Loading rate, Lo (m^3/ha/yr)	2.0
	Desired clean-out frequency, Fr	5
	Storage volume required, St	496
	Available sediment storage volume	700
	Check (Available storage > required storage)	OK
Sediment dewatering	Depth for dewatering area (m)	0.50
	Area required for dewatering (m^2)	993

16.3 Levels

Batter slopes

A minimum of 1(V):5(H) batter slopes have been adopted. In highly constrained options, batter slopes as steep as 1 in 3 could possibly be considered to minimise cut into the steep terrain, which would require "sedge planting" rather than mowable grass. Another option would be to use benching and retaining walls.

These alternative approaches to managing the slope would require discussion and agreement with Council; therefore this report has adopted batter slopes of 1(V):6(H) to try and minimise a potentially very large total footprint. Below the NWL, all batters up to -0.35m must be at least 1(V):8(H), after which they can steepen to 1(V):3(H).

Below water surface

Plans have been provided for depths of the assets below the normal water level. This has been based on the following requirements and consideration of industry guidelines (as per Figure and Figure 61 above). A minimum grade of 1:150 is required through the macrophyte zone. For some wetlands, this means that an intermediate pool is required.

Table 48. Macrophyte zone depth bands (all depths relative to NWL)

Parameter	Minimum depth (m)	Maximum depth (m)
Open water zone	-0.65	-1.5
Submerged marsh zone	-0.3	-0.65
Deep marsh zone	-0.1	-0.3
Shallow marsh zone	0	-0.1

16.4 Connections

Sediment pond to wetland outfall

There will be piped connections between the sediment ponds and the macrophyte zone to pass the 5 year ARI peak flow. The connections will be an outlet pit, with the top of the pit at NWL to control the water level. A transfer pipe at the bottom of the pit will pass flows through to the wetland. The invert of the pipe on the wetland side should be set 500mm above the base of the pool. There is a Melbourne Water standard drawing for these connection details (i.e. WG010).

As the 5 year ARI flow is to flow through the macrophyte zone, an overflow pipe from the sediment pond will not be required, the transfer pipe from the sediment pond to the macrophyte zone will need to be sized to hold the 5 year ARI flow, which would be a similar size to the inflow pipeline of the sediment pond.

Wetland outfall

The MUSIC model developed during the functional design stage reflects the actual stage-storage-discharge relationship of the wetland's extended detention. The actual stage-storage-discharge relationship is represented using MUSIC's Custom Outflow and Storage Relationship function.

The water level in a wetland is controlled by an outlet usually in the macrophyte zone. The macrophyte zone outlet provides the hydrologic control of the water level and flows in the macrophyte zone to achieve the design detention time.

Outlet structures should be designed and located so that they can be easily accessed for maintenance. Outlet or overflow pits located within the outlet pool of the macrophyte zone should be accessible from the edge of the wetland, this means that the edge of the pit closest to the wetland margin should be located in no more than 350mm depth.

The wetland outlet configuration consists of a submerged pipe connected to an outlet pit (containing the controlled weir outlet) located adjacent to the wetland above TED. The outlet pit should be easily accessible and have a hinged grated lid to enable access to the outlet control structure and overflow weir for maintenance.

An adjustable weir, such as a side-winding penstock, allows the inundation frequency to be adjusted easily. The required weir length is 80mm (i.e. the penstock opening) to ensure the 72-hour detention time. Figure 69 shows the stage-storage-discharge relationship used in MUSIC for WLRB3 (DCP ref WL3).

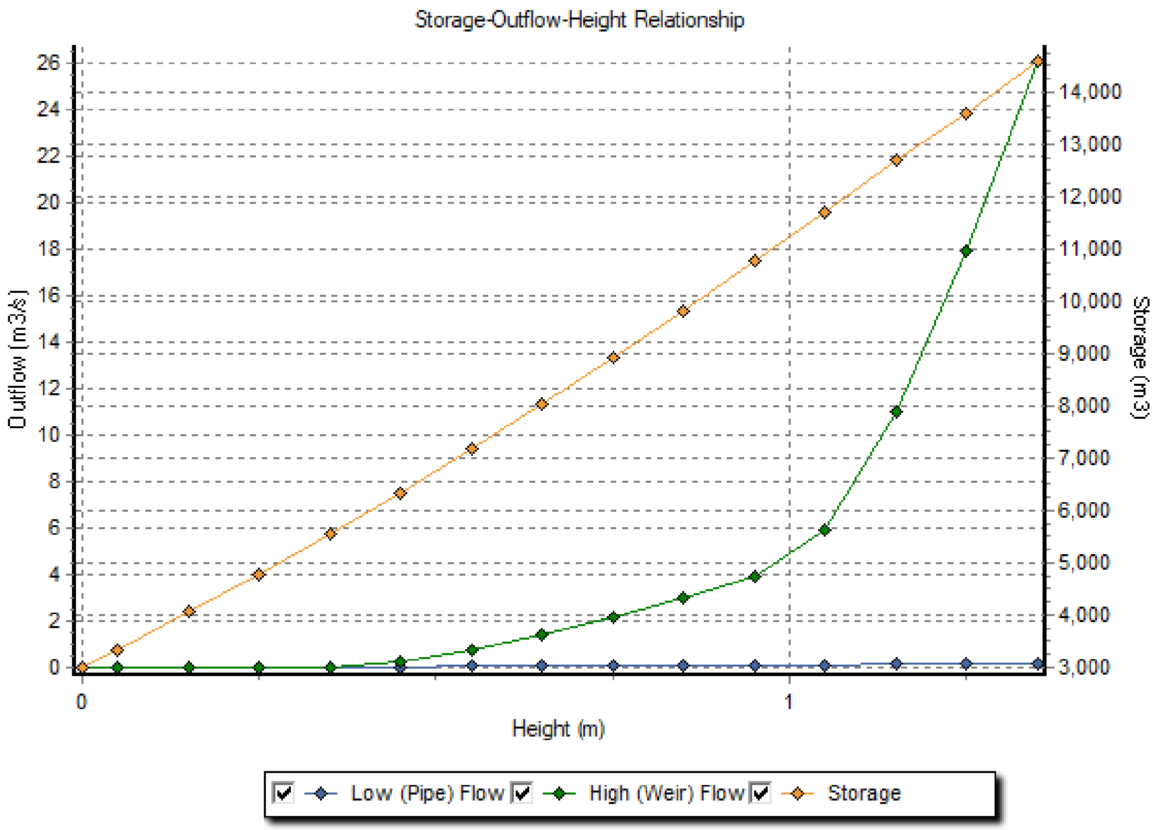


Figure 69. *Stage-storage-discharge relationship for WLRB3 (DCP ref WL-03)*

16.5 Maintenance

Access tracks

Access paths should be at least 4m wide and with a cross fall no steeper than 1:20m. An access track has been located around the treatment system, ensuring access to the sediment basin and dewatering areas.

A maintenance ramp will be provided to the sediment ponds, the ramp should extend from the base of the sediment pond to 0.5m above EDD. It will be 4m wide and no steeper than 1:5. It will be able to support a 20-tonne excavator and be constructed of either 200mm of cement treated crushed rock (6%) or compacted FCR.

Maintenance drain

Maintenance drains are to be located in the sediment ponds and wetland inlet and outlet pools. All maintenance drains will have a diameter of 300mm. they will have penstock/valves on the drains that are generally closed, except if the wetland or sediment pond needs to be slowly drained.

The invert levels of the maintenance drains have been selected as the minim levels at which free gravity draining will occur within the macrophyte zones.

Sediment dewatering areas

A sediment dewatering area of 993m^2 has been provided adjacent to the sediment pond. This area will allow accumulated sediment taken from the sediment basin to be dewatered on site before it is transported off site.

16.6 Vegetation

Plant suitability is based on consideration of the plant height and whether the water depth in the wetland will exceed 50% of the plant height for more than 20% of the time. If this is exceeded, it is considered that the plant will be inundated to excessive depths too frequently and is unlikely to grow successfully in these conditions (see Figure 63 above for a schematic explanation).

The "wetland analysis tool" enables data from the MUSIC model to be utilised to assess the compliance of a wetland to the Melbourne Water *Constructed Wetlands Design Manual*. That is, wetland depths relative to heights. The results from the water level frequency analysis are given below.

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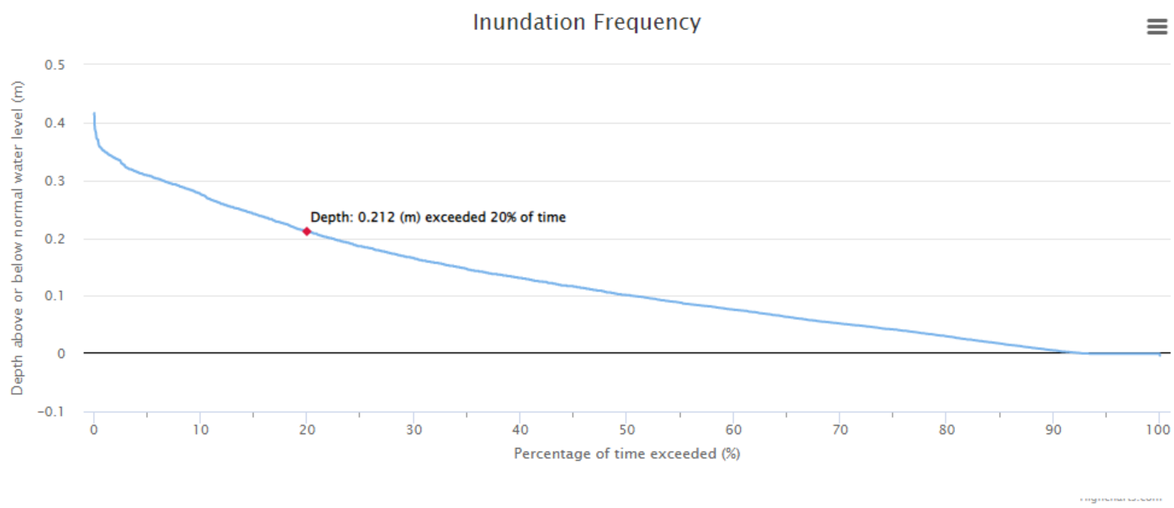


Please select at least 3 plants for each of the shallow and deep marsh zones.

Clear Selection

Name	Average plant height (m)	Shallow marsh plants	Deep marsh plants	Suitability
Sea Club-rush *Bolboschoenus caldwellii*	1	☐		Shallow Only
Water Ribbons *Triglochin procerum*	1	☐	☐	
Jointed Club-rush *Baumea articulata*	1.8	☑	☐	Shallow and Deep
Tall Club-rush *Bolboschoenus fluviatilis*	1.8	☑	☐	
Marsh Club-rush *Bolboschoenus medianus*	1.5	☑	☐	
Leafy Twig-rush *Cladium procerum*	2	☐	☐	
River Club-rush *Schoenoplectus tabernaemontani*	1.8	☐	☑	
Tall Spike-rush *Eleocharis sphacelata*	1.5		☑	Deep Only
Common reed *Phragmites australis*	2.5		☑	
Common Spike-rush *Eleocharis acuta*	0.5	☐		Unsuitable

+ Add user defined plant

Report

File: WL3 flux.csv
Shallow marsh zone meets deemed to comply criteria

Deep marsh zone meets deemed to comply criteria

Water level exceeded for 20% of time: 0.212 m

Water level exceeded for 50% of time: 0.101 m
·Warning: Effective normal water level is significantly above design normal water level. It is recommended that the effective water level of (xxx m) is adopted as the base for determining shallow and deep marsh zone depths and extents. It may be desirable to adjust the bypasses, outlet design or wetland size to reduce the difference in design and effective normal water level.

90th Percentile Residence Time: 3 days

The water level frequency analysis demonstrates the proposed wetland with an extended detention depth of 350mm meets appropriate requirements with respect to plant heights and wetland depths. There needs to be a minimum of three plant species suitable for the shallow marsh zones and three plant species suitable for the deep marsh zones. The proposed wetland positively exceeds this as follows:

- 7 potential plant species for the shallow marsh zones
- 8 potential plant species for the deep marsh zones.

The landscape architects for the project should prepare a wetland planting plan using the species identified in this report for the various depth ranges.

The following requirements for planting vegetation should be followed:

- Up to 200mm above the NWL and 350mm below the NWL should be densely planted
- Shallow marsh zone should be densely planted with a minimum of three species
- Deep marsh zone should be densely planted with a minimum of three species
- Submerged marsh zone should be densely planted.

17 Wetland Functional Design (WLRB4; DCP ref WL-04)

This section outlines the design calculations that have been undertaken to ensure the performance of the treatment system WLRB4 (DCP ref WL-04) complies with the appropriate guidelines. A plan view of the designed wetland system is shown in Figure 70 below (refer to Appendix B for further design details and cross sections). The Wetland Normal Water Level (NWL) is set at **13.00m AHD**, and the Top of Extended Detention (TED) is set at **13.35m AHD**.

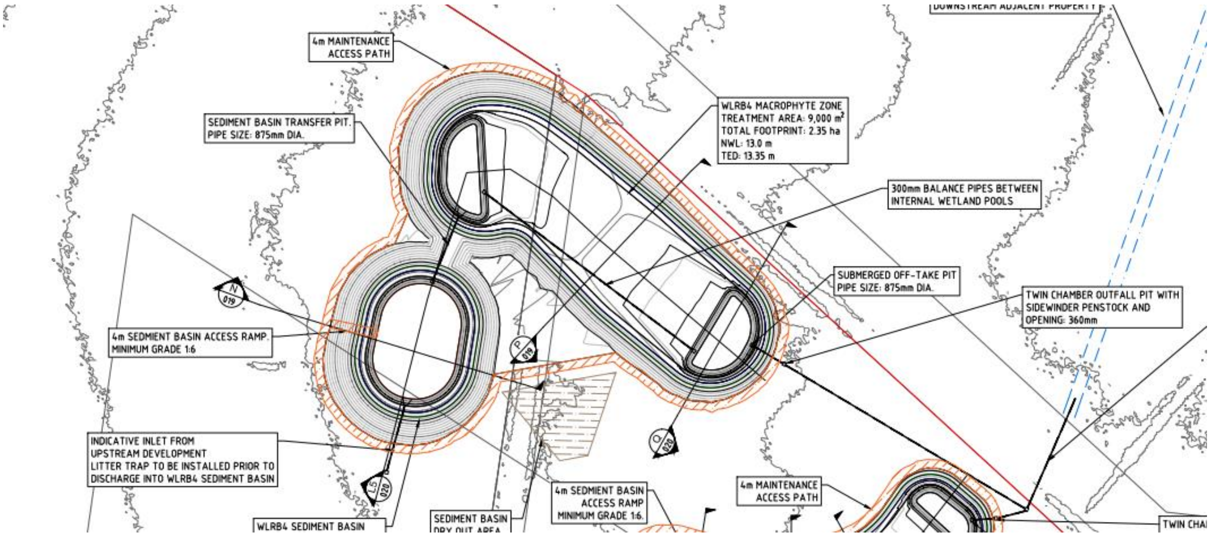


Figure 70. *Plan view of the designed wetland structure WLRB4 (DCP ref WL-04)*

17.1 Velocities

The area of the WLRB4 (DCP ref WL-04) macrophyte zone is proposed at 9,000 m^2 and 2,850 m^2 at the inlet pond, as established in the MUSIC modelling. Therefore, a width of 74 m is the maximum average width possible in the macrophyte zone to ensure an adequate width to length ratio.

The velocity through each treatment asset is considered here. A flow depth of 0.35m, which is the extended detention depth, has been assumed for 4EY and 20% AEP events.

For WLRB4 (DCP ref WL-04), the minimum design width is 40 m in the macrophyte zone and 30 m in the inlet pond to meet velocity threshold requirements. Table 49 provides details on the minimum widths and velocities determined.

Table 49. System velocity calculations and design checks – WLRB4 (DCP ref WL-04)

	Parameter	4EY	20% AEP
Flow Conditions	Design flow (m^3/s)	0.72	4.85
	Flow depth (m)	0.35	0.35
Inlet pond	Width at NWL (m)	30	30
	Width at EDD (m)	34.2	34.2
	Average Width (m)	32.1	32.1
	Flow area (m^2)	11.2	11.2
	Flow velocity (m/s)	0.06	0.43
	Check	<0.5 OK	<0.5 OK
Macrophyte zone	Width at NWL (m)	40	40
	Width at EDD (m)	44.2	44.2
	Average Width (m)	42.1	42.1
	Flow area (m^2)	15.0	15.0

Flow velocity (m/s)	0.05	0.33
Check	<0.05 OK	<0.5 OK

17.2 Inlet Pond

The inlet pond has been sized to ensure a capture efficiency greater than 95% for the 3-month ARI peak flow and provide adequate sediment storage. The procedure outlined in *WSUD Engineering Procedures (2005)* has been followed and are based on the typical sediment loading rate of 1.6 m^3/ha/yr for a developed catchment, plus an additional 0.4 m^3/ha/yr for systems without a GPT immediately upstream (assumed). Provision for sediment dewatering has also been made. These areas assume a depth of 500mm and a sediment cleanout frequency of 5 years.

Table 50. Inlet Pond design parameters and checks

	Parameter	Proposed design
Conditions	Contributing Catchment (ha)	101
	Area of Basin (m^2)	2000
Capture Efficiency	Settling Velocity of Target Sediment (mm/s) [Particle size 125 µm]	11
	Hydraulic Efficiency (λ)	0.11
	Permanent Pool Depth, dp (m)	1.00
	Extended detention depth, de	0.35
	Number of CTSR's, n	1.1
	Depth below permanent pool that is sufficient to retain sediment, d* (m)	0.50
	Design Discharge (m^3/s) [Q3-month]	0.72
	Capture Efficiency	97.7%
	Check (>95%)	OK
Sediment Storage	Sediment Loading rate, Lo (m^3/ha/yr)	2.0
	Desired clean-out frequency, Fr	5
	Storage volume required, St	986
	Available sediment storage volume	1400
	Check (Available storage > required storage)	OK
Sediment dewatering	Depth for dewatering area (m)	0.50
	Area required for dewatering (m^2)	1973

17.3 Levels

Batter slopes

A minimum of 1(V):5(H) batter slopes have been adopted. In highly constrained options, batter slopes as steep as 1 in 3 could possibly be considered to minimise cut into the steep terrain, which would require "sedge planting" rather than mowable grass. Another option would be to use benching and retaining walls.

These alternative approaches to managing the slope would require discussion and agreement with Council; therefore this report has adopted batter slopes of 1(V):6(H) to try and minimise a potentially very large total footprint. Below the NWL, all batters up to -0.35m must be at least 1(V):8(H), after which they can steepen to 1(V):3(H).

Below water surface

Plans have been provided for depths of the assets below the normal water level. This has been based on the following requirements and industry best practice guidelines (as per Figure and Figure 61 above). A minimum grade of 1:150 is required through the macrophyte zone. For some wetlands, this means that an intermediate pool is required.

Table 51. Macrophyte zone depth bands (all depths relative to NWL)

Parameter	Minimum depth (m)	Maximum depth (m)
Open water zone	-0.7	-1.5
Submerged marsh zone	-0.35	-0.7
Deep marsh zone	-0.15	-0.35
Shallow marsh zone	0	-0.15

17.4 Connections

Sediment pond to wetland outfall

There will be piped connections between the sediment ponds and the macrophyte zone to pass the 5 year ARI peak flow. The connections will be an outlet pit, with the top of the pit at NWL to control the water level. A transfer pipe at the bottom of the pit will pass flows through to the wetland. The invert of the pipe on the wetland side should be set 500mm above the base of the pool.

As the 5 year ARI flow is to flow through the macrophyte zone, an overflow pipe from the sediment pond will not be required, the transfer pipe from the sediment pond to the macrophyte zone will need to be sized to hold the 5 year ARI flow, which would be a similar size to the inflow pipeline of the sediment pond.

Wetland outfall

The MUSIC model developed during the functional design stage reflects the actual stage-storage-discharge relationship of the wetland's extended detention. The actual stage-storage-discharge relationship is represented using MUSIC's Custom Outflow and Storage Relationship function.

The water level in a wetland is controlled by an outlet usually in the macrophyte zone. The macrophyte zone outlet provides the hydrologic control of the water level and flows in the macrophyte zone to achieve the design detention time.

Outlet structures should be designed and located so that they can be easily accessed for maintenance. Outlet or overflow pits located within the outlet pool of the macrophyte zone should be accessible from the edge of the wetland, this means that the edge of the pit closest to the wetland margin should be located in no more than 350mm depth.

The wetland outlet configuration consists of a submerged pipe connected to an outlet pit (containing the controlled weir outlet) located adjacent to the wetland above TED. The outlet pit should be easily accessible and have a hinged grated lid to enable access to the outlet control structure and overflow weir for maintenance.

An adjustable weir, such as a side-winding penstock, allows the inundation frequency to be adjusted easily. The required weir length is 360mm (i.e. the penstock opening) to ensure the 72-hour detention time. Figure 71 shows the stage-storage-discharge relationship used in MUSIC for WLRB4 (DCP ref WL-04).

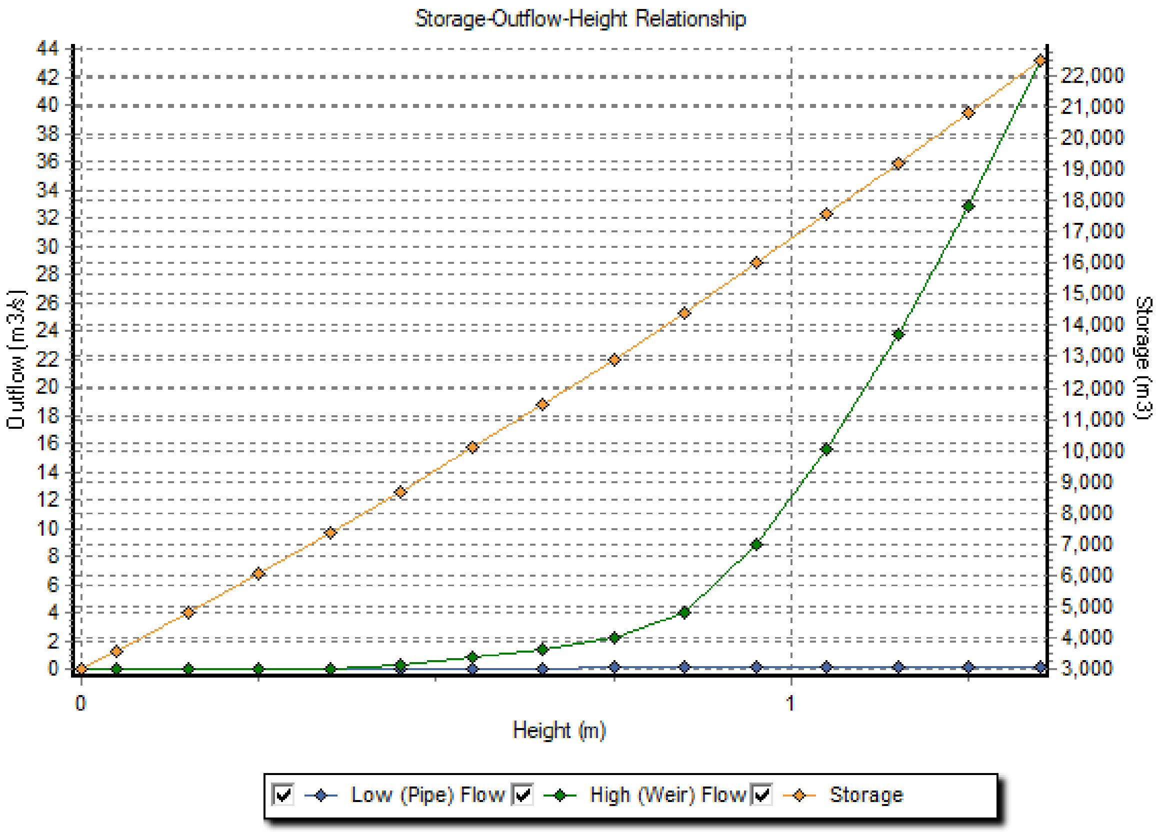


Figure 71. *Stage-storage-discharge relationship*

17.5 Maintenance

Access tracks

Access paths should be at least 4m wide and with a cross fall no steeper than 1:20m. An access track has been located around the treatment system, ensuring access to the sediment basin and dewatering areas.

A maintenance ramp will be provided to the sediment ponds, the ramp should extend from the base of the sediment pond to 0.5m above EDD. It will be 4m wide and no steeper than 1:5. It will be able to support a 20-tonne excavator and be constructed of either 200mm of cement treated crushed rock (6%) or compacted FCR.

Maintenance drain

Maintenance drains are to be located in the sediment ponds and wetland inlet and outlet pools. All maintenance drains will have a diameter of 300mm. they will have penstock/valves on the drains that are generally closed, except if the wetland or sediment pond needs to be slowly drained.

The invert levels of the maintenance drains have been selected as the minim levels at which free gravity draining will occur within the macrophyte zones.

Sediment dewatering areas

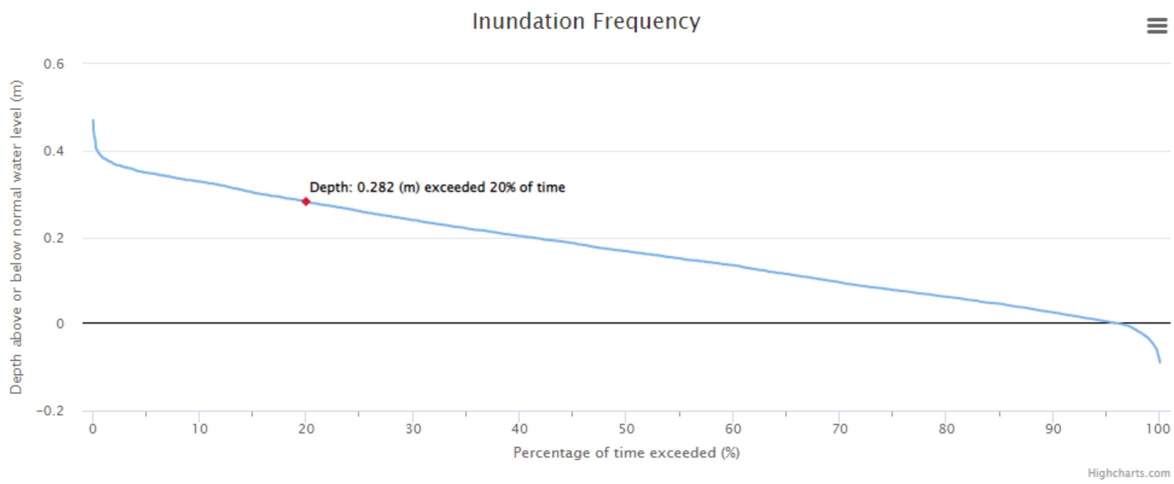
A sediment dewatering area of 1973m^2 has been provided adjacent to the sediment pond. This area will allow accumulated sediment taken from the sediment basin to be dewatered on site before it is transported off site.

17.6 Vegetation

Plant suitability is based on consideration of the plant height and whether the water depth in the wetland will exceed 50% of the plant height for more than 20% of the time. If this is exceeded, it is considered that the plant will be inundated to excessive depths too frequently and is unlikely to grow successfully in these conditions (see Figure 63 above for a schematic explanation).

The "wetland analysis tool" enables data from the MUSIC model to be utilised to assess the compliance of a wetland to the Melbourne Water *Constructed Wetlands Design Manual*. That is, wetland depths relative to heights. The results from the water level frequency analysis are given below.

Choose file WL4 flux.csv
FILE IS UPLOADED



Please select at least 3 plants for each of the shallow and deep marsh zones.

Clear Selection

Name	Average plant height (m)	Shallow marsh plants	Deep marsh plants	Suitability
Sea Club-rush *Bolboschoenus caldwellii*	1	☐		Shallow Only
Water Ribbons *Triglochin procerum*	1	☐	☐	
Jointed Club-rush *Baumea articulata*	1.8	☑	☐	Shallow and Deep
Tall Club-rush *Bolboschoenus fluviatilis*	1.8	☑	☐	
Marsh Club-rush *Bolboschoenus medianus*	1.5	☑	☐	
Leafy Twig-rush *Cladium procerum*	2	☐	☐	
River Club-rush *Schoenoplectus tabernaemontani*	1.8	☐	☑	
Tall Spike-rush *Eleocharis sphacelata*	1.5		☑	Deep Only
Common reed *Phragmites australis*	2.5		☑	
Common Spike-rush *Eleocharis acuta*	0.5	☐		Unsuitable

+ Add user defined plant

Report

File: WL4 flux.csv
Shallow marsh zone meets deemed to comply criteria

Deep marsh zone meets deemed to comply criteria

Water level exceeded for 20% of time: 0.282 m

Water level exceeded for 50% of time: 0.168 m
·Warning: Effective normal water level is significantly above design normal water level. It is recommended that the effective water level of (xxx m) is adopted as the base for determining shallow and deep marsh zone depths and extents. It may be desirable to adjust the bypasses, outlet design or wetland size to reduce the difference in design and effective normal water level.

90th Percentile Residence Time: 3 days

The water level frequency analysis demonstrates the proposed wetland with an extended detention depth of 350mm meets appropriate requirements with respect to plant heights and wetland depths. There needs to be a minimum of three plant species suitable for the shallow marsh zones and three plant species suitable for the deep marsh zones. The proposed wetland positively exceeds this as follows:

- 7 potential plant species for the shallow marsh zones
- 8 potential plant species for the deep marsh zones.

The landscape architects for the project should prepare a wetland planting plan using the species identified in this report for the various depth ranges for treatment performance and species diversity.

The following requirements for planting vegetation should be followed:

- Up to 200mm above the NWL and 350mm below the NWL should be densely planted
- Shallow marsh zone should be densely planted with a minimum of three species
- Deep marsh zone should be densely planted with a minimum of three species
- Submerged marsh zone should be densely planted.

18 Sediment Basin Functional Design (SB1; DCP ref SB3)

This section outlines the design calculations that have been undertaken to ensure the performance of the treatment system SB1 (DCP ref SB3) complies with the appropriate guidelines. A plan view of the designed sediment basin is shown in Figure 72 below. Refer to Appendix B for further design details and cross sections. The Sediment Basin Normal Water Level (NWL) is set at **24.62m AHD**, and the Top of Extended Detention (TED) is set at **24.97m AHD**.

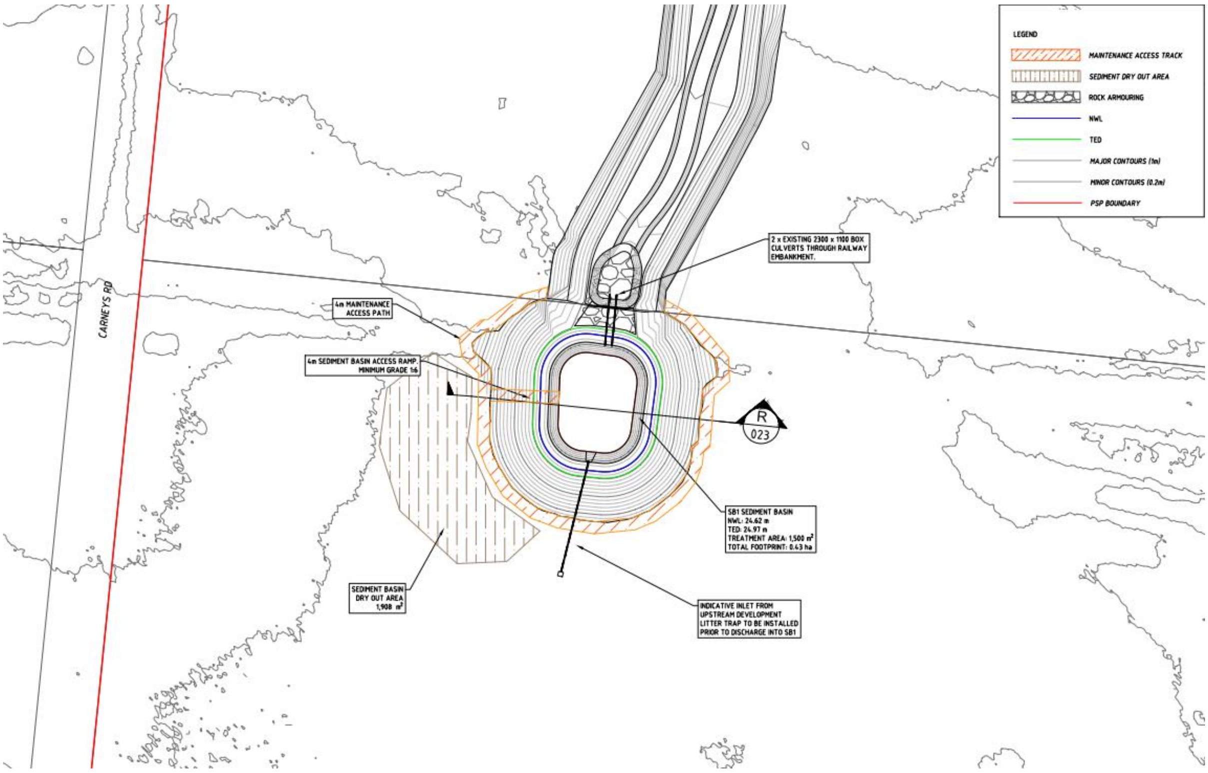


Figure 72. *Plan view of the designed wetland structure SB1(DCP ref SB3)*

18.1 Velocities

As established in the MUSIC modelling, the area of the sediment basin SB1 (DCP ref SB3) will be 1,500 m^2.

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

For SB1 (DCP ref SB3) the minimum design width is 31m to meet velocity requirements.

Table 52. System velocity calculations and design checks

	Parameter	Q3-month	Q5 year
Flow Conditions	Design flow (m^3/s)	1.02	5.67
	Flow depth (m)	0.35	0.35
Sediment Pond (WL3)	Width at NWL (m)	31	31
	Width at EDD (m)	35.2	35.2
	Average Width (m)	33.1	33.1
	Flow area (m^2)	11.6	11.6
	Flow velocity (m/s)	0.09	0.49

	Check	<0.5 OK	<0.5 OK

18.2 Sediment Basin

The sediment pond has been sized to ensure a capture efficiency greater than 95% for the 3-month ARI peak flow and provide adequate sediment storage. The procedure outlined in *WSUD Engineering Procedures (2005)* has been followed and are based on the typical sediment loading rate of 1.6 m^3/ha/yr for a developed catchment, plus an additional 0.4 m^3/ha/yr for systems without a GPT immediately upstream (assumed). Provision for sediment dewatering has also been made. These areas assume a depth of 500mm and a sediment cleanout frequency of 5 years.

Table 53. Sediment Pond design parameters and checks

	Parameter	Proposed design
Conditions	Contributing Catchment (ha)	150
	Area of Basin (m^2)	1,500
Capture Efficiency	Settling Velocity of Target Sediment (mm/s) [Particle size 125 µm]	11
	Hydraulic Efficiency (λ)	0.11
	Permanent Pool Depth, dp (m)	0.5
	Extended detention depth, de	0.35
	Number of CTSR's, n	1.10
	Depth below permanent pool that is sufficient to retain sediment, d* (m)	0.5
	Design Discharge (m^3/s) [Q3-month]	1.02
	Capture Efficiency	95.4%
	Check (>95%)	OK
Sediment Storage	Sediment Loading rate, Lo (m^3/ha/yr)	2
	Desired clean-out frequency, Fr	5
	Storage volume required, St	1,431
	Available sediment storage volume	1,500
	Check (Available storage > required storage)	OK
Sediment dewatering	Depth for dewatering area (m)	0.5
	Area required for dewatering (m^2)	2,861

18.3 Maintenance

Access tracks

Access paths should be at least 4m wide and with a cross fall no steeper than 1:20m. An access track has been located around the treatment system, ensuring access to the sediment basin and dewatering areas.

A maintenance ramp will be provided to the sediment ponds, the ramp should extend from the base of the sediment pond to 0.5m above EDD. It will be 4m wide and no steeper than 1:5. It will be able to support a 20-tonne excavator and be constructed of either 200mm of cement treated crushed rock (6%) or compacted FCR.

Sediment dewatering areas

A sediment dewatering area of 2,860m^2 has been provided adjacent to the sediment pond. This area will allow accumulated sediment taken from the sediment basin to be dewatered on site before it is transported off site.

19 Sediment Basin Functional Design (SB4; DCP ref SB7)

This section outlines the design calculations that have been undertaken to ensure the performance of the treatment system SB4 (DCP ref SB7) complies with the appropriate guidelines. A plan view of the designed sediment basin is shown in Figure 73 below. Refer to Appendix B for further design details and cross sections. The Sediment Basin Normal Water Level (NWL) is set at **16.18m AHD**, and the Top of Extended Detention (TED) is set at **16.53m AHD**.

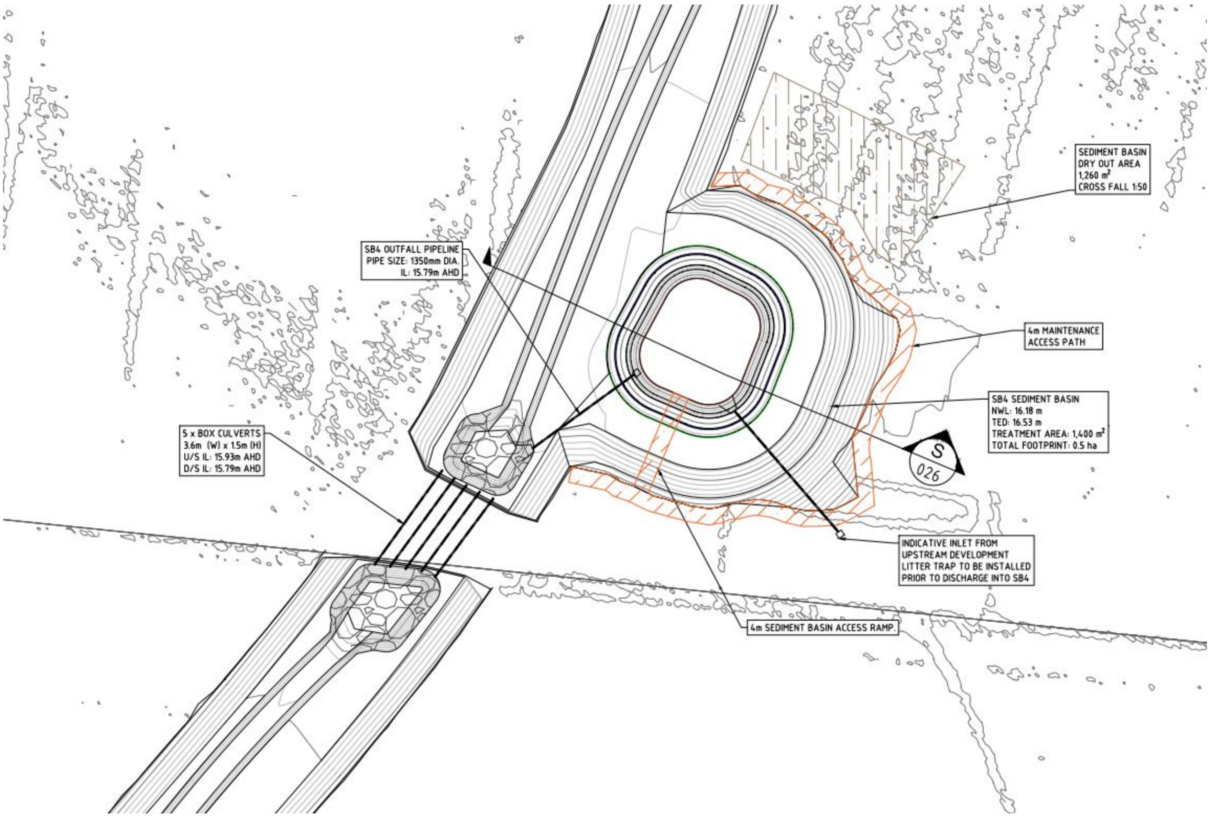


Figure 73. *Plan view of the designed wetland structure SB4 (DCP ref SB7)*

19.1 Velocities

As established in the MUSIC modelling, the area of the sediment basin SB4 (DCP ref SB7) will be 1,400 m^2.

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

For SB4 (DCP ref SB7) the minimum design width is 29m to meet velocity requirements.

Table 54. System velocity calculations and design checks

	Parameter	Q3-month	Q5 year
Flow Conditions	Design flow (m^3/s)	0.97	5.39
	Flow depth (m)	0.35	0.35
Sediment Pond (WL3)	Width at NWL (m)	29	29
	Width at EDD (m)	33.2	33.2
	Average Width (m)	31.1	31.1
	Flow area (m^2)	10.9	10.9

Flow velocity (m/s)	0.09	0.50
Check	<0.5 OK	<0.5 OK

19.2 Sediment Basin

The sediment pond has been sized to ensure a capture efficiency greater than 95% for the 3-month ARI peak flow and provide adequate sediment storage. The procedure outlined in *WSUD Engineering Procedures (2005)* has been followed and are based on the typical sediment loading rate of 1.6 m^3/ha/yr for a developed catchment, plus an additional 0.4 m^3/ha/yr for systems without a GPT immediately upstream (assumed). Provision for sediment dewatering has also been made. These areas assume a depth of 500mm and a sediment cleanout frequency of 5 years.

Table 55. Sediment Pond design parameters and checks

	Parameter	Proposed design
Conditions	Contributing Catchment (ha)	63.90
	Area of Basin (m^2)	1400
Capture Efficiency	Settling Velocity of Target Sediment (mm/s) [Particle size 125 µm]	11
	Hydraulic Efficiency (λ)	0.11
	Permanent Pool Depth, dp (m)	0.50
	Extended detention depth, de	0.35
	Number of CTSR's, n	1.1
	Depth below permanent pool that is sufficient to retain sediment, d* (m)	0.5
	Design Discharge (m^3/s) [Q3-month]	0.97
	Capture Efficiency	95.3%
	Check (>95%)	OK
Sediment Storage	Sediment Loading rate, Lo (m^3/ha/yr)	2
	Desired clean-out frequency, Fr	5
	Storage volume required, St	609
	Available sediment storage volume	980
	Check (Available storage > required storage)	OK
Sediment dewatering	Depth for dewatering area (m)	0.5
	Area required for dewatering (m^2)	1218

19.3 Maintenance

Access tracks

Access paths should be at least 4m wide and with a cross fall no steeper than 1:20m. An access track has been located around the treatment system, ensuring access to the sediment basin and dewatering areas.

A maintenance ramp will be provided to the sediment ponds, the ramp should extend from the base of the sediment pond to 0.5m above EDD. It will be 4m wide and no steeper than 1:5. It will be able to support a 20-tonne excavator and be constructed of either 200mm of cement treated crushed rock (6%) or compacted FCR.

Sediment dewatering areas

A sediment dewatering area of 1,220m^2 has been provided adjacent to the sediment pond. This area will allow accumulated sediment taken from the sediment basin to be dewatered on site before it is transported off site.

20 Sediment Basin Functional Design (SB5; DCP ref SB15)

This section outlines the design calculations that have been undertaken to ensure the performance of the treatment system SB5 (DCP ref SB15) complies with the appropriate guidelines. A plan view of the designed sediment basin is shown in Figure 74 below. Refer to Appendix B for further design details and cross sections. The Sediment Basin Normal Water Level (NWL) is set at 22.30m AHD, and the Top of Extended Detention (TED) is set at 22.65m AHD.

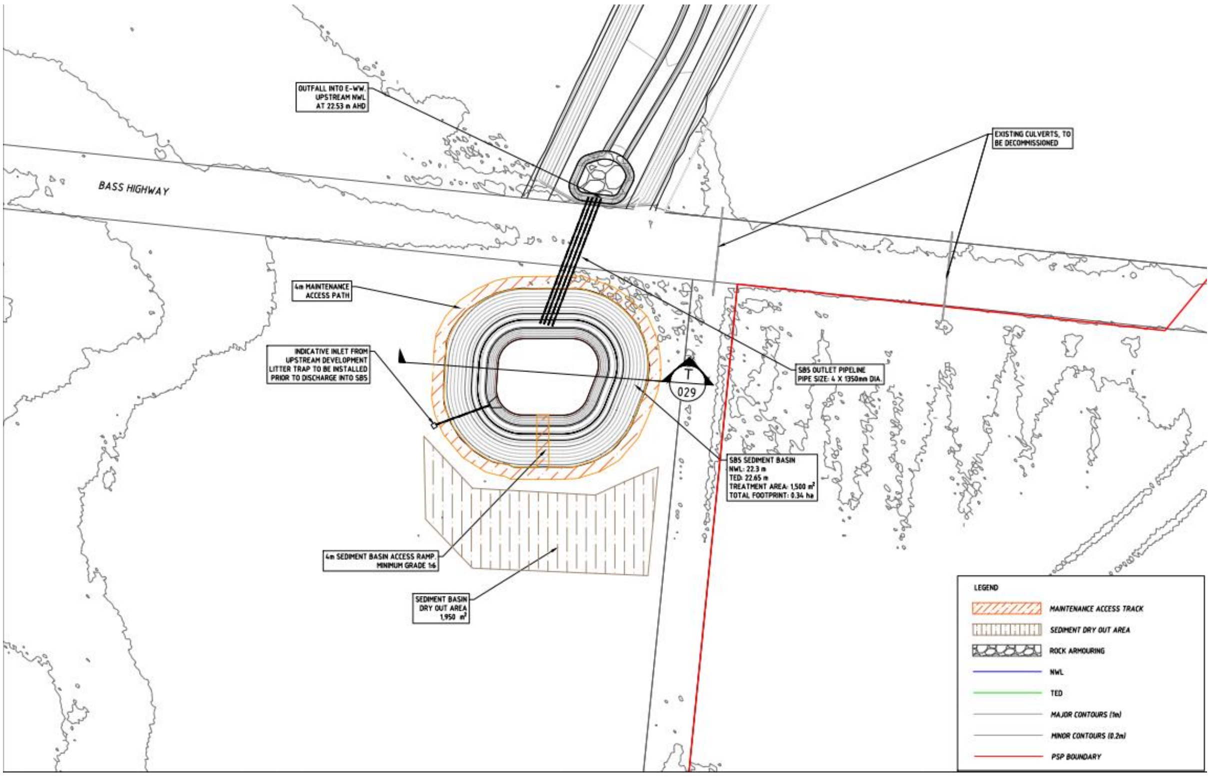


Figure 74. *Plan view of the designed wetland structure SB5 (DCP ref SB15)*

20.1 Velocities

As established in the MUSIC modelling, the area of the sediment basin SB5 (DCP ref SB15) will be 1500 m^2.

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

For SB5 (DCP ref SB15) the minimum design width is 16 m to meet velocity requirements.

Table 56. System velocity calculations and design checks

	Parameter	Q3-month	Q5 year
Flow Conditions	Design flow (m^3/s)	0.57	3.17
	Flow depth (m)	0.35	0.35
Sediment Pond (WL3)	Width at NWL (m)	16	16
	Width at EDD (m)	20.2	20.2
	Average Width (m)	18.1	18.1
	Flow area (m^2)	6.3	6.3
	Flow velocity (m/s)	0.09	0.50

Check	<0.5 OK	<0.5 OK

20.2 Sediment Basin

The sediment pond has been sized to ensure a capture efficiency greater than 95% for the 3-month ARI peak flow and provide adequate sediment storage. The procedure outlined in *WSUD Engineering Procedures (2005)* has been followed and are based on the typical sediment loading rate of 1.6 m^3/ha/yr for a developed catchment, plus an additional 0.4 m^3/ha/yr for systems without a GPT immediately upstream (assumed). Provision for sediment dewatering has also been made. These areas assume a depth of 500mm and a sediment cleanout frequency of 5 years.

Table 57. Sediment Pond design parameters and checks

	Parameter	Proposed design
Conditions	Contributing Catchment (ha)	150
	Area of Basin (m^2)	1500
Capture Efficiency	Settling Velocity of Target Sediment (mm/s) [Particle size 125 µm]	11
	Hydraulic Efficiency (λ)	0.11
	Permanent Pool Depth, dp (m)	0.50
	Extended detention depth, de	0.35
	Number of CTSR's, n	1.1
	Depth below permanent pool that is sufficient to retain sediment, d* (m)	0.50
	Design Discharge (m^3/s) [Q3-month]	0.57
	Capture Efficiency	97.5%
	Check (>95%)	OK
Sediment Storage	Sediment Loading rate, Lo (m^3/ha/yr)	2
	Desired clean-out frequency, Fr	5
	Storage volume required, St	1463
	Available sediment storage volume	1500
	Check (Available storage > required storage)	OK
Sediment dewatering	Depth for dewatering area (m)	0.50
	Area required for dewatering (m^2)	2925

20.3 Maintenance

Access tracks

Access paths should be at least 4m wide and with a cross fall no steeper than 1:20m. An access track has been located around the treatment system, ensuring access to the sediment basin and dewatering areas.

A maintenance ramp will be provided to the sediment ponds, the ramp should extend from the base of the sediment pond to 0.5m above EDD. It will be 4m wide and no steeper than 1:5. It will be able to support a 20-tonne excavator and be constructed of either 200mm of cement treated crushed rock (6%) or compacted FCR.

Sediment dewatering areas

A sediment dewatering area of 2925m^2 has been provided adjacent to the sediment pond. This area will allow accumulated sediment taken from the sediment basin to be dewatered on site before it is transported off site.

21 Sediment Basin Functional Design (SB6)

This section outlines the design calculations that have been undertaken to ensure the performance of the treatment system SB6 complies with the appropriate guidelines. A plan view of the designed sediment basin is shown in Figure 75 below. Refer to Appendix B for further design details and cross sections. The Sediment Basin Normal Water Level (NWL) is set at **17.50m AHD**, and the Top of Extended Detention (TED) is set at **17.85m AHD**.

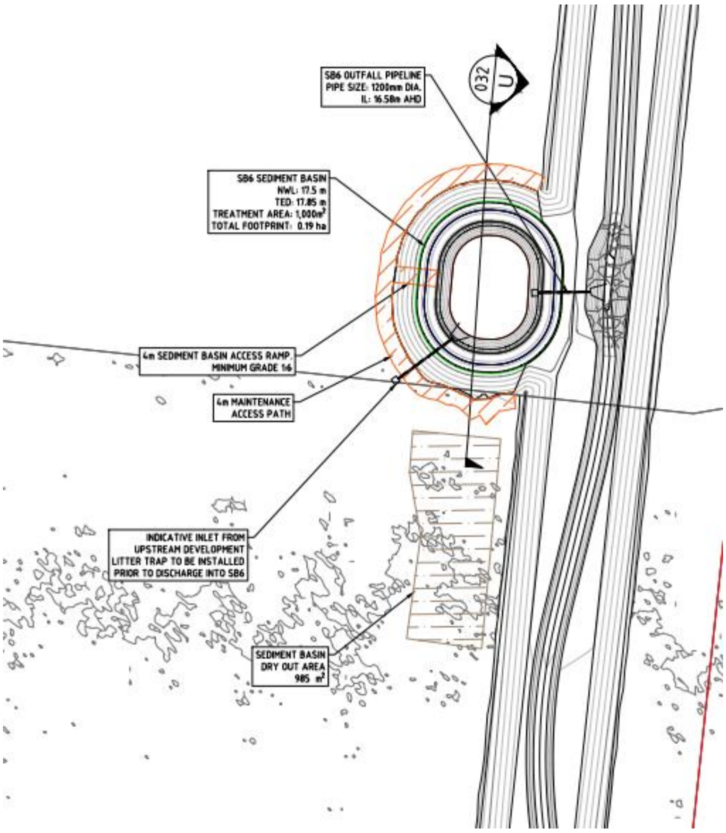


Figure 75. *Plan view of the designed wetland structure SB6*

21.1 Velocities

As established in the MUSIC modelling, the area of the sediment basin SB6 will be 1,000 m^2.

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

For SB6 the minimum design width is 20 m to meet velocity requirements.

Table 58. System velocity calculations and design checks

	Parameter	Q3-month	Q5 year
Flow Conditions	Design flow (m^3/s)	0.73	3.65
	Flow depth (m)	0.35	0.35
Sediment Pond (WL3)	Width at NWL (m)	20	20
	Width at EDD (m)	24.2	24.2
	Average Width (m)	22.1	22.1

Flow area (m^2)	7.7	7.7
Flow velocity (m/s)	0.09	0.47
Check	<0.5 OK	<0.5 OK

21.2 Sediment Basin

The sediment pond has been sized to ensure a capture efficiency greater than 95% for the 3-month ARI peak flow and provide adequate sediment storage. The procedure outlined in *WSUD Engineering Procedures (2005)* has been followed and are based on the typical sediment loading rate of 1.6 m^3/ha/yr for a developed catchment, plus an additional 0.4 m^3/ha/yr for systems without a GPT immediately upstream (assumed). Provision for sediment dewatering has also been made. These areas assume a depth of 500mm and a sediment cleanout frequency of 5 years.

Table 59. Sediment Pond design parameters and checks

	Parameter	Proposed design
Conditions	Contributing Catchment (ha)	48.36
	Area of Basin (m^2)	1000
Capture Efficiency	Settling Velocity of Target Sediment (mm/s) [Particle size 125 µm]	11
	Hydraulic Efficiency (λ)	0.11
	Permanent Pool Depth, dp (m)	0.50
	Extended detention depth, de	0.35
	Number of CTSR's, n	1.1
	Depth below permanent pool that is sufficient to retain sediment, d* (m)	0.50
	Design Discharge (m^3/s) [Q3-month]	0.73
	Capture Efficiency	95.0%
	Check (>95%)	OK
Sediment Storage	Sediment Loading rate, Lo (m^3/ha/yr)	2
	Desired clean-out frequency, Fr	5
	Storage volume required, St	459
	Available sediment storage volume	500
	Check (Available storage > required storage)	OK
Sediment dewatering	Depth for dewatering area (m)	0.5
	Area required for dewatering (m^2)	919

21.3 Maintenance

Access tracks

Access paths should be at least 4m wide and with a cross fall no steeper than 1:20m. An access track has been located around the treatment system, ensuring access to the sediment basin and dewatering areas.

A maintenance ramp will be provided to the sediment ponds, the ramp should extend from the base of the sediment pond to 0.5m above EDD. It will be 4m wide and no steeper than 1:5. It will be able to support a 20-tonne excavator and be constructed of either 200mm of cement treated crushed rock (6%) or compacted FCR.

Sediment dewatering areas

A sediment dewatering area of 920m^2 has been provided adjacent to the sediment pond. This area will allow accumulated sediment taken from the sediment basin to be dewatered on site before it is transported off site.

22 Sediment Basin Functional Design (SB7)

This section outlines the design calculations that have been undertaken to ensure the performance of the treatment system SB7 complies with the appropriate guidelines. A plan view of the designed sediment basin is shown in Figure 72 below. Refer to Appendix B for further design details and cross sections. The Sediment Basin Normal Water Level (NWL) is set at **20.20m AHD**, and the Top of Extended Detention (TED) is set at **20.55m AHD.**

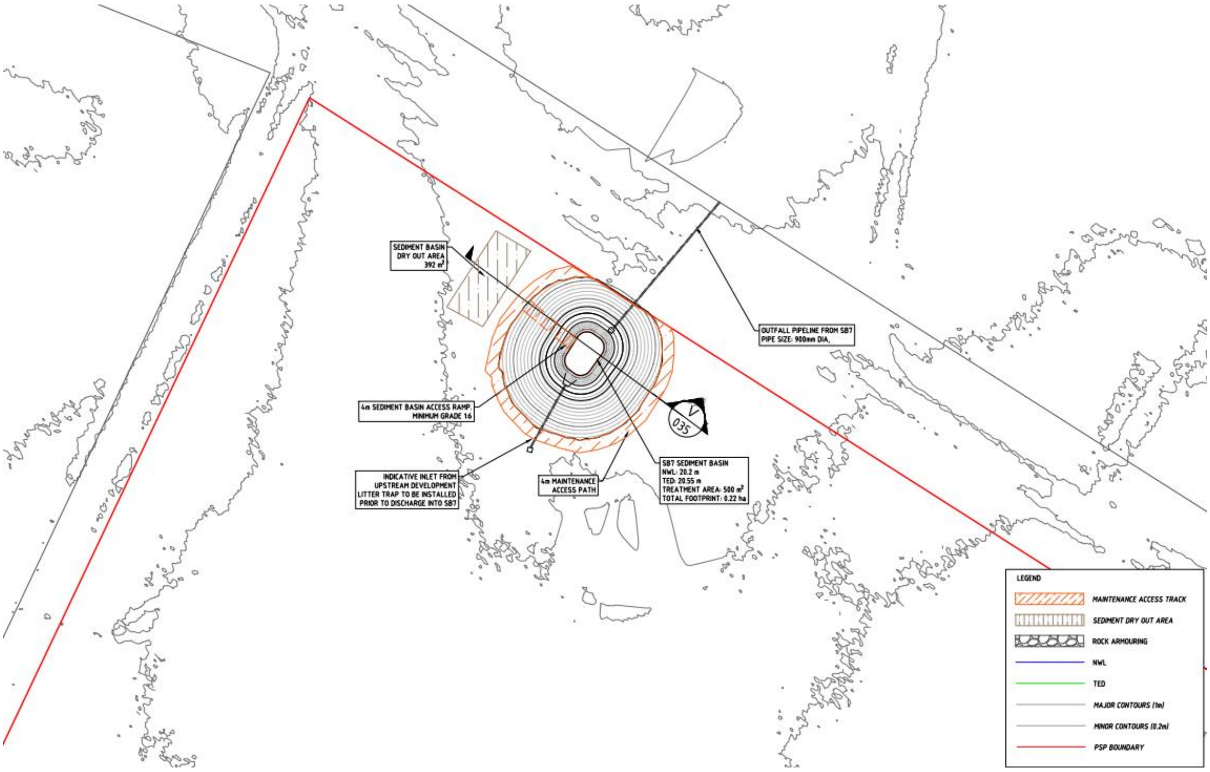


Figure 76. *Plan view of the designed wetland structure SB7*

22.1 Velocities

As established in the MUSIC modelling, the area of the sediment basin SB7 will be 500 m^2.

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

For SB7 the minimum design width is 39 m to meet velocity requirements.

Table 60. System velocity calculations and design checks

	Parameter	Q3-month	Q5 year
Flow Conditions	Design flow (m^3/s)	0.25	1.25
	Flow depth (m)	0.35	0.35
Sediment Pond (WL3)	Width at NWL (m)	13	13
	Width at EDD (m)	17.2	17.2
	Average Width (m)	15.1	15.1
	Flow area (m^2)	5.3	5.3

Flow velocity (m/s)	0.05	0.24
Check	<0.5 OK	<0.5 OK

22.2 Sediment Basin

The sediment pond has been sized to ensure a capture efficiency greater than 95% for the 3-month ARI peak flow and provide adequate sediment storage. The procedure outlined in *WSUD Engineering Procedures (2005)* has been followed and are based on the typical sediment loading rate of 1.6 m^3/ha/yr for a developed catchment, plus an additional 0.4 m^3/ha/yr for systems without a GPT immediately upstream (assumed). Provision for sediment dewatering has also been made. These areas assume a depth of 500mm and a sediment cleanout frequency of 5 years.

Table 61. Sediment Pond design parameters and checks

	Parameter	Proposed design
Conditions	Contributing Catchment (ha)	20.25
	Area of Basin (m^2)	500
Capture Efficiency	Settling Velocity of Target Sediment (mm/s) [Particle size 125 µm]	11
	Hydraulic Efficiency (λ)	0.11
	Permanent Pool Depth, dp (m)	0.50
	Extended detention depth, de	0.35
	Number of CTSR's, n	1.1
	Depth below permanent pool that is sufficient to retain sediment, d* (m)	0.50
	Design Discharge (m^3/s) [Q3-month]	0.25
	Capture Efficiency	96.7%
	Check (>95%)	OK
Sediment Storage	Sediment Loading rate, Lo (m^3/ha/yr)	2
	Desired clean-out frequency, Fr	5
	Storage volume required, St	196
	Available sediment storage volume	350
	Check (Available storage > required storage)	OK
Sediment dewatering	Depth for dewatering area (m)	0.50
	Area required for dewatering (m^2)	391

22.3 Maintenance

Access tracks

Access paths should be at least 4m wide and with a cross fall no steeper than 1:20m. An access track has been located around the treatment system, ensuring access to the sediment basin and dewatering areas.

A maintenance ramp will be provided to the sediment ponds, the ramp should extend from the base of the sediment pond to 0.5m above EDD. It will be 4m wide and no steeper than 1:5. It will be able to support a 20-tonne excavator and be constructed of either 200mm of cement treated crushed rock (6%) or compacted FCR.

Sediment dewatering areas

A sediment dewatering area of 392m^2 has been provided adjacent to the sediment pond. This area will allow accumulated sediment taken from the sediment basin to be dewatered on site before it is transported off site.

23 Costing

Costing of the various stormwater quality treatment and storage options has been undertaken to provide a cost estimate at a functional design level. This includes the costs associated with the construction of the retarding basins, wetland treatment aspects of the designs, as well as the proposed waterway works. The cost estimates include all excavation, planting, and infrastructure requirements, although this will be subject to site constraints and complexity.

Construction estimation rates were used based on previous works within the area, and the Melbourne Water standard reimbursement rates for the south east region. The construction estimates have been peer reviewed and updated accordingly following the initial estimates from Alluvium.

Following the initial submission of the stormwater management strategy by Alluvium, and following the peer review by Craigie, N. & Daff, G. the major change to the costing rates is from adjusting the excavation rate from $38/m3 to $25/m3 (as approved by VPA) and applying to all PSP assets, on the basis that:

- The majority of excavation is undertaken in broad greenfield land (i.e. not in public roads)
- Much of the excavated material can be reused as filling on site
- There is little or no offsite disposal of excavated material.

In revising cost estimates, the following volumes and reuse estimates have been adopted (and align with above conditions):

- An excavated volume of 5% has been assumed for offsite disposal
- An excavated volume of 95% has been assumed to be reused on site for filling
- An allowance of 5% has been assumed for some rock excavation / potential reuse in waterways
- Excavated topsoil has assumed 5% for removal and 95% for stockpiling on site for later reuse on site
- An allowance of 5% has been assumed to import clean topsoil to cover for topsoil losses (shortfall due to above).

The total cost estimate for Wonthaggi North East PSP drainage strategy is $ 61,357,076, which represents a 74% increase in cost estimates from the Engeny 2019 Strategy ($ 35,354,000). This is likely due to:

- some updates in costing rates from 2019 to 2021
- an accurate earthworks modelling of proposed assets undertaken at the functional design phase (not required at concept stage)
- further design refinement of the wetland-retarding basins, inlet zones and sediment basins
- and constructed waterway infrastructure design considerations (sheer stress, velocity controls, etc) as per industry (constructed waterway) design guidelines.

Additionally, the Engeny estimate represented the initial 2019 drainage strategy and concepts. Engeny were subsequently engaged by the VPA to review the strategy (Aug 2021) following new modelling (March 2021). Updating cost estimates was not part of the Engeny scope. The revised modelling and strategy formed the basis for the functional designs process by Alluvium.

The Alluvium design costings includes the following (additional) delivery fees as per VPA guidance:

- 3.25% rate for Council fees
- 1.00% rate for VicRoads fees
- 5.00% rate for traffic management
- 0.50% rate for environmental management
- 5.00% rate for survey & design
- 9.00% rate for supervision & project management
- 2.50% rate for site establishment
- and a 20% contingency.

This represents an increase of 46.25% to the overall PSP cost for overheads and contingency, which is slightly higher than the original Engeny concept strategy (which assumed a 35% contingency).

Costing estimates have been set out in a way that allows for staging of assets (i.e. separating out asset costs).

A summary of the cost estimates for the Wonthaggi North East PSP stormwater management strategy is provided below. A costing breakdown for each individual asset is provided in Appendix C.

WONTHAGGI NORTH EAST PSP - FUNCTIONAL DESIGN COSTINGS

ITEM	Description of works		TOTAL
A1	DR-01 WEST WATERWAY (W-WW)		$ 11,219,641
A2	DR-02 EAST WATERWAY (E-WW)		$ 10,532,750
A3	DR-03 MAIN OUTFALL TO POWLETT RIVER (MOP)		$ 2,362,902
A4	WL-01 WETLAND RETARDING BASIN 1 (WLRB1A&B)		$ 15,828,798
A5	WL-02 WETLAND RETARDING BASIN 2 (WLRB2)		$ 1,516,298
A6	WL-03 WETLAND RETARDING BASIN 3 (WLRB3)		$ 1,531,274
A7	WL-04 WETLAND RETARDING BASIN 4 (WLRB4)		$ 3,763,272
A8	SB-01 SEDIMENT BASIN 1 (SB1)		$ 1,203,729
A9	SB-02 SEDIMENT BASIN 4 (SB4)		$ 953,651
A10	SB-03 SEDIMENT BASIN 5 (SB5)		$ 765,905
A11	SB-04 SEDIMENT BASIN 6 (SB6)		$ 603,778
A12	SB-05 SEDIMENT BASIN 7 (SB7)		$ 583,972
A13	CU-01 INDUSTRIAL BOULVERAD CROSSING (LCT 16-17) (3 x 1350mm dia. AS PER ENGENY STRATEGY)		$ 215,000
A14	CU-02 BASS HIGHWAY CULVERTS (LCT 18-19) (3 x 1500mm dia.)		$ 255,000
A15	CU-03 BASS HIGHWAY CULVERTS (LCT 2-3) (3 x 1500mm dia. AS PER ENGENY STRATEGY)		$ 255,000
A16	CU-04 MCGIBBONYS ROAD (LCT 21-22) (4 x 1650mm dia.) COST CALCULATED BY VPA		$ 206,048
A17	CU-05 (5 x 3600mm x 1500mm BOX CULVERTS) (BASED ON ENGENY COST ESTIMATION)		$ 717,500
A18	CU-06 (5 x 3600mm x 1500mm BOX CULVERTS) (BASED ON ENGENY COST ESTIMATION)		$ 717,500
A19	CU-07(5 x 3600mm x 1500mm BOX CULVERTS) (BASED ON ENGENY COST ESTIMATION)		$ 717,500
A20	CU-08 KORRUMBURRA - WONTHAGGI ROAD LOW FLOW OUTLET (LCT 12-13) (AS PER ENGENY STRATEGY)		$ 975,000
A21	CU-09 HESLOP ROAD (LCT 37-38) (1 x 1650mm dia. AS PER ENGENY STRATEGY)		$ 134,000
A22	CU-010 HESLOP ROAD (LCT 41-42) (3 x 1200mm x 600mm AS PER ENGENY STRATEGY)		$ 456,000
A23	CU-012 HESLOP ROAD (LCT 45-46) (4 x 750mm dia. AS PER ENGENY STRATEGY)		$ 157,000
A24	CU-013 MCGIBBONYS ROAD (LCT 21-22) (4 x 1650mm dia.)		$ 206,048
A25	CU-014 NEW CROSSING OVER DR-03 (DESIGNED AND COSTED BY CARDNO)		$ 284,206
A26	CU-015 NEW CROSSING OVER DR-03 (DESIGNED AND COSTED BY CARDNO)		$ 225,967
A27	CU-016 NEW CROSSING OVER DR-03 (DESIGNED AND COSTED BY CARDNO)		$ 114,140
A28	PIPELINE 1-2 (1 x 1350mm dia. AS PER ENGENY STRATEGY)		$ 471,276
A29	PIPELINE 15-16 (1 x 1050mm dia. AS PER ENGENY STRATEGY)		$ 499,488
A30	PIPELINE 14-16 (1 x 1050mm dia. AS PER ENGENY STRATEGY)		$ 386,338
A31	PIPELINE 26-17 (1 x 1350mm dia. AS PER ENGENY STRATEGY)		$ 232,693
A32	PIPELINE 27-28 (1 x 1200mm dia. AS PER ENGENY STRATEGY)		$ 443,313

A33	PIPELINE 30-28 (1 x 825mm dia. AS PER ENGENY STRATEGY)		$	29,367
A34	PIPELINE 28-29 (1 x 1200mm dia. AS PER ENGENY STRATEGY)		$	200,722
A35	PIPELINE 31-32 (1 x 1200mm dia. AS PER ENGENY STRATEGY)		$	582,464
A36	PIPELINE 33-34 (1 x 900mm dia. AS PER ENGENY STRATEGY)		$	982,800
A37	PIPELINE 39A-39C (1 x 600mm dia. AS PER ENGENY STRATEGY)		$	76,237
A38	PIPELINE 39C-40 (1 x 600mm dia. AS PER ENGENY STRATEGY)		$	55,590
A39	PIPELINE 47-47A (1 x 750mm dia. AS PER ENGENY STRATEGY)		$	63,911
A40	PIPELINE 47A-40 (1 x 750mm dia. AS PER ENGENY STRATEGY)		$	153,526
A41	PIPELINE 40-48 (1 x 900mm dia. AS PER ENGENY STRATEGY)		$	491,400
A42	PIPELINE 43-45 (1 x 450mm dia. AS PER ENGENY STRATEGY)		$	80,774
A43	GROSS POLLUTANT TRAP 1		$	35,100
A44	GROSS POLLUTANT TRAP 2		$	35,100
A45	GROSS POLLUTANT TRAP 3		$	35,100
		TOTAL	**$**	**61,357,076**

24 Summary

The remodelling and redesign undertaken by Engeny and Alluvium respectively (April 2022), was to find a means to improve DCP cost estimates through remodelling and asset redesigns (where possible) in response to the independent Preliminary Drainage Review (Craigie et al, 2021). The following summarises the key findings that have informed the PSP Functional Designs package to date:

1) Main Outfall to Powlett (MOP) River

It is noted there is a high level of sensitivity to any design changes to the existing farm channels downstream of the PSP (to the north) through to the Powlett River (existing main outfall downstream of Pinkerton Rd).

The existing channel downstream of the PSP, through the constriction, is very sensitive to changes in cross sectional flow area, where any change was found to alter how the floodplain behaves. A fairly significant increase to flood depth (100-150mm) in the 50% AEP was found on the subject property (465 Heslop Rd, downstream of PSP). There is also some uncertainty on the existing conditions modelling given this area has not had detailed feature survey undertaken, and the presence of vegetation cover along the channel length needs consideration. The area to be surveyed is approximately 2km in length and should cost in the order of $20,000 to undertake. This estimate is indicative only and will vary slightly based on accessibility, line of sight etc.

The modelling undertaken on the MOP has therefore been based on a cross section at the upstream reach of the channel length and one a few hundred metres downstream. This design supersedes the previous Addendum MOP design.

Alluvium's functional design for the MOP is based on the best available information at the time of this project. A more detailed design would benefit from a full survey of the channel outfall to the Powlett River to better inform the MOP design, given current time constraints. It is anticipated that the overall cost to the DCP should not be significant given a channel width variation of a few metres is likely.

The design extends from the PSP WLRB1 outfall to the existing choke point (on the subject property). Given flood behaviour sensitivity to any further modifications to the downstream channel sections, at future detailed design phase, detailed survey should be undertaken along the MOP outfall to Powlett River.

Recommendation: the cross sectional flow area of the existing channel outfall (MOP) needs to be surveyed (approx. cost $20K) and further design undertaken as part of the detailed design stage to ensure flood behaviour is not made worse upstream and downstream.

2) Wetlands and Retarding Basins – WLRB1

The redesign of WLRB1 a and b looked at raising the NWL to reduce excavation costs and reduction in macrophyte zone without compromising upstream and downstream conditions and achieve best practice treatment performance.

WLRB1a and b were redesigned with a raised NWL to 14.0m AHD. Macrophyte zones were reduced without compromising width to length ratio (stress) on the system (asset integrity) and sediment basins (wetland inlets) modelled in RORB. Inverts to the upstream constructed waterways were raised to 14.0m AHD to transition with new wetland NWL. The remodelling noted positive increases in floodplain storage under all scenarios for WLRBs 1 and 3, necessary to accommodate the additional volumes of runoff being generated (hence, additional storage above the existing conditions will be required). The results provide a good indication of how the design changes have impacted on the available flood storage and decreased excavation volumes. DCP costs have come down considerably for WLRB1a and b (refer to detailed costings tables below).

The reduction in flood storage associated with WLRB2 is offset by the increases in WLRB1 and is also partly a function of removing a set of culverts from under Wonthaggi-Korumburra Road and considered of low concern given the relative magnitudes and flow diversions in play. This sensitivity check on WLRBs 2 and 3 was undertaken to test for any negative impacts on performance with the redesign changes to WLRB1, given the shared main outfall of PSP assets.

3) Waterways & Corridors (W-WW and E-WW) and SB 4 & SB6 integration

The redesign of W-WW and E-WW looked at adjusting the waterway inverts without compromising channel capacity in the 1% AEP, to reduce overall excavation and (DCP) costs, and consideration of a minimum waterway corridor width without compromising hydraulic capacity.

Consideration was given to the NWL of WLRB 1a and 1b and the interface with waterway levels. Both W-WW and E-WW inverts have been redesigned to 14.0m AHD to complement a revised WLRB1 NWL at 14.0m AHD. These were then re-modelled to determine performance outcomes. Designs were refined further to address emerging impacts of flooding to agricultural land east of the PSP (eastern levee on E-WW), with flows breaking out within the PSP during the 1% AEP. W-WW has been adjusted to remain outside an adjacent property as requested through stakeholder feedback.

Waterway and corridor aspects are outlined below for both PSP constructed waterways with recommended hydraulic and overall waterway corridor widths based on a road along the active edge of the corridor.

Redesign	W-WW	E-WW
Invert	14.0m AHD	14.0m AHD
Hydraulic width	40m	35m
Waterway corridor width	50m	45m

SB 4 and SB 6 have been relocated to within the respective PSP waterway floodplain to reduce overall developable area land take and reduce asset footprints. Both systems remain offline to stream flows to ensure asset integrity, function and longevity is protected (e.g. from scour, resuspension of suspended solids) and to minimise impacts on council’s future maintenance and / or asset renewal.

4) Revised PSP Cost Estimates

Following the remodelling and redesign of PSP assets (where possible) the cost estimates have been revised accordingly. Further, a separation of the following, relating to excavation / spoil disposal / soil import have been detailed:

- Excavated volume for offsite disposal
- Excavated volume to be reused on site for filling
- Allowance for some rock excavation / potential reuse in waterways (pool / riffles)
- Excavated topsoil for removal and 95% stockpiling on site for reuse (filling)
- Allowance for 5% losses of topsoil due to unsuitable quality
- Allowance to import clean topsoil to cover for topsoil losses (shortfall due to above).

5) Catchment Contributions

To assist the VPA in determining a fair and equitable apportionment, if any, of DCP costs for landowners within the PSP, that arise from accommodating overland flows from outside the PSP area, a breakdown of PSP internal and external flows (contributions) considered:

- overland flows generated within the PSP land under a fully developed scenario
- overland flows travelling through the PSP land from external catchments (likely benefitting from PSP assets)
- whether external flows have necessitated an upsizing of drainage assets (proportionate)
- proportion of external flows that use the PSP drainage infrastructure
- proportion of external agricultural catchment vs existing/proposed urban catchment.

While PSP assets have increased in size overall to accommodate catchment conditions, the increase cannot be directly apportioned to asset sizing as the fraction impervious of the external (undeveloped) catchments are lower than that of the proposed PSP (developed).

Table 1 (*Catchment breakdowns within the PSP and external areas*) and Figure 16 (*Map of external drainage catchments and respective contributing 1% AEP flows)* provides a summary of surface flows to be managed by the PSP assets.

The accommodation of external catchment inflows was critical in ensuring in the developed scenario PSP assets can perform as required for flood protection (quantity) and waterway protection (quality). Where surface waters from the external urban or external agricultural areas are currently not being retarded, the PSP assets need to account for this to ensure asset performance (and compliance) is met and maintained in accordance with industry best practice standards, guidelines, and State requirements, for the duration of the PSP asset's design life (subject to appropriate maintenance regime).

The developed areas to the west of the Wonthaggi NE PSP currently have untreated flows passing through the PSP (as per Table 1). For areas developed prior to the introduction of Clause 56.07-4 (Residential Subdivisions) or its recent expansion (VC154) to all developments a retrospective apportionment of cost is not possible given age of developments.

To improve overall catchment condition of receiving environments in Wonthaggi, this will require Council's future consideration to determine opportunities to retrofit these areas with appropriate stormwater management measures to best practice (and in accordance with the State IWM Framework). This would need to be part of Council's future capital works delivery – a precinct scale treatment/retardation and potentially stormwater harvesting system (the latter improving the cost-benefit to council and community, and depending on end use, may result in reduced treatment systems, UV being the exception).

Future development timing or likelihood of the external agricultural catchments to the east and south of the Wonthaggi NE PSP is currently an unknown. A future developed scenario through a future PSP will need to retard and treat the future PSP imperviousness flows to pre-developed conditions. As these areas remain as pre-developed (agricultural) condition, there is no apportionment of PSP costs appropriate (that is, no change to land imperviousness to warrant apportionment).

25 References

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APPENDICES

Appendix A – Proof of Concept (Table 1) Asset Summary

Table 62. Taken from Alluvium's Proof of Concept Report (Table 1) – Summary of assets and revision updates.

The following table captures the changes from the DCP and Stormwater Management Strategy (Engeny, 2019) to the remodelling study (Engeny, March 2021) various strategy iterations (March 2021-Aug 2021), and Engeny's Final Strategy (Sept 2021). through to Proof of Concept analysis by Alluvium (Sept 2021). This table was produced to aide reader's tracking of assets across the many document / concept revisions leading up to the functional design stage.

	As per DCP Assets		As per ENGENY – FINAL REVISED STRATEGY			ENGENY	PROOF OF CONCEPT - as per ALLUVIUM		
Funct. Design #	DCP Asset ID	Asset type	Dimensions/ footprint	Asset Description (ID)	Issue	Sept 2021 Final Strategy ID	Proposed changes	Alluvium PoC ID	Updates since PoC (Council)
1	DR1	Constructed Waterway	Length (m) – TBC	Western Waterway (DR1)	Low sinuosity, leading to high velocity flows and channel scouring, and impacts on wetland performance / vegetation degradation	DR1	Increase sinuosity to lower velocities and reduce bed scour / protect downstream assets / ensure long term increase in ecological value of new waterway	W-WW	
2	DR2	Constructed Waterway	Length (m) – TBC	Eastern Waterway (DR2)	Low sinuosity, leading to high velocity flows and channel scouring, and impacts on wetland performance / vegetation degradation	DR2	Remove 90-degree bend at d/s to prevent short circuit / asset failure Increase sinuosity to lower velocities and reduce bed scour / protect downstream assets / ensure long term increase in ecological value of new waterway	E-WW	
3	WL-01 /RB-01	Wetland and Retarding Basin	Treatment Area 58,000 (m^2)	Wetland and Retarding Basin 1	System is online which will lead to wetland scour, poor performance and vegetation losses Advised by Engeny 13 Aug wetland is retarding	WL1	Re-orient asset from 'online' system to 'offline' system (from waterways) to protect from wetland failure Altered wetland form to improve performance / function and protect wetland integrity / vegetation survival	WLRB1A (east) WLRB1B (west)	

	As per DCP Assets		As per ENGENY – FINAL REVISED STRATEGY			ENGENY	PROOF OF CONCEPT - as per ALLUVIUM	
					approx. 200mm above NWL Sept 2021 – WL retarding 320mm above NWL		Wetland split to manage catchments size / waterway inflows (two inlet zones) to WLRB1A (east) and WLRB1B (west)	
4	WL-02	Wetland and Retarding Basin	Treatment Area 8,000 (m^2)	Treatment Wetland	Advised by Engeny 13 Aug wetland is retarding approx. 100mm above NWL Sept 2021 – WL retarding 170mm above NWL	WL2	Now treatment and retarding function	WLRB2
5	WL-03	Wetland and Retarding Basin	Treatment Area 13,220 (m^2)	Wetland and Retarding Basin 3	Advised by Engeny 13 Aug wetland is retarding approx. 100mm above NWL Sept 2021 – WL retarding 144mm above NWL	WL3	New concept to improve function and performance to BPEM	WLRB3
6	WL-04	Wetland and Retarding Basin	Treatment Area 5,850 (m^2)	Treatment Wetland	Advised by Engeny 13 Aug wetland is retarding approx. 100mm above NWL Sept 2021 – WL retarding 166mm above NWL	WL4	Now treatment and retarding function	WLRB4
-	SB1	Sediment Basin	Treatment Area 520 (m^2) Footprint 2875 (m^2)		Same location	SB1	Recommend omit as small contributing catchment / negligible impact to PSP	N/A

	As per DCP Assets		As per ENGENY – FINAL REVISED STRATEGY		ENGENY	PROOF OF CONCEPT - as per ALLUVIUM		
7	SB2	Sediment Basin	Treatment Area 810 (m^2) Footprint 4290 (m^2)	Same location	SB2	Upsize - proposed treatment area: 1,000 (m^2)	SB2	
8	SB3	Sediment Basin	Treatment Area 700 (m^2) Footprint 2670 (m^2)	Same location	SB3	Upsize - proposed treatment area: 1,500 (m^2) This is a critical SB as it is located at the headwaters of the proposed W-WW	SB3	
9	SB4	Sediment Basin	Treatment Area 850 (m^2) Footprint 4440 (m^2)	Moved to upstream (further south) location; reduce size	SB4	To be resized & remodelled at Functional Stage – asset to be relocated further upstream (Engeny Sept strategy. Proposed treatment area: 1,300 (m^2)	SB4	*GPT recommended in lieu of SB due to small catchment upstream. Council advises (Oct) GPT now installed by developer*
-	SB5	Sediment Basin	Treatment Area 880 (m^2) Footprint 4380 (m^2)	Sept strategy suggest remove	SB5	Removed - Consistent with Engeny & considered obsolete to PSP.	N/A	*School site: OD flow from Jean Dennis Rd to discharge into waterway via GPT to be approved by the landowner and constructed by Powlett Ridge. Town drainage from the south to be redirected to a GPT in the drainage reserve in Powlett Ridge stage 6 (Council advice, Oct)*
10	SB6	Sediment Basin	Treatment Area 1030 (m^2) Footprint 5070 (m^2)	Same location	SB6	Upsized Proposed treatment area: 1,400 (m^2)	SB6	
11	SB7	Sediment Basin	Treatment Area 980	Same location	SB7	Upsized - proposed treatment area: 1,400 (m^2)	SB7	

	As per DCP Assets		As per ENGENY – FINAL REVISED STRATEGY		ENGENY	PROOF OF CONCEPT - as per ALLUVIUM	
			(m^2) Footprint 4900 (m^2)				
-	SB8	Sediment Basin	Treatment Area 1230 (m^2) Footprint 5990 (m^2)	Double ID – this is now the wetland inlet zone	SB8	Removed. New WLRB1B design incorporates primary treatment (sediment forebay) therefore this independent SB is not required – obsolete to PSP.	N/A
-	SB9	Sediment Basin	Treatment Area 700 (m^2) Footprint 5990 (m^2)	Upstream of Western waterway	SB9	Removed. New WLRB1A design incorporates primary treatment (sediment forebay) therefore this independent SB not required – obsolete to PSP.	N/A
Now part of #4 design NEW asset (25 Aug)	No ID	Sediment Basin		New SB as inlet to WL1	No ID	This sediment basin is already part of Alluvium's new WLRB1 concept design and has been sized accordingly to eliminate the need for SB8 and SB9.	N/A
Now part of #5 design	SB10	Sediment Basin	Treatment Area 1080 (m^2) Footprint 4100 (m^2)	Now part of WL2	SB10	Relocated / integrated to be primary treatment / inlet zone for WLRB2 therefore does not require an Asset ID	N/A
Now part of #6 design	SB11	Sediment Basin	Treatment Area 920 (m^2) Footprint 2800 (m^2)	Now part of WL3	SB11	Relocated / integrated to be primary treatment / inlet zone for WLRB3 therefore does not require an Asset ID	N/A
Now part of	SB11A	Sediment Basin	Treatment Area 900 (m^2)	Now part of WL4	SB11A	Relocated / integrated to be primary treatment / inlet zone for	N/A

	As per DCP Assets		As per ENGENY – FINAL REVISED STRATEGY			ENGENY	PROOF OF CONCEPT - as per ALLUVIUM		
#7 design			Footprint 4320 (m^2)				WLRB4 therefore does not require an Asset ID		
12	SB12	Sediment Basin	Treatment Area 500 (m^2) Footprint 2620 (m^2)		North-west corner of precinct	SB12	Unchanged	SB12	
-	SB13	Sediment Basin	-	-	Missing from strategy layout 2021 (Engeny)	Missing from new layout	Removed - assumed not required	N/A	
-	SB14	Sediment Basin	Treatment Area 500 (m^2) Footprint 2500 (m^2)			SB14	Removed - recommended obsolete due to small catchment area.	N/A	
13	SB15	Sediment Basin	Treatment Area 500 (m^2) Footprint 2500 (m^2)			SB15	Upsized - proposed treatment area: 1,500 (m^2) This is a critical SB as it is located at the headwaters of the proposed E-WW	SB15	
-	-	-			New SB for revised WLRB1 - unnamed	NEW unnamed	Integrated as part of WLRB1 – not an independent asset design	N/A	
14	CU1	Culvert		Outfall to DR1	Missing from new layout	No ID	Assumed no change – critical to W-WW	CU1	*Council advises (Oct) existing rail bridge / culvert provides a drainage outlet for flows from the south.*
-	CU2	Culvert		Outfall to DR1	Renamed Bass Highway/ CDS unit (culverts 18-19)	now Bass Highway/ CDS unit (culverts 18-19)	Existing CDS Unit & highway culverts (18-19)	N/A	*It was noted from late information provided that this culvert is not existing and required a design (was missing from Engeny final layout)*

	As per DCP Assets		As per ENGENY – FINAL REVISED STRATEGY		ENGENY	PROOF OF CONCEPT - as per ALLUVIUM		
15	CU3	Culvert	Outfall to DR2	Missing from new layout	No ID	Assumed no change – critical to E-WW	CU3	
-	CU4	Culvert	Outfall to DR1	Inconsistent naming/ already existing	now McGibbonys (culverts 22-23)	Existing asset Assumed no functional design required	N/A	*Northern end wall to be constructed in addition to ~5m pipe extension into drainage reserve (Council, Oct)*
16	CU5	Culvert	Outfall to DR1	Renamed C4	Now C4 (culverts 23-23A)	Assumed no change	CU5	
17	CU6	Culvert	Outfall to DR1	Renamed C5	Now C5 (culverts 23B-23C)	Assumed no change	CU6	
18	CU7	Culvert	Outfall to DR1	Renamed C6	Now C6 (culverts 24-24A)	Assumed no change	CU7	
19	CU8	Culvert	Outfall to main outfall		Missing from new layout	Assumed no change – critical to WLRB1 outfall to Main Outfall Powlett (River)	CU8	
-	CU9	Culvert	Outfall to main outfall	Existing	Missing from new layout	Assumed no functional design required existing asset – critical to WLRB2 outfall to main outfall – design to account for asset's existing levels	N/A	
20	CU10	Culvert	Outfall to North Heslop Rd		Missing from new layout	Assumed no change – critical to WLRB3 outfall to Heslop Rd	CU10	
21	CU11	Culvert	Outfall to North Heslop Rd		Missing from new layout	Assumed no change – critical to WLRB4 outfall to Heslop Rd	CU11	
22	CU12	Culvert	Outfall to North Heslop Rd		Missing from new layout	Assumed no change – related to SB12 in north-west corner of precinct to account for untreated inflows to PSP assets.	CU12	

	As per DCP Assets	As per ENGENY – FINAL REVISED STRATEGY	ENGENY	PROOF OF CONCEPT - as per ALLUVIUM	
23 NEW	Main Outfall	Precinct ultimate outfall	Main Outfall to Powlett River	No change – critical asset– Main Outfall to Powlett (MOP) River	MOP
Total Assets to Design	DCP = 29+				Alluvium = 23 designs

Appendix B – Functional Design Package (attached separately)

Appendix C – Costings breakdown

West Waterway (W-WW)

Item	Description	Quantity	Unit	Rate $	Amount $	Comments
	W-WW WORKS					
1	**SITEWORKS AND EARTHWORKS**					
1.1	Site preparation	1	Item	$ 10,000	$ 10,000	
1.2	Diversion works	1	Item	$ 20,000	$ 20,000	
1.3	Waterway re-shaping	1	Item	$ 20,000	$ 20,000	
1.4	Stripping of topsoil	122,193	m2	$ 5	$ 610,965	
1.5	Excavation	156,201	m3	$ 25	$ 3,905,025	Excavation in broad greenfield land, excavated material to be reused on site for filling, allowance of 95% reuse on site for filling
1.6	Formation of batters	1,076	m3	$ 10	$ 10,760	
2	**DRAINAGE**					
2.1	Rockwork for waterway pool formation					
2.1.1	Supply and install D50=400mm rock, 800 mm thick to form pool No 1.	228	m3	$ 197	$ 44,916	Assumed 5% of potential excavated material for reuse in waterways
2.1.2	Supply and install D50=400mm rock, 800 mm thick to form Bass Hwy Inlet Pool.	185	m3	$ 197	$ 36,382	
2.1.3	Supply and install D50=400mm rock, 800 mm thick to form Bass Hwy Outlet Pool.	184	m3	$ 197	$ 36,232	
2.1.4	Supply and install D50=400mm rock, 800 mm thick to form pool No 2.	312	m3	$ 197	$ 61,385	
2.1.5	Supply and install D50=400mm rock, 800 mm thick to form Culvert 4 Inlet Pool.	340	m3	$ 197	$ 66,925	
2.1.6	Supply and install D50=400mm rock, 800 mm thick to form Culvert 4 Outlet Pool.	247	m3	$ 197	$ 48,659	
2.1.7	Supply and install D50=400mm rock, 800 mm thick to form Culvert 5 Inlet Pool.	366	m3	$ 197	$ 72,015	
2.1.8	Supply and install D50=400mm rock, 800 mm thick to form Culvert 5 Outlet Pool.	246	m3	$ 197	$ 48,509	
2.1.9	Supply and install D50=400mm rock, 800 mm thick to form Culvert 6 Inlet Pool.	354	m3	$ 197	$ 69,770	
2.1.10	Supply and install geofabric (Bidim A44 or equivalent) for all rock work	1032	LM	$ 25	$ 25,803	
3	**OTHER WORKS**					
3.1	Re spread 200 mm topsoil for planting areas	116,083	m2	$ 5.00	$ 580,417	Allowance of 95% of topsoil stripped from site, 5% assumed as unsuitable for reuse
3.2	Additional topsoil to be imported for planting areas	6,110	m2	$ 20.00	$ 122,193	
3.3	Supply and install shallow marsh planting (600cm3 tube, 2/m2).	56,122	No.	$ 5.00	$ 280,610	
3.4	Supply and install wet ephemeral planting (90cm3 tube, 6/m2).	44,568	No.	$ 2.50	$ 111,420	
3.5	Supply and install dry ephemeral planting (virocell planting, 6/m2).	151,110	No.	$ 2.50	$ 377,775	
3.6	Supply and install native grasses (virocell planting) @ 6p/m2 spacing incl. 50mm organic mulch.	232,782	No.	$ 2.50	$ 581,955	
3.7	Supply and install native planting (virocell planting) @ 6p/m2 spacing.	31,734	No.	$ 2.50	$ 79,335	
3.8	Supply and install heavy jute mat (800gsm) pre-slit at density 6/m2 to channel benches.	37,902	m2	$ 10	$ 379,020	
3.9	Supply and spread 50mm settled depth heavy grade 12-20mm Euca mulch to Bank Planting.	1,940	m3	$ 10	$ 19,399	
3.10	Supply and install Coir logs along channel for temporary erosion control.	2,604	LM	$ 20	$ 52,080	
4	**MISCELLANEOUS**					
4.1			Item			

4.2	Other *(Description)*		Item			
	SUB-TOTAL WORKS				$ 7,671,549	
5	**DELIVERY**					
5.1	Council Fees	3.25	%		$ 249,325	
5.2	VicRoads Fees	1	%		$ 76,715	
5.3	Traffic Management	5	%		$ 383,577	
5.4	Environmental Management	0.5	%		$ 38,358	
5.5	Survey & Design	5	%		$ 383,577	
5.6	Supervision & Project Management	9	%		$ 690,439	
5.7	Site Establishment	2.5	%		$ 191,789	
5.8	Contingency	20	%		$ 1,534,310	
	SUB-TOTAL DELIVERY				$ 3,548,092	
6	**TOTAL ESTIMATED COST**				$ 11,219,641	

East Waterway (E-WW)

Item	Description	Quantity	Unit	Rate $	Amount $	Comments
	E-WW WORKS					
1	**SITEWORKS AND EARTHWORKS**					
1.1	Site preparation	1	Item	$ 10,000	$ 10,000	
1.2	Diversion works	1	Item	$ 20,000	$ 20,000	
1.3	Waterway re-shaping	1	Item	$ 20,000	$ 20,000	
1.4	Stripping of topsoil	114,927	m2	$ 5	$ 574,635	
1.5	Excavation	88,278	m3	$ 25	$ 2,206,950	Excavation in broad greenfield land, excavated material to be reused on site for filling, allowance of 95% reuse on site for filling
1.6	Formation of batters	3,992	m3	$ 10	$ 39,920	
2	**DRAINAGE**					
2.1	Rockwork for waterway pool formation					
2.1.1	Supply and install D50=400mm rock, 800 mm thick to form Bass Hwy Outlet Pool	224	m3	$ 197	$ 44,167	Assumed 5% of potential excavated material for reuse in waterways
2.1.2	Supply and install D50=400mm rock, 800 mm thick to form McGibbonys Rd Inlet Pool	288	m3	$ 197	$ 56,744	
2.1.3	Supply and install D50=400mm rock, 800 mm thick to form McGibbonys Rd Outlet Pool	240	m3	$ 197	$ 47,312	
2.1.4	Supply and install D50=400mm rock, 800 mm thick to form pool No 1.	377	m3	$ 197	$ 74,261	
2.1.5	Supply and install D50=400mm rock, 800 mm thick to form pool No 2.	313	m3	$ 197	$ 61,685	
2.1.6	Supply and install D50=400mm rock, 800 mm thick to form pool No 3.	393	m3	$ 197	$ 77,405	
2.1.7	Supply and install D50=400mm rock, 800 mm thick to form pool No 4.	350	m3	$ 197	$ 69,021	
2.1.8	Supply and install geofabric (Bidim A44 or equivalent) for all rock work	917	LM	$ 25	$ 22,918	
3	**OTHER WORKS**					
3.1	Re spread 200 mm topsoil for planting areas	109,181	m2	$ 5.00	$ 545,903	Allowance of 95% of topsoil stripped from site, 5% assumed as unsuitable for reuse

3.2	Additional topsoil to be imported for planting areas	5,746	m2	$ 20.00	$ 114,927	
3.3	Supply and install shallow marsh planting (600cm3 tube, 2/m2).	67,596	No.	$ 5.00	$ 337,980	
3.4	Supply and install wet ephemeral planting (90cm3 tube, 6/m2).	22,398	No.	$ 2.50	$ 55,995	
3.5	Supply and install dry ephemeral planting (virocell planting, 6/m2).	305,538	No.	$ 2.50	$ 763,845	
3.6	Supply and install native grasses (virocell planting) @ 6p/m2 spacing incl. 50mm organic mulch.	399,264	No.	$ 2.50	$ 998,160	
3.7	Supply and install native planting (virocell planting) @ 6p/m2 spacing.	55,692	No.	$ 2.50	$ 139,230	
3.8	Supply and install heavy jute mat (800gsm) pre-slit at density 6/m2 to channel benches.	63,938	m2	$ 10	$ 639,380	
3.9	Supply and spread 50mm settled depth heavy grade 12-20mm Euca mulch to Bank Planting .	19,963	m3	$ 10	$ 199,632	
3.10	Supply and install Coir logs along channel for temporary erosion control.	4,091	LM	$ 20	$ 81,810	
4	**MISCELLANEOUS**					
4.1			Item			
4.2	Other *(Description)*		Item			
	SUB-TOTAL WORKS				$ 7,201,880	
5	**DELIVERY**					
5.1	Council Fees	3.25	%		$ 234,061	
5.2	VicRoads Fees	1	%		$ 72,019	
5.3	Traffic Management	5	%		$ 360,094	
5.4	Environmental Management	0.5	%		$ 36,009	
5.5	Survey & Design	5	%		$ 360,094	
5.6	Supervision & Project Management	9	%		$ 648,169	
5.7	Site Establishment	2.5	%		$ 180,047	
5.8	Contingency	20	%		$ 1,440,376	
	SUB-TOTAL DELIVERY				$ 3,330,870	
6	**TOTAL ESTIMATED COST**				$ 10,532,750	

Main Outfall to Powlett (MOP)

Item	Description	Quantity	Unit	Rate $	Amount $	Comments
	MOP WORKS					
1	**SITEWORKS AND EARTHWORKS**					
1.1	Site preparation	1	Item	$ 10,000	$ 10,000	
1.2	Diversion works	1	Item	$ 20,000	$ 20,000	
1.3	Waterway re-shaping	1	Item	$ 20,000	$ 20,000	
1.4	Stripping of topsoil	17,424	m2	$ 5	$ 87,120	

1.5	Excavation	20,284	m3	$ 25	$ 507,100	Excavation in broad greenfield land, excavated material to be reused on site for filling, allowance of 95% reuse on site for filling
2	**DRAINAGE**					
2.1	Rockwork for waterway pool formation					
2.1.1	Supply and install D50=400mm rock, 800 mm thick to form WLRB1 Outlet Pool	461	m3	$ 197	$ 90,880	Assumed 5% of potential excavated material for reuse in waterways
2.1.2	Supply and install D50=400mm rock, 800 mm thick to form WLRB2 Outlet Pool	112	m3	$ 197	$ 22,159	
2.1.3	Supply and install D50=400mm rock, 800 mm thick to form connection to existing downstream drain and stabilisation of locations of high shear stresses along existing waterway	496	m3	$ 197	$ 97,712	
2.1.4	Supply and install geofabric (Bidim A44 or equivalent) for all rock work	5093	LM	$ 25	$ 127,320	
3	**OTHER WORKS**					
3.1	Re spread 200 mm topsoil for planting areas	16,553	m2	$ 5.00	$ 82,764	Allowance of 95% of topsoil stripped from site, 5% assumed as unsuitable for reuse
3.2	Additional topsoil to be imported for planting areas	871	m2	$ 20.00	$ 17,424	
3.3	Supply and install shallow marsh planting (600cm3 tube, 2/m2).	7,128	No.	$ 5.00	$ 35,640	
3.4	Supply and install wet ephemeral planting (90cm3 tube, 6/m2).	56,622	No.	$ 2.50	$ 141,555	
3.5	Supply and install dry ephemeral planting (virocell planting, 6/m2).	26,214	No.	$ 2.50	$ 65,535	
3.6	Supply and install heavy jute mat (800gsm) pre-slit at density 6/m2 to channel benches.	26,214	m2	$ 10	$ 262,140	
3.7	Supply and spread 50mm settled depth heavy grade 12-20mm Euca mulch to Bank Planting.	2,831	m3	$ 10	$ 28,311	
4	**MISCELLANEOUS**					
4.1			Item			
4.2	Other *(Description)*		Item			
	SUB-TOTAL WORKS				$ 1,615,660	
5	**<u>DELIVERY</u>**					
5.1	Council Fees	3.25	%		$ 52,509	
5.2	VicRoads Fees	1	%		$ 16,157	
5.3	Traffic Management	5	%		$ 80,783	
5.4	Environmental Management	0.5	%		$ 8,078	
5.5	Survey & Design	5	%		$ 80,783	
5.6	Supervision & Project Management	9	%		$ 145,409	
5.7	Site Establishment	2.5	%		$ 40,391	
5.8	Contingency	20	%		$ 323,132	
	SUB-TOTAL DELIVERY				$ 747,243	
6	**TOTAL ESTIMATED COST**				$ 2,362,902	

<u>Wetland / Retarding Basin 1 (WLRB-1A & -1B; DCP ref WL-01)</u>

Item	Description	Quantity	Unit	Rate $	Amount $	Comments
	<u>WLRB1A&B WORKS</u>					
1	**SITEWORKS AND EARTHWORKS**					

1.1	Site preparation	2	Item	$ 10,000	$ 20,000	
1.2	Diversion works	2	Item	$ 20,000	$ 40,000	
1.3	Waterway re-shaping	2	Item	$ 20,000	$ 40,000	
1.4	Stripping of topsoil	189,544	m2	$ 5	$ 947,720	
1.5	Excavation	225,114	m3	$ 25	$ 5,627,850	Excavation in broad greenfield land, excavated material to be reused on site for filling, allowance of 95% reuse on site for filling
1.6	Formation of batters	21,375	m3	$ 10	$ 213,750	Excavation in broad greenfield land, excavated material to be reused on site for filling, allowance of 95% reuse on site for filling
2	**DRAINAGE**					
2.1	Rockwork					
2.1.1	Supply and install D50=400mm rock, 800 mm thick to form WL1A Wetland inlet	637	m3	$ 197	$ 125,465	Assumed 5% of potential excavated material for reuse in wetland
2.1.2	Supply and install D50=400mm rock, 800 mm thick to form WL1A Wetland overflow spillway	476	m3	$ 197	$ 93,725	
2.1.3	Supply and install D50=400mm rock, 800 mm thick to form WL1B Wetland inlet channel	644	m3	$ 197	$ 126,963	
2.1.4	Supply and install D50=400mm rock, 800 mm thick to form WL1B Wetland overflow spillway	233	m3	$ 197	$ 45,964	
2.2	Concrete					
2.2.1	Supply and install reinforced N32 grade concrete weir to form WL1A Wetland spillway weir	1	Item	$ 10,000	$ 10,000	
2.2.2	Supply and install reinforced N32 grade concrete, 150 mm deep to form WL1A Wetland sediment basin base	396	m3	$ 350	$ 138,600	
2.2.3	Supply and install reinforced N32 grade concrete weir to form WL1B Wetland spillway weir	1	Item	$ 10,000	$ 10,000	
2.2.4	Supply and install reinforced N32 grade concrete, 150 mm deep to form WL1B Wetland sediment basin base	520	m3	$ 350	$ 182,000	
2.3	Drainage					
2.3.1	Supply and install D50=200mm with Class 2 FCR backfill to form 4m wide sediment pond maintenance access (WL1A wetland), including sub base preparation	20	m3	$ 100	$ 2,000	
2.3.2	Supply and install 900 mm dia sediment pond transfer pipe incl excavation, crushed rock bedding and back fill (WL1A wetland)	40	m	$ 748	$ 29,920	
2.3.3	Supply and install submerged offtake pit (WL1A wetland)	1	No.	$ 6,710	$ 6,710	
2.3.4	Supply and install 300 mm dia RCP balance pipes (WL1A wetland)	298	m	$ 219	$ 65,262	
2.3.5	Supply and install submerged offtake pits for balance pipes (WL1A wetland)	4	No.	$ 6,710	$ 26,840	
2.3.6	Supply and install 900 mm dia wetland outfall pipe incl excavation, crushed rock bedding and back fill (WL1A wetland)	40	m	$ 748	$ 29,920	
2.3.7	Supply and install twin chamber outfall pit with penstock and concrete weir (WL1A wetland)	1	No.	$ 15,000	$ 15,000	
2.3.8	Supply and install D50=200mm with Class 2 FCR backfill to form 4m wide sediment pond maintenance access (WL1B wetland), including sub base preparation	20	m3	$ 100	$ 2,000	
2.3.9	Supply and install 900 mm dia sediment pond transfer pipe incl excavation, crushed rock bedding and back fill (WL1B wetland)	80	m	$ 748	$ 59,840	
2.3.10	Supply and install submerged offtake pit (WL1B wetland)	1	No.	$ 6,710	$ 6,710	
2.3.11	Supply and install 300 mm dia RCP balance pipes (WL1B wetland)	342	m	$ 219	$ 74,898	

2.3.12	Supply and install submerged offtake pits for balance pipes (WL1B wetland)	4	No.	$ 6,710	$ 26,840	
2.3.13	Supply and install 1050 mm dia wetland outfall pipe incl excavation, crushed rock bedding and back fill (WL1B wetland)	40	m	$ 927	$ 37,080	
2.3.14	Supply and install twin chamber outfall pit with penstock and concrete weir (WL1B wetland)	1	No.	$ 15,000	$ 15,000	
3	**OTHER WORKS**					
3.1	Re spread 200 mm topsoil for planting areas	180,067	m2	$ 5.00	$ 900,334	Allowance of 95% of topsoil stripped from site, 5% assumed as unsuitable for reuse
3.2	Additional topsoil to be imported for planting areas	9,477	m2	$ 20.00	$ 189,544	
3.3	Placement of 300 mm compacted clay liners for sedimentation basin and wetland (clay sourced onsite)	39,000	m2	$ 8.00	$ 312,000	
3.4	Supply and install submerged marsh planting (600cm3 tube, 1/m2).	2,824	No.	$ 5.00	$ 14,120	
3.5	Supply and install deep marsh planting (600cm3 tube, 2/m2).	15,756	No.	$ 5.00	$ 78,780	
3.6	Supply and install shallow marsh planting (600cm3 tube, 2/m2).	31,480	No.	$ 5.00	$ 157,400	
3.7	Supply and install wet ephemeral planting (90cm3 tube, 6/m2).	22,584	No.	$ 2.50	$ 56,460	
3.8	Supply and install dry ephemeral planting (90cm3 tube, 6/m2).	174,098	No.	$ 2.50	$ 435,245	
3.9	Supply and install sediment drying area planting (virocell planting, 6/m2).	125,400	No.	$ 2.50	$ 313,500	
3.10	Supply and install heavy jute mat (800gsm) pre-slit at density 6/m2 to TED to 350mm below NWL as specified for all Wet Ephemeral Planting	16,767	m2	$ 10	$ 167,670	
3.11	Supply, install and maintain plant protection netting for a selected species in the aquatic zones.	2	No.	$ 20,000	$ 40,000	
4	**MISCELLANEOUS**					
4.1	Allowance for timber bollards	1	Item	$ 3,000	$ 3,000	
4.2	Allowance for shared paths	1	Item	$ 100,000	$ 100,000	
4.3	Allowance for seats	1	Item	$ 35,000	$ 35,000	
4.4	Other *(Description)*		Item			
	SUB-TOTAL WORKS				$ 10,823,110	
5	**DELIVERY**					
5.1	Council Fees	3.25	%		$ 351,751	
5.2	VicRoads Fees	1	%		$ 108,231	
5.3	Traffic Management	5	%		$ 541,155	
5.4	Environmental Management	0.5	%		$ 54,116	
5.5	Survey & Design	5	%		$ 541,155	
5.6	Supervision & Project Management	9	%		$ 974,080	
5.7	Site Establishment	2.5	%		$ 270,578	
5.8	Contingency	20	%		$ 2,164,622	
	SUB-TOTAL DELIVERY				$ 5,005,688	
6	**TOTAL ESTIMATED COST**				$ 15,828,798	

Wetland / Retarding Basin 2 (WLRB2; DCP ref WL-02)

Item	Description	Quantity	Unit	Rate $	Amount $	Comments
	WLRB2 WORKS					
1	**SITEWORKS AND EARTHWORKS**					
1.1	Site preparation	1	Item	$ 10,000	$ 10,000	
1.2	Diversion works	1	Item	$ 20,000	$ 20,000	
1.3	Waterway re-shaping	1	Item	$ 20,000	$ 20,000	
1.4	Stripping of topsoil	12,200	m2	$ 5	$ 61,000	
1.5	Excavation	9,814	m3	$ 25	$ 245,350	Excavation in broad greenfield land, excavated material to be reused on site for filling, allowance of 95% reuse on site for filling
2	**DRAINAGE**					
2.1	Concrete					
2.2.1	Supply and install reinforced N32 grade concrete, 150 mm deep to form WL2 Wetland sediment basin base	76	m3	$ 350	$ 26,600	
2.3	Drainage					
2.3.1	Supply and install D50=200mm with Class 2 FCR backfill to form 4m wide sediment pond maintenance access (WL2 wetland), including sub base preparation	20	m3	$ 100	$ 2,000	
2.3.2	Supply and install 600 mm dia sediment pond transfer pipe incl excavation, crushed rock bedding and back fill	35	m	$ 444	$ 15,540	
2.3.3	Supply and install submerged offtake pit	1	No.	$ 6,710	$ 6,710	
2.3.4	Supply and install 300 mm dia RCP balance pipes	100	m	$ 219	$ 21,900	
2.3.5	Supply and install submerged offtake pits for balance pipes	2	No.	$ 6,710	$ 13,420	
2.3.6	Supply and install 1350 mm dia wetland high flow bypass pipeline	50	m	$ 1,346	$ 67,300	
2.3.7	Supply and install submerged offtake pit for high flow bypass	1	No.	$ 6,710	$ 6,710	
2.3.8	Supply and install 750 mm dia wetland outfall pipe incl excavation, crushed rock bedding and back fill	40	m	$ 586	$ 23,440	
2.3.9	Supply and install twin chamber outfall pit with penstock and concrete weir	1	No.	$ 15,000	$ 15,000	
3	**OTHER WORKS**					
3.1	Re spread 200 mm topsoil for planting areas	11,590	m2	$ 5.00	$ 57,950	Allowance of 95% of topsoil stripped from site, 5% assumed as unsuitable for reuse
3.2	Additional topsoil to be imported for planting areas	610	m2	$ 20.00	$ 12,200	
3.2	Placement of 300 mm compacted clay liners for sedimentation basin and wetland (clay sourced onsite)	8,650	m2	$ 8.00	$ 69,200	
3.3	Supply and install submerged marsh planting (600cm3 tube, 1/m2).	786	No.	$ 5.00	$ 3,930	
3.4	Supply and install deep marsh planting (600cm3 tube, 2/m2).	4,254	No.	$ 5.00	$ 21,270	
3.5	Supply and install shallow marsh planting (600cm3 tube, 2/m2).	7,398	No.	$ 5.00	$ 36,990	
3.6	Supply and install wet ephemeral planting (90cm3 tube, 6/m2).	6,774	No.	$ 2.50	$ 16,935	
3.7	Supply and install dry ephemeral planting (90cm3 tube, 6/m2).	14,532	No.	$ 2.50	$ 36,330	
3.8	Supply and install sediment drying area planting (virocell planting, 6/m2).	8,292	No.	$ 2.50	$ 20,730	
3.9	Supply and install heavy jute mat (800gsm) pre-slit at density 6/m2 to TED to 350mm below NWL as specified for all Wet Ephemeral Planting	4,828	m2	$ 10	$ 48,280	
3.10	Supply, install and maintain plant protection netting for a selected species in the aquatic zones.	1	No.	$ 20,000	$ 20,000	

4	**MISCELLANEOUS**					
4.1	Allowance for timber bollards	1	Item	$ 3,000	$ 3,000	
4.2	Allowance for shared paths	1	Item	$ 100,000	$ 100,000	
4.3	Allowance for seats	1	Item	$ 35,000	$ 35,000	
4.4	Other *(Description)*		Item			
	SUB-TOTAL WORKS				$ 1,036,785	
5	**DELIVERY**					
5.1	Council Fees	3.25	%		$ 33,696	
5.2	VicRoads Fees	1	%		$ 10,368	
5.3	Traffic Management	5	%		$ 51,839	
5.4	Environmental Management	0.5	%		$ 5,184	
5.5	Survey & Design	5	%		$ 51,839	
5.6	Supervision & Project Management	9	%		$ 93,311	
5.7	Site Establishment	2.5	%		$ 25,920	
5.8	Contingency	20	%		$ 207,357	
	SUB-TOTAL DELIVERY				$ 479,513	
6	**TOTAL ESTIMATED COST**				$ 1,516,298	

Wetland / Retarding Basin 3 (WLRB3; DCP ref WL-03)

Item	Description	Quantity	Unit	Rate $	Amount $	Comments
	WLRB3 WORKS					
1	**SITEWORKS AND EARTHWORKS**					
1.1	Site preparation	1	Item	$ 10,000	$ 10,000	
1.2	Diversion works	1	Item	$ 20,000	$ 20,000	
1.3	Waterway re-shaping	1	Item	$ 20,000	$ 20,000	
1.4	Stripping of topsoil	10,469	m2	$ 5	$ 52,345	
1.5	Excavation	11,977	m3	$ 25	$ 299,425	Excavation in broad greenfield land, excavated material to be reused on site for filling, allowance of 95% reuse on site for filling
2	**DRAINAGE**					
2.1	Concrete					
2.2.1	Supply and install reinforced N32 grade concrete, 150 mm deep to form WL3 Wetland sediment basin base	97	m3	$ 350	$ 33,950	
2.3	Drainage					
2.3.1	Drainage: Supply and install 600 mm dia sediment pond transfer pipe incl excavation, crushed rock bedding and back fill	20	m	$ 444	$ 8,880	
2.3.2	Drainage: Supply and install submerged offtake pit	1	No.	$ 6,710	$ 6,710	
2.3.3	Drainage: Supply and install 300 mm dia RCP balance pipes	88	m	$ 216	$ 19,008	
2.3.4	Drainage: Supply and install submerged offtake pits for balance pipes	2	No.	$ 6,710	$ 13,420	
2.3.5	Drainage: Supply and install 1200 mm dia wetland high flow bypass pipeline	30	m	$ 1,126	$ 33,780	
2.3.6	Drainage: Supply and install submerged offtake pit for high flow bypass	1	No.	$ 6,710	$ 6,710	

2.3.7	Drainage: Supply and install 675 mm dia wetland outfall pipe incl excavation, crushed rock bedding and back fill	40	m	$ 514	$ 20,560	
2.3.8	Drainage: Supply and install twin chamber outfall pit with penstock and concrete weir	1	No.	$ 15,000	$ 15,000	
2.3.9	Drainage: Supply and install 1200 mm dia retarding basin outfall pipes incl excavation, crushed rock bedding and back fill	50	m	$ 1,126	$ 56,300	
3	**OTHER WORKS**					
3.1	Re spread 200 mm topsoil for planting areas	9,946	m2	$ 5.00	$ 49,728	Allowance of 95% of topsoil stripped from site, 5% assumed as unsuitable for reuse
3.2	Additional topsoil to be imported for planting areas	523	m2	$ 20.00	$ 10,469	
3.3	Placement of 300 mm compacted clay liners for sedimentation basin and wetland (clay sourced onsite)	6,825	m2	$ 8.00	$ 54,600	
3.4	Supply and install submerged marsh planting (600cm3 tube, 1/m2).	687	No.	$ 5.00	$ 3,435	
3.5	Supply and install deep marsh planting (600cm3 tube, 2/m2).	2,414	No.	$ 5.00	$ 12,070	
3.6	Supply and install shallow marsh planting (600cm3 tube, 2/m2).	6,384	No.	$ 5.00	$ 31,920	
3.7	Supply and install wet ephemeral planting (90cm3 tube, 6/m2).	5,598	No.	$ 2.50	$ 13,995	
3.8	Supply and install dry ephemeral planting (90cm3 tube, 6/m2).	15,636	No.	$ 2.50	$ 39,090	
3.9	Supply and install sediment drying area planting (virocell planting, 6/m2).	6,552	No.	$ 2.50	$ 16,380	
3.10	Supply and install heavy jute mat (800gsm) pre-slit at density 6/m2 to TED to 350mm below NWL as specified for all Wet Ephemeral Planting	4,125	m2	$ 10	$ 41,250	
3.11	Supply, install and maintain plant protection netting for a selected species in the aquatic zones.	1	No.	$ 20,000	$ 20,000	
4	**MISCELLANEOUS**					
4.1	Allowance for timber bollards	1	Item	$ 3,000	$ 3,000	
4.2	Allowance for shared paths	1	Item	$ 100,000	$ 100,000	
4.3	Allowance for seats	1	Item	$ 35,000	$ 35,000	
4.4	Other *(Description)*		Item			
	SUB-TOTAL WORKS				$ 1,047,025	
5	**<u>DELIVERY</u>**					
5.1	Council Fees	3.25	%		$ 34,028	
5.2	VicRoads Fees	1	%		$ 10,470	
5.3	Traffic Management	5	%		$ 52,351	
5.4	Environmental Management	0.5	%		$ 5,235	
5.5	Survey & Design	5	%		$ 52,351	
5.6	Supervision & Project Management	9	%		$ 94,232	
5.7	Site Establishment	2.5	%		$ 26,176	
5.8	Contingency	20	%		$ 209,405	
	SUB-TOTAL DELIVERY				$ 484,249	
6	**TOTAL ESTIMATED COST**				$ 1,531,274	

Wetland / Retarding Basin 4 (WLRB4; DCP ref WL-04)

Item	Description	Quantity	Unit	Rate $	Amount $	Comments
	WLRB4 WORKS					
1	**SITEWORKS AND EARTHWORKS**					
1.1	Site preparation	1	Item	$ 10,000	$ 10,000	
1.2	Diversion works	1	Item	$ 20,000	$ 20,000	
1.3	Waterway re-shaping	1	Item	$ 20,000	$ 20,000	
1.4	Stripping of topsoil	22,387	m2	$ 5	$ 111,935	
1.5	Excavation	37,904	m3	$ 25	$ 947,600	Excavation in broad greenfield land, excavated material to be reused on site for filling, allowance of 95% reuse on site for filling
2	**DRAINAGE**					
2.1	Concrete					
2.2.1	Supply and install reinforced N32 grade concrete, 150 mm deep to form WL4 Wetland sediment basin base	265	m3	$ 350	$ 92,750	Allowance of 95% of topsoil stripped from site, 5% assumed as unsuitable for reuse
2.3	Drainage					
2.3.1	Drainage: Supply and install D50=200mm with Class 2 FCR backfill to form 4m wide sediment pond maintenance access (WL4 wetland), including sub base preparation	20	m3	$ 100	$ 2,000	
2.3.2	Drainage: Supply and install 825 mm dia sediment pond transfer pipe incl excavation, crushed rock bedding and back fill	40	m	$ 664	$ 26,560	
2.3.3	Drainage: Supply and install submerged offtake pit	1	No.	$ 6,710	$ 6,710	
2.3.4	Drainage: Supply and install 300 mm dia RCP balance pipes	100	m	$ 219	$ 21,900	
2.3.5	Drainage: Supply and install submerged offtake pits for balance pipes	2	No.	$ 6,710	$ 13,420	
2.3.6	Drainage: Supply and install 1500 mm dia wetland high flow bypass pipeline	320	m	$ 1,583	$ 506,560	
2.3.7	Drainage: Supply and install submerged offtake pit for high flow bypass	1	No.	$ 6,710	$ 6,710	
2.3.8	Drainage: Supply and install 900 mm dia wetland outfall pipe incl excavation, crushed rock bedding and back fill	40	m	$ 748	$ 29,920	
2.3.9	Drainage: Supply and install twin chamber outfall pit with penstock and concrete weir	1	No.	$ 15,000	$ 15,000	
3	**OTHER WORKS**					
3.1	Re spread 200 mm topsoil for planting areas	21,268	m2	$ 5.00	$ 106,338	
3.2	Additional topsoil to be imported for planting areas	1,895	m2	$ 20.00	$ 37,904	
3.3	Placement of 300 mm compacted clay liners for sedimentation basin and wetland (clay sourced onsite)	11,850	m2	$ 8.00	$ 94,800	
3.4	Supply and install submerged marsh planting (600cm3 tube, 1/m2).	1,136	No.	$ 5.00	$ 5,680	
3.5	Supply and install deep marsh planting (600cm3 tube, 2/m2).	410	No.	$ 5.00	$ 2,050	
3.6	Supply and install shallow marsh planting (600cm3 tube, 2/m2).	13,636	No.	$ 5.00	$ 68,180	
3.7	Supply and install wet ephemeral planting (90cm3 tube, 6/m2).	8,034	No.	$ 2.50	$ 20,085	
3.8	Supply and install dry ephemeral planting (90cm3 tube, 6/m2).	54,804	No.	$ 2.50	$ 137,010	
3.9	Supply and install sediment drying area planting (virocell planting, 6/m2).	12,198	No.	$ 2.50	$ 30,495	
3.10	Supply and install heavy jute mat (800gsm) pre-slit at density 6/m2 to TED to 350mm below NWL as specified for all Wet Ephemeral Planting	8,157	m2	$ 10	$ 81,570	

3.11	Supply, install and maintain plant protection netting for a selected species in the aquatic zones.	1	No.	$ 20,000	$ 20,000	
4	**MISCELLANEOUS**					
4.1	Allowance for timber bollards	1	Item	$ 3,000	$ 3,000	
4.2	Allowance for shared paths	1	Item	$ 100,000	$ 100,000	
4.3	Allowance for seats	1	Item	$ 35,000	$ 35,000	
4.4	Other *(Description)*		Item			
	SUB-TOTAL WORKS				$ 2,573,177	
5	**DELIVERY**					
5.1	Council Fees	3.25	%		$ 83,628	
5.2	VicRoads Fees	1	%		$ 25,732	
5.3	Traffic Management	5	%		$ 128,659	
5.4	Environmental Management	0.5	%		$ 12,866	
5.5	Survey & Design	5	%		$ 128,659	
5.6	Supervision & Project Management	9	%		$ 231,586	
5.7	Site Establishment	2.5	%		$ 64,329	
5.8	Contingency	20	%		$ 514,635	
	SUB-TOTAL DELIVERY				$ 1,190,094	
6	**TOTAL ESTIMATED COST**				$ 3,763,272	

Sediment Basin 1 (SB1; DCP ref SB3)

Item	Description	Quantity	Unit	Rate $	Amount $	Comments
	SB1 WORKS					
1	**SITEWORKS AND EARTHWORKS**					
1.1	Site preparation	1	Item	$ 10,000	$ 10,000	
1.2	Diversion works	1	Item	$ 20,000	$ 20,000	
1.3	Waterway re-shaping	1	Item	$ 20,000	$ 20,000	
1.4	Stripping of topsoil	4,323	m2	$ 5	$ 21,615	
1.5	Excavation	14,285	m3	$ 25	$ 357,125	Excavation in broad greenfield land, excavated material to be reused on site for filling, allowance of 95% reuse on site for filling
2	**DRAINAGE**					
2.1	Concrete					
2.2.1	Supply and install reinforced N32 grade concrete, 150 mm deep to form SB1 sediment basin base	113	m3	$ 350	$ 39,550	
2.3	Drainage					
2.3.1	Supply and install D50=200mm with Class 2 FCR backfill to form 4m wide sediment pond maintenance access, including sub base preparation	20	m3	$ 100	$ 2,000	
2.3.2	Supply and install 1500 mm dia sediment pond outfall pipe incl excavation, crushed rock bedding and back fill	40	m	$ 1,583	$ 63,320	
2.3.3	Supply and install submerged offtake pit	1	No.	$ 6,710	$ 6,710	

3	**OTHER WORKS**					
3.1	Re spread 200 mm topsoil for planting areas	4,107	m2	$ 5.00	$ 20,534	Allowance of 95% of topsoil stripped from site, 5% assumed as unsuitable for reuse
3.2	Additional topsoil to be imported for planting areas	216	m2	$ 20.00	$ 4,323	
3.3	Placement of 300 mm compacted clay liners for sedimentation basin and wetland (clay sourced onsite)	1,500	m2	$ 8.00	$ 12,000	
3.4	Supply and install submerged marsh planting (600cm3 tube, 1/m2).	124	No.	$ 5.00	$ 620	
3.5	Supply and install shallow marsh planting (600cm3 tube, 2/m2).	732	No.	$ 5.00	$ 3,660	
3.6	Supply and install wet ephemeral planting (90cm3 tube, 6/m2).	1,788	No.	$ 2.50	$ 4,470	
3.7	Supply and install dry ephemeral planting (90cm3 tube, 6/m2).	15,156	No.	$ 2.50	$ 37,890	
3.8	Supply and install sediment drying area planting (virocell planting, 6/m2).	11,898	No.	$ 2.50	$ 29,745	
3.9	Supply and install heavy jute mat (800gsm) pre-slit at density 6/m2 to TED to 350mm below NWL as specified for all Wet Ephemeral Planting	1,150	m2	$ 10	$ 11,500	
3.10	Supply, install and maintain plant protection netting for a selected species in the aquatic zones.	1	No.	$ 20,000	$ 20,000	
4	**MISCELLANEOUS**					
4.1	Allowance for timber bollards	1	Item	$ 3,000	$ 3,000	
4.2	Allowance for shared paths	1	Item	$ 100,000	$ 100,000	
4.3	Allowance for seats	1	Item	$ 35,000	$ 35,000	
4.4	Other *(Description)*		Item			
	SUB-TOTAL WORKS				$ 823,062	
5	**DELIVERY**					
5.1	Council Fees	3.25	%		$ 26,750	
5.2	VicRoads Fees	1	%		$ 8,231	
5.3	Traffic Management	5	%		$ 41,153	
5.4	Environmental Management	0.5	%		$ 4,115	
5.5	Survey & Design	5	%		$ 41,153	
5.6	Supervision & Project Management	9	%		$ 74,076	
5.7	Site Establishment	2.5	%		$ 20,577	
5.8	Contingency	20	%		$ 164,612	
	SUB-TOTAL DELIVERY				$ 380,666	
6	**TOTAL ESTIMATED COST**				$ 1,203,729	

Sediment Basin 4 (SB4; DCP ref SB7)

Item	Description	Quantity	Unit	Rate $	Amount $	Comments
	SB4 WORKS					
1	**SITEWORKS AND EARTHWORKS**					
1.1	Site preparation	1	Item	$ 10,000	$ 10,000	
1.2	Diversion works	1	Item	$ 20,000	$ 20,000	
1.3	Waterway re-shaping	1	Item	$ 20,000	$ 20,000	
1.4	Stripping of topsoil	4,745	m2	$ 5	$ 23,725	

1.5	Excavation	8,138	m3	$ 25	$ 203,450	Excavation in broad greenfield land, excavated material to be reused on site for filling, allowance of 95% reuse on site for filling
2	**DRAINAGE**					
2.1	Concrete					
2.2.1	Supply and install reinforced N32 grade concrete, 150 mm deep to form SB4 sediment basin base	104	m3	$ 350	$ 36,400	
2.3	Drainage					
2.3.1	Supply and install D50=200mm with Class 2 FCR backfill to form 4m wide sediment pond maintenance access, including sub base preparation	20	m3	$ 100	$ 2,000	
2.3.2	Supply and install 1350 mm dia sediment pond outfall pipe incl excavation, crushed rock bedding and back fill	40	m	$ 1,346	$ 53,840	
2.3.3	Supply and install submerged offtake pit	1	No.	$ 6,710	$ 6,710	
3	**OTHER WORKS**					
3.1	Re spread 200 mm topsoil for planting areas	4,508	m2	$ 5.00	$ 22,539	Allowance of 95% of topsoil stripped from site, 5% assumed as unsuitable for reuse
3.2	Additional topsoil to be imported for planting areas	237	m2	$ 20.00	$ 4,745	
3.3	Placement of 300 mm compacted clay liners for sedimentation basin and wetland (clay sourced onsite)	1,400	m2	$ 8.00	$ 11,200	
3.4	Supply and install submerged marsh planting (600cm3 tube, 1/m2).	119	No.	$ 5.00	$ 595	
3.5	Supply and install shallow marsh planting (600cm3 tube, 2/m2).	666	No.	$ 5.00	$ 3,330	
3.6	Supply and install wet ephemeral planting (90cm3 tube, 6/m2).	1,824	No.	$ 2.50	$ 4,560	
3.7	Supply and install dry ephemeral planting (90cm3 tube, 6/m2).	18,264	No.	$ 2.50	$ 45,660	
3.8	Supply and install sediment drying area planting (virocell planting, 6/m2).	7,578	No.	$ 2.50	$ 18,945	
3.9	Supply and install heavy jute mat (800gsm) pre-slit at density 6/m2 to TED to 350mm below NWL as specified for all Wet Ephemeral Planting	637	m2	$ 10	$ 6,370	
3.10	Supply, install and maintain plant protection netting for a selected species in the aquatic zones.	1	No.	$ 20,000	$ 20,000	
4	**MISCELLANEOUS**					
4.1	Allowance for timber bollards	1	Item	$ 3,000	$ 3,000	
4.2	Allowance for shared paths	1	Item	$ 100,000	$ 100,000	
4.3	Allowance for seats	1	Item	$ 35,000	$ 35,000	
4.4	Other *(Description)*		Item			
	SUB-TOTAL WORKS				$ 652,069	
5	**DELIVERY**					
5.1	Council Fees	3.25	%		$ 21,192	
5.2	VicRoads Fees	1	%		$ 6,521	
5.3	Traffic Management	5	%		$ 32,603	
5.4	Environmental Management	0.5	%		$ 3,260	
5.5	Survey & Design	5	%		$ 32,603	
5.6	Supervision & Project Management	9	%		$ 58,686	
5.7	Site Establishment	2.5	%		$ 16,302	
5.8	Contingency	20	%		$ 130,414	

	SUB-TOTAL DELIVERY	$ 301,582	
6	TOTAL ESTIMATED COST	$ 953,651	

Sediment Basin 5 (SB5; DCP ref SB15)

Item	Description	Quantity	Unit	Rate $	Amount $	Comments
	SB5 WORKS					
1	SITEWORKS AND EARTHWORKS					
1.1	Site preparation	1	Item	$ 10,000	$ 10,000	
1.2	Diversion works	1	Item	$ 20,000	$ 20,000	
1.3	Waterway re-shaping	1	Item	$ 20,000	$ 20,000	
1.4	Stripping of topsoil	3,401	m2	$ 5	$ 17,005	
1.5	Excavation	5,814	m3	$ 25	$ 145,350	Excavation in broad greenfield land, excavated material to be reused on site for filling, allowance of 95% reuse on site for filling
2	DRAINAGE					
2.1	Concrete					
2.2.1	Supply and install reinforced N32 grade concrete, 150 mm deep to form SB5 sediment basin base	113	m3	$ 350	$ 39,550	
2.3	Drainage					
2.3.1	Supply and install submerged offtake pit	1	No.	$ 6,710	$ 6,710	
3	OTHER WORKS					
3.1	Re spread 200 mm topsoil for planting areas	3,231	m2	$ 5.00	$ 16,155	Allowance of 95% of topsoil stripped from site, 5% assumed as unsuitable for reuse
3.2	Additional topsoil to be imported for planting areas	170	m2	$ 20.00	$ 3,401	
3.3	Placement of 300 mm compacted clay liners for sedimentation basin and wetland (clay sourced onsite)	1,500	m2	$ 8.00	$ 12,000	
3.4	Supply and install submerged marsh planting (600cm3 tube, 1/m2).	125	No.	$ 5.00	$ 625	
3.5	Supply and install shallow marsh planting (600cm3 tube, 2/m2).	732	No.	$ 5.00	$ 3,660	
3.6	Supply and install wet ephemeral planting (90cm3 tube, 6/m2).	1,842	No.	$ 2.50	$ 4,605	
3.7	Supply and install dry ephemeral planting (90cm3 tube, 6/m2).	9,552	No.	$ 2.50	$ 23,880	
3.8	Supply and install sediment drying area planting (virocell planting, 6/m2).	12,498	No.	$ 2.50	$ 31,245	
3.9	Supply and install heavy jute mat (800gsm) pre-slit at density 6/m2 to TED to 350mm below NWL as specified for all Wet Ephemeral Planting	1,151	m2	$ 10	$ 11,510	
3.10	Supply, install and maintain plant protection netting for a selected species in the aquatic zones.	1	No.	$ 20,000	$ 20,000	
4	MISCELLANEOUS					
4.1	Allowance for timber bollards	1	Item	$ 3,000	$ 3,000	
4.2	Allowance for shared paths	1	Item	$ 100,000	$ 100,000	
4.3	Allowance for seats	1	Item	$ 35,000	$ 35,000	
4.4	Other *(Description)*		Item			

	SUB-TOTAL WORKS				$ 523,696	
5	**DELIVERY**					
5.1	Council Fees	3.25	%		$ 17,020	
5.2	VicRoads Fees	1	%		$ 5,237	
5.3	Traffic Management	5	%		$ 26,185	
5.4	Environmental Management	0.5	%		$ 2,618	
5.5	Survey & Design	5	%		$ 26,185	
5.6	Supervision & Project Management	9	%		$ 47,133	
5.7	Site Establishment	2.5	%		$ 13,092	
5.8	Contingency	20	%		$ 104,739	
	SUB-TOTAL DELIVERY				$ 242,209	
6	**TOTAL ESTIMATED COST**				$ 765,905	

Sediment Basin 6 (SB6)

Item	Description	Quantity	Unit	Rate $	Amount $	Comments
	SB6 WORKS					
1	**SITEWORKS AND EARTHWORKS**					
1.1	Site preparation	1	Item	$ 10,000	$ 10,000	
1.2	Diversion works	1	Item	$ 20,000	$ 20,000	
1.3	Waterway re-shaping	1	Item	$ 20,000	$ 20,000	
1.4	Stripping of topsoil	1,773	m2	$ 5	$ 8,865	
1.5	Excavation	2,726	m3	$ 25	$ 68,150	Excavation in broad greenfield land, excavated material to be reused on site for filling, allowance of 95% reuse on site for filling
2	**DRAINAGE**					
2.1	Concrete					
2.2.1	Supply and install reinforced N32 grade concrete, 150 mm deep to form SB6 sediment basin base	66	m3	$ 350	$ 23,100	
2.3	Drainage					
2.3.1	Supply and install 1200 mm dia sediment pond outfall pipe incl excavation, crushed rock bedding and back fill	40	m	$ 1,126	$ 45,040	
2.3.2	Supply and install submerged offtake pit	1	No.	$ 6,710	$ 6,710	
3	**OTHER WORKS**					
3.1	Re spread 200 mm topsoil for planting areas	1,684	m2	$ 5.00	$ 8,422	Allowance of 95% of topsoil stripped from site, 5% assumed as unsuitable for reuse
3.2	Additional topsoil to be imported for planting areas	89	m2	$ 20.00	$ 1,773	
3.3	Placement of 300 mm compacted clay liners for sedimentation basin and wetland (clay sourced onsite)	1,000	m2	$ 8.00	$ 8,000	
3.4	Supply and install submerged marsh planting (600cm3 tube, 1/m2).	97	No.	$ 5.00	$ 485	
3.5	Supply and install shallow marsh planting (600cm3 tube, 2/m2).	586	No.	$ 5.00	$ 2,930	
3.6	Supply and install wet ephemeral planting (90cm3 tube, 6/m2).	1,284	No.	$ 2.50	$ 3,210	

3.7	Supply and install dry ephemeral planting (90cm3 tube, 6/m2).	3,324	No.	$ 2.50	$ 8,310	
3.8	Supply and install sediment drying area planting (virocell planting, 6/m2).	5,910	No.	$ 2.50	$ 14,775	
3.9	Supply and install heavy jute mat (800gsm) pre-slit at density 6/m2 to TED to 350mm below NWL as specified for all Wet Ephemeral Planting	507	m2	$ 10	$ 5,070	
3.10	Supply, install and maintain plant protection netting for a selected species in the aquatic zones.	1	No.	$ 20,000	$ 20,000	
4	**MISCELLANEOUS**					
4.1	Allowance for timber bollards	1	Item	$ 3,000	$ 3,000	
4.2	Allowance for shared paths	1	Item	$ 100,000	$ 100,000	
4.3	Allowance for seats	1	Item	$ 35,000	$ 35,000	
4.4	Other *(Description)*		Item			
	SUB-TOTAL WORKS				$ 412,840	
5	**DELIVERY**					
5.1	Council Fees	3.25	%		$ 13,417	
5.2	VicRoads Fees	1	%		$ 4,128	
5.3	Traffic Management	5	%		$ 20,642	
5.4	Environmental Management	0.5	%		$ 2,064	
5.5	Survey & Design	5	%		$ 20,642	
5.6	Supervision & Project Management	9	%		$ 37,156	
5.7	Site Establishment	2.5	%		$ 10,321	
5.8	Contingency	20	%		$ 82,568	
	SUB-TOTAL DELIVERY				$ 190,938	
6	**TOTAL ESTIMATED COST**				$ 603,778	

Sediment Basin 7 (SB7)

Item	Description	Quantity	Unit	Rate $	Amount $	Comments
	SB7 WORKS					
1	**SITEWORKS AND EARTHWORKS**					
1.1	Site preparation	1	Item	$ 10,000	$ 10,000	
1.2	Diversion works	1	Item	$ 20,000	$ 20,000	
1.3	Waterway re-shaping	1	Item	$ 20,000	$ 20,000	
1.4	Stripping of topsoil	2,216	m2	$ 5	$ 11,080	
1.5	Excavation	3,178	m3	$ 25	$ 79,450	Excavation in broad greenfield land, excavated material to be reused on site for filling, allowance of 95% reuse on site for filling
2	**DRAINAGE**					
2.1	Concrete					
2.2.1	Supply and install reinforced N32 grade concrete, 150 mm deep to form SB7 sediment basin base	19	m3	$ 350	$ 6,650	
2.3	Drainage					

2.3.1	Supply and install 900 mm dia sediment pond outfall pipe incl excavation, crushed rock bedding and back fill	40	m	$ 748	$ 29,920	
2.3.2	Supply and install submerged offtake pit	1	No.	$ 6,710	$ 6,710	
3	**OTHER WORKS**					
3.1	Re spread 200 mm topsoil for planting areas	2,105	m2	$ 5.00	$ 10,526	Allowance of 95% of topsoil stripped from site, 5% assumed as unsuitable for reuse
3.2	Additional topsoil to be imported for planting areas	111	m2	$ 20.00	$ 2,216	
3.3	Placement of 300 mm compacted clay liners for sedimentation basin and wetland (clay sourced onsite)	500	m2	$ 8.00	$ 4,000	
3.4	Supply and install submerged marsh planting (600cm3 tube, 1/m2).	63	No.	$ 5.00	$ 315	
3.5	Supply and install shallow marsh planting (600cm3 tube, 2/m2).	402	No.	$ 5.00	$ 2,010	
3.6	Supply and install wet ephemeral planting (90cm3 tube, 6/m2).	1,098	No.	$ 2.50	$ 2,745	
3.7	Supply and install dry ephemeral planting (90cm3 tube, 6/m2).	9,156	No.	$ 2.50	$ 22,890	
3.8	Supply and install sediment drying area planting (virocell planting, 6/m2).	2,406	No.	$ 2.50	$ 6,015	
3.9	Supply and install heavy jute mat (800gsm) pre-slit at density 6/m2 to TED to 350mm below NWL as specified for all Wet Ephemeral Planting	677	m2	$ 10	$ 6,770	
3.10	Supply, install and maintain plant protection netting for a selected species in the aquatic zones.	1	No.	$ 20,000	$ 20,000	
4	**MISCELLANEOUS**					
4.1	Allowance for timber bollards	1	Item	$ 3,000	$ 3,000	
4.2	Allowance for shared paths	1	Item	$ 100,000	$ 100,000	
4.3	Allowance for seats	1	Item	$ 35,000	$ 35,000	
4.4	Other *(Description)*		Item			
	SUB-TOTAL WORKS				$ 399,297	
5	**<u>DELIVERY</u>**					
5.1	Council Fees	3.25	%		$ 12,977	
5.2	VicRoads Fees	1	%		$ 3,993	
5.3	Traffic Management	5	%		$ 19,965	
5.4	Environmental Management	0.5	%		$ 1,996	
5.5	Survey & Design	5	%		$ 19,965	
5.6	Supervision & Project Management	9	%		$ 35,937	
5.7	Site Establishment	2.5	%		$ 9,982	
5.8	Contingency	20	%		$ 79,859	
	SUB-TOTAL DELIVERY				$ 184,675	
6	**TOTAL ESTIMATED COST**				$ 583,972	

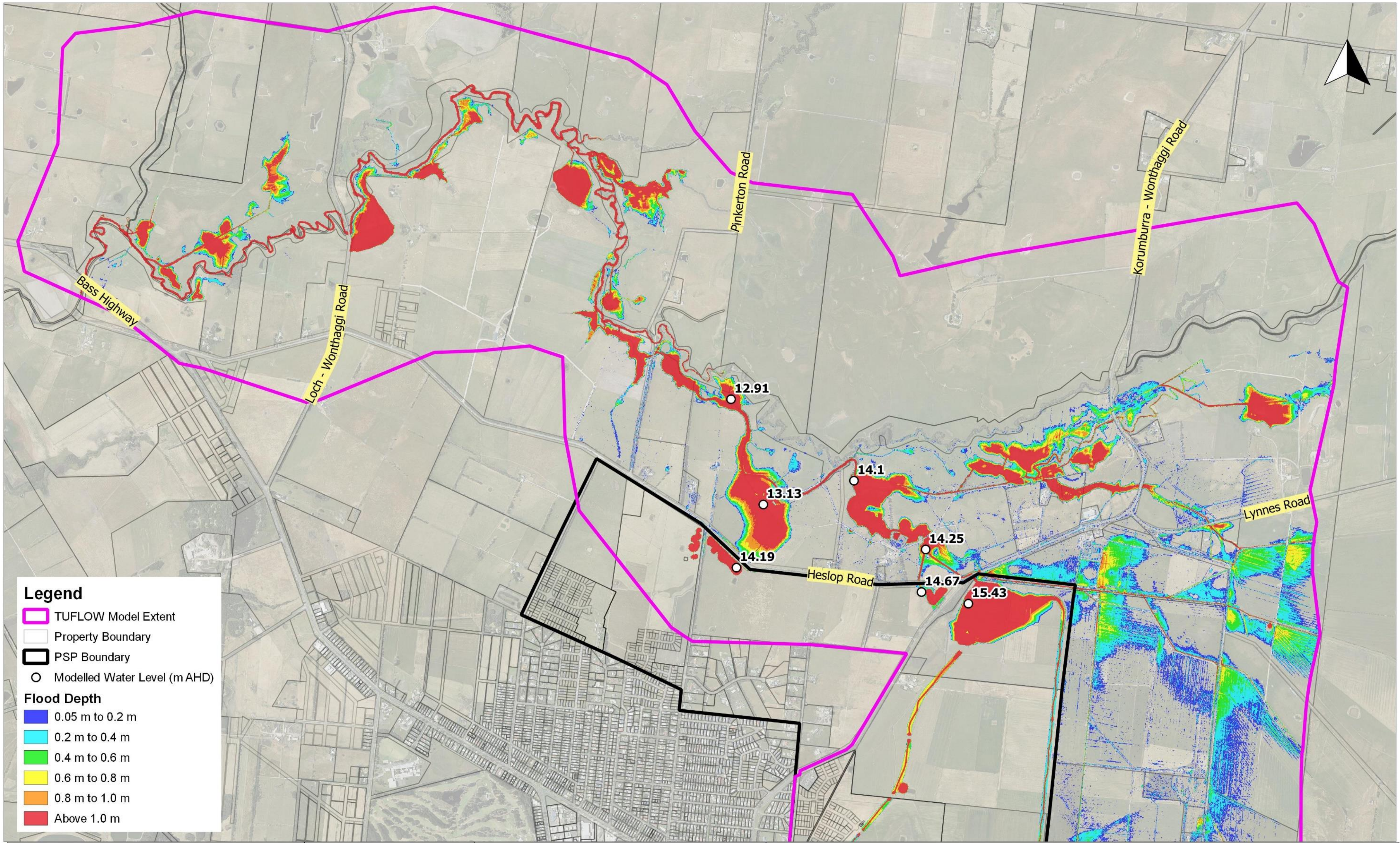
Appendix D – Alluvium response to Craigie/Daff Preliminary Drainage Review

	Feedback & Recommendations (Craigie/Daff) - Preliminary Drainage Review (Dec 2021)	Changes made by Alluvium Consulting and reflected in the April 2022 Drainage Report
	Discussion of Wetland Sizing	
1	Given the very high costs proposed, strict adherence to the very conservative MWC DTC guidelines should be tempered with practical considerations. We acknowledge the DTC approach may have proved the easiest pathway to project approvals in greater Melbourne, but in this regional setting longer term maintenance costs for over-sized assets will be a significant burden on limited Council budgets.	**Engeny has re-run the storage elevation component of the TUFLOW model per the below scope: 1. Rerun TUFLOW model for the following two scenarios: o DEM of revised wetland footprint @ 13.6 AHD with modified downstream channel outfall and updated outfall pipe arrangement provided by Alluvium. o DEM of revised wetland footprint @ 14.0 AHD with modified downstream channel outfall and updated outfall pipe arrangement provided by Alluvium. o DEM of revised wetland footprint @ 14.0 AHD with modified downstream channel outfall and updated outfall pipe arrangement provided by Alluvium. This run includes updates to the constructed waterways, which were raised to match the proposed higher wetland level. 2. Rerun TUFLOW model for the following events: o 50% AEP and 1% AEP excluding Powlett River flows o 50% AEP and 1% AEP including Powlett River flows 3. Review previous flood mapping results for the existing and developed conditions to determine if wetlands 2 and 3 could also be raised from a flooding/retardation point of view. Alluvium has adjusted wetland sizes and designs accordingly, with most of the changes focused on WLRB1a and WLRB1b, and the two constructed waterways. Alluvium has reduced the macrophyte zones of all wetlands (WLRB4 footprint has been approved by Council so no changes made). Alluvium has raised the normal water level of WLRB1a and WLRB1b to reduce overall excavation costs, without compromising flood storage requirements and water quality treatment compliance.**
2	Particularly in a location such as this where the wetland area is well and truly drowned out in events less than 1EY (1 year) the DTC approach taken by Alluvium should be revisited to better acknowledge the reality of the site environment and to scale back the treatment outcomes. 1EY flood level is 15.4 m cf. wetland NWL of 13.6 m and TEDD of 13.95 m.	Refer to item 1.
3	The 4EY flow estimates should be checked first. These appear to have been adopted as 40% of 1EY flows entering the basins (although this is hard to confirm from the report).	**Alluvium has completed this check.**
4	Given the large size of the inlet sediment ponds and hydraulic control separation from the macrophyte zones, the retarding effects of the inlet ponds could be incorporated into a separate version of the RORB model to determine peak outflow rate into the macrophyte zones in the 4EY event. The ARR 2019 rainfall data allows direct simulation of events less than 1 EY. (It should be noted that this model structure would not be suited to large flood event simulations).	Refer to item 1.
5	Based on our experience it is likely that 4EY flow peaks entering the macrophyte zone would be significantly mitigated with this design approach. Reduction in flows would directly reduce macrophyte zone width and then length and hence overall area. We recommend this be done.	Refer to item 1.
6	Macrophyte areas could also be reduced by about 25% just by adopting a length to width ratio of 3 which should still be sufficient to ensure plug flow through the wetland. We recommend this be adopted.	Refer to item 1.
7	Lastly a 2D model such as TUFLOW can be used to confirm actual hydraulic behaviour in the macrophyte zone during the 4EY event and show the velocity criteria of 0.05 m/s will be achieved. This work should form part of final design.	No action. This is an issue for the detailed design phase.
	Discussion of Cost Items and Rates	

8	The designs for the East and West Waterways are similar so that quantities should be about the same for both consultants. Despite this Alluvium estimated base costs of $38.6M cf. Engeny at $16.4M, an increase of 235%.	**Alluvium has raised the invert of the two constructed waterways to reduce overall excavation quantities associated with the development of the PSP and DCP without losing flood conveyance and capacity.**
9	(Note: Alluvium report high flow capacity of the lower reaches of both waterways as the same at 31.4 m3/s whereas Engeny get 21 m3/s for E-WW. This needs to be clarified given the same RORB model is used. If Alluvium have over-estimated the required capacity, then this will be reflected in higher quantities and costs)	**Alluvium has completed this check.**
	Cost Rates	
10	One partial explanation for cost differentials would be that the Engeny cost estimates are from the 2019 report. Their November 2021 update didn't include new cost estimates. We accept that construction rates are likely to have been significantly increased from 2019 but certainly not by 235%.	**Alluvium has updated costing rates and items using region-specific costing estimates.**
11	The excavation rate of $38 per cubic metre for the bulk excavation of the retarding basins, wetlands and waterways appears to be high and needs to be justified. We understand rates around $25 or less are currently used in south eastern Melbourne	**Alluvium has included a lower excavation rate of $25/m3.**
12	Importation of topsoil for all earthworks projects within the PSP also needs to be justified. There is no explanation offered in the report. In nearly all drainage projects topsoil removed during the construction of the water asset is returned following excavation. Sometimes topsoil removed from adjacent roads is also used. The estimates allow a base cost of $10M just for the importation of topsoil. If there is a geotechnical reason for such a massive extra cost, then this needs to be clearly stated.	**Alluvium have revised cost estimates using the following volumes and reuse estimates:** **• An excavated volume of 5% assumed for offsite disposal** **• An excavated volume of 95% assumed to be reused on site for filling** **• An allowance of 5% assumed for some rock excavation / potential reuse in waterways** **• Excavated topsoil has assumed 5% for removal and 95% for stockpiling on site for later reuse on site** **• An allowance of 5% assumed to import clean topsoil to cover for topsoil losses (shortfall due to above).**
13	The total supervision costs of 12.25% comprising 3.25% council fees and 9.0% supervision and project management appears excessive and should be reviewed.	No action for Alluvium - VPA to consider.
	Other Design Suggestions to Reduce Costs	
	(a) Wetland NWL	
14	One factor that will significantly affect final costs is the NWL chosen for wetland design. Currently Engeny and Alluvium both have NWL at 13.6 m for WLRB1. We believe this is way too low given natural surface levels of about 16 m and downstream inverts about 13.1 (after construction of the outfall).	Refer to item 1.
15	It is recommended that macrophyte zone NWL be raised to 14.2 m in WLRB1. That equates to excavation saving of about 60,000 m3 for the Alluvium WLRB1a+b design. At their base rate of $38/m3 that is a saving of $2.3M.	Refer to item 1.
16	The higher NWL also increases clearance over inevitable vegetation growth in the MOP outfall over time and enhances hydraulic grade for culvert/pipe outfall design.	Refer to item 1.
17	In turn this change in NWL raises the invert levels of the lower portions of the E-WW and W-WW waterways so that further significant savings in excavation can be made on those assets. Such invert raising should not significantly impact on calculated flood levels or finished surface levels.	Refer to item 1.
18	Grades averaging 1 in 750 are achievable in the lower reaches of both waterways with the raised NWL which are still within normal guidelines. Inclusion of online pools for habitat and aesthetic values can also increase effective bed grades. We have not had time to check the other wetlands, but similar comments and potential savings may apply.	Refer to item 1.
	(b) SB4/SB6 Locations	
19	These basins are currently shown as offline to W-WW and E-WW occupying large areas of otherwise developable land. It is our view that these basins should be integrated online to reduce land take, earthworks, plantings and to improve aesthetics. Design would need to satisfy	**Alluvium have relocated SB4 and SB6 into the respective waterway corridors. These SBs have been integrated into the waterway 'floodplains' to reduce overall land take.**

	velocity and maintenance criteria, but we expect no real problems. We see significant cost savings and greatly improved waterway corridor aesthetics accruing through this change.	
	(c) WLRB1 Low flow outlet	
20	The current Alluvium low flow outlet design for WLRB1a+b reflects the Engeny proposal. It provides for 10*300 mm pipes (length ~100 m), to get under/over the gas main and the water mains. Figure 1 refers.	**Alluvium have included an updated design comprising 3 x 900mm (W) x 300mm (H) box culverts, which would transition to a single 1200mm (W) x 600mm (H) box culvert midway through the road crossing, once the existing services requiring appropriate cover was passed. The proposed outfall arrangement is considered a more feasible and effective approach in comparison to a 10 x 300mm HDPE pipe arrangement (Engeny, 2021) given the propensity to blockages.**
21	There will be inevitable operation and maintenance problems with this design. There are more practical and less costly arrangements available which should be considered in future design. A quick check on the capacity of the designed outlet system at headwater level of 14.5 m (crest of the high flow outlet culverts under Wonthaggi Korumburra Road) shows that no more than 650 l/s can be discharged to the MOP outfall. Figure 2 shows a suggested alternative that matches this capacity with a simple box culvert arrangement. A small pool should be added at the outlet end to the MOP outfall regardless of whatever design solution is adopted.	
	(d) Asset Locations and alignments	
22	Although not part of our brief we would like to suggest that flexibility be retained in the PSP DCP wording to allow future subdivisional and drainage asset design to be varied from the adopted functional layouts, subject to still meeting the best practice performance requirements for drainage. Our experience convinces us that unless the wording is flexible it will prove to be difficult to adjust drainage asset location/alignment/shape in future design. One example is the functional design report mentions that roads should be constructed alongside the W-WW and E-WW waterways. We believe there is a need to create more interest in the layout of the subdivision and variety in the lots to assist in long term success of waterway design and ongoing maintenance. This could be achieved by having a number of sections along the waterways where lots face directly onto the waterway with only a pedestrian/maintenance track between the lots and the waterway. A small lane could run along the rear of these lots to give access to their garages. The owners of these lots have "ownership" of the waterway that they are overlooking. The main road would have to dogleg around these areas which would help restrict high speeds along these roads. We understand this arrangement was shown in a number of PSPs in northern Melbourne. It is ideally suited to pockets of medium density development as well.	Alluvium has considered this, but no change proposed to designs.
23	(e) Contributions The drainage costs for this PSP were always going to be high because of the large areas outside the PSP that have to drain through the PSP. Page 12 of Alluviums' report states that 720 ha of agriculture and existing/proposed urban catchments external to the PSP drain to WLRB1a and WLRB1b. A drainage contribution from the external existing and proposed urban areas should be considered in a similar manner to the way they are treated in the Melbourne Water area. No contributions are sought from rural areas as they have not increased the runoff i.e., no increase in impervious areas.	**Alluvium has completed an analysis of volume data from external catchments.**
	Although we didn't mention it in our report, another point that could be considered in determining the width of E-WW is the width of vegetated buffer that needs to be set aside on the eastern side of the waterway. This width should be less that that recommended in Melbourne Water's guidelines as the eastern side of the waterway is rural and not urbanised i.e. the width of the vegetated buffer should be less on the eastern side of the waterway than on the western side.	**Alluvium have shifted the eastern waterway as close to the eastern boundary of the PSP as possible while maintaining a total 19m minimum offset for bushfire protection through the waterway corridor.**

Appendix E – TUFLOW modelling output maps (Engeny, April 2022)



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ENGENY WATER MANAGEMENT

BASS COAST

200 0 200 400 600 800 m

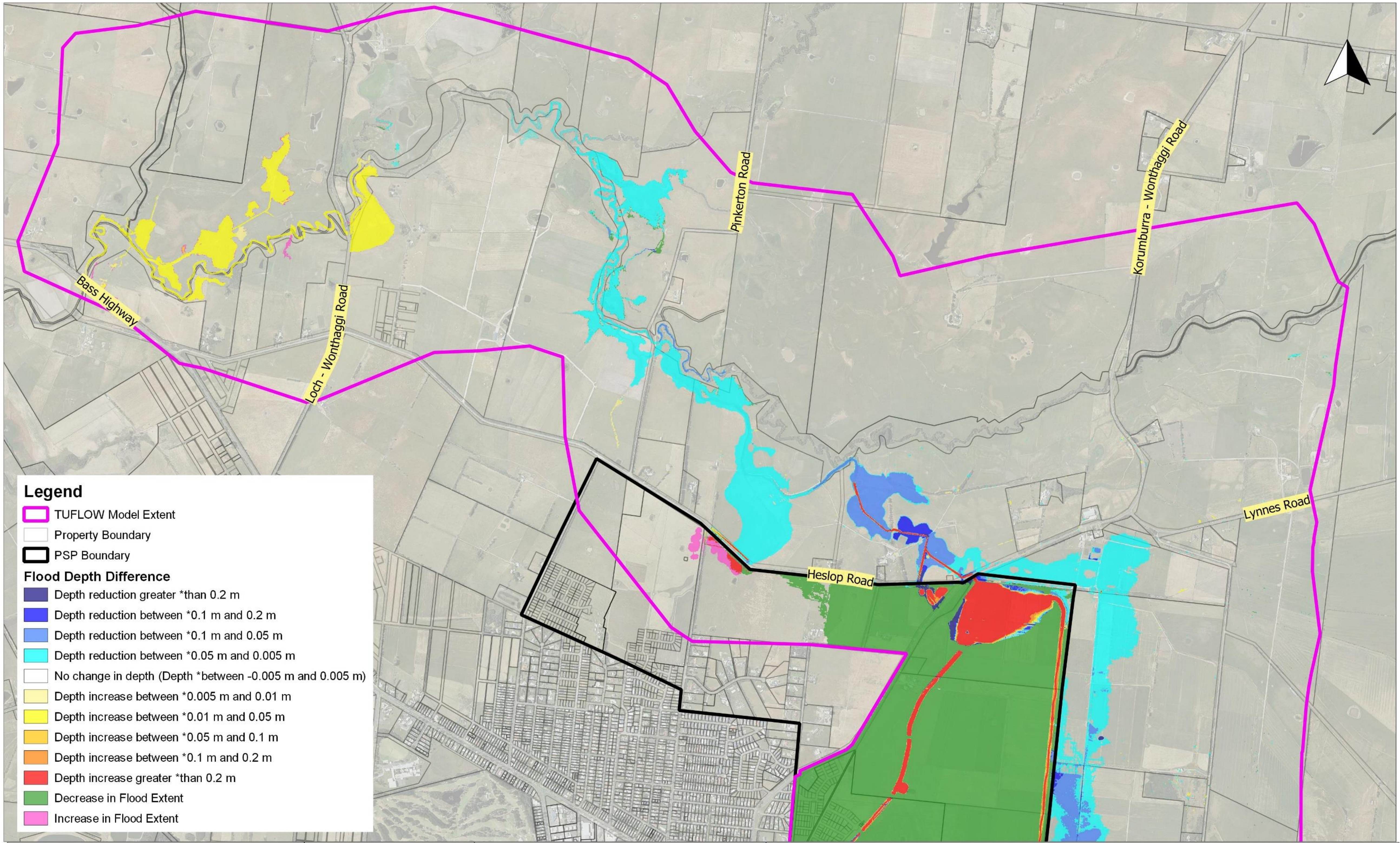
Scale in metres (1:20,000 @ A3)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 55

Wonthaggi NE PSP - 2022 Updated Flood Modelling

50 % AEP Flood Depth
Developed Conditions
No Powlett River Inflows

Job Number: V5000_002
Revision: 0
Drawn: AN
Checked: GTO
Date: 28/4/2022



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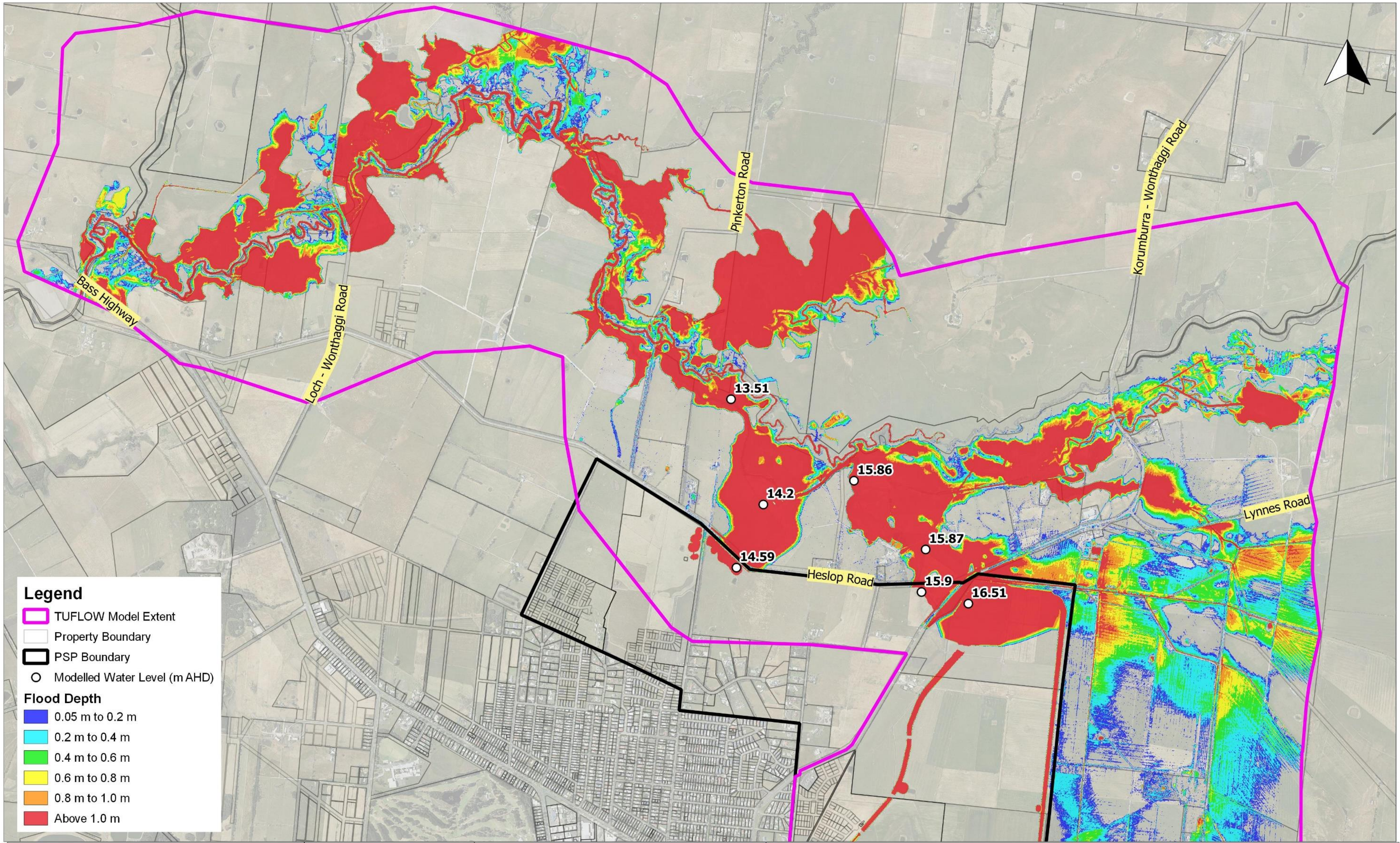
Wonthaggi NE PSP - 2022 Updated Flood Modelling

50 % AEP Flood Difference Plot (Afflux)
Developed Conditions Minus Predeveloped Conditions
No Powlett River Inflows

Job Number: V5000_002
Revision: 0
Drawn: AN
Checked: GTO
Date: 28/4/2022



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BASS COAST

200 0 200 400 600 800 m

Scale in metres (1:20,000 @ A3)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 55

Wonthaggi NE PSP - 2022 Updated Flood Modelling

1 % AEP Flood Depth
Developed Conditions
No Powlett River Inflows

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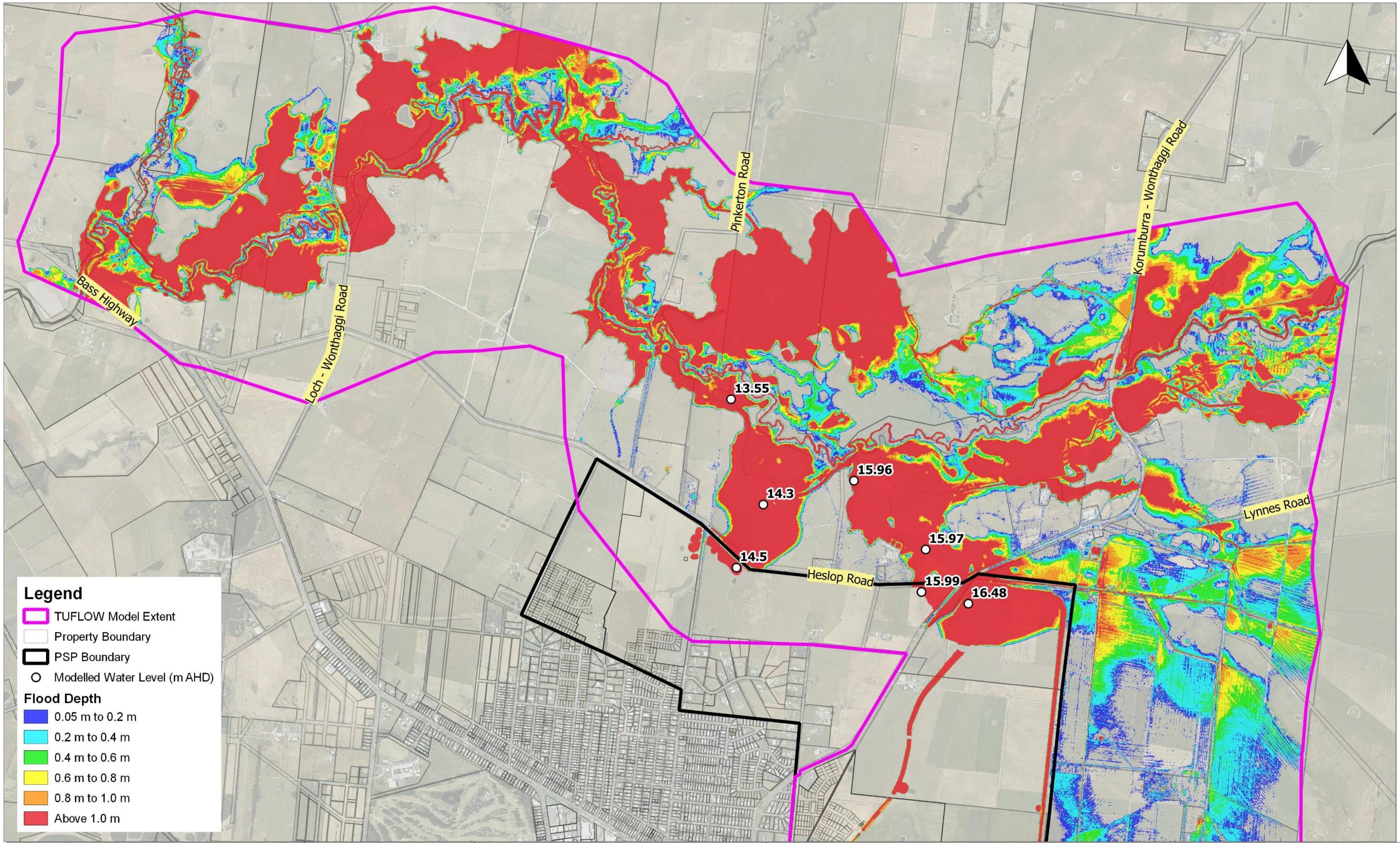

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ENGENY WATER MANAGEMENT

BASS COAST

200 0 200 400 600 800 m

Scale in metres (1:20,000 @ A3)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 55

Wonthaggi NE PSP - 2022 Updated Flood Modelling

1 % AEP Flood Depth
Developed Conditions
With Powlett River Inflows

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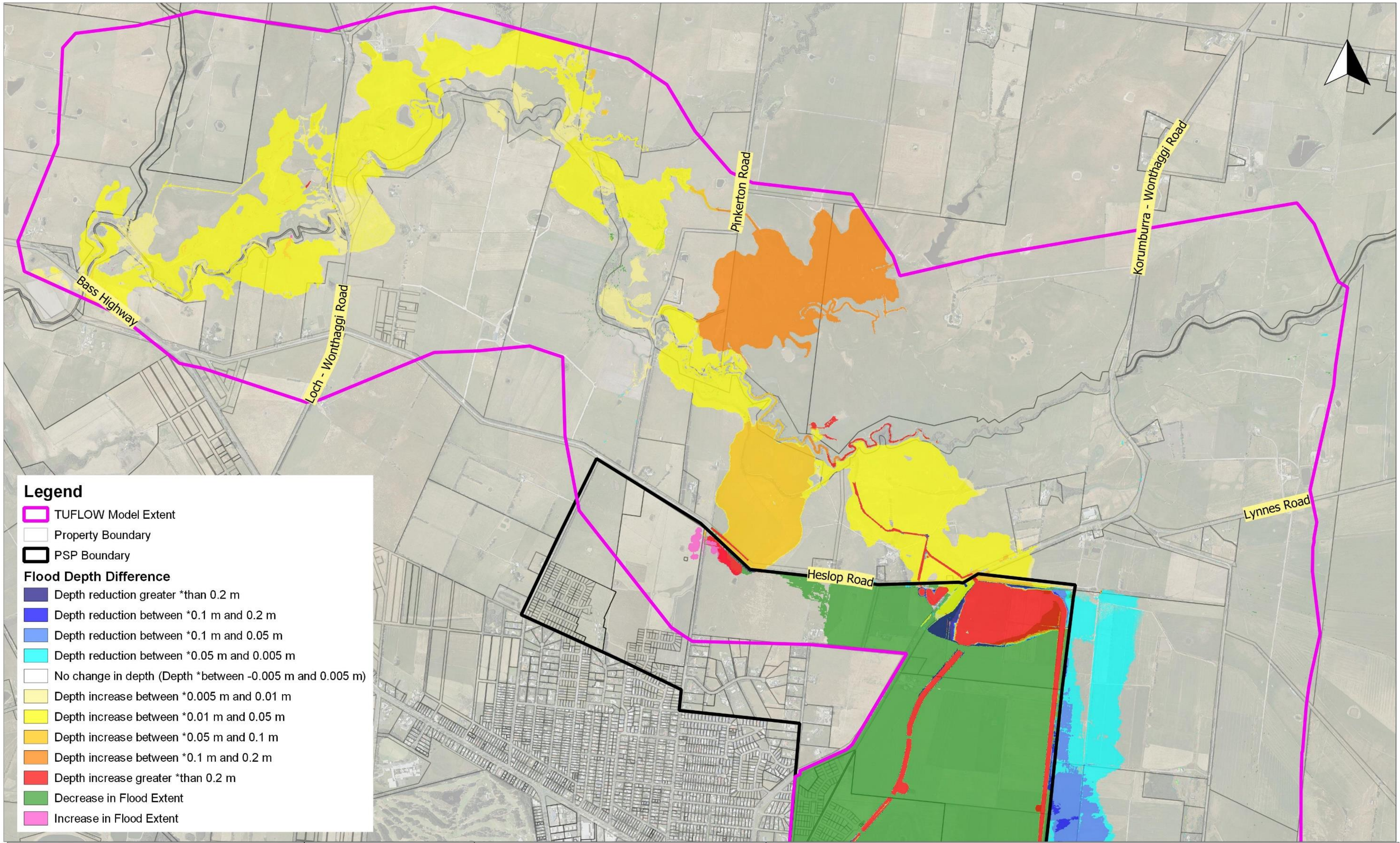

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ENGENY WATER MANAGEMENT

BASS COAST

200 0 200 400 600 800 m

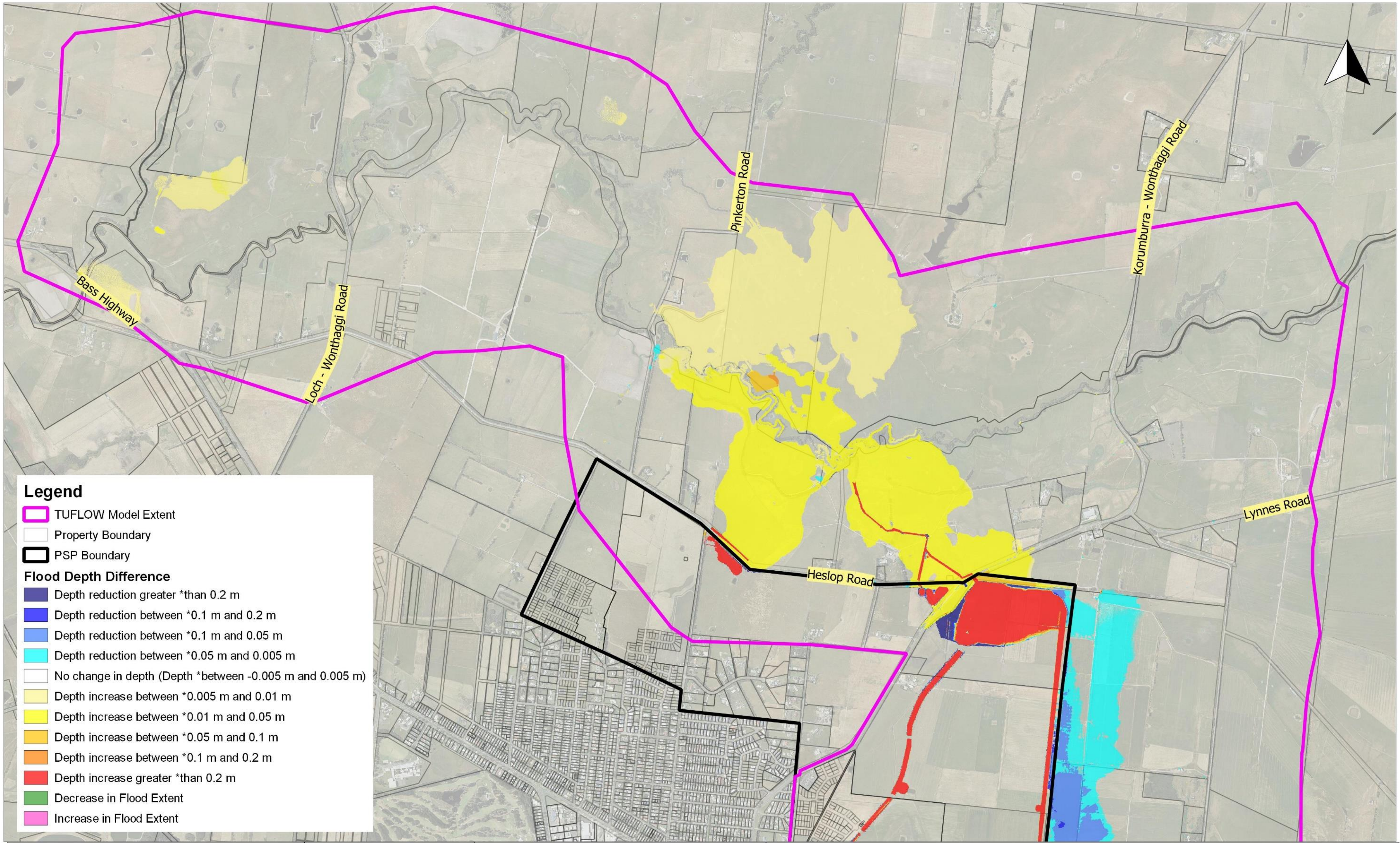
Scale in metres (1:20,000 @ A3)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 55

Wonthaggi NE PSP - 2022 Updated Flood Modelling

1 % AEP Flood Difference Plot (Afflux)
Developed Conditions Minus Predeveloped Conditions
No Powlett River Inflows

Job Number: V5000_002
Revision: 0
Drawn: AN
Checked: GTO
Date: 28/4/2022



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ENGENY WATER MANAGEMENT

BASS COAST

200 0 200 400 600 800 m

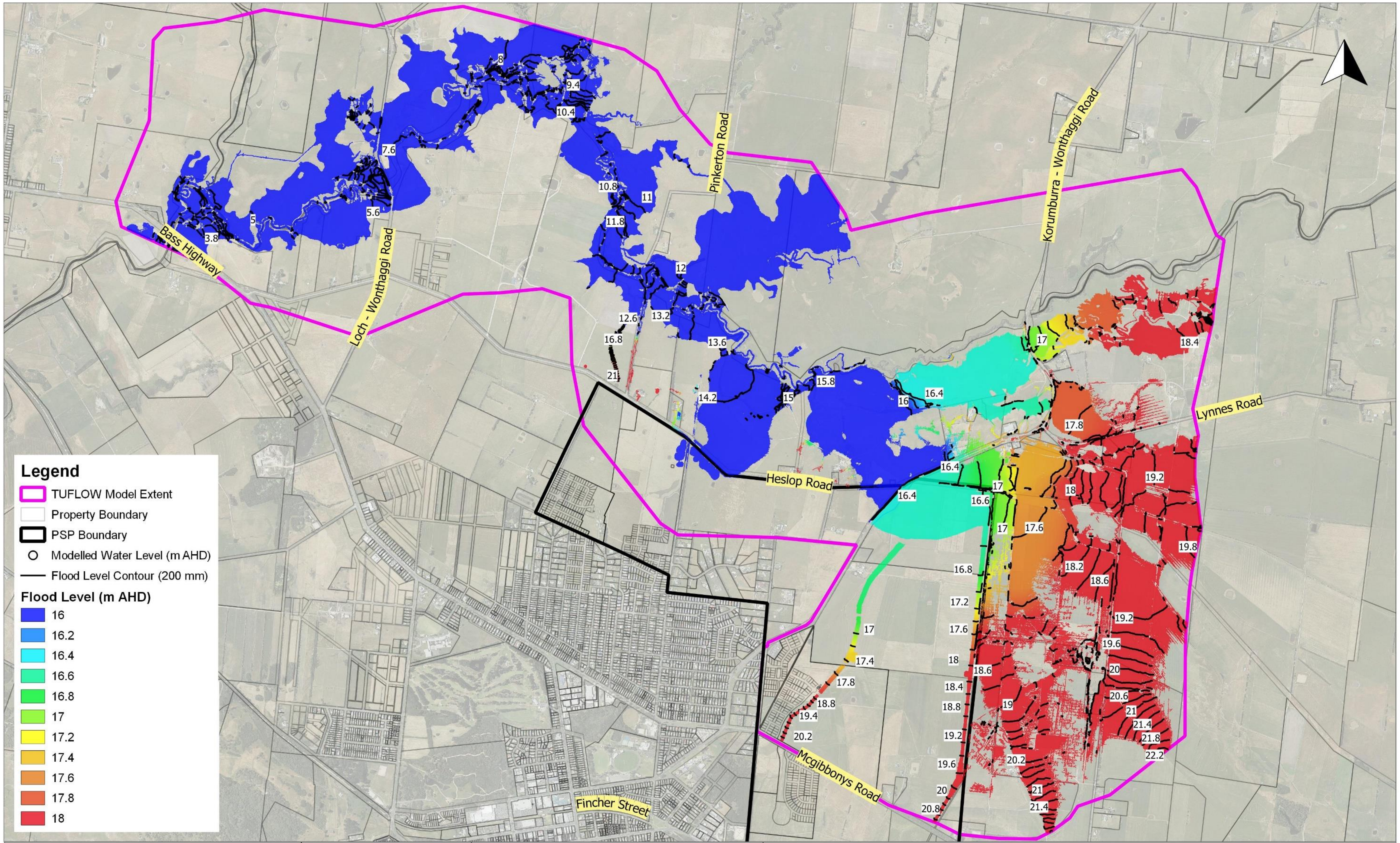
Scale in metres (1:20,000 @ A3)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 55

Wonthaggi NE PSP - 2022 Updated Flood Modelling

1 % AEP Flood Difference Plot (Afflux)
Developed Conditions Minus Predeveloped Conditions
With Powlett River Inflows

Job Number: V5000_002
Revision: 0
Drawn: AN
Checked: GTO
Date: 28/4/2022



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ENGENY WATER MANAGEMENT

BASS COAST

200 0 200 400 600 800 m

Scale in metres (1:24000 @ A3)

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 55

Wonthaggi NE PSP - 2022 Updated Flood Modelling

1 % AEP Flood Level
Developed Conditions
No Powlett River Inflows

Job Number: V5000_002
Revision: 0
Drawn: AN
Checked: GTO
Date: 29/4/2022