Wonthaggi North East Precinct Structure Plan and Development Contributions Plan

FUNCTIONAL DESIGN REPORT

November 2021

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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Abbreviations

Alluvium	Alluvium Consulting Australia Pty Ltd
BCSC	Bass Coast Shire Council
BPEMG	Best Practice Environmental Management Guidelines
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
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.

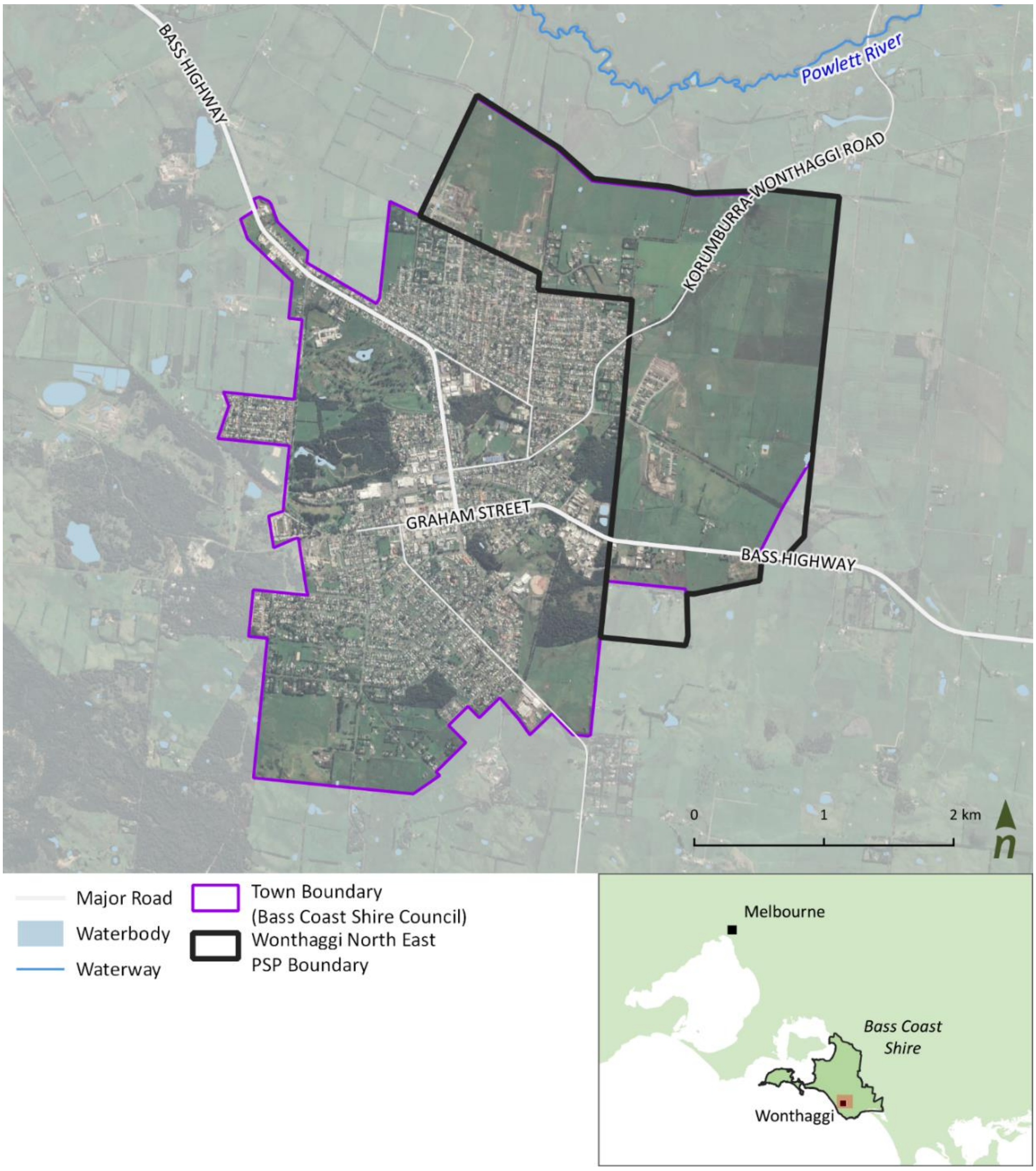


Figure 1. *Site location*

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/RB-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 precinct outfall).

A number of 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. This is addressed further in Section 4.

Error! Reference source not found. 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.

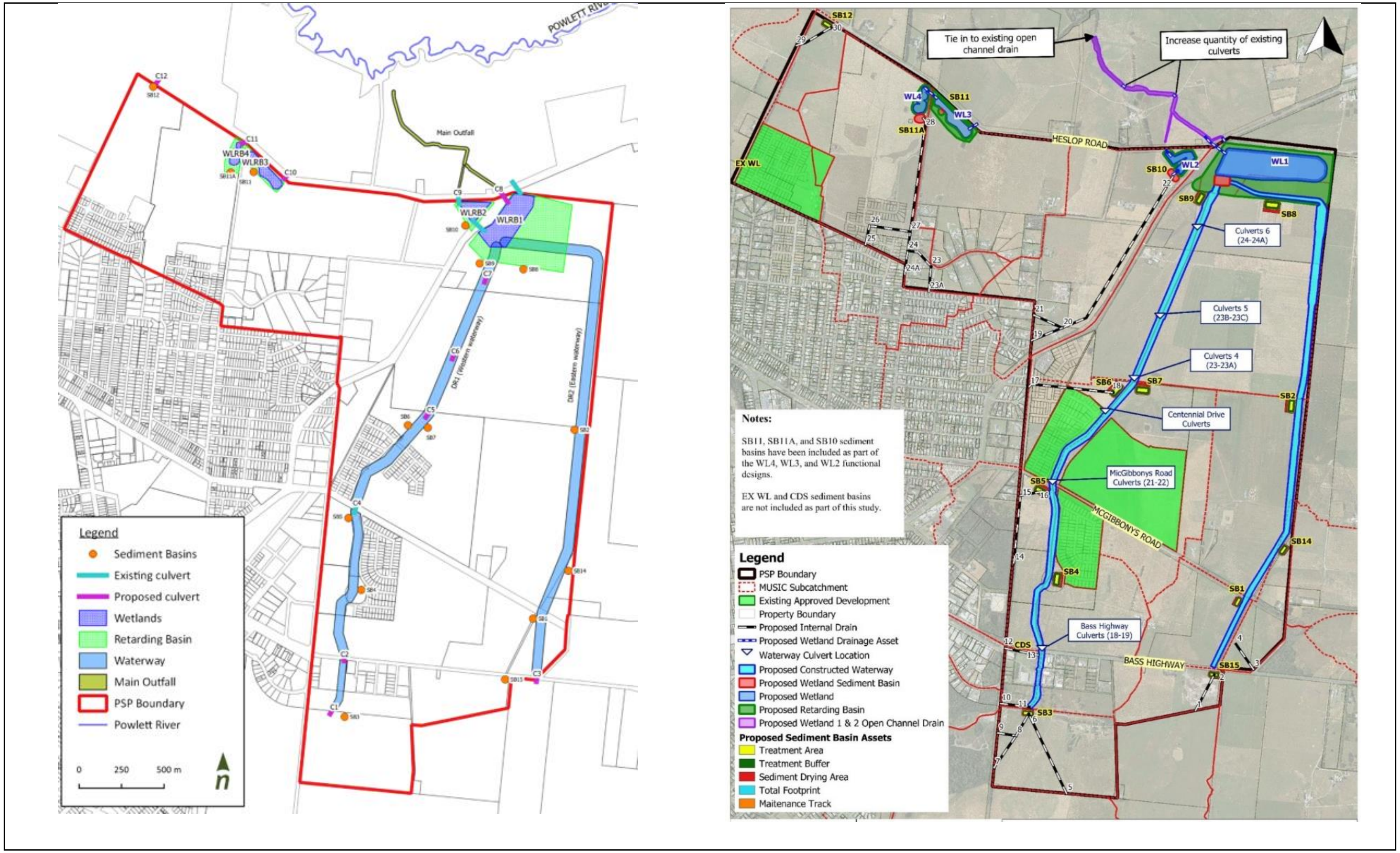


Figure 2. *Showing comparative changes in proposed assets for the PSP from October 2019 to September 2021 (Engeny)*

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, a number of previously identified and independent assets (e.g. 16 x sediment basins) were integrated into the designs of other systems (e.g. 4x wetlands) while some were made redundant due to small contributing catchment, 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 (DPC ref WL-01/RB-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 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) suggesting no design necessary. However, Alluvium notes the critical need for CU2 on E-WW at McGibbonys Road (culvert is not existing as per council feedback) and a design required.
- **1** main outfall (and associated infrastructure) **–** this PSP asset is an additional (expected) asset for functional design.

The above details are summarised in Table 1 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 (October 2021)

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 in order 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 (undertaken 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 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
- project objectives and stakeholder inputs, including core and added value / future opportunities
- recommendations presented in our Proof of Concept Report 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.

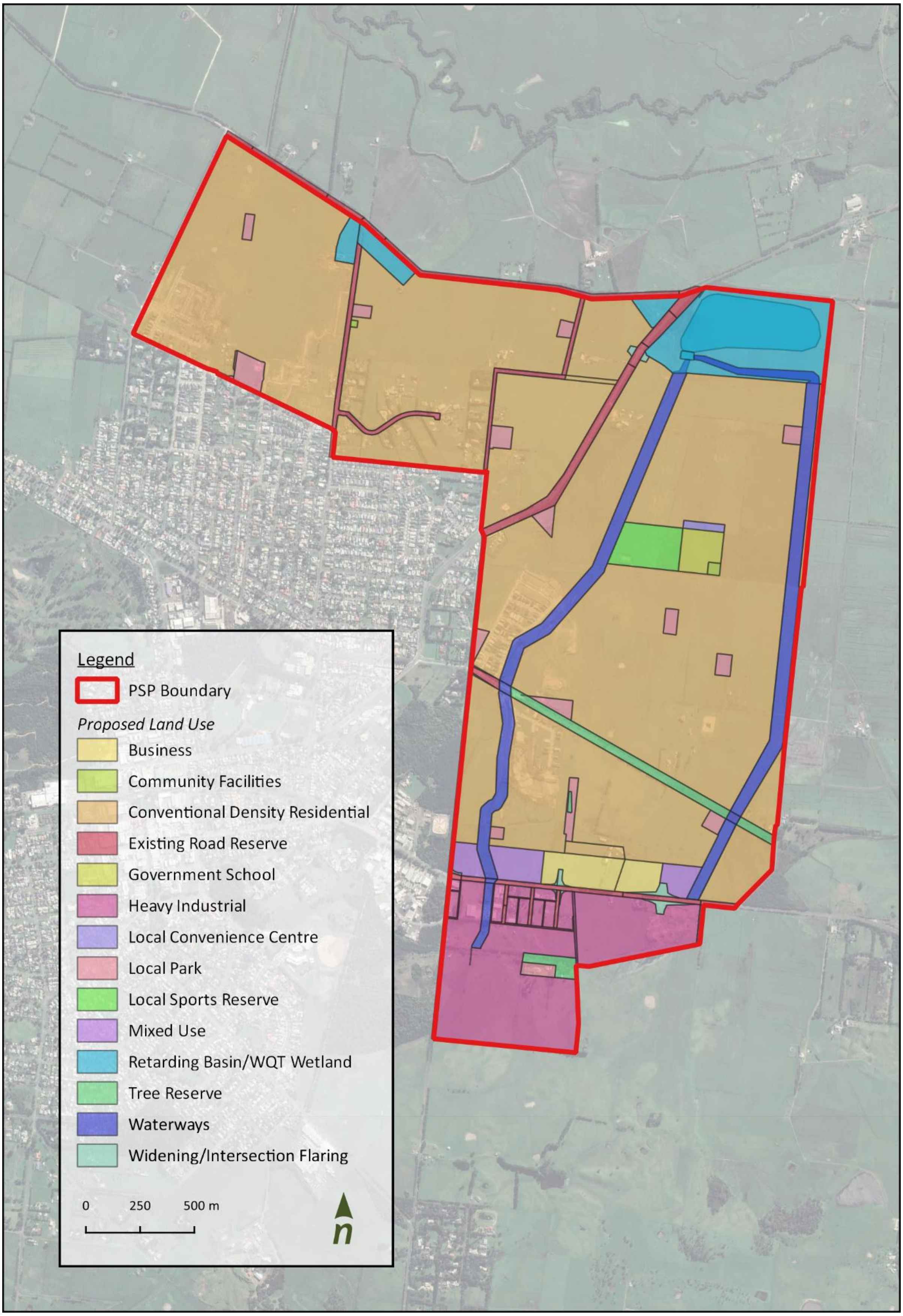


Figure 3. *Site Overview - project PSP area and proposed land use (source: modified from GIS proposed land use data, VPA).*

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 the majority of 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.

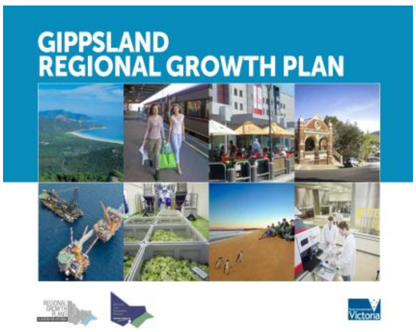
Bass Coast Shire Council is the local drainage authority for all urban land in the region, while West Gippsland Catchment Management Authority (WGCMA) is the rural drainage and floodplains manager. Together, with Traditional Owners, local landowners and the broader community, they represent the key stakeholders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



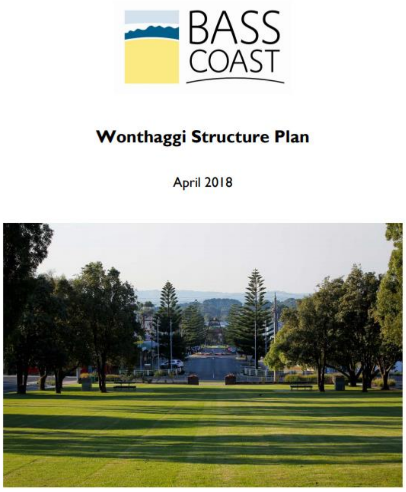
Gippsland Regional Growth Plan (VPA, 2014)

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.

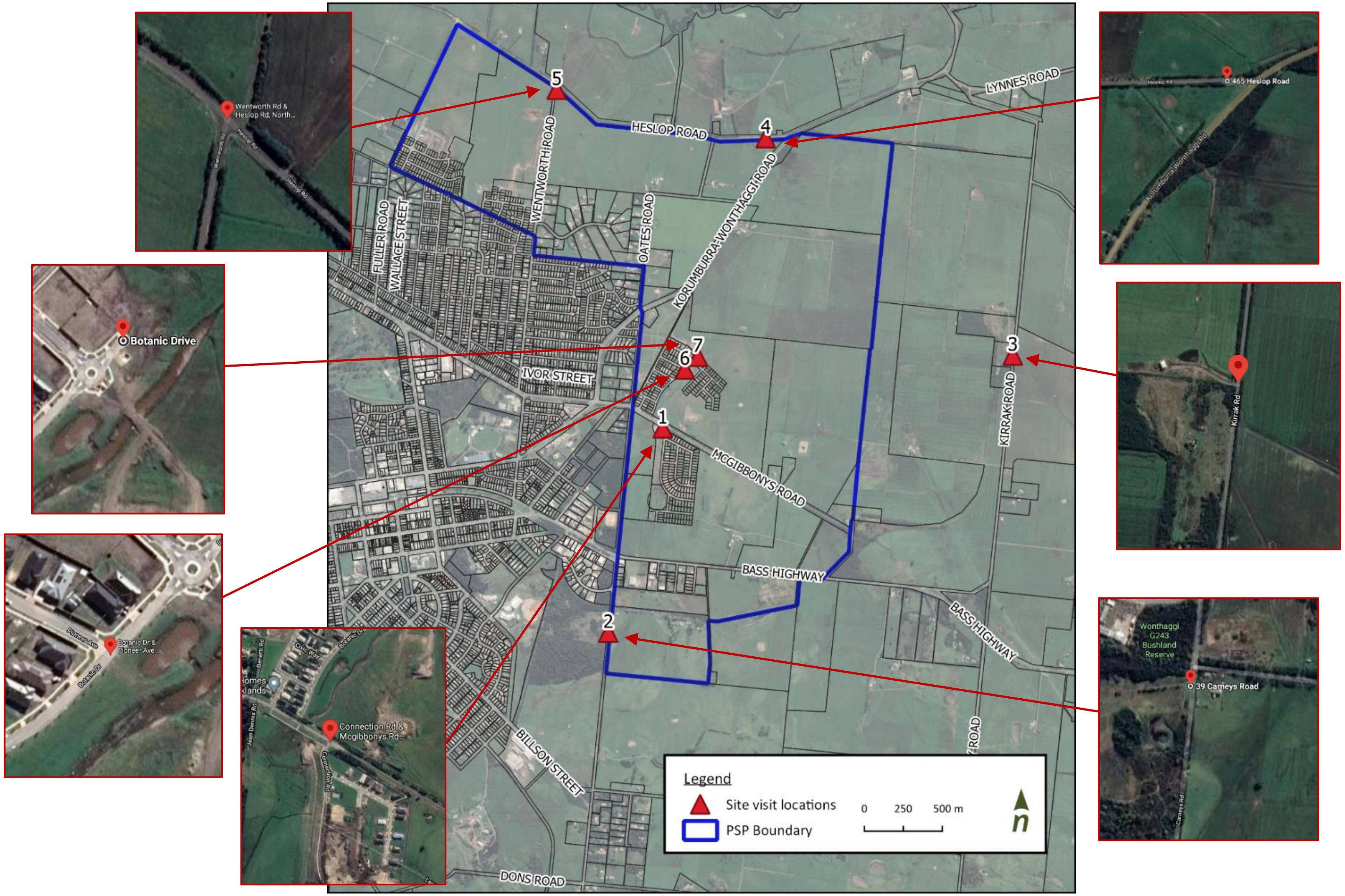


***Figure 4**. Site visit locations with georeferenced site photos (July 2021)*

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.

Advice Note to Council: While this situation is outside this study scope and the issues relate to approved development activity, we offer this as advice in support of Council's planning compliance, who should act and ensure rectification to protect this new asset from potential rework. These matters do not affect the functional designs and costings for the PSP and are offered only as guidance here, for council-community benefit and to ensure issues are addressed sooner than later, so as to protect the assets being designed as part of this study.

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.

Advice Note to Council: Any investment into the two constructed waterways for the precinct should be made with confidence that the ecology and stream integrity will be protected, sustainable, and over time, naturally enhanced to become centralised features of the developed landscape and future community neighbourhood. It is highly recommended that Council consider / negotiate an appropriate treatment asset (e.g. triple interceptor or similarly appropriate to the site conditions) to manage the quality of stormwater discharges from the industrial area, before they enter the precinct's constructed waterways and the downstream wetlands. This would ensure investment and effort is not undermined at the outset, and asset function and integrity is maintained for the life of the downstream 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/RB-01)

The Engeny stormwater strategy proposed an integrated wetland and retarding basin (DCP WL-01/RB-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/RB-01) was completed, based on a desktop analysis, using NearMap and Google maps.

WLRB1 (DPC ref WL-01/RB-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/RB-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 actually 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 Dve

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)

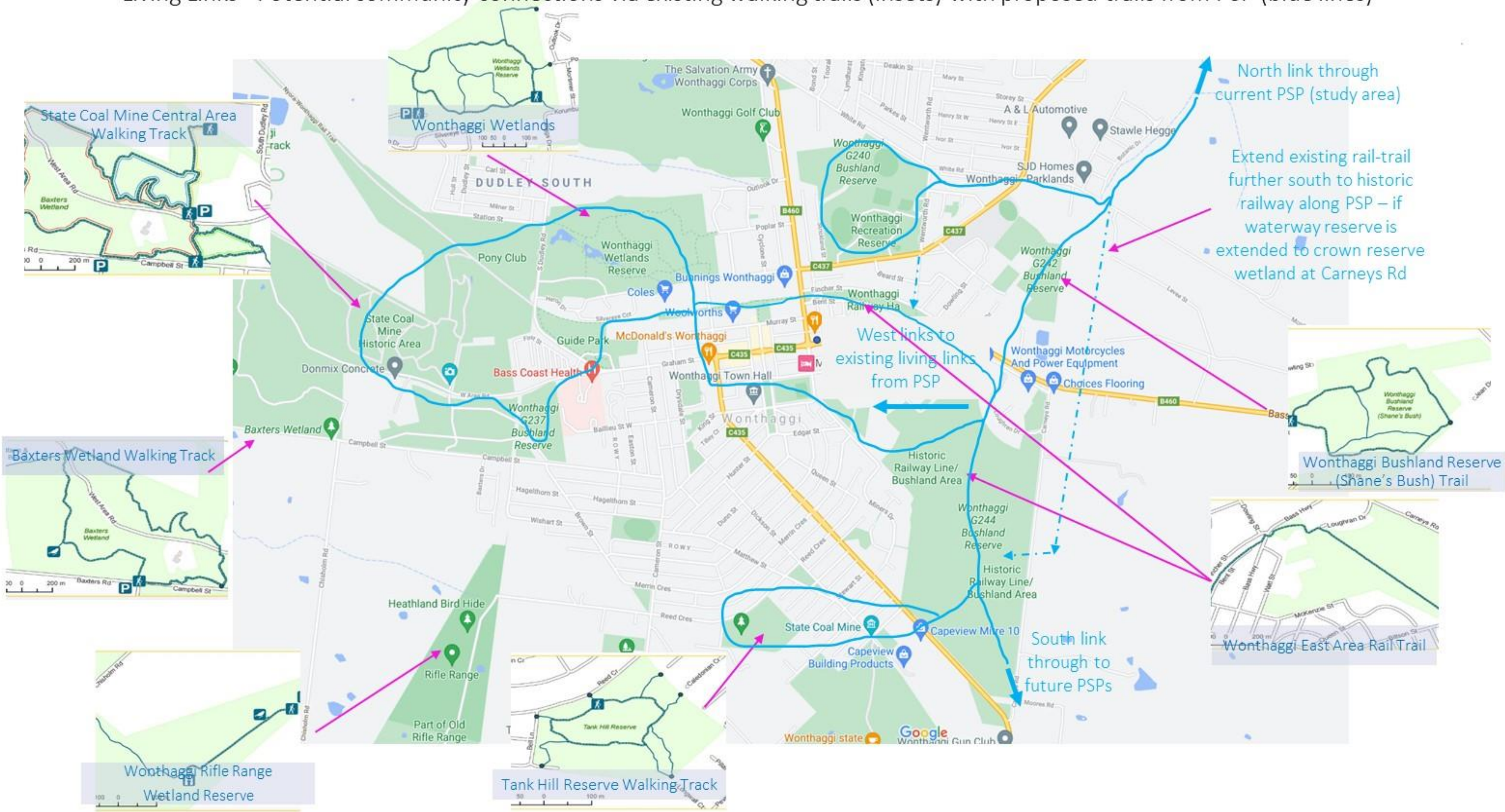


Figure 10. *Map of proposed trails from the Wonthaggi North East PSP to existing mapped trails as potential community connections along 'living links' (Updated Oct 2021).*

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.

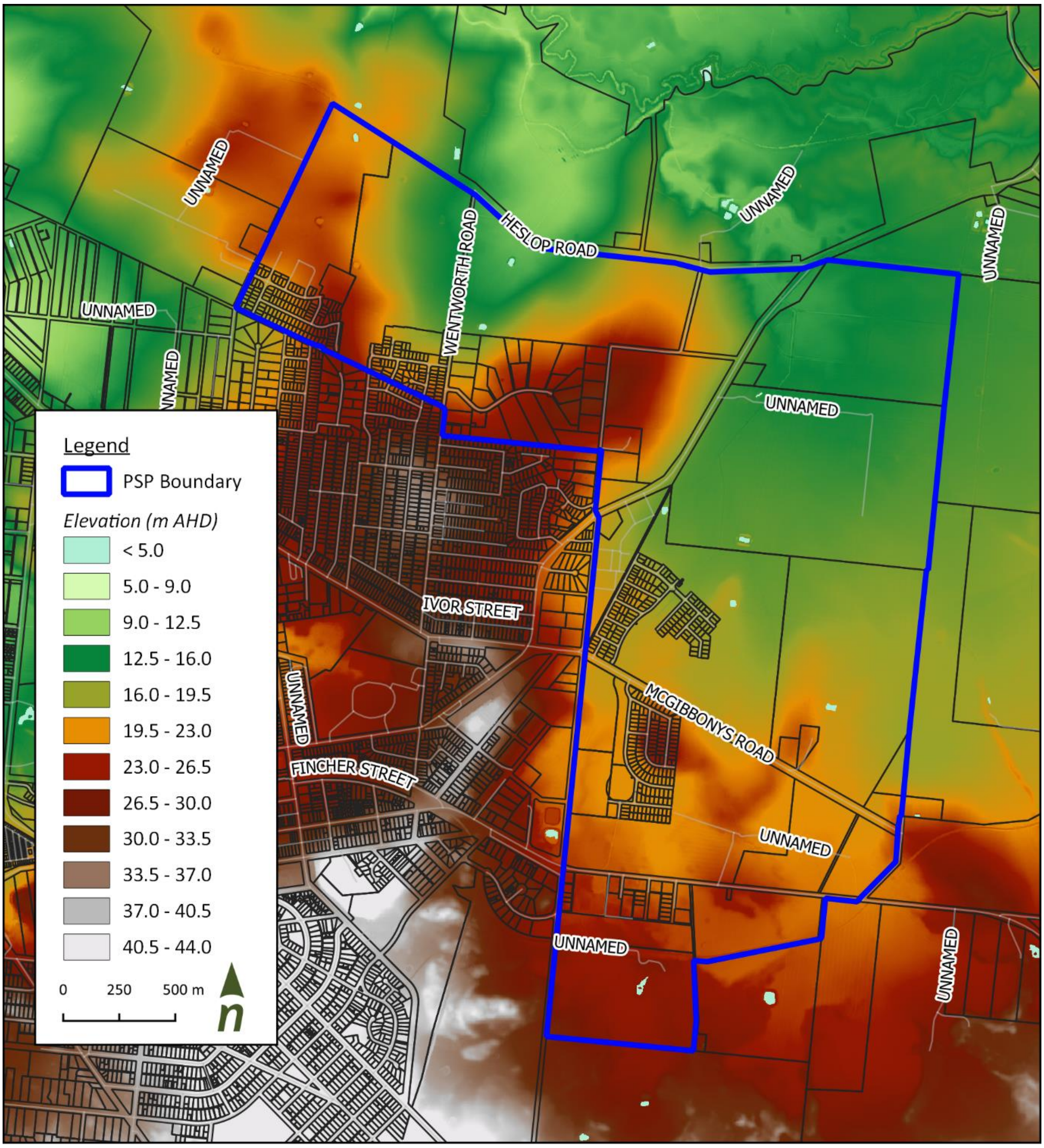


Figure 12. *Topography of PSP and surrounding area*

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.

Dial Before You Dig 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.

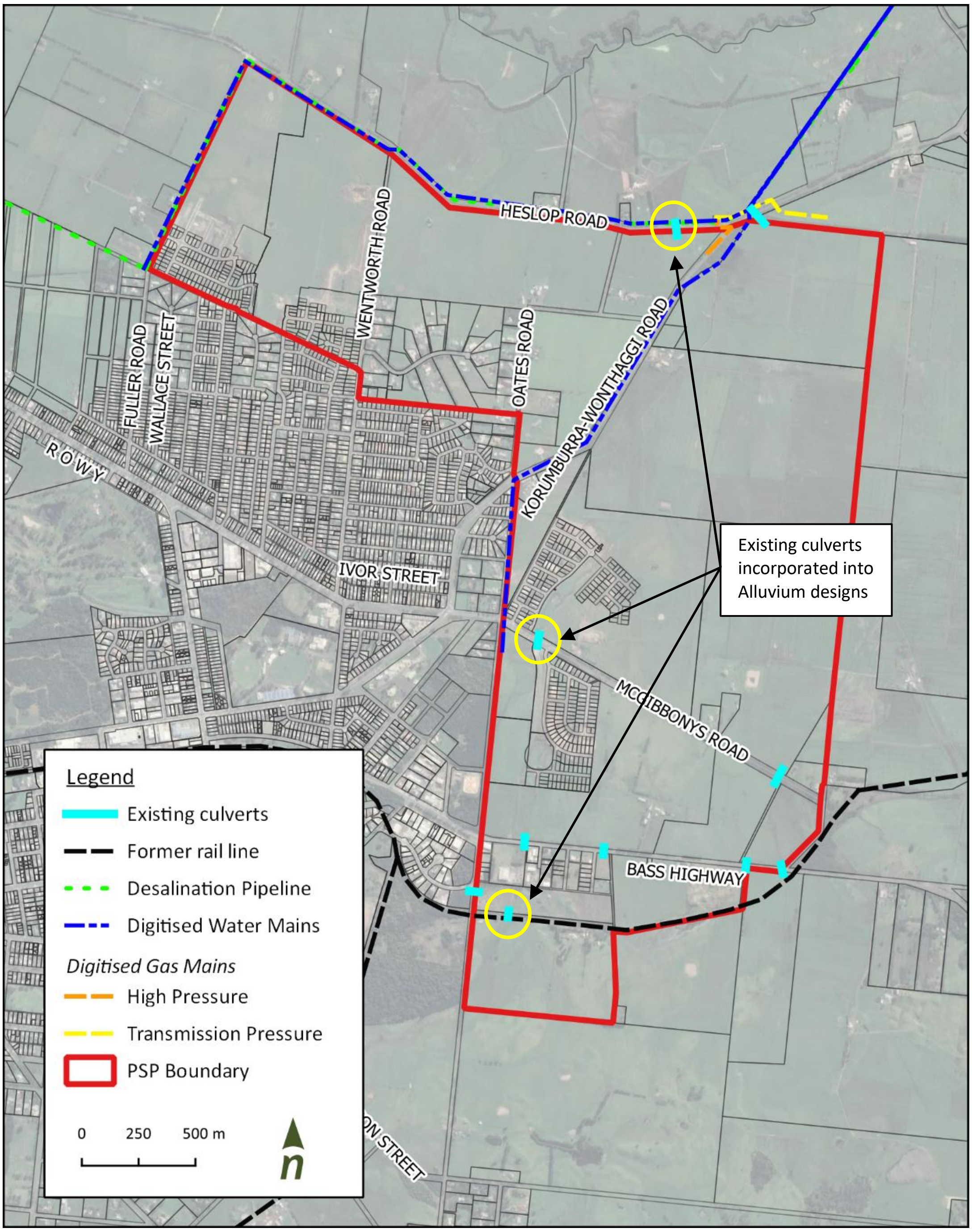


Figure 13. *Existing services and infrastructure in PSP area. Water mains digitised based on images by South Gippsland Water, gas mains digitised based on images by Multinet Gas - based on data provided 27/08/2021)*

4.4 Catchments & Sub-Catchments

There are three distinct catchments that cross the PSP study area (Figure 14) all of which 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 the majority 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).

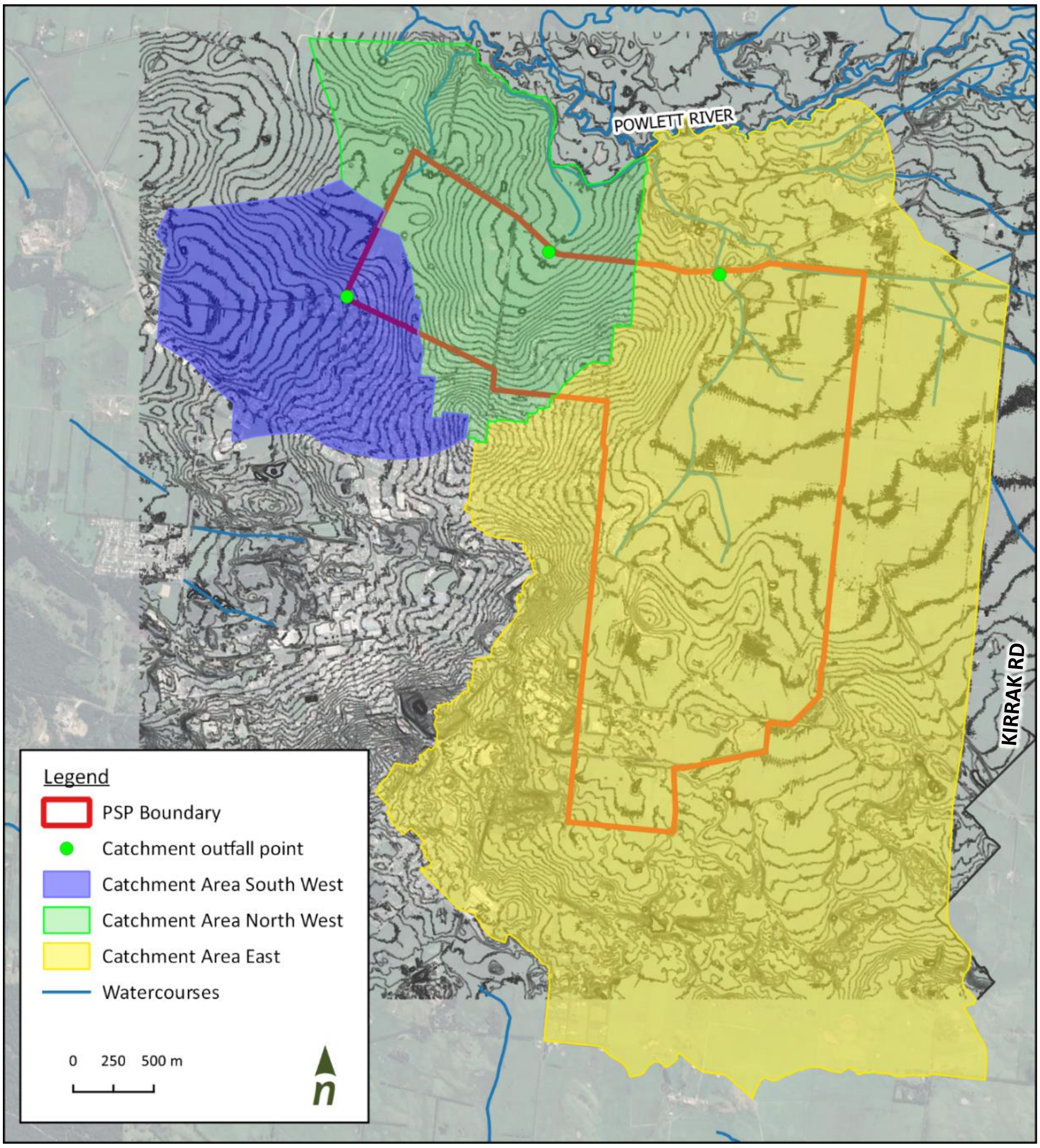


Figure 14. *Catchments across the PSP and broader area*

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).

Recommendations:

- White – proposed assets for the Wonthaggi North East PSP identified and being resolved in this study
- Green – existing subdivisional treatment wetlands
- Red – untreated existing subdivisional areas – these have been flagged as potential Council opportunities to retrofit the catchments and protect PSP WLRBs and waterways through council works. This would form part of Council's long term capital works delivery to protect the Powlett River given development has been completed/subdivisions already approved.
- Purple – current Council negotiations with developers for provision of GPTs (Powlett Ridge)
- Blue – current Council negotiations with developers for provision of RBs/Wetlands (Draft Development Plan for agricultural landscape south of PSP)
- Orange – untreated agricultural landscape – VPA future opportunity to flag treatment systems for future PSPs / growth area planning.

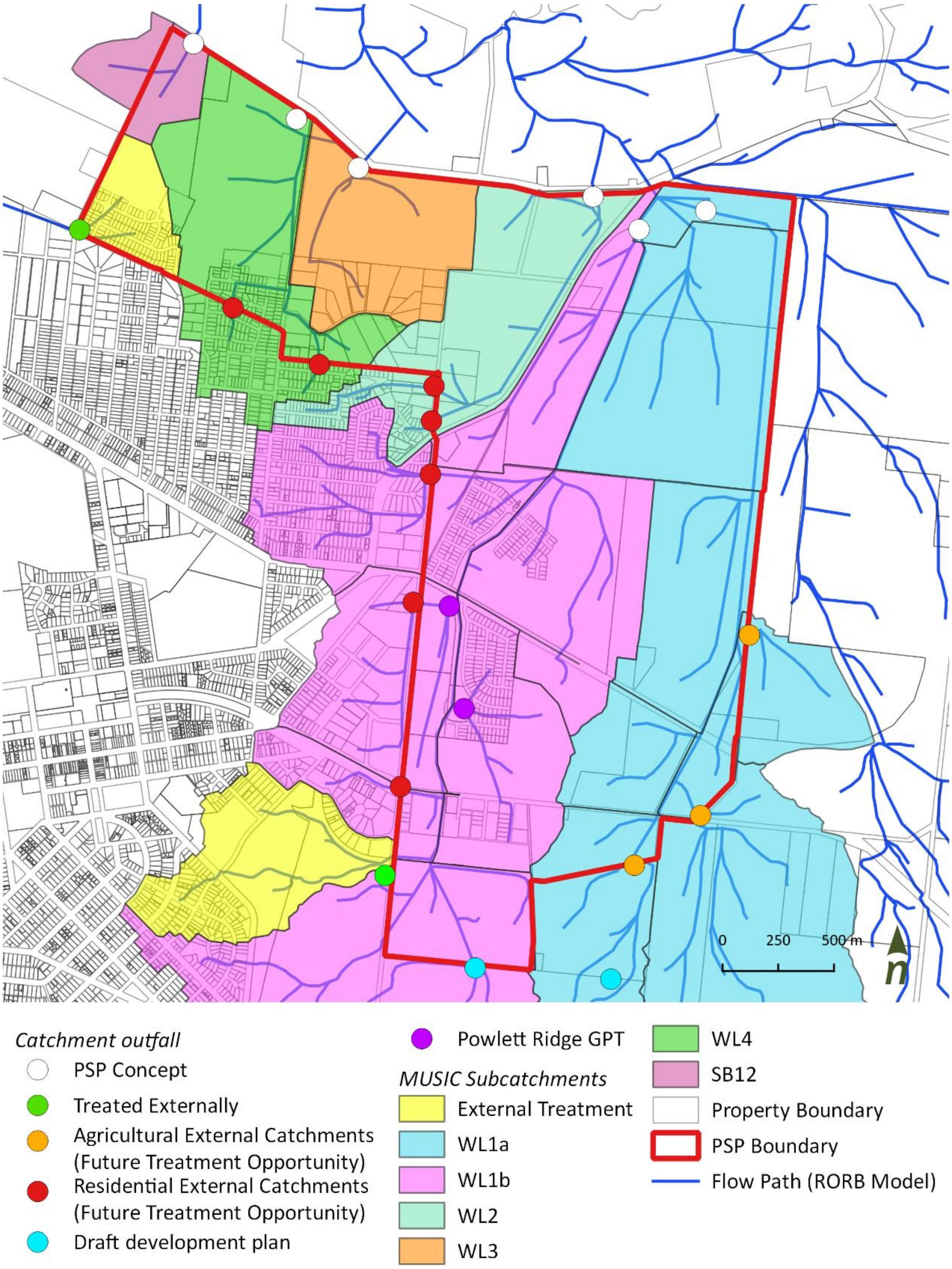


Figure 15. *Map of drainage catchments and respective outfalls indicating ideal treatment asset locations within/beyond PSP.*

The three catchments that cross the PSP may be further broken down into smaller stormwater drainage sub-catchments (Figure 16). 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/RB-01) functional design footprints.

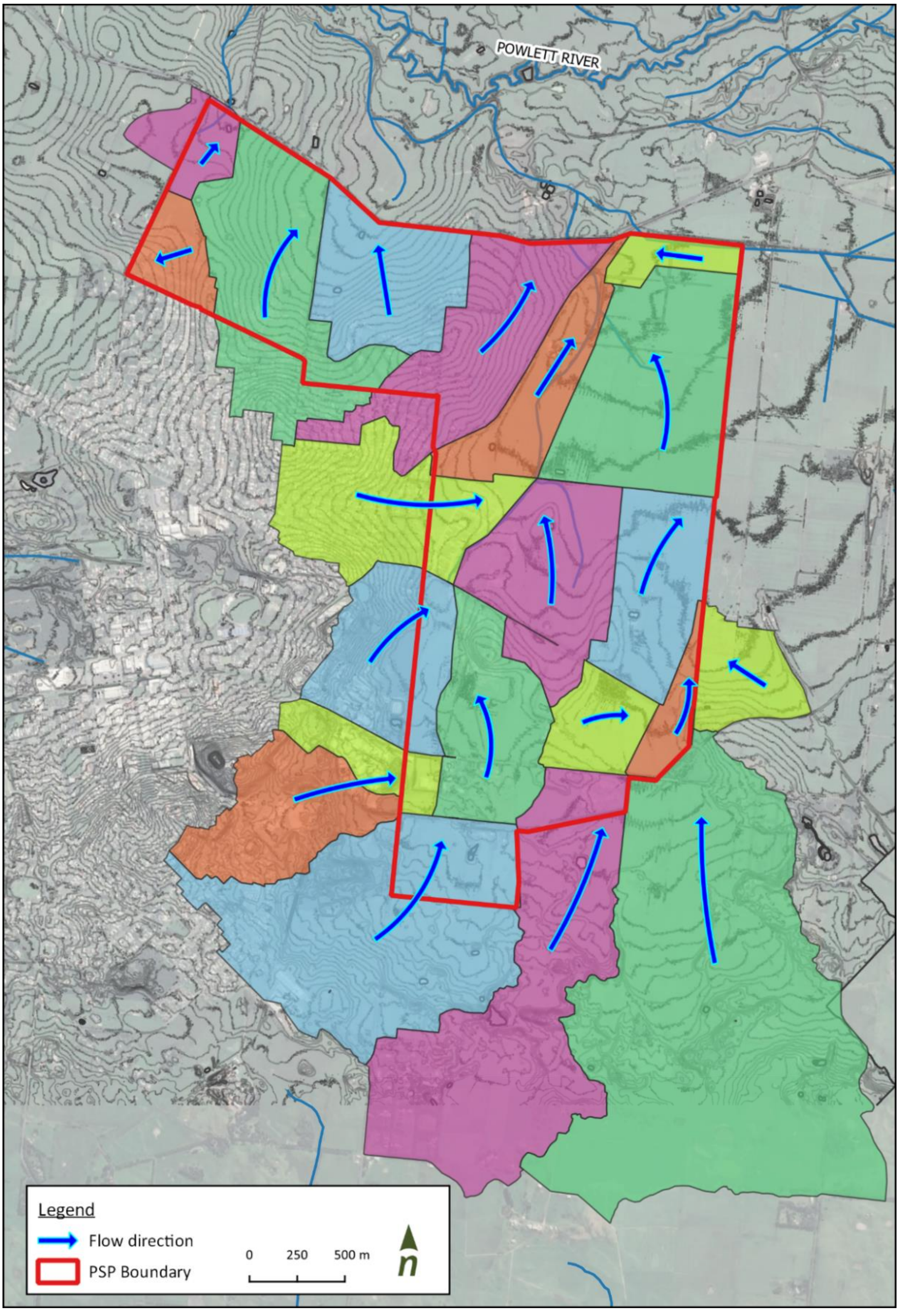


Figure 16. *Stormwater drainage sub-catchments across the PSP area (Engeny delineations, 2021)*

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 17.

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 18 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.

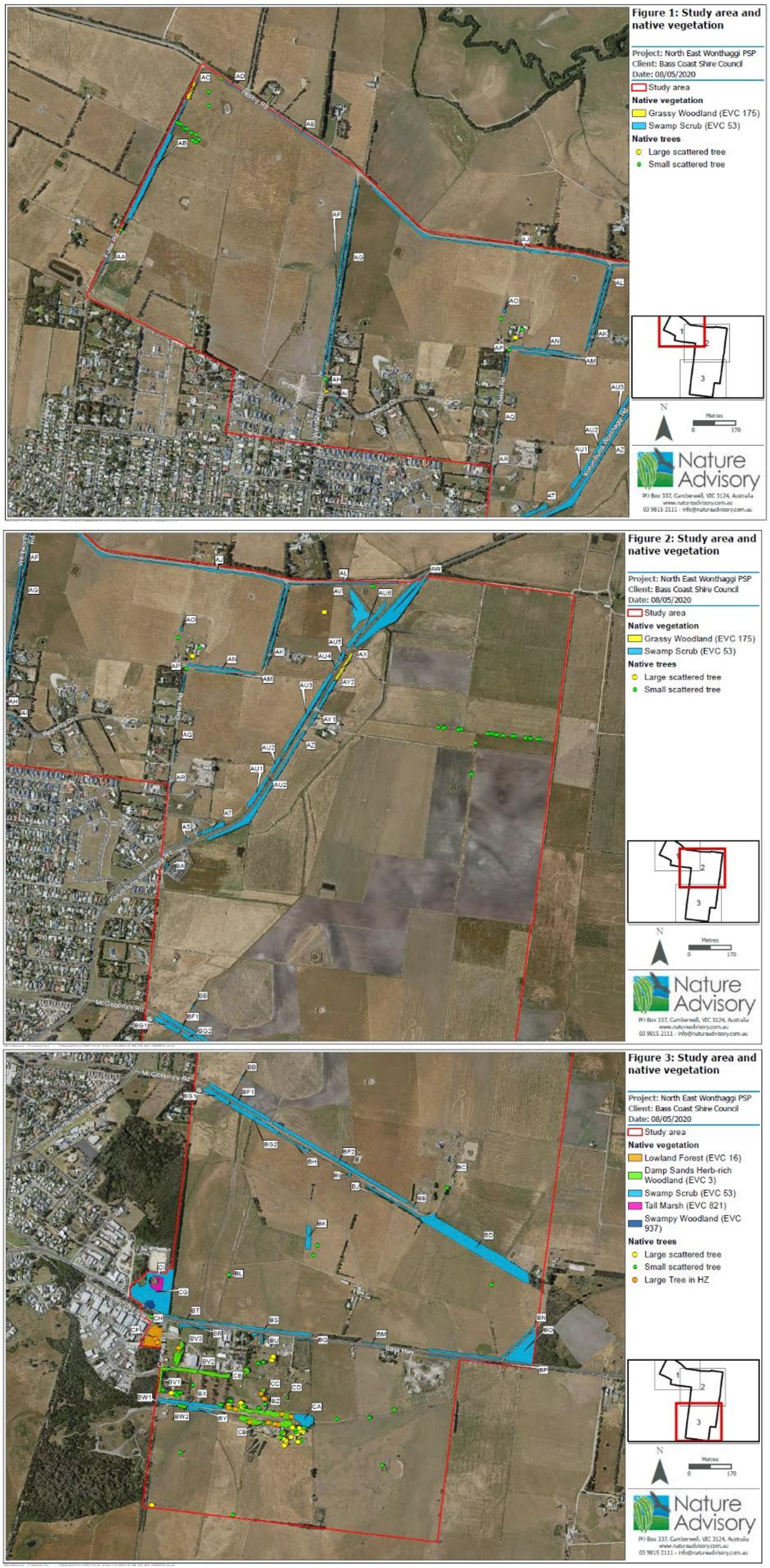


Figure 17. *Native vegetation in PSP area (source: Nature Advisory, May 2020)*

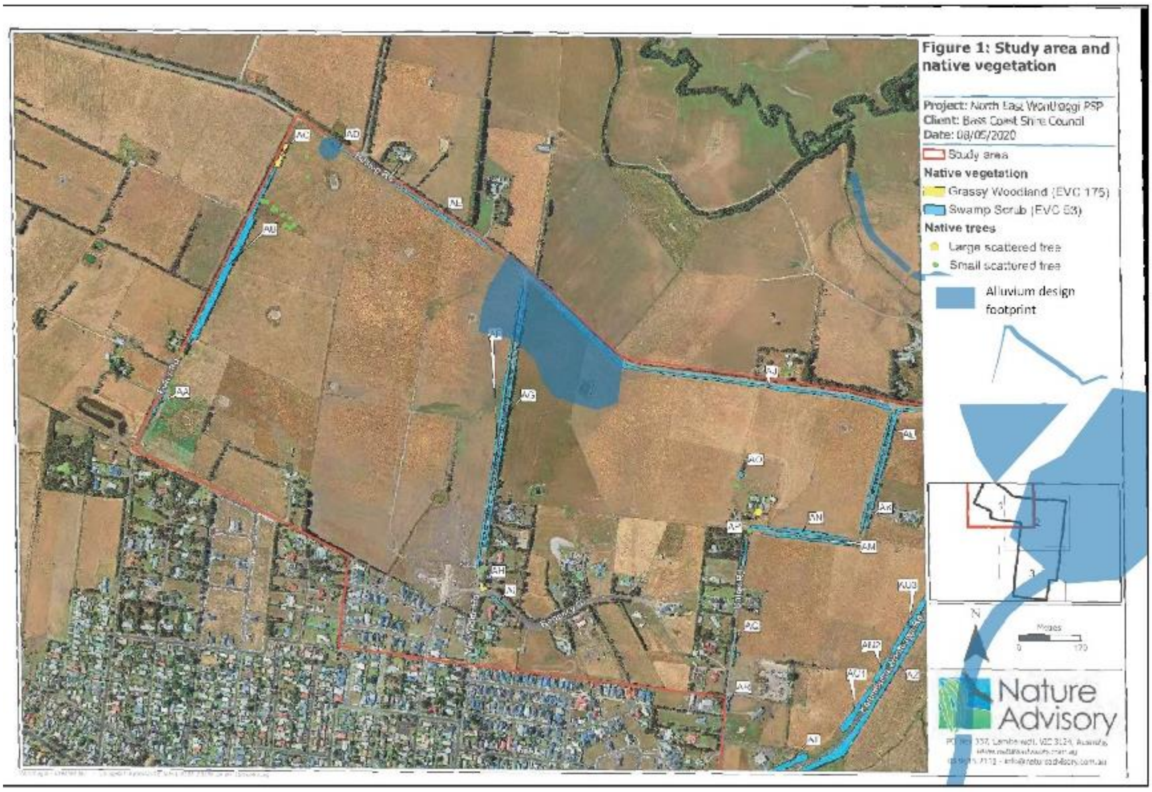


Figure 1: Study area and native vegetation
Project: North East Wonthaggi PSP
Client: Bass Coast Shire Council
Date: 08/05/2020
Study area
Native vegetation
Grassy Woodland (EVC 175)
Swamp Scrub (EVC 53)
Native trees
Large scattered tree
Small scattered tree
Alluvium design footprint
Nature Advisory

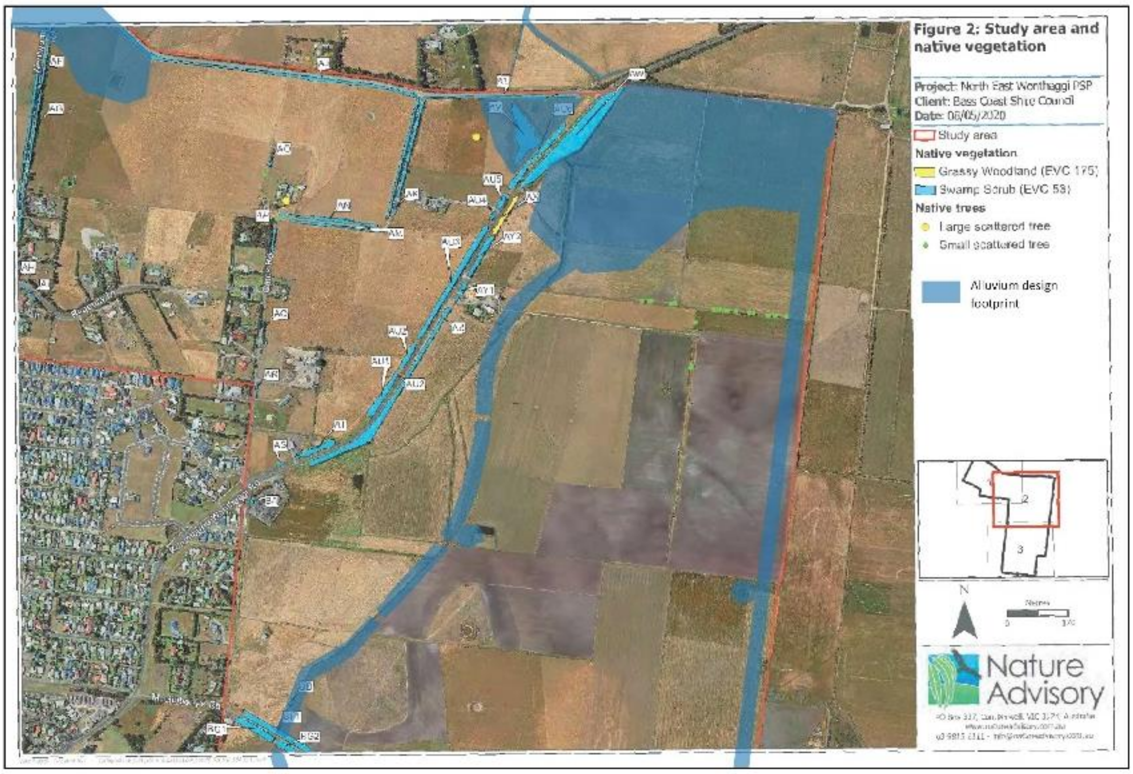


Figure 2: Study area and native vegetation
Project: North East Wonthaggi PSP
Client: Bass Coast Shire Council
Date: 08/05/2020
Study area
Native vegetation
Grassy Woodland (EVC 175)
Swamp Scrub (EVC 53)
Native trees
Large scattered tree
Small scattered tree
Alluvium design footprint
Nature Advisory

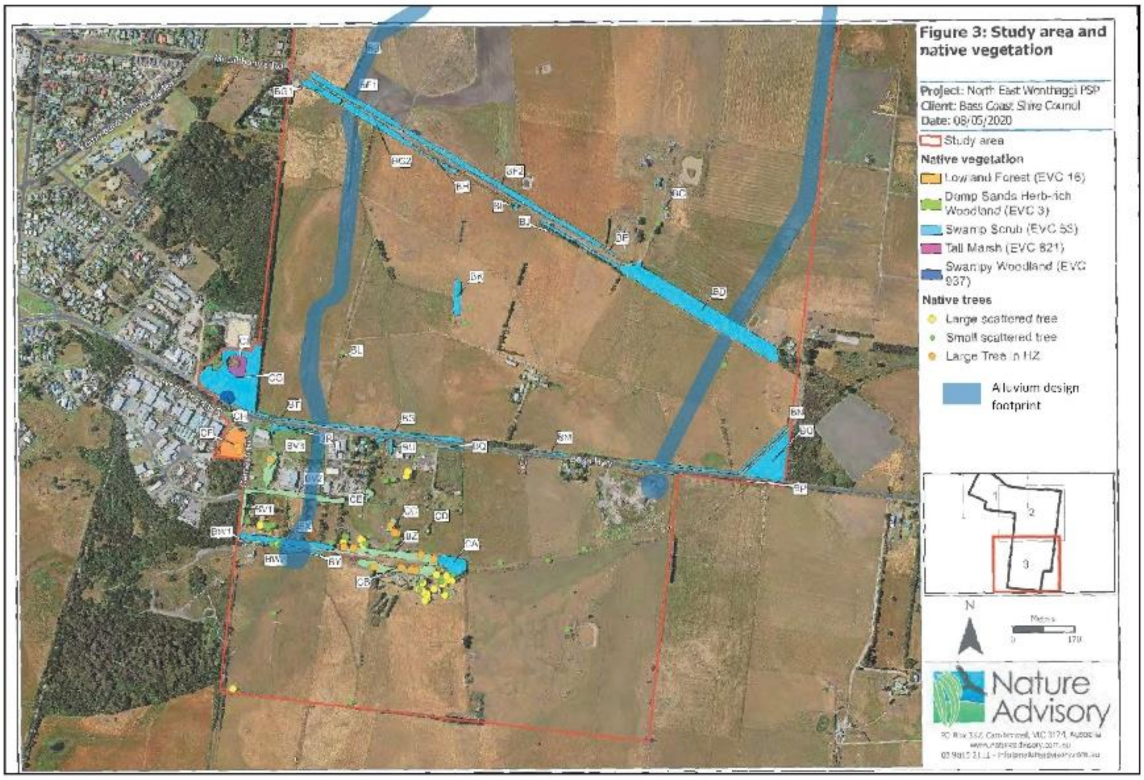


Figure 18. *Design footprint and native vegetation in PSP area (source: Nature Advisory, May 2020)*

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 19) 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. 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 19. *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 20, 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 a number of 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 21).

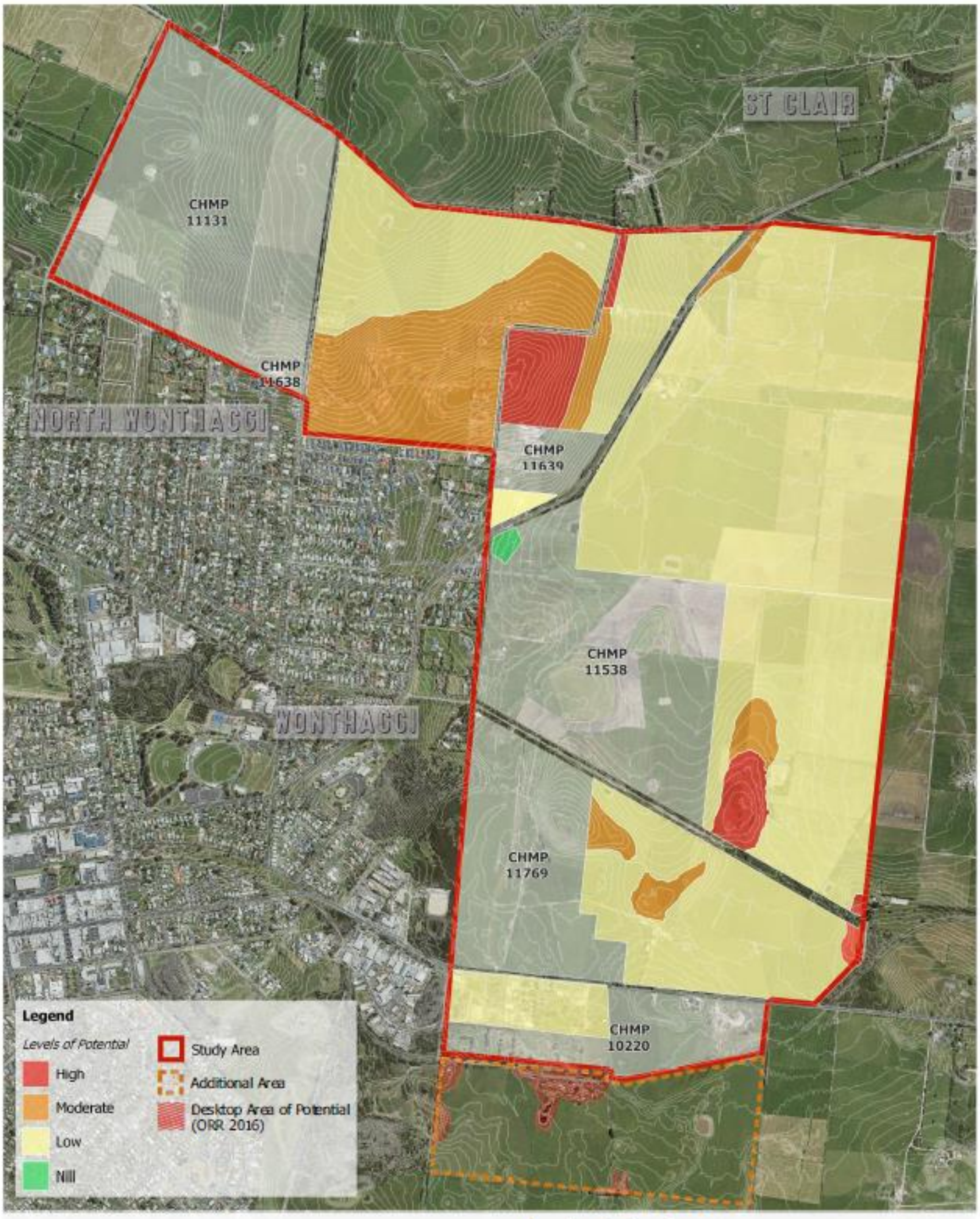


Figure 20. *Areas of potential Aboriginal cultural heritage values (source: Triskel, May 2017)*

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 21 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.

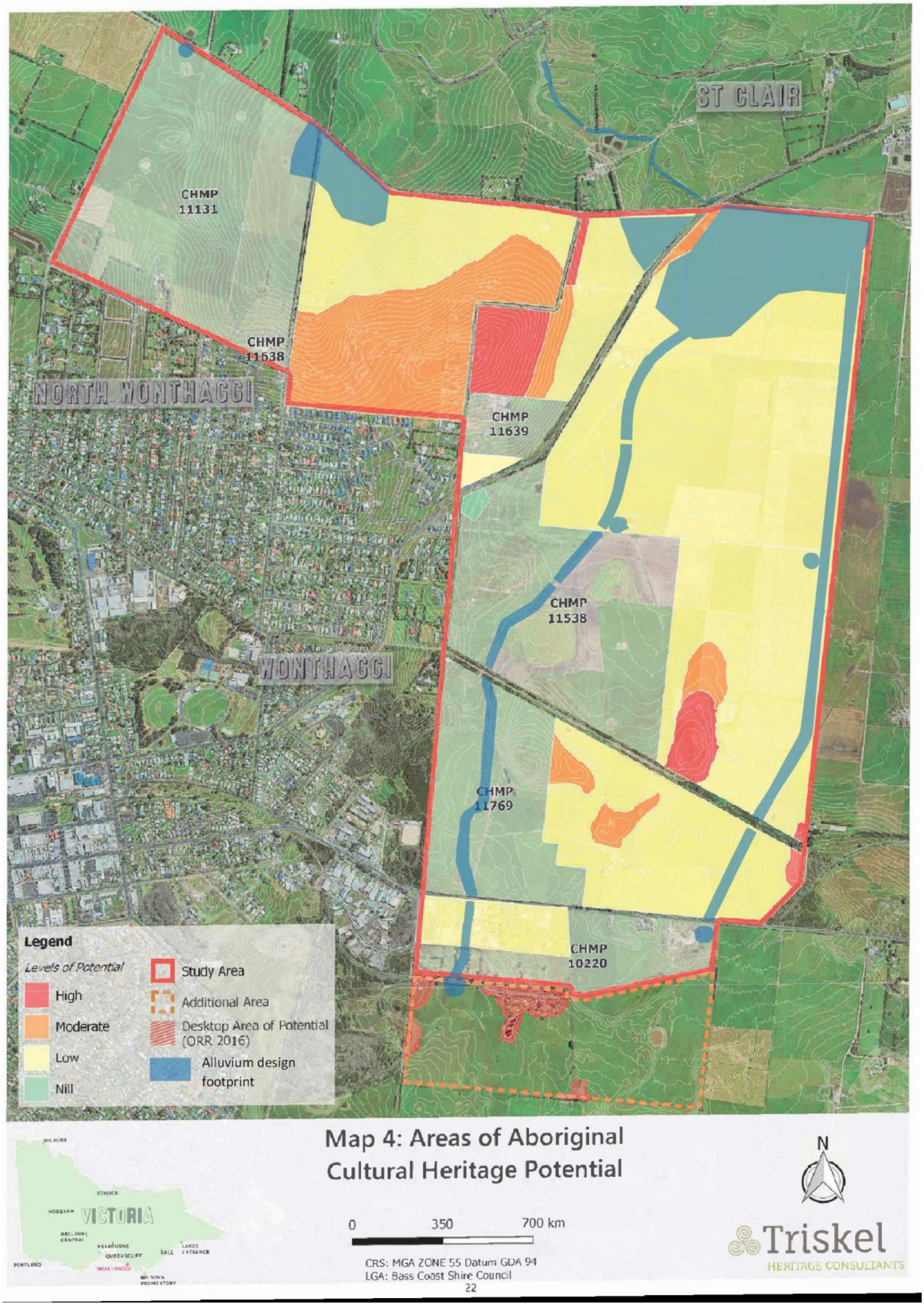


Figure 21. *Map overlay of PSP asset footprint relative to identified areas of Aboriginal culture / heritage values (source: Triskel 2017, modified by Alluvium 2021)*

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.

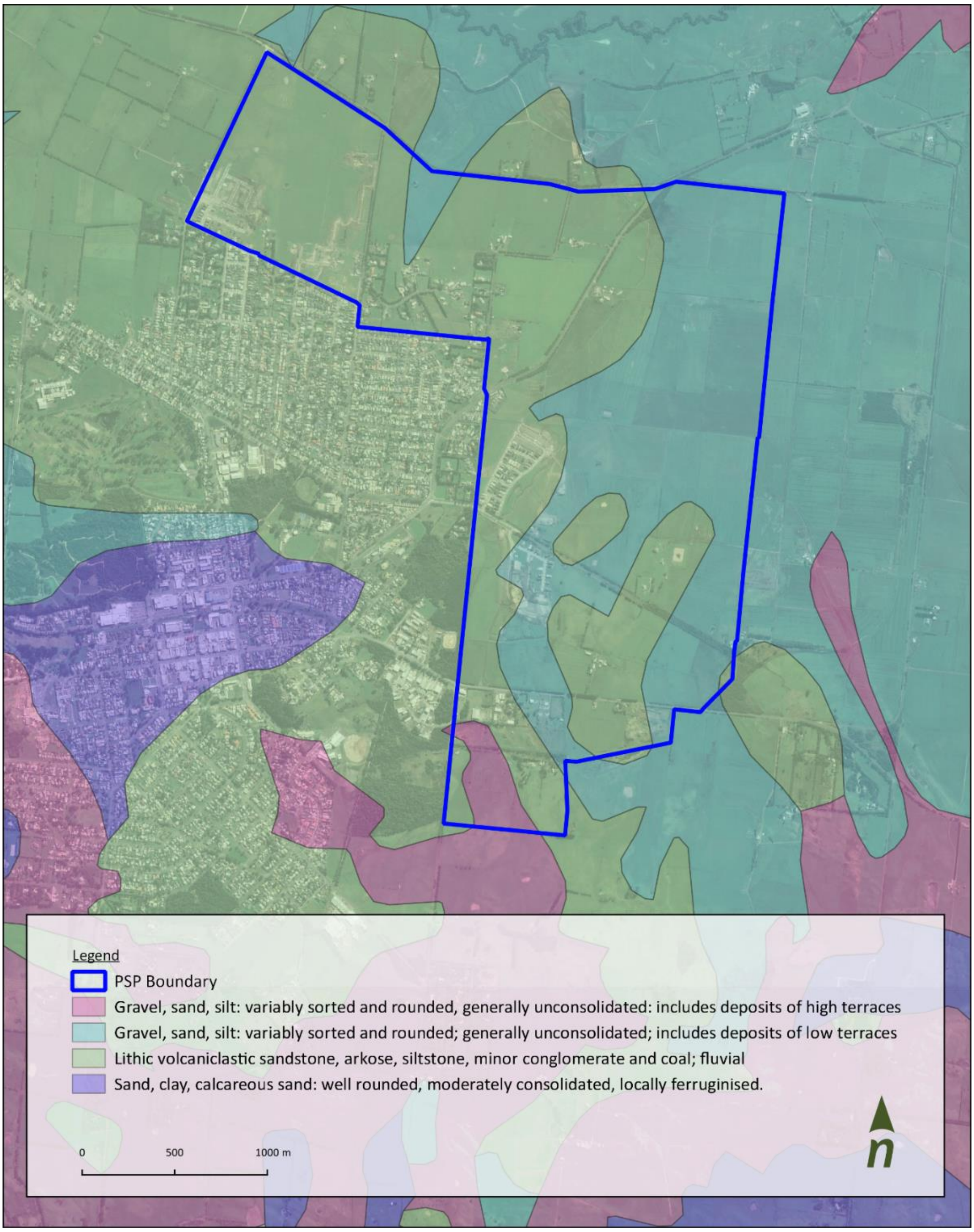


Figure 22. *Geological features of PSP and surrounding areas*

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.

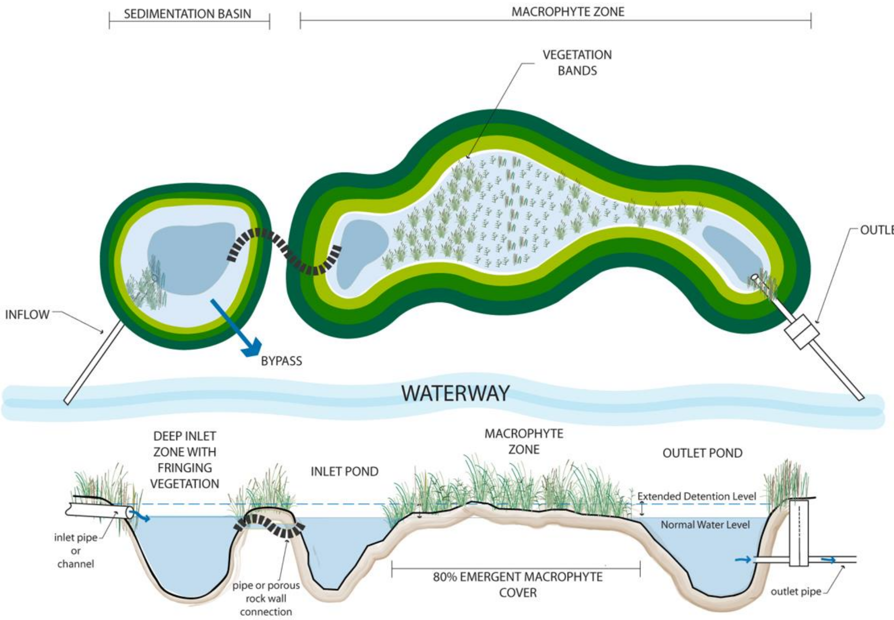


Figure 23. Typical concept layout of a treatment wetland (source: Constructed Wetlands Design Manual, Melbourne Water)

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.

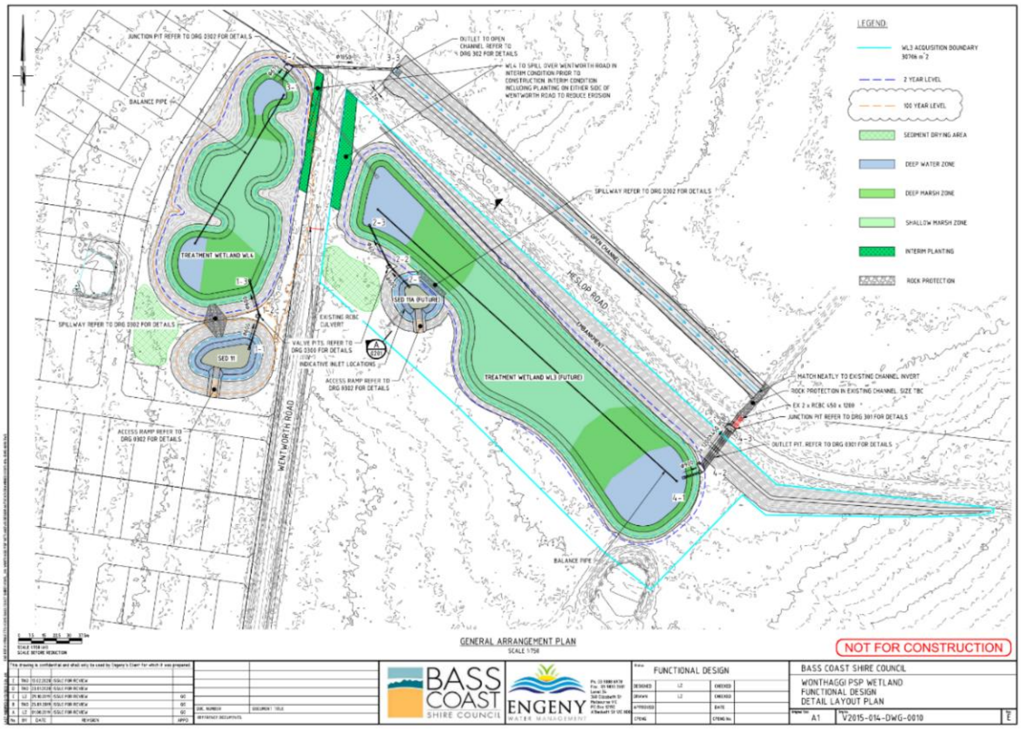


Figure 24. *Layout plans for wetlands (WLRB3 & WLRB4; DCP ref WL-03&04) at Wentworth/Heslop roads (Engeny, 2020)*

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).

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: Main Outfall to Powlett (MOP) River

To reduce impacts of flooding, Engeny proposed increasing the capacity of existing open farm channels on the subject property (see Figure 25) to receive conveyed flows from the PSP (WLRB 1 & 2 outfalls), and ultimately discharging these channelised flows initially to a vegetated area adjacent to the Powlett River. This was not advised in Alluvium's PoC. Subsequent outfall concepts by Engeny look to sizing the existing open farm channels to convey a 50% AEP flow with works estimated (Engeny) at $511,800 likely to be funded by the PSP and undertaken by Council (or contractor working on their behalf).

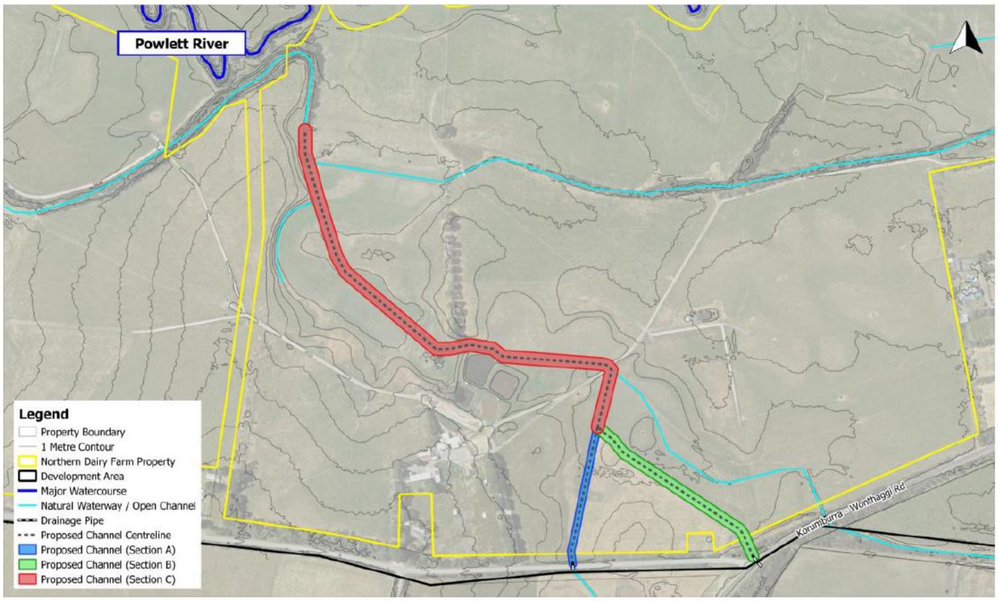


Figure 25. *Planned mitigation works to reduce flooding on the subject property – 465 Heslop Road (source: Engeny, 2021)*

Summary of assessment – *Flooding and Outfall*

- The outfall concept design falls short of the Powlett River - connects to an existing open farm channel
- Farm levees (non-engineered) have been constructed along the reach of the river at this location, preventing direct connection with the river for discharges
- The main outfall channel from the PSP is proposed to discharge to existing open farm channels (considered currently to be under capacity (Alluvium and Engeny) to receive PSP flows), before discharging to the river further downstream
- Impact of PSP discharges at end of precinct outfall and intersection with existing open channels – likely point of flooding / backwash / ponding on subject property
- Any channelisation of flows from distributed asset outfalls (within the PSP) into the main outfall to the river, will naturally increase velocities as flows are concentrated within a defined channel
- There is a sharp (horseshoe) bend in the existing open farm channel adjacent to the river – a likely point of scour, bank collapse and channel short circuiting
- Any PSP discharges to the downstream river environs will need to consider the potential impact on existing riparian vegetation (including trees) and therefore river bank stability (long term). Direct discharge to any given point in the riparian zone of the river, can cause - in the short term site erosion, medium term loss of riparian vegetation and bank erosion/collapse, and potentially in the longer term, headward erosion back up the outfall channel to the subject property.
- The land parcel downstream of WLRB 3 & WLRB4 (DCP ref WL-03&04) (western portion of the subject land) will connect into the existing drain to Powlett River. Following discussions with Engeny, it was acknowledged by the landowner that this land (west paddock) is subject to regular inundation, and only the eastern parcel of land (aligned with outfall from WLRB1 & WLRB2; DCP ref WL-01/RB-01 and WL-02) will likely be used during wetter periods of the year. As a result, the outfall from WLRB1 & WLRB2 (DCP ref WL-01/RB-01 and WL-02) is the only formal outfall that would require further modelling and design work to provide necessary flood protection.

Advice to VPA/Council: The capacity of the existing open farm channels to receive PSP outfall discharges will need to be considered in a further scope of works to resolve the ultimate outfall design of the PSP to the Powlett River given existing conditions / constraints. This will need to address the alignment through the subject property to the river and ensuring no further flooding to the subject property from the PSP;

improved flood conditions at the subject property (where possible); managing potentially erosive PSP flows on the existing, open farm channels (instability issues); protection of existing riparian vegetation (to maintain bank stability); and consideration of existing river bank and levees – all part of a future scope of works to complete the Main Outfall to Powlett (MOP) River .

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).

Advice to Council: To ensure appropriate flood control, it is recommended that culverts are sized appropriately to convey 1% AEP flows; and consideration of flow velocities and potential erosion due to channel change should be considered if undertaken in future. While revision to straighten the upstream section of W-WW (DCP ref DR1) under Whalebone Blvd will allow for a more direct passage of water through the reserve, consideration of flow velocities / erosion impacts / waterway stability and potential sediment loading on downstream PSP assets is required.

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 of 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, the majority of 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/RB-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.

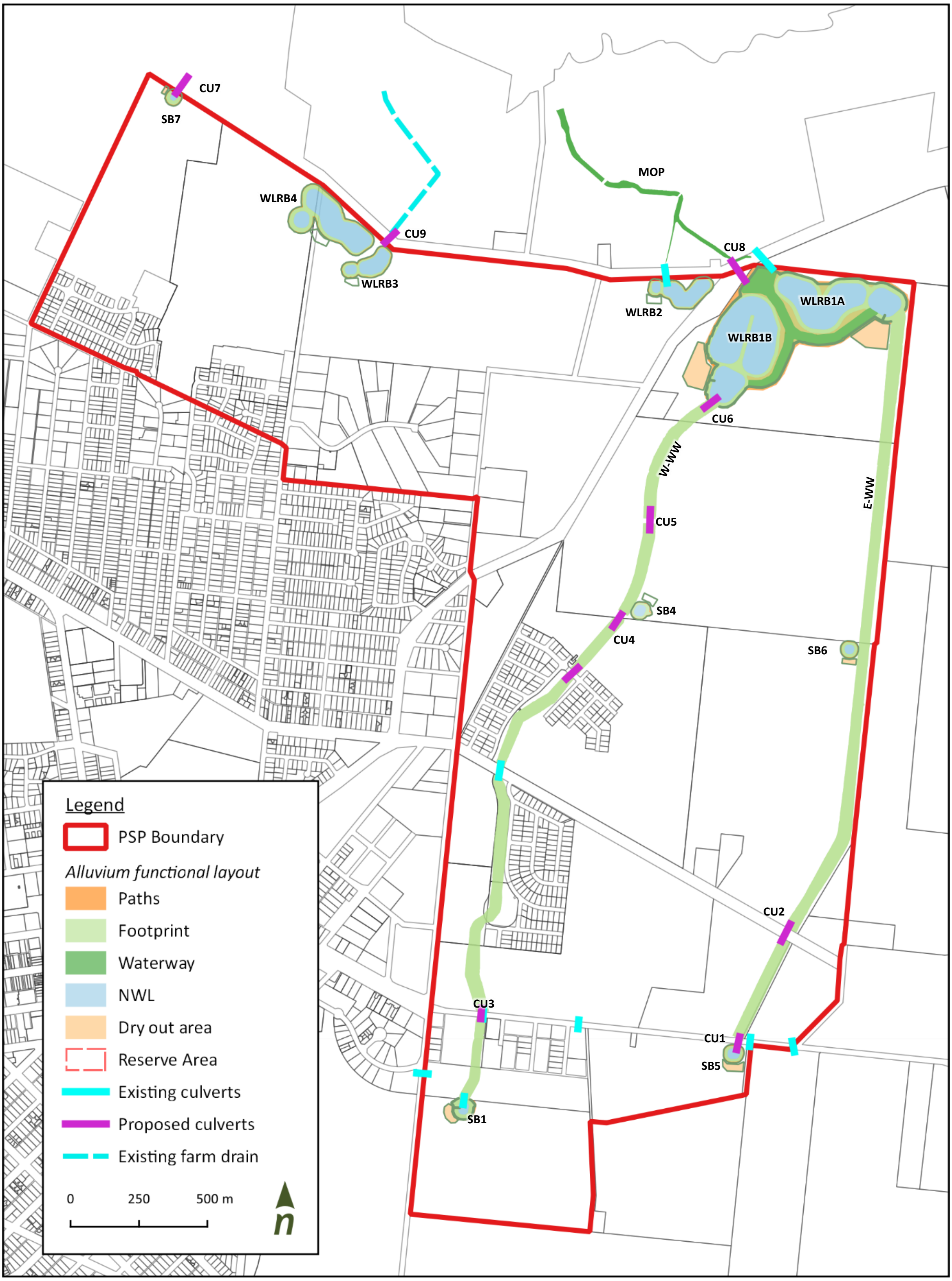


Figure 26. *Overall layout of stormwater assets for the PSP – Alluvium 2021*

Table 1. 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
3A	WLRB1A (east)	WL-01/RB-01	18.40 ha^	Section 13
3B	WLRB1B (west)	WL-01/RB-01	(incl. above)*	Section 14
4	WLRB2	WL-02	1.51 ha^	Section 15
5	WLRB3	WL-03	1.10 ha^	Section 16
6	WLRB4	WL-04	3.52 ha^	Section 17
7	SB1	SB3	0.43 ha^	Section 18
8	SB2	SB4	redundant	GPT recommended in lieu of SB – catchment too small to warrant SB cost. GPT now installed as per developer works (Council advice Oct 2021)
9	SB3	SB6	redundant	GPT recommended in lieu of SB – catchment too small to warrant SB cost.
10	SB4	SB7	0.30 ha^	Relocated north into downstream property (council reserve) Section 19
11	SB5	SB15	0.34 ha^	Section 20
12	SB6	SB8	0.27 ha^	Section 21
13	SB7	SB12	0.22 ha^	Section 22
14	CU1	CU-03	-	Section 10.3
15	CU2	-	-	Missing from Engeny final layout but critical to PSP - see Section 10.3
16	CU3	CU-02	-	Section 9.3
17	CU4	CU-04	-	Section 9.3
18	CU5	CU-05	-	Section 9.3
19	CU6	CU-06	-	Section 9.3
20	CU7	CU-07	-	Section 22
21	CU8	CU-08	-	Section 13
22	CU9	-	-	Section 16
23	MOP	-	-	Section 11
TOTAL	23 functional designs			

* Total footprint of WLRB1A & WLRB1B (DCP ref WL-01/RB-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.

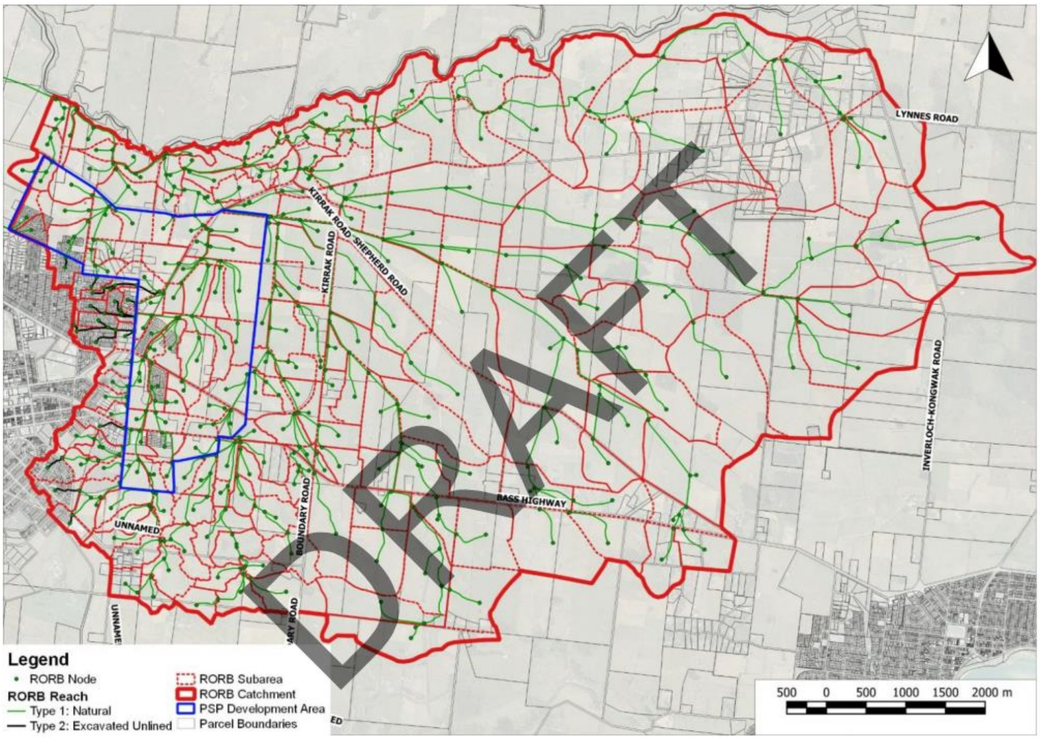


Figure 27. *RORB model layout for the Wonthaggi North East PSP (source: Engeny, Aug 2021)*

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

Table 2. 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

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.

Table 3. RORB modelling results for the Wonthaggi North East catchment

DCP reference	WLRB1 (WL-01/RB-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

* Under existing conditions, runoff generated from WLRB1 (DCP ref WL-01/RB-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.

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.

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 only. This increase is slightly higher than the Engeny strategy in the RCP8.5 scenario.

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

Table 4. WLRB1 (DCP ref WL-01/RB-01) retarding basin requirements

Parameter	**Retarding Basin WLRB1** (DCP ref WL-01/RB-01)
Peak RB storage required (m^3)	471,801
Outlet pipe size (mm)	3 X 1200mm X 1200mm Box culverts (High flow) 10 X 300mm dia. pipelines (Low flow)
Surface Area (ha)	18.40

Table 5. WLRB2 (DCP ref WL-02) retarding basin requirements

Parameter	Retarding Basin WLRB2 (DCP ref WL-02)
Peak RB storage (m^3)	31,840
Outlet pipe size (mm)	3 X 1650 mm dia. pipelines
Surface Area (ha)	1.51

Table 6. WLRB3 (DCP ref WL-03) retarding basin requirements

Parameter	Retarding Basin WLRB3 (DCP ref WL-03)
Peak RB storage (m^3)	11,258
Outlet pipe size (mm)	5 X 1200mm X 450mm box culverts
Surface Area (ha)	1.10

Table 7. WLRB4 (DCP ref WL-04) retarding basin requirements

Parameter	Retarding Basin WLRB4 (DCP ref WL-04)
Peak RB storage (m^3)	36,450
Outlet pipe size (mm)	5 X 1200mm X 450mm box culverts
Surface Area (ha)	3.52

The climate change assessment is provided below (assuming same mitigation measures as above).

Table 8. Climate change results for WLRB systems

RCP 8.5 (19% increase in rainfall intensity)	WLRB1 (DCP ref WL-01/RB-01)	WLRB2 (DCP ref WL-02)	WLRB3 (DCP ref WL-03)	WLRB4 (DCP ref WL-04)
Peak RB storage (m^3)	499,366	34,852	14,380	45,717

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.

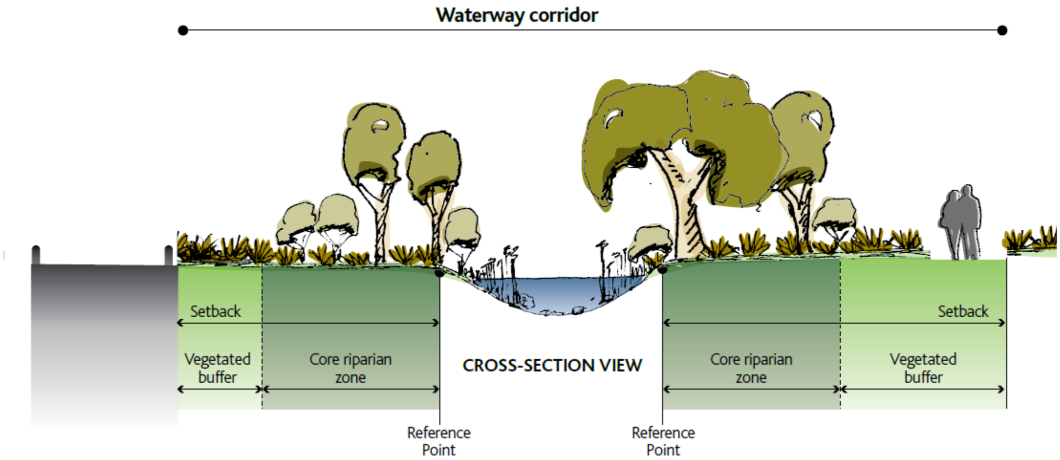


Figure 28. *Waterway corridor (source: Waterway Corridors, Guidelines for Greenfield Developments, Melbourne Water, 2019)*

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 9. 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.

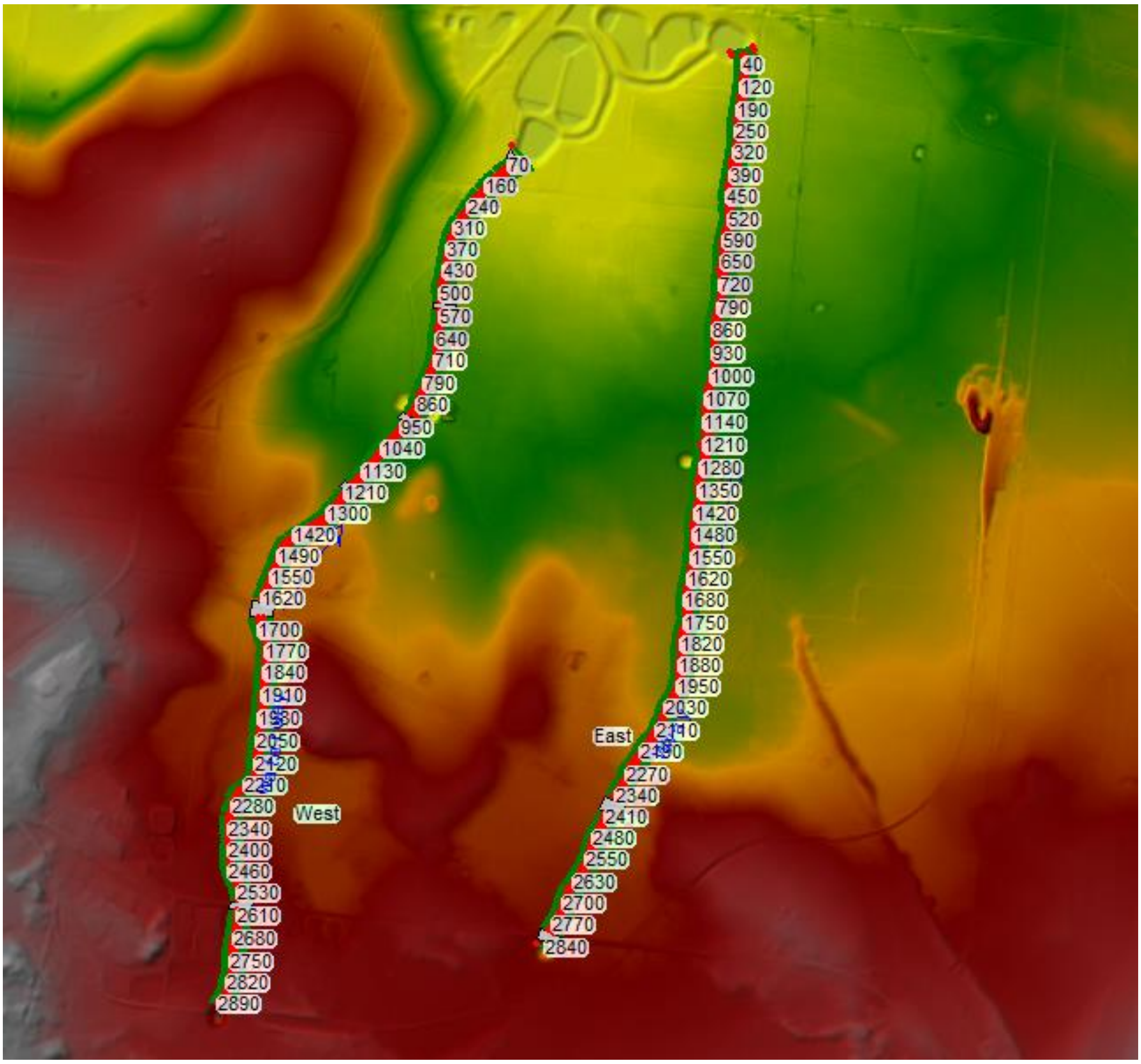


Figure 29. *HECRAS model layout*

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 10. 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 10. 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 2890)	Bass Hwy (stn 2600)	24.0	22.7	223
2	Bass Hwy (stn 2570)	McGibbonys Rd (stn 1680)	22.5	19.2	269
3	McGibbonys Rd (stn 1620)	Centennial Dr (stn 1210)	19.0	16.8	186
4	Centennial Dr (stn 1170)	Culvert #4 (stn 930)	16.5	15.9	400
5	Culvert #4 (stn 890)	Culvert #5 (stn 560)	15.8	14.9	367
6	Culvert #5 (stn 530)	Culvert #6 (stn 50)	14.8	13.6	400

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 11. The alternate slope along the alignment leads to the differing channel capacities for the reach sections in Table 12.

Table 11. 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 12. 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 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).

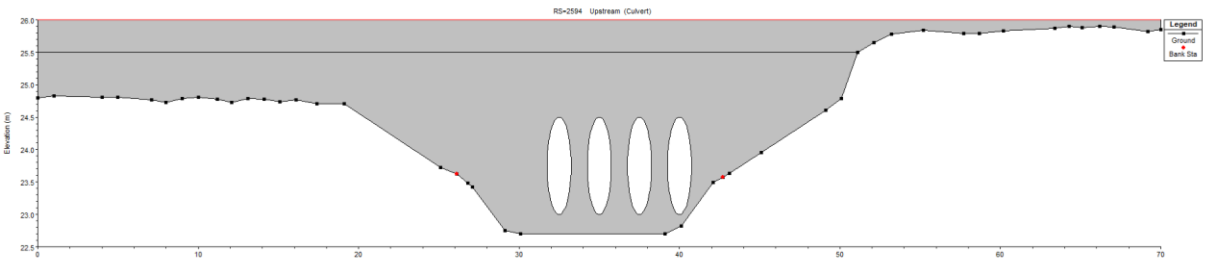


Figure 30. *Upstream Bass Hwy design cross section (looking downstream)*

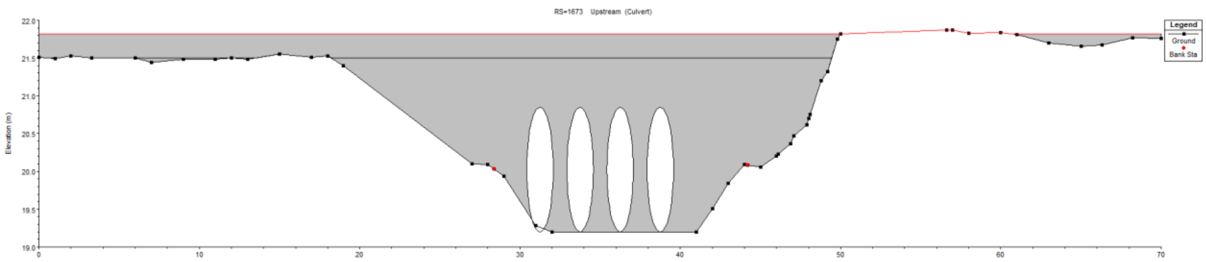


Figure 31. *Upstream McGibbonys Rd cross section (looking downstream)*

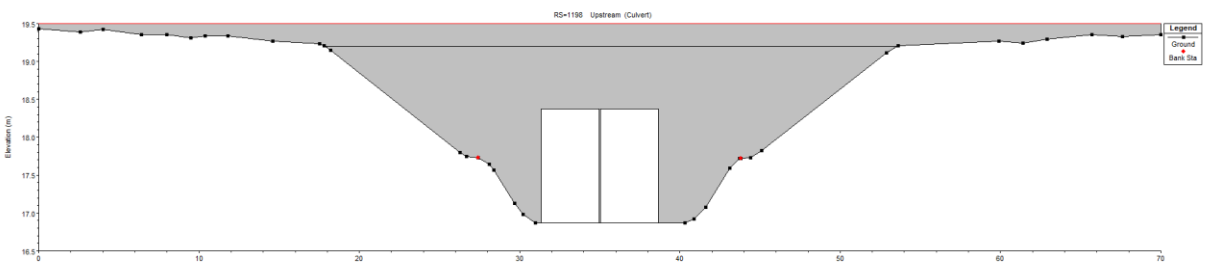


Figure 32. *Upstream Centennial Dr cross section (looking downstream)*

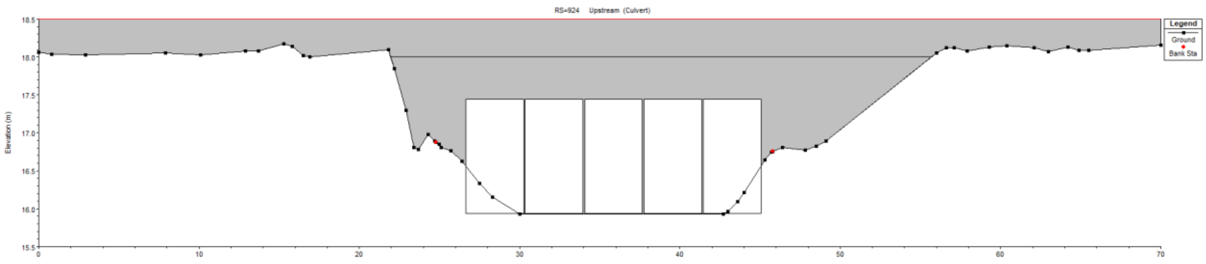


Figure 33. *Upstream culverts 4, 5, 6 cross-sections (looking downstream)*

9.4 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.

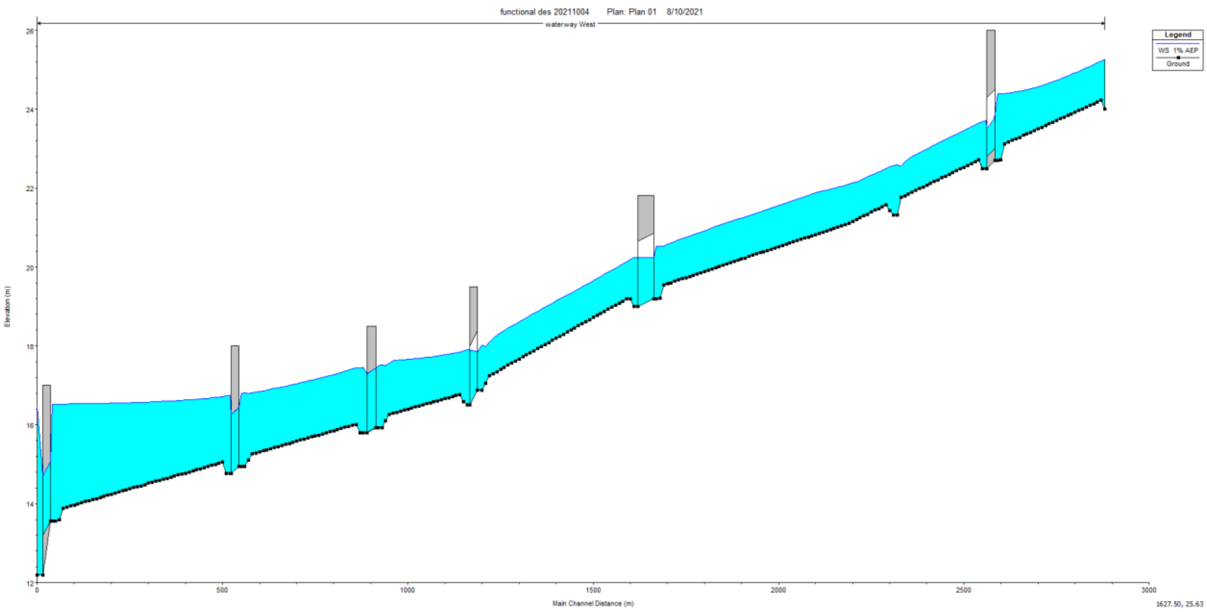


Figure 34. *1% AEP water surface elevation along the waterway alignment with culverts unimpeded*

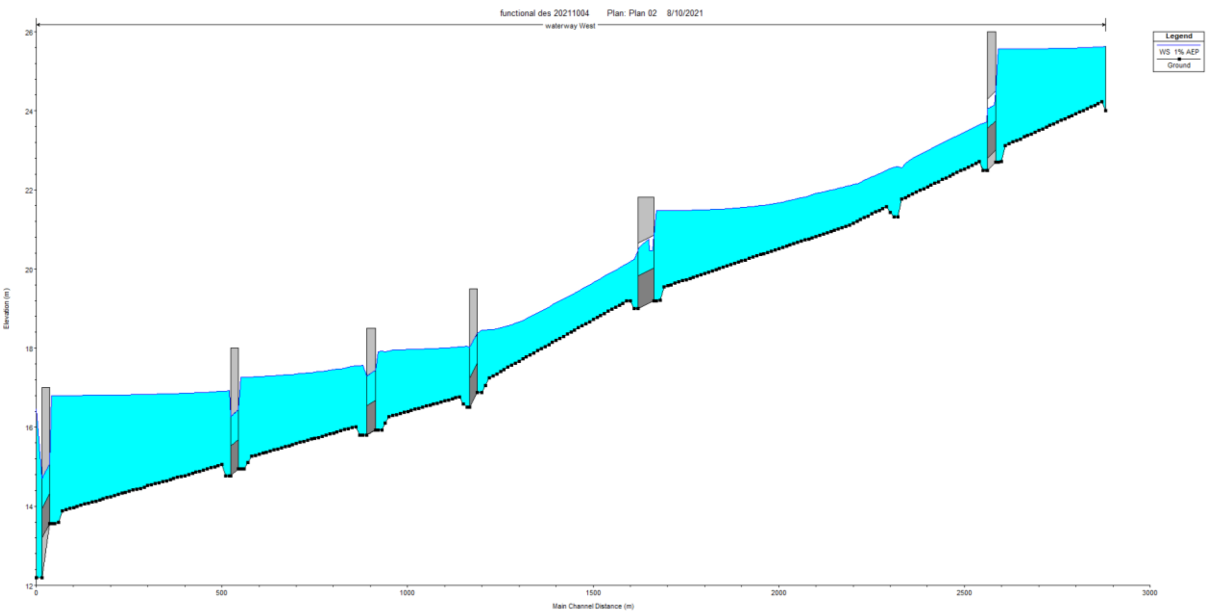


Figure 35. *1% AEP water surface elevation along the waterway alignment with culverts 50% blocked*

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

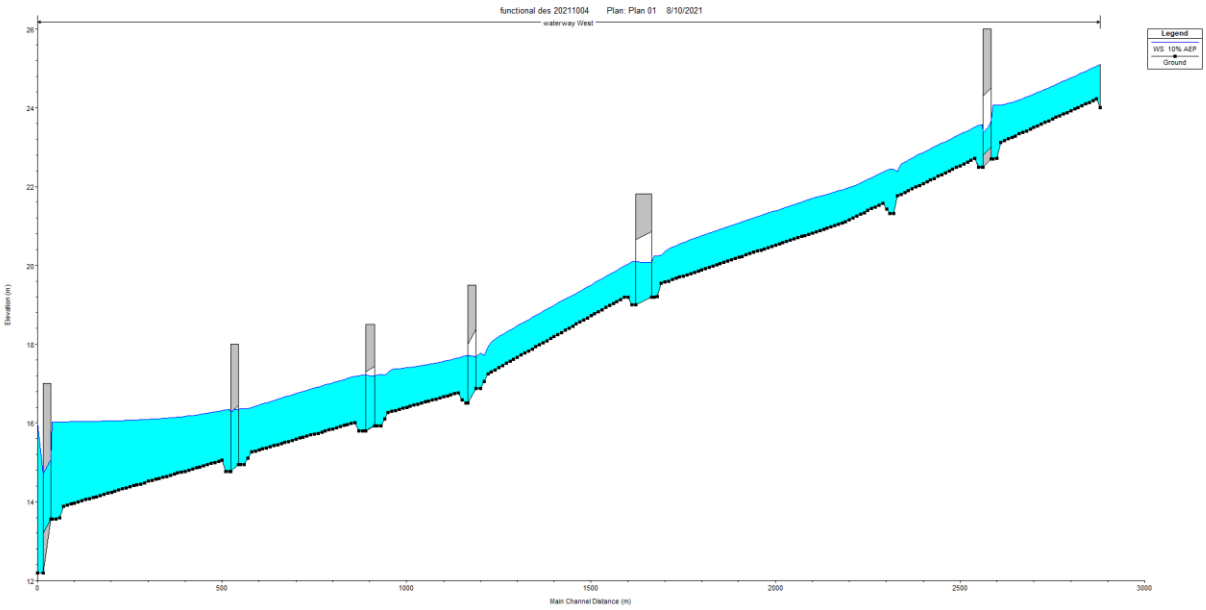


Figure 36. *10% AEP water surface elevation along the waterway alignment with culverts unimpeded*

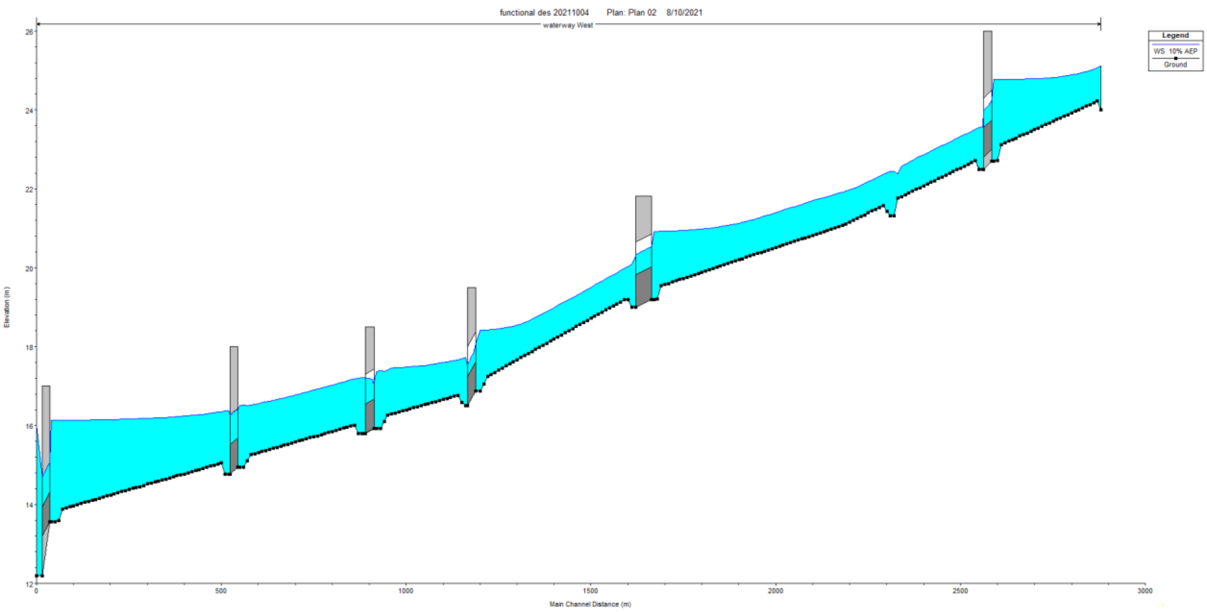


Figure 37. *10% AEP water surface elevation along the waterway alignment with culverts 50% blocked*

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

Table 13. Hydraulic results through culverts for both scenarios for the 1% AEP flow

Culvert Crossing		Open culverts	Blocked culverts
Bass Hwy			
	Head loss (m)	0.68	1.84
	Freeboard to road (m)*	1.59	0.44
	Average velocity (m/s)	0.52	0.40
McGibbonys Rd			
	Head loss (m)	0.27	1.22

Culvert Crossing		Open culverts	Blocked culverts
	Freeboard to road (m)*	1.30	0.35
	Average velocity (m/s)	0.63	0.47
Centennial Dr			
	Head loss (m)	0.12	0.39
	Freeboard to road (m)*	1.41	0.55
	Average velocity (m/s)	0.61	0.46
Culvert #4			
	Head loss (m)	0.04	0.35
	Freeboard to road (m)*	0.98	0.60
	Average velocity (m/s)	0.80	0.65
Culvert #5			
	Head loss (m)	0.06	0.34
	Freeboard to road (m)*	1.18	0.74
	Average velocity (m/s)	0.60	0.49
Culvert #6			
	Head loss (m)	0.08	0.35
	Freeboard to road (m)*	0.47	0.20
	Average velocity (m/s)	0.22	0.20

*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 14. Hydraulic results through culverts for both scenarios for the 10% AEP flow

Culvert Crossing		Open culverts	Blocked culverts
Bass Hwy			
	Head loss (m)	0.49	1.19
	Freeboard to road (m)*	1.93	1.23
	Average velocity (m/s)	0.41	0.34
McGibbonys Rd			
	Head loss (m)	0.15	0.83
	Freeboard to road (m)*	1.57	0.90
	Average velocity (m/s)	0.51	0.38
Centennial Dr			
	Head loss (m)	0.06	0.70
	Freeboard to road (m)*	1.44	1.08
	Average velocity (m/s)	0.51	0.35
Culvert #4			
	Head loss (m)	0.01	0.17
	Freeboard to road (m)*	1.27	1.11
	Average velocity (m/s)	0.64	0.58
Culvert #5			
	Head loss (m)	0.02	0.13
	Freeboard to road (m)*	1.65	1.49
	Average velocity (m/s)	0.52	0.48
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 15 provides the finished surface level, flood level and freeboard level.

Table 15. 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)
CH2800	2800	24.88	26.97	26.72	1.84
CH2700	2700	24.54	26.07	26.14	1.53
CH2600	2600	24.40	25.84	24.71	0.31
CH2594		Bass Hwy Culverts			
CH2500	2500	23.41	25.15	25.11	1.70
CH2400	2400	22.95	24.76	24.99	1.81
CH2300	2300	22.49	23.39	23.65	0.90
CH2200	2200	22.10	23.05	23.11	0.95
CH2100	2100	21.84	23.11	23.06	1.22
CH2000	2000	21.53	23.20	23.25	1.67
CH1900	1900	21.21	23.00	23.38	1.79
CH1800	1800	20.89	22.43	22.60	1.54
CH1700	1700	20.53	22.08	21.72	1.19
CH1673		McGibbonys Rd Culverts			
CH1600	1600	20.13	21.21	21.25	1.08
CH1500	1500	19.60	21.22	21.02	1.42
CH1400	1400	19.09	20.95	20.83	1.74
CH1300	1300	18.56	20.41	20.05	1.49
CH1200	1200	18.02	19.21	19.23	1.19
CH1198		Centennial Dr Culverts			
CH1100	1100	17.76	18.57	18.61	0.81
CH1000	1000	17.65	18.35	18.26	0.61
CH924		Culvert #4 Location			
CH900	900	17.46	18.07	18.05	0.59
CH800	800	17.25	17.97	17.90	0.65
CH700	700	17.02	17.95	17.74	0.72
CH600	600	16.83	17.68	17.57	0.74
CH554		Culvert #5 Location			
CH500	500	16.70	17.76	17.73	1.03
CH400	400	16.62	17.50	17.50	0.88
CH300	300	16.57	17.21	17.22	0.64
CH200	200	16.55	16.92	17.18	0.37
CH100	100	16.53	16.67	16.66	0.13
CH45		Culvert #6 Location			

9.5 Waterway shear stresses

Figure 38 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.

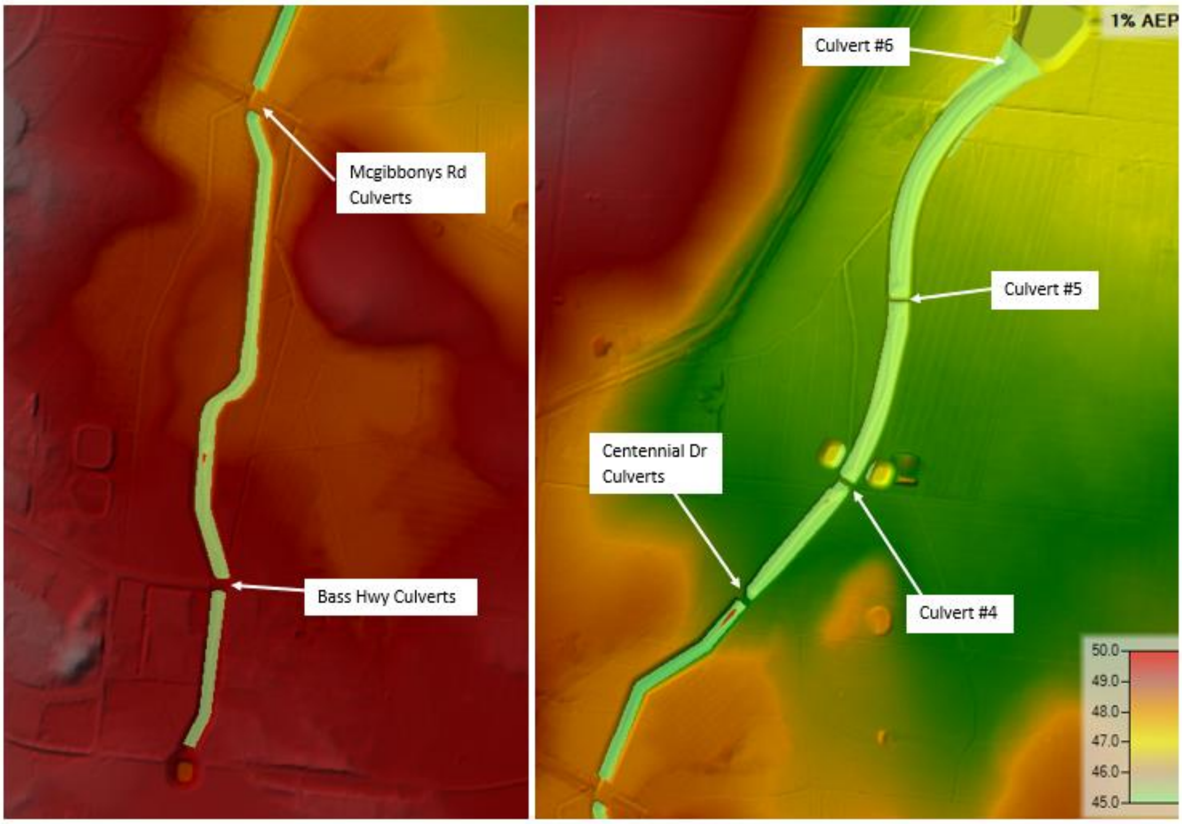


Figure 38. *Average shear stress map through constructed waterway (in N/m²)*

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 16. 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 2840)	McGibbonys Rd (stn 2400)	21.6	20.3	338
2	McGibbonys Rd (stn 2340)	WLRB1A (DCP ref WL-01/RB-01) (stn 10)	19.6	12.2	314

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 17. The alternate slope along the alignment leads to the differing channel capacities for the reach sections outlined inTable 18.

Table 17. 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 18. Channel design capacities

Reach	Low flow capacity (m^3/s)	High flow capacity (m^3/s)
1, 2	2.7	31.4

10.3 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).

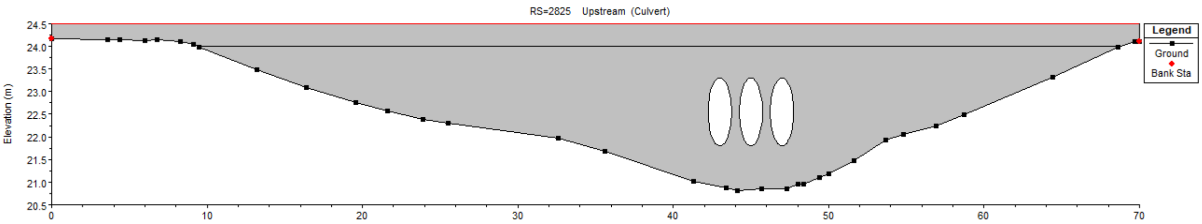


Figure 39. *Upstream Bass Hwy design cross section (looking downstream)*

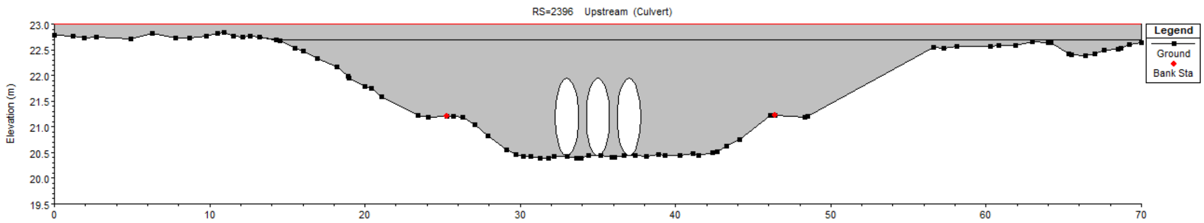


Figure 40. *Upstream McGibbonys Rd design cross section (looking downstream)*

10.4 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.

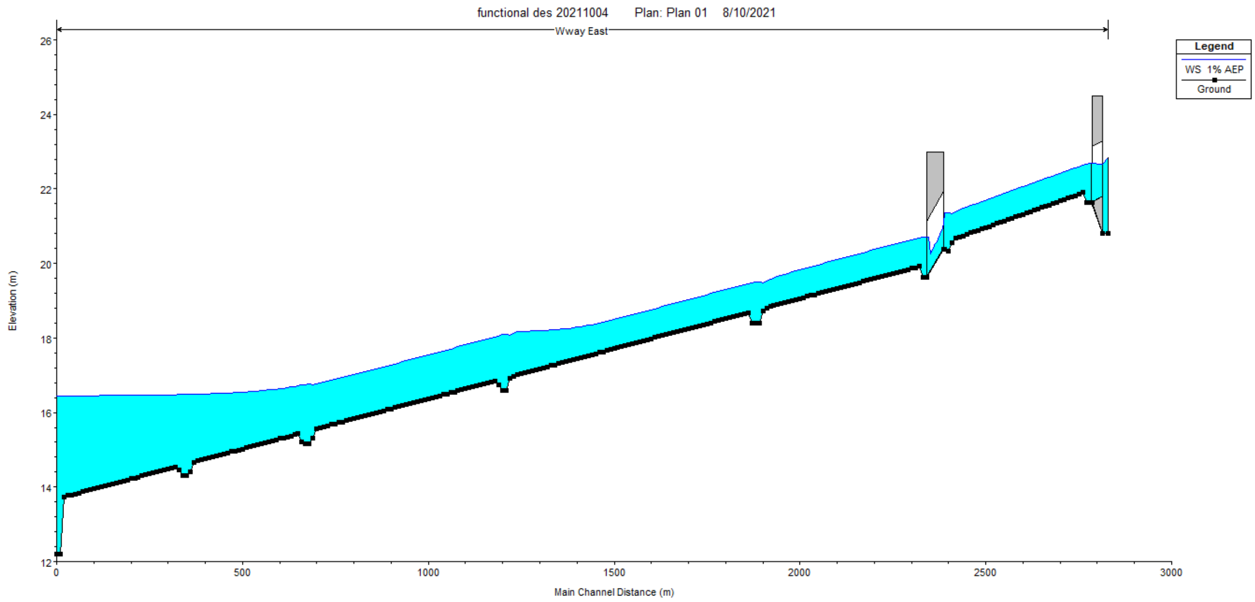


Figure 41. *1% AEP water surface elevation along the waterway alignment with culverts unimpeded*

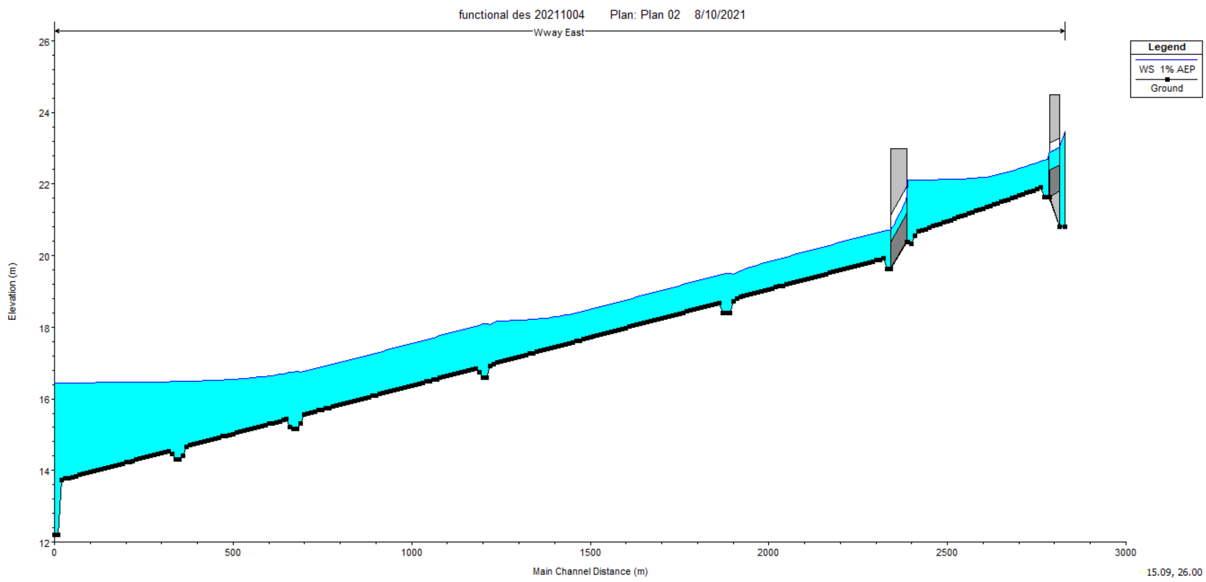


Figure 42. *1% AEP water surface elevation along the waterway alignment with culverts 50% blocked*

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

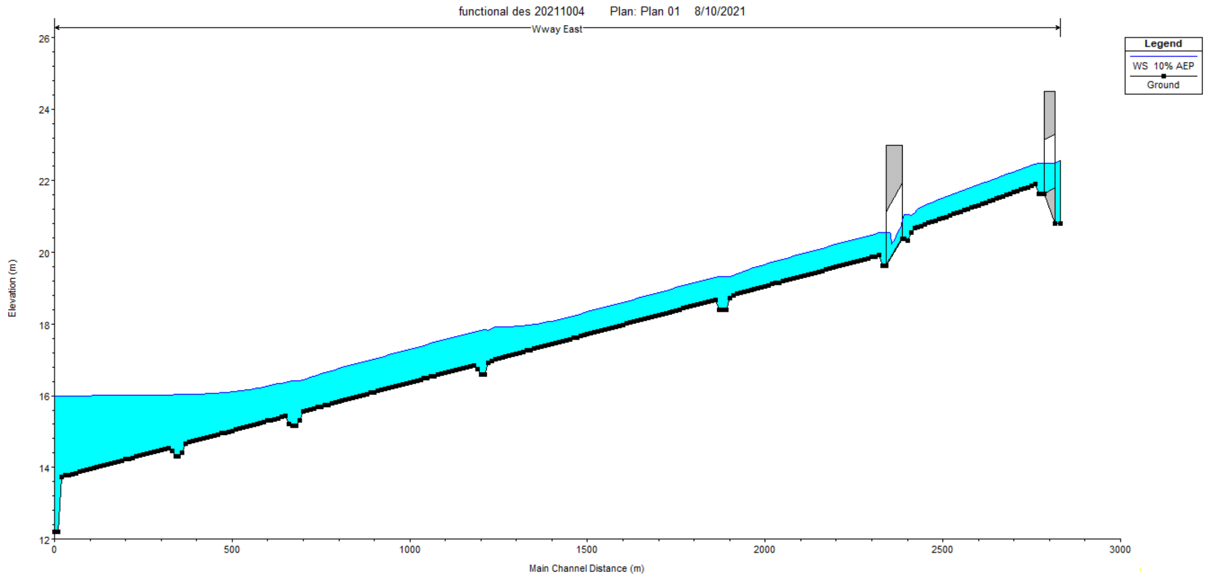


Figure 43. *10% AEP water surface elevation along the waterway alignment with culverts unimpeded*

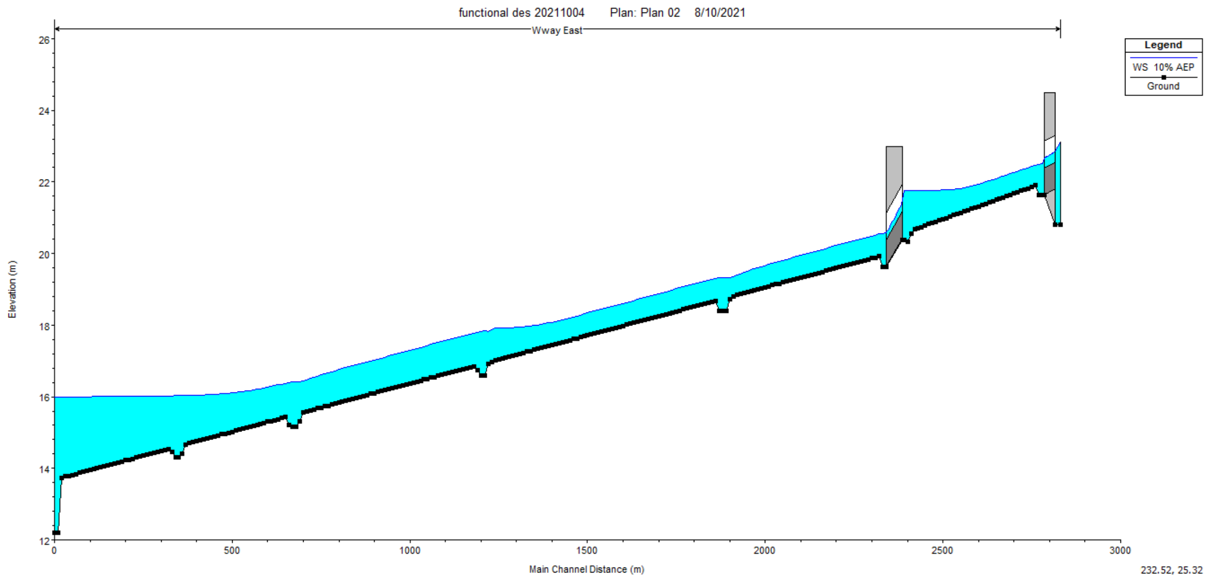


Figure 44. *10% AEP water surface elevation along the waterway alignment with culverts 50% blocked*

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

Table 19. Hydraulic results through culverts for both scenarios for the 1% AEP flow

Culvert Crossing		Open culverts	Blocked culverts
Bass Hwy			
	Head loss (m)	0.17	0.80
	Freeboard to road (m)*	1.65	1.02
	Average velocity (m/s)	0.20	0.18
McGibbonys Rd			
	Head loss (m)	0.63	1.40
	Freeboard to road (m)*	1.65	0.88
	Average velocity (m/s)	0.30	0.21

*Note: Road deck levels are assumed

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

Table 20. Hydraulic results through culverts for both scenarios for the 10% AEP flow

Culvert Crossing		Open culverts	Blocked culverts
Bass Hwy			
	Head loss (m)	0.07	0.62
	Freeboard to road (m)*	1.93	1.38
	Average velocity (m/s)	0.13	0.11
McGibbonys Rd			
	Head loss (m)	0.50	1.20
	Freeboard to road (m)*	1.94	1.24
	Average velocity (m/s)	0.22	0.14

* 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 21 provides the finished surface level, flood level and freeboard level.

Table 21. 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)
CH2825		Bass Hwy Culverts			
CH2800	2800	22.68	24.04	23.94	1.26
CH2700	2700	22.38	23.74	23.92	1.36
CH2600	2600	22.02	23.31	23.56	1.29
CH2500	2500	21.66	22.95	23.21	1.29
CH2400	2400	21.35	22.54	22.84	1.19
CH2396		McGibbonys Rd Culverts			
CH2300	2300	20.61	22.04	22.28	1.43
CH2200	2200	20.34	21.35	21.31	0.97
CH2100	2100	20.07	21.05	21.09	0.98
CH2000	2000	19.80	20.77	20.78	0.97
CH1900	1900	19.49	20.51	20.55	1.02
CH1800	1800	19.27	20.30	20.25	0.98
CH1700	1700	19.00	19.98	19.96	0.96
CH1600	1600	18.73	19.68	19.76	0.95
CH1500	1500	18.47	19.53	19.61	1.06
CH1400	1400	18.27	19.24	19.18	0.91
CH1300	1300	18.19	19.06	19.04	0.85
CH1200	1200	18.05	18.67	18.68	0.62
CH1100	1100	17.79	18.48	18.46	0.67
CH1000	1000	17.52	18.23	18.13	0.61
CH900	900	17.25	17.95	17.96	0.70
CH800	800	16.99	17.81	17.78	0.79
CH700	700	16.75	17.59	17.53	0.78
CH600	600	16.63	17.39	17.33	0.70
CH500	500	16.54	17.38	17.26	0.72

CH400	400	16.49	17.08	16.90	0.41
CH300	300	16.47	17.17	17.02	0.55
CH200	200	16.46	17.19	16.87	0.41
CH100	100	16.45	16.66	16.58	0.13

10.5 Waterway shear stresses

Figure 45 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.

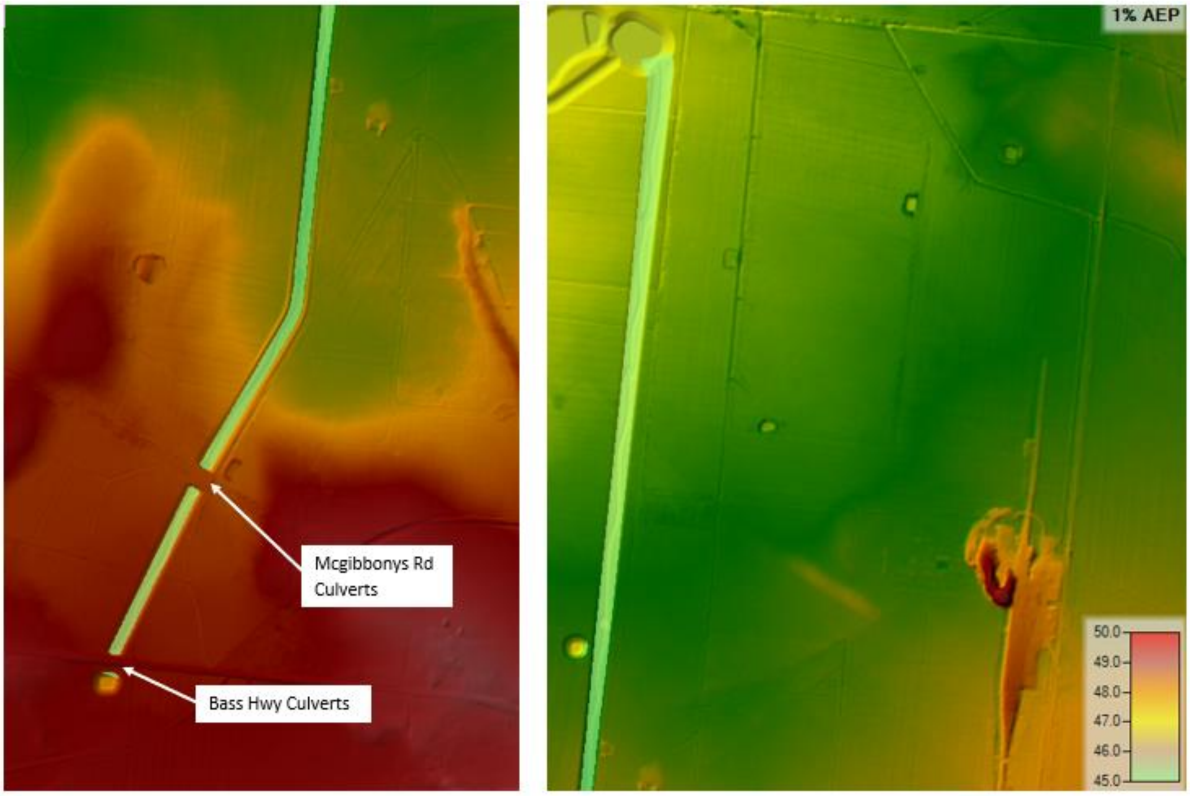


Figure 45. *Average shear stress map through constructed waterway (in N/m^2)*

11 MOP – Main Outfall to Powlett

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/RB-01) and WLRB2 (DCP ref WL-02) outflow location. The main outfall alignment remains similar to the concept design proposed by Engeny. This is due to design constraints associated within crossing existing infrastructure along Korumburra-Wonthaggi Road (gas transmission main, desalination water supply main, and mains water supply line).

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

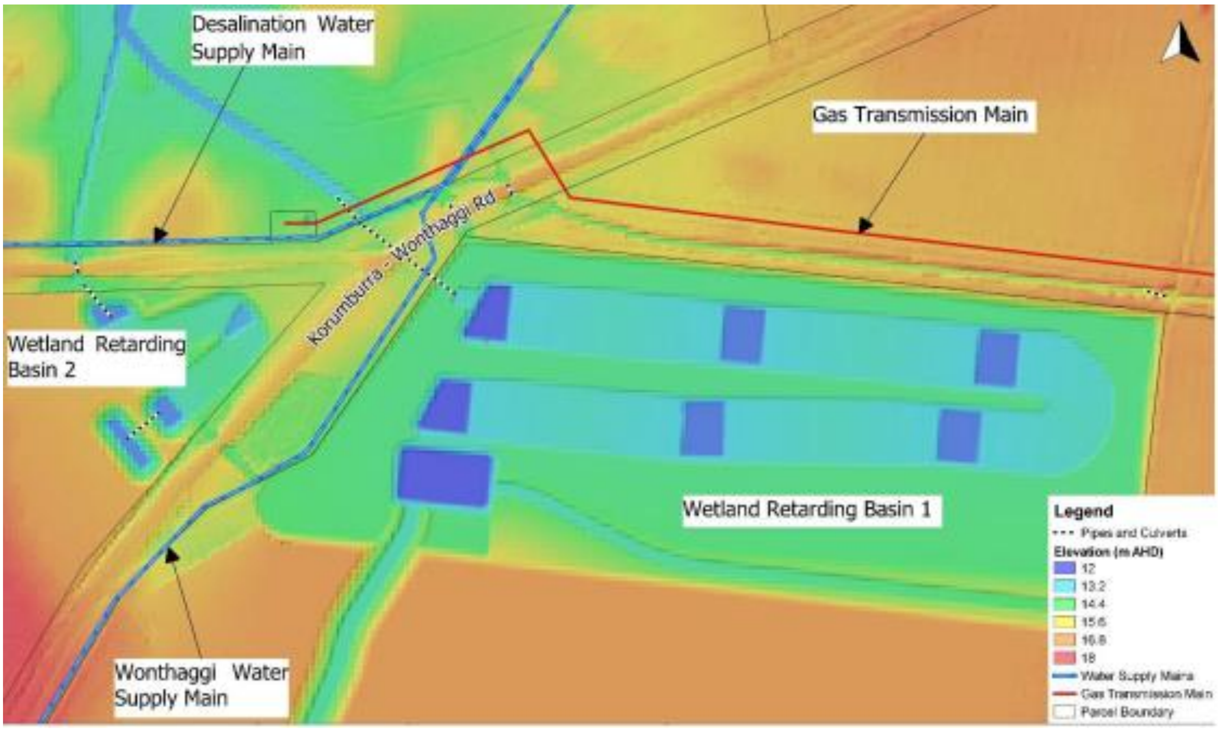


Figure 46. *Existing gas and water service pipelines (Engeny, August 2021)*

Design recommendations included:

- low flow pipes to cross the gas transmission main line with a clearance of 500mm
- a high flow outfall channel to cross the gas pipeline with vertical separation of 70mm between the top of the gas main and the invert of the channel
- maximising pipeline offset (143m) for water infrastructure
- a 200mm thick concrete slab to protect the pipe from erosion (Note: during the functional design process alternatives to the concrete slab arrangement were investigated, e.g. rock armouring treatments).

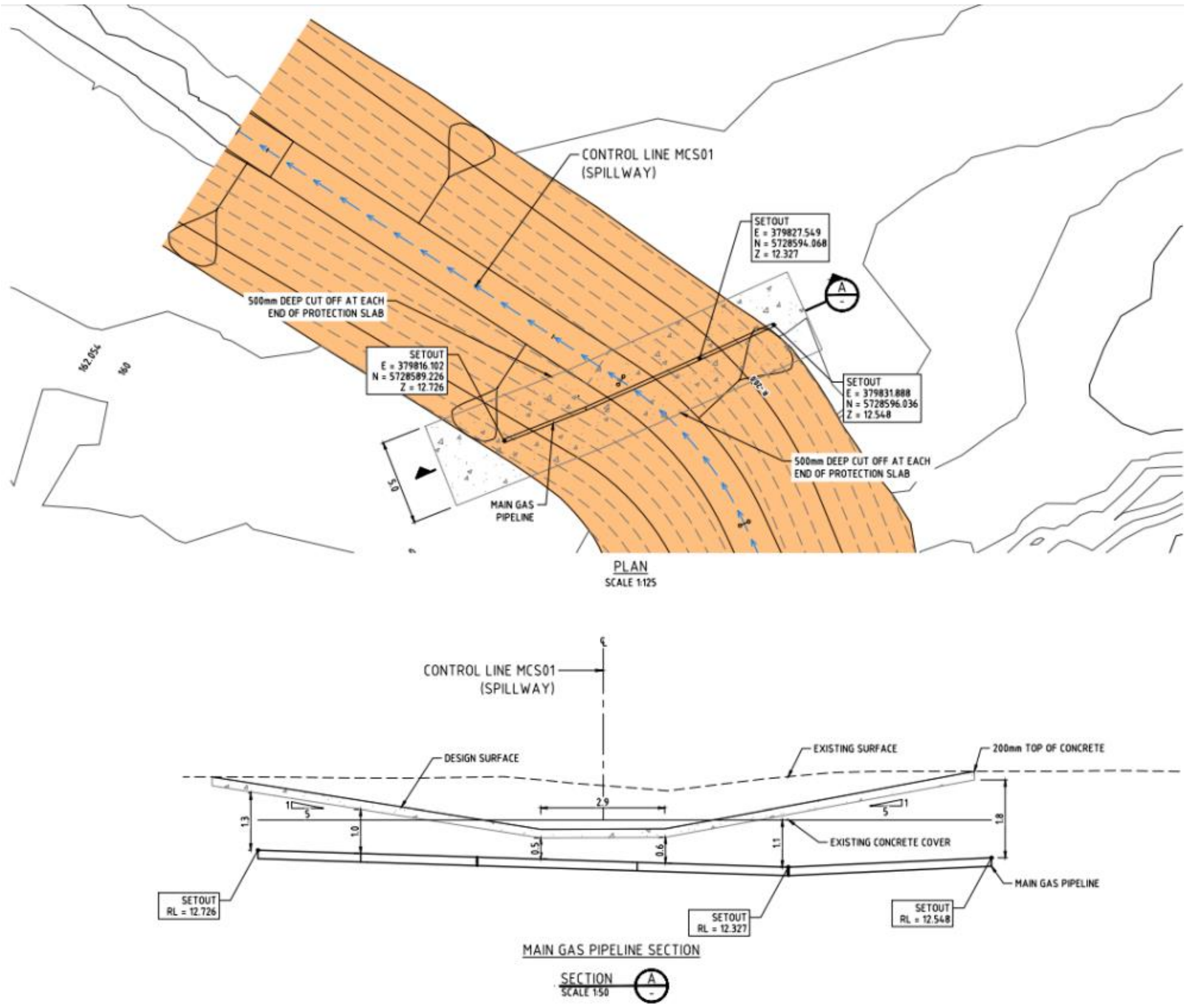


Figure 47. *Proposed channel crossing of the gas transmission main (Engeny, Aug 2021)*

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 22. 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/RB-01) Out (stn 1030)	Culvert 1 (stn 620)	14.43	12.52	214
2	Culvert 1 (stn 600)	Culvert 2 (stn 340)	12.47	11.95	500
3	Culvert 2 (stn 310)	Outlet (stn 010)	11.89	11.30	508

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 23 below. The alternate slope along the alignment leads to the differing channel capacities for the reach sections as shown in Table 24.

Table 23. Channel cross-section geometry and design parameters

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

Table 24. Channel design capacities

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

11.3 Culvert design

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).

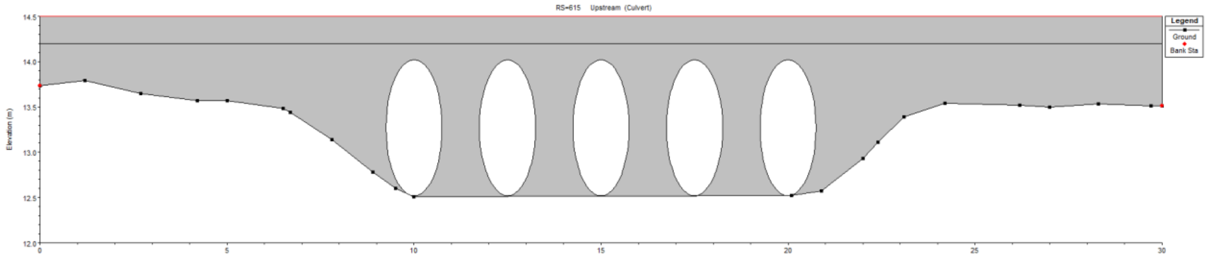


Figure 48. *Upstream Culvert 1 cross section (looking downstream)*

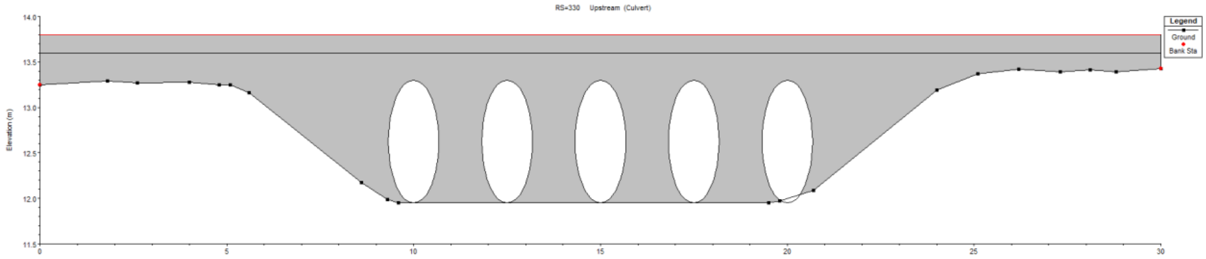


Figure 49. *Upstream Culvert 2 cross section (looking downstream)*

11.4 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 50% AEP flow for culverts open (unimpeded) and blocked.

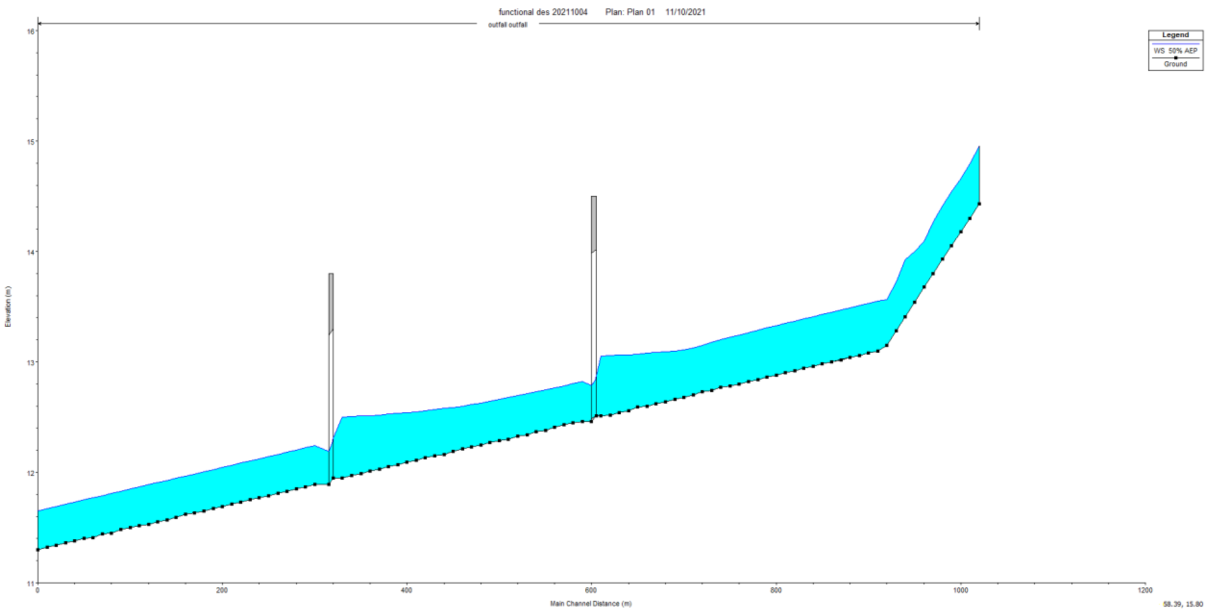


Figure 50. *50% AEP water surface elevation along the waterway alignment with culverts unimpeded*

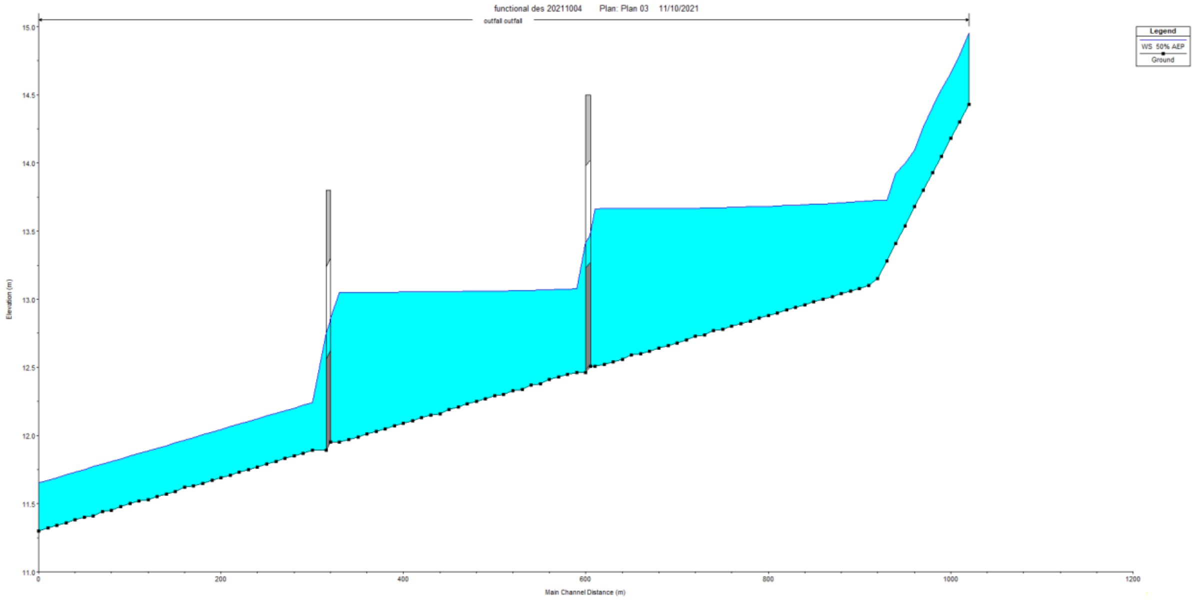


Figure 51. *50% AEP water surface elevation along the waterway alignment with culverts blocked*

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

Table 25. 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

11.5 Waterway shear stresses

Figure 52 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.

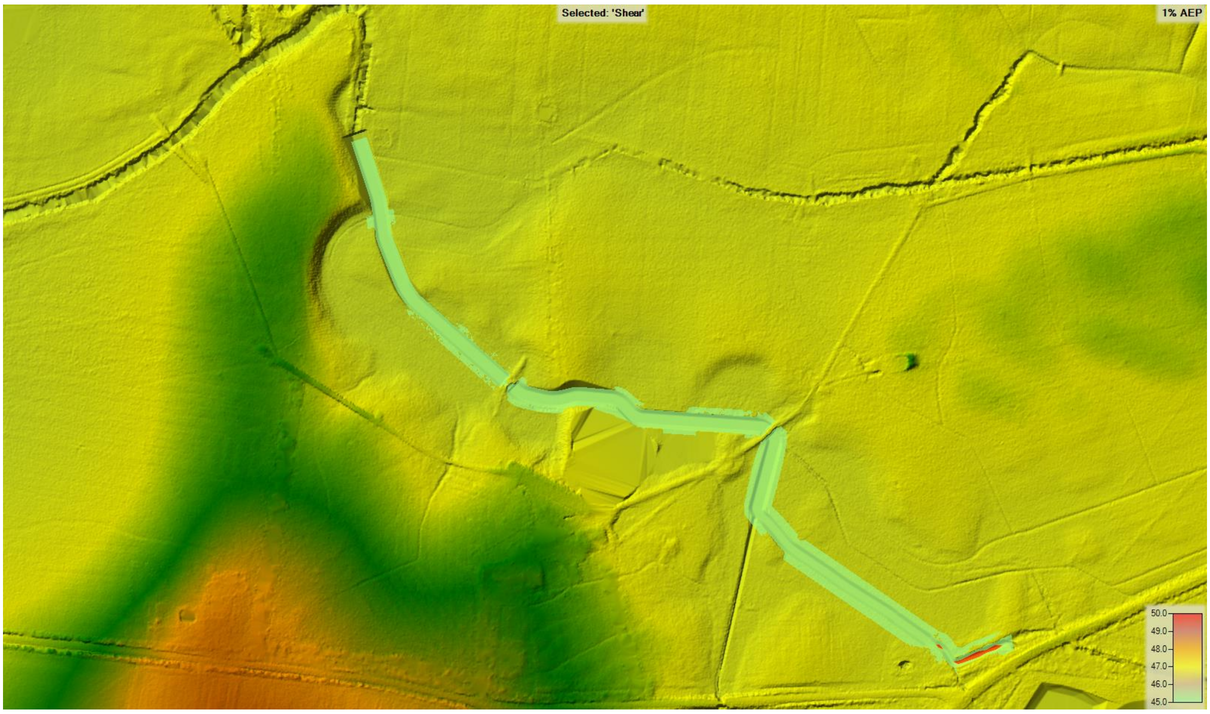


Figure 52. *Average shear stress map through constructed waterway (in N/m^2) – note red grading near WLRB1 (DCP ref WL-01/RB-01) outfall to MOP.*

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 26 shows the multiple sub-catchments (as previously shown in Figure 16 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 26. 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/RB-01)	External Agricultural	442	9,100	35,000
	PSP	199		
	Total	640		
WLRB 1B (DCP ref WL-01/RB-01)	External Agricultural	137	11,900	47,500
	External Urban	146		
	PSP	225		
	Total	507		
WLRB2 (DCP ref WL-02)	External Urban	14	1,100	10,000
	PSP	59		
	Total	73		
WLRB3 (DCP ref WL-03)	PSP	52	1,200	6,200
	Total	52		
WLRB4 (DCP ref WL-04)	External Urban	23	2,800	22,000
	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 53 below.

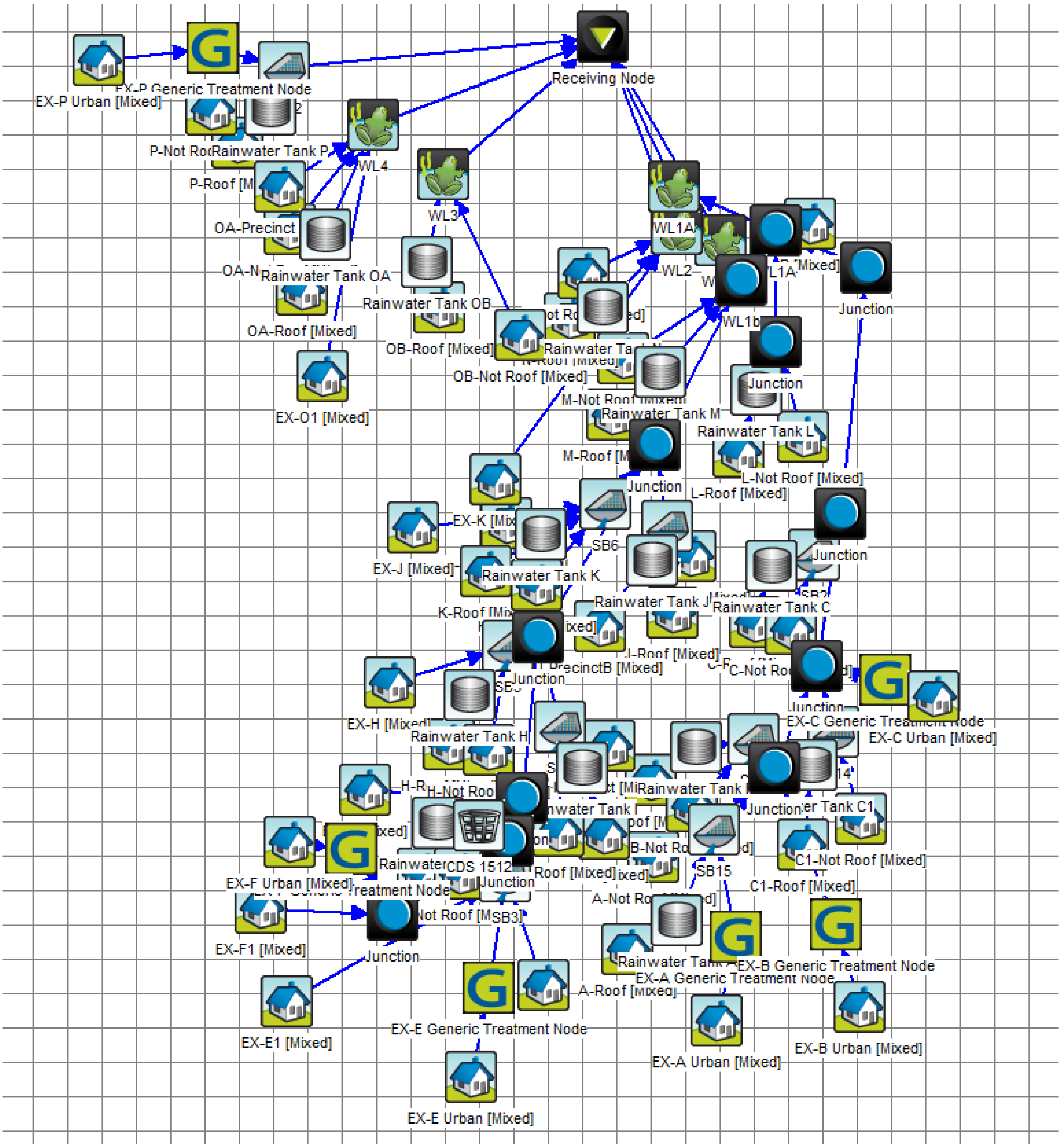


Figure 53. *MUSIC model for the Wonthaggi North East PSP (Alluvium, Aug 2021)*

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 27 and Table 28 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 54**).

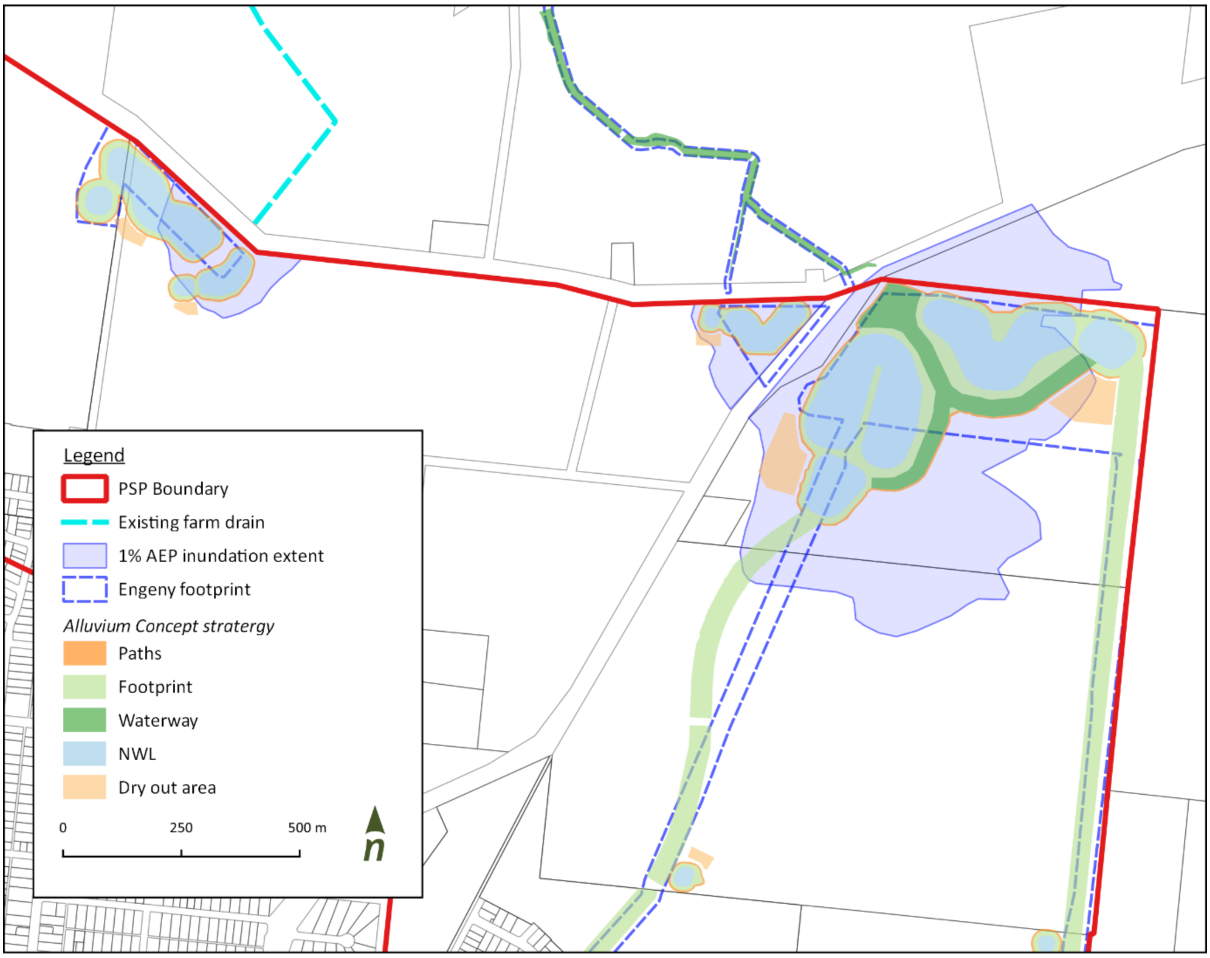


Figure 54. *Wetland assets and inundation extents*

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 27. Wetland treatment asset parameters for the Wonthaggi North East PSP

	WLRB1A	WLRB1B	WLRB2	WLRB3	WLRB4
DCP reference	WL-01/RB-01	WL-01/RB-01	WL-02	WL-03	WL-04
NWL area, m^2	35,000	47,500	10,000	6,200	22,000
Inlet pond area, m^2	9,100	11,900	1,100	1,200	2,800
Inlet pond volume m^3	7280	9,.520	880	960	2,240
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 28. 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 in order 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 <u>are met</u> with the performance of the wetland and sediment basin assets, as shown below.

Table 29. 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 30. 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	136,000	84.8	764,000	110%
TP (kg/yr)	2,070	1,470	618	70.1	1,452	98%
TN (kg/yr)	15,500	10,740	9,010	42.0	9,490	60%
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/RB-01)

This section outlines the design calculations that have been undertaken to ensure the performance of the treatment system WLRB1A (DCP ref WL-01/RB-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).

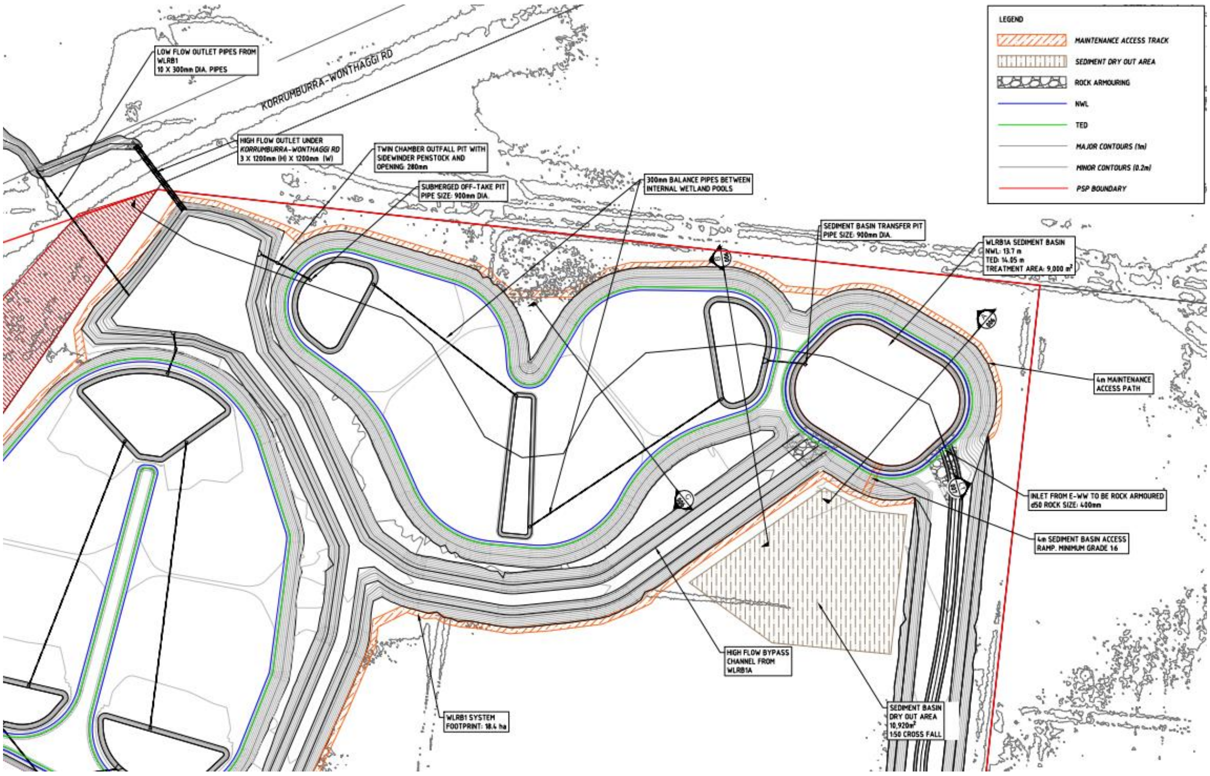


Figure 55. *Plan view of the designed wetland structure WLRB1A (DCP ref* WL-01/RB-01*) (east)*

13.1 Velocities

WLRB1A (DCP ref WL-01/RB-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/RB-01) macrophyte zone is proposed at 35,000 m^2 and 9,000 m^2 at the inlet pond, as established in the MUSIC modelling. Therefore a width of 93m 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 WLRB1A (DCP ref WL-01/RB-01), the minimum design width is 90m in the macrophyte zone and 49m in the inlet pond to meet velocity threshold requirements. The table below provides details on the minimum widths and velocities determined.

Table 31. System velocity calculations and design checks – WLRB1A (DCP ref WL-01/RB-01)

	Parameter	4EY	20% AEP
Flow Conditions	Design flow (m^3/s)	1.61	8.92
	Flow depth (m)	0.35	0.35
Inlet pond	Width at NWL (m)	49	49
	Width at EDD (m)	53.2	53.2

	Average Width (m)	51.1	51.1
	Flow area (m^2)	17.9	17.9
	Flow velocity (m/s)	0.09	0.50
	Check	<0.5 OK	<0.5 OK
Macrophyte zone	Width at NWL (m)	90	90
	Width at EDD (m)	94.2	94.2
	Average Width (m)	92.1	92.1
	Flow area (m^2)	32	32
	Flow velocity (m/s)	0.05	0.28
	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 32. Inlet Pond design parameters and checks

	Parameter	Proposed design
Conditions	Contributing Catchment (ha)	552
	Area of Basin (m^2)	9,000
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	1.12
	Depth below permanent pool that is sufficient to retain sediment, d* (m)	0.50
	Design Discharge (m^3/s) [Q3-month]	1.61
	Capture Efficiency	98.9%
	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	5,460
	Available sediment storage volume	7,170
	Check (Available storage > required storage)	OK
Sediment dewatering	Depth for dewatering area (m)	0.50
	Area required for dewatering (m^2)	10,920

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 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 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).

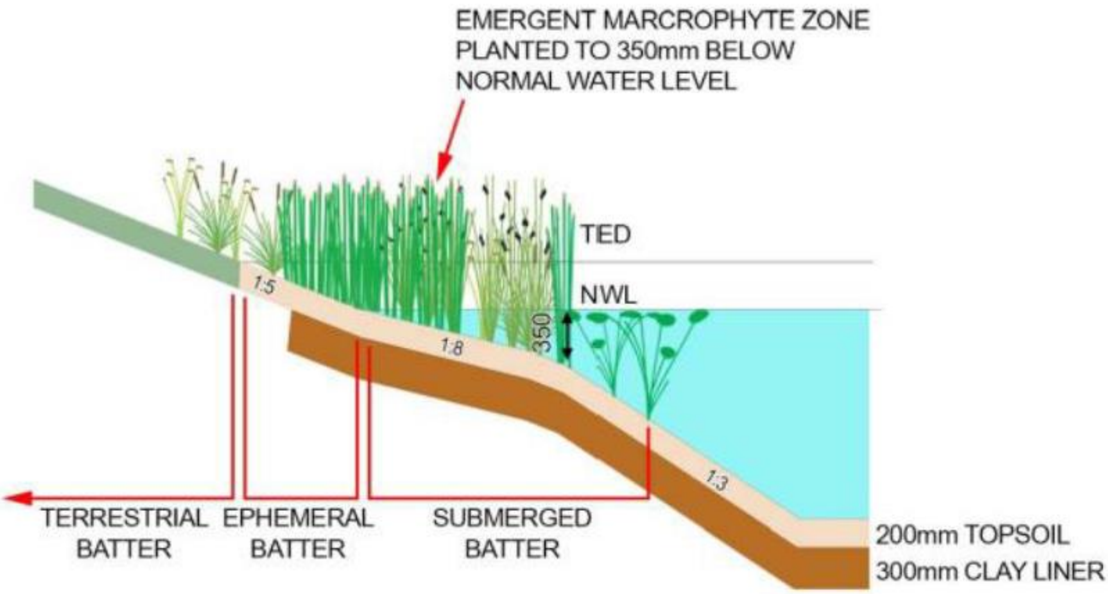


Figure 56. *Edge treatment for batter slopes (Melbourne Water 2014)*

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 57). A minimum grade of 1:150 is required through the macrophyte zone. For some wetlands, this means that an intermediate pool is necessary.

Table 33. 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

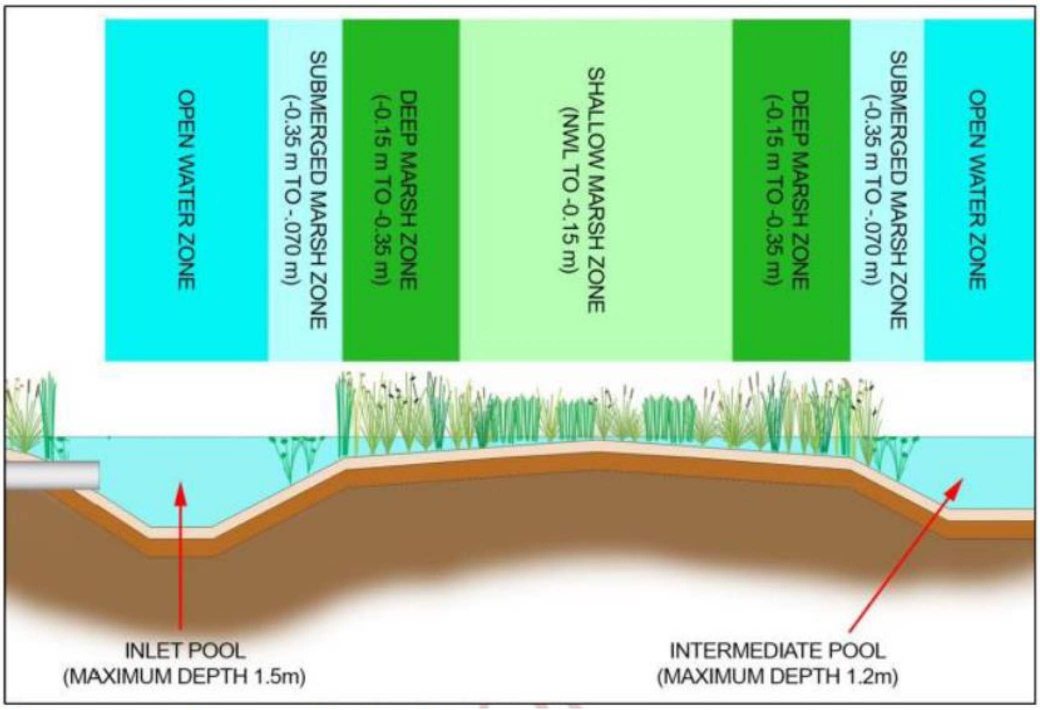


Figure 57. *Macrophyte zone planting bands (Melbourne Water 2014)*

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 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 280mm (i.e. the penstock opening) to ensure the 72-hour detention time. Figure 58 shows the stage-storage-discharge relationship used in MUSIC.

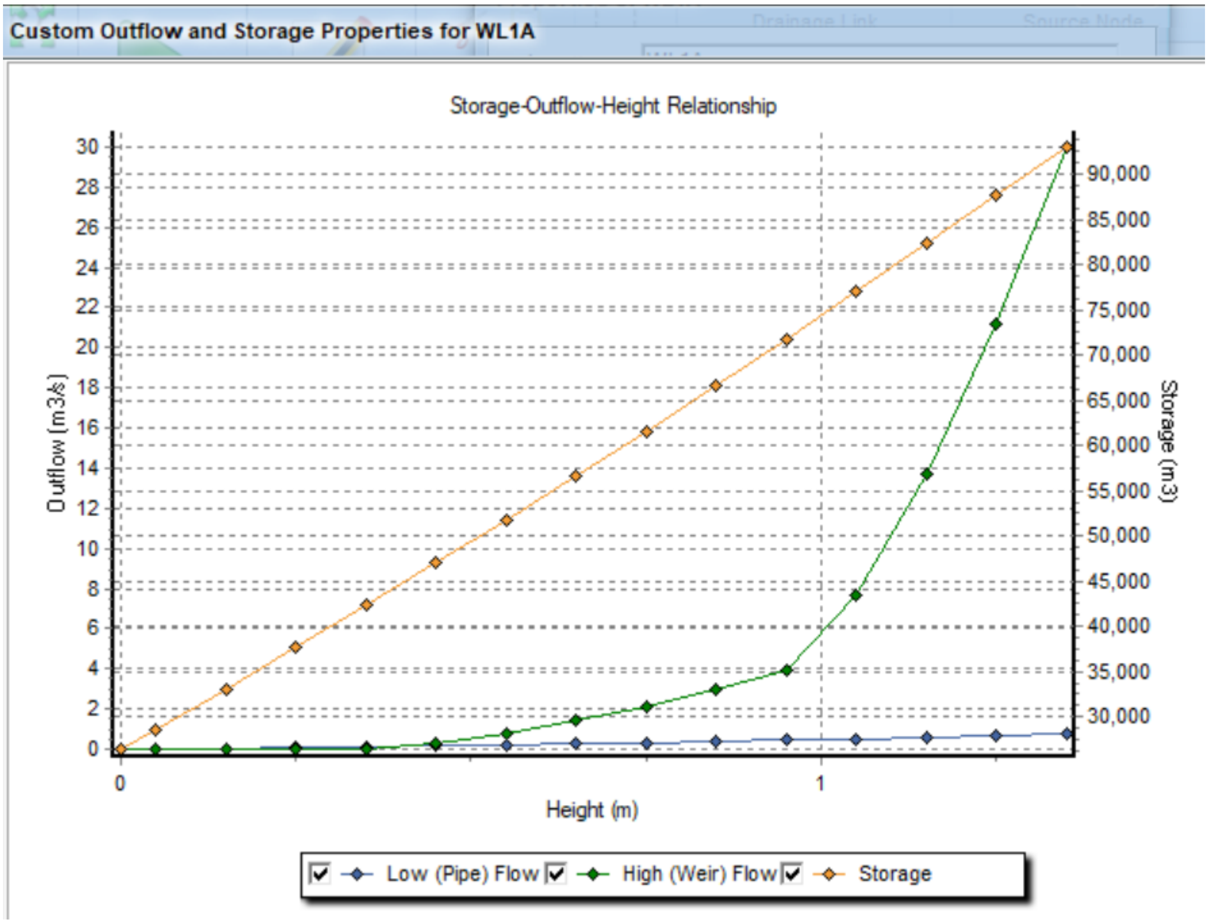


Figure 58. *Stage-storage-discharge relationship*

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 10,920m^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 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).

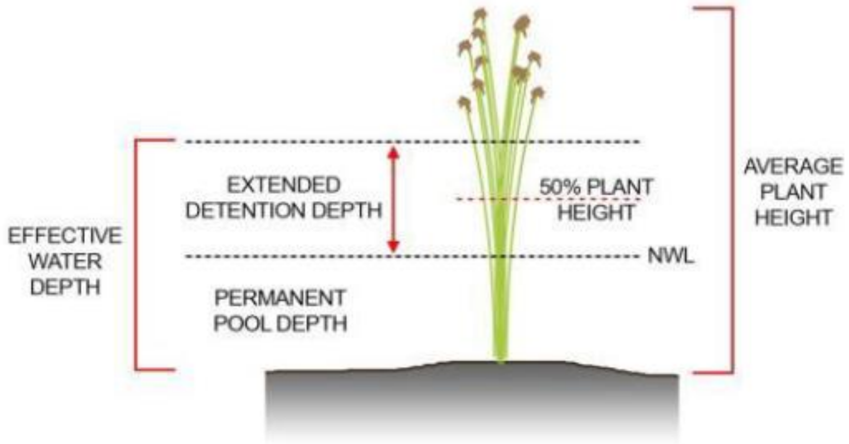
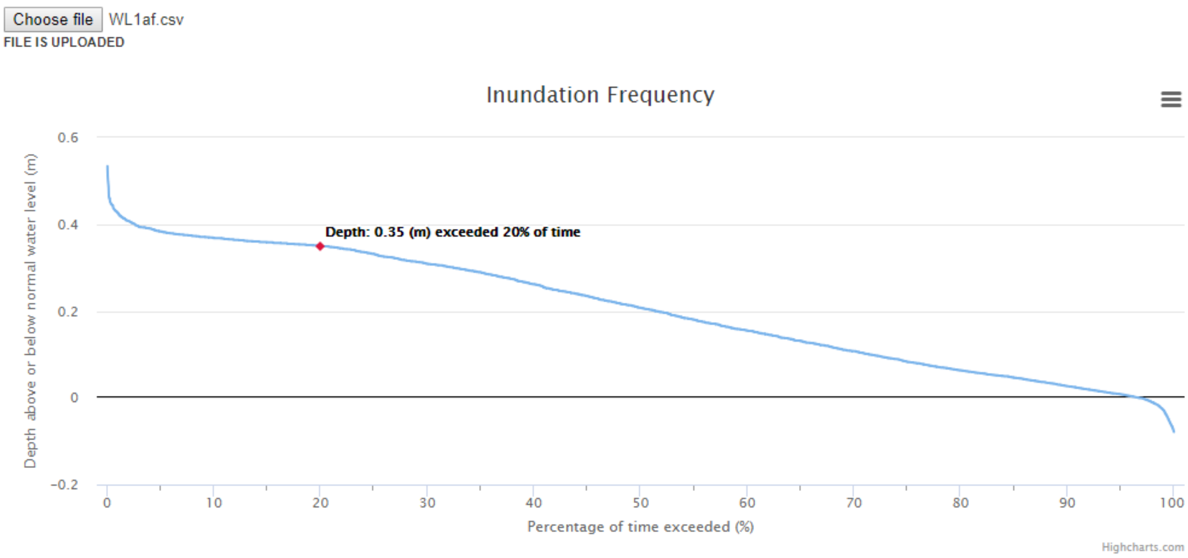


Figure 59. *Effective plant heights*

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
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		☑	
Sea Club-rush *Bolboschoenus caldwellii*	1	☐		Unsuitable
Common Spike-rush *Eleocharis acuta*	0.5	☐		
Water Ribbons *Triglochin procerum*	1	☐	☐	

+ Add user defined plant

Report

File: WL1af.csv
Shallow marsh zone meets deemed to comply criteria

Deep marsh zone does not meet the deemed to comply criteria, please select at least 3 plants

Water level exceeded for 20% of time: 0.343 m

Water level exceeded for 50% of time: 0.192 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/RB-01)

This section outlines the design calculations that have been undertaken to ensure the performance of the treatment system WLRB1B (DCP ref WL-01/RB-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).

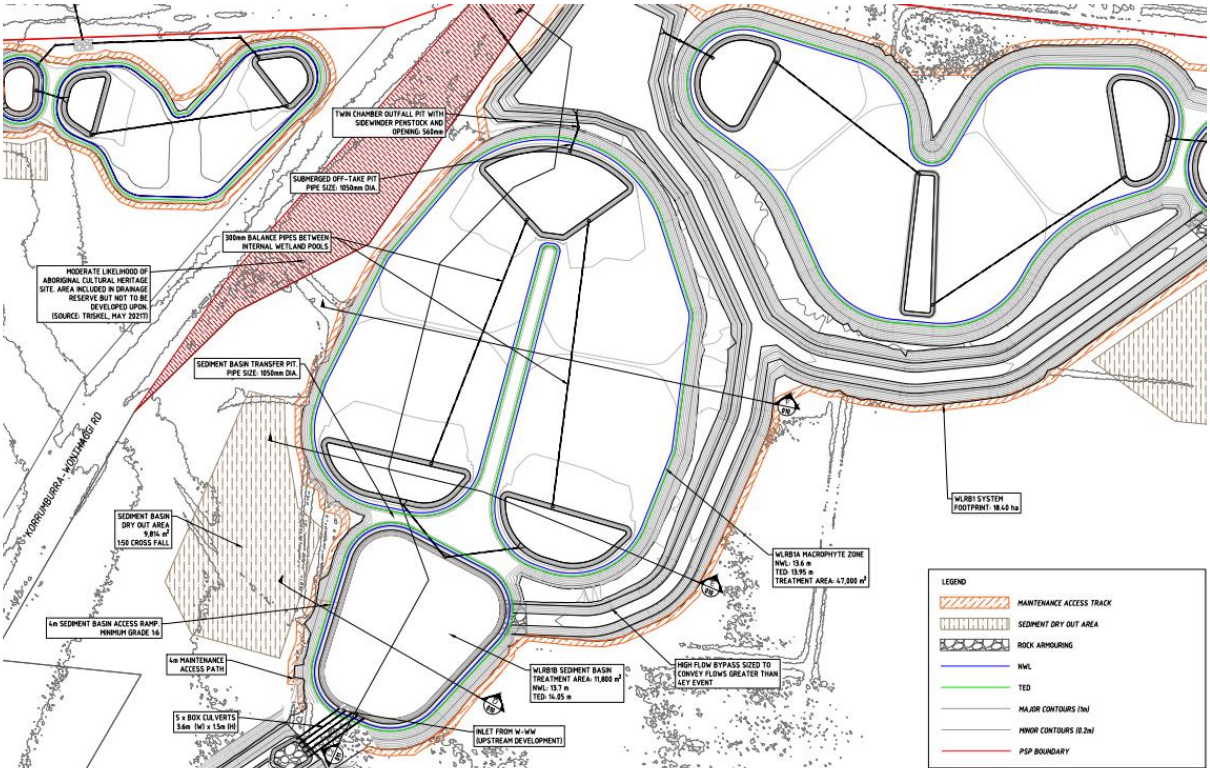


Figure 60. *Plan view of the designed wetland structure WLRB1B (DCP ref* WL-01/RB-01*) (west)*

14.1 Velocities

The area of the WLRB1B (DCP ref WL-01/RB-01) macrophyte zone is proposed as 47,500 m^2 and 11,800 m^2 at the inlet pond, as established in the MUSIC modelling. Therefore, a width of 158m 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/RB-01), the minimum design width is 77 m in the macrophyte zone and 86 m in the inlet pond to meet velocity threshold requirements. The table below provides details on the minimum widths and velocities determined.

Table 34. System velocity calculations and design checks – WLRB1B (DCP ref WL-01/RB-01)

	Parameter	4EY	20% AEP
Flow Conditions	Design flow (m^3/s)	2.76	15.34
	Flow depth (m)	0.35	0.35
Inlet pond	Width at NWL (m)	86	86
	Width at EDD (m)	90.2	90.2

	Average Width (m)	88.1	88.1
	Flow area (m^2)	30.8	30.8
	Flow velocity (m/s)	0.09	0.50
	Check	<0.5 OK	<0.5 OK
Flow Conditions	Design flow (m^3/s)	1.38	7.67
(split)	Flow depth (m)	0.35	0.35
Macrophyte	Width at NWL (m)	77	77
zone	Width at EDD (m)	81.2	81.2
	Average Width (m)	79.1	79.1
	Flow area (m^2)	28.0	28.0
	Flow velocity (m/s)	0.05	0.28
	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 35. Inlet Pond design parameters and checks

	Parameter	Proposed design
Conditions	Contributing Catchment (ha)	498
	Area of Basin (m^2)	11,800
Capture	Settling Velocity of Target Sediment (mm/s) [Particle size 125 µm]	11
Efficiency	Hydraulic Efficiency (λ)	0.11
	Permanent Pool Depth, dp (m)	0.50
	Extended detention depth, de	0.35
	Number of CTSR's, n	1.12
	Depth below permanent pool that is sufficient to retain sediment, d* (m)	0.50
	Design Discharge (m^3/s) [Q3-month]	2.76
	Capture Efficiency	98.5%
	Check (>95%)	OK
Sediment	Sediment Loading rate, Lo (m^3/ha/yr)	2.0
Storage	Desired clean-out frequency, Fr	5
	Storage volume required, St	4,907
	Available sediment storage volume	9,400
	Check (Available storage > required storage)	OK
Sediment	Depth for dewatering area (m)	0.50
dewatering	Area required for dewatering (m^2)	9,814

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 57 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 36. 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 58 shows the stage-storage-discharge relationship used in MUSIC for WLRB1B (DCP ref WL-01/RB-01).

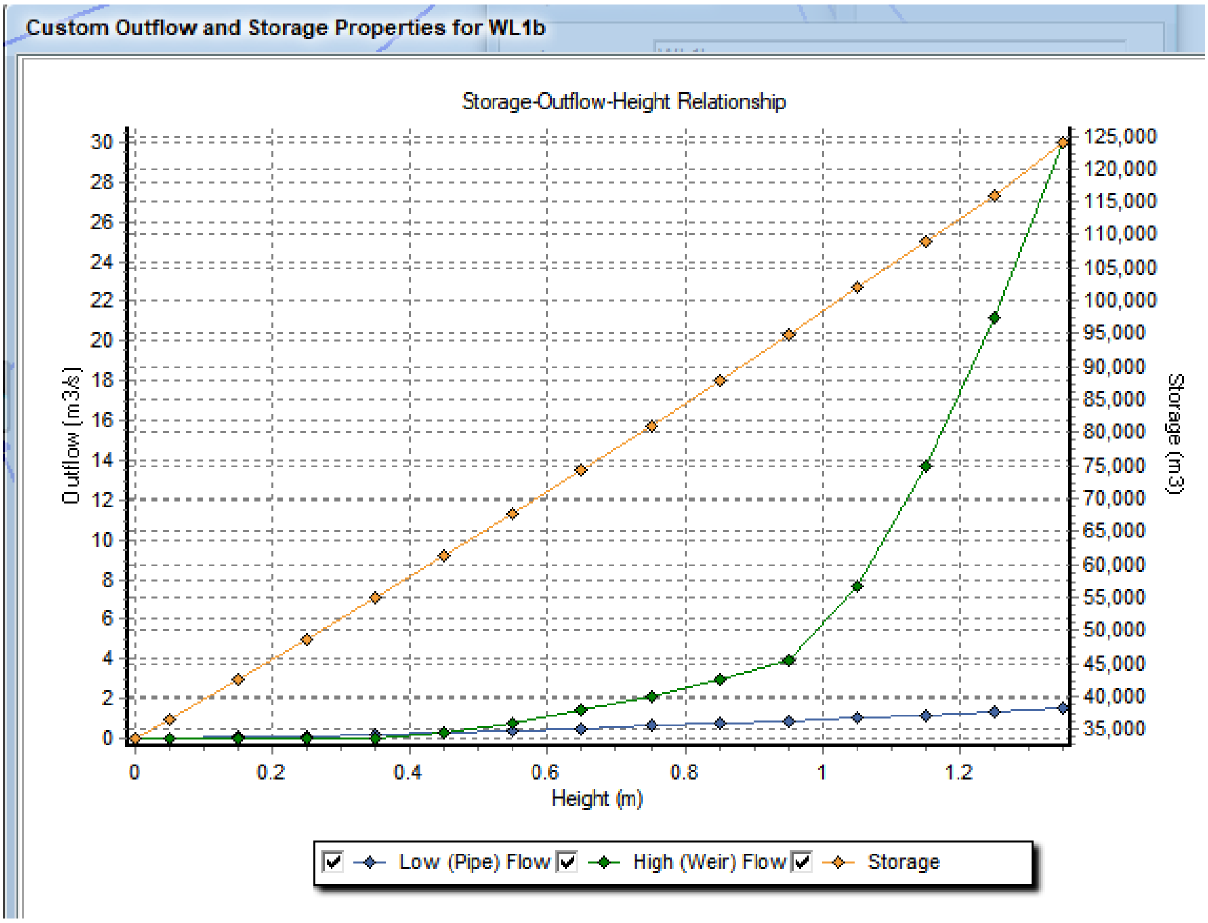


Figure 61. *Stage-storage-discharge relationship*

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 9814m^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 59 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 WL1bf.csv
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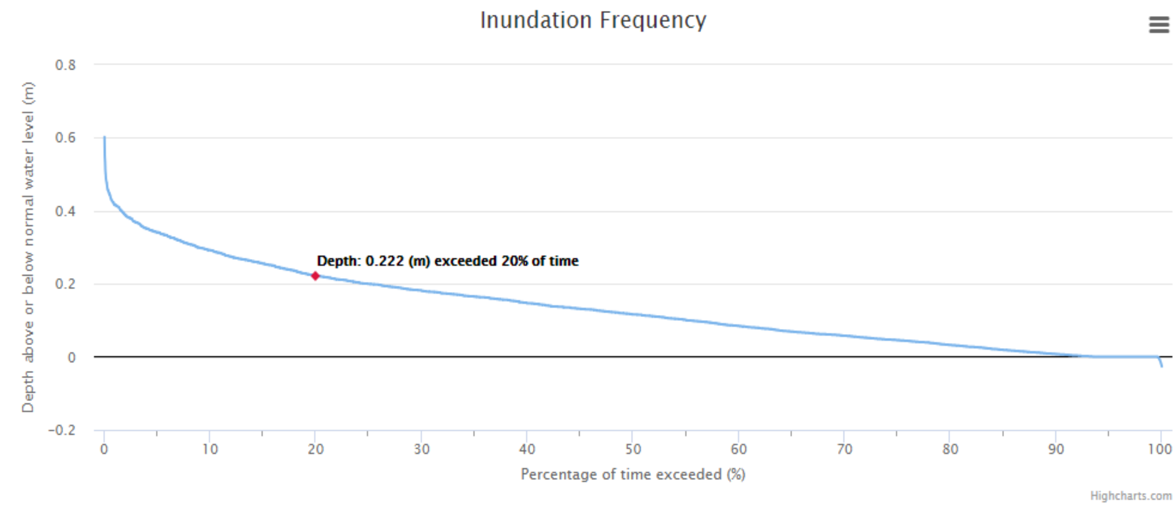


Please select at least 3 plants for each of the shallow and deep marsh zones.

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: WL1bf.csv
Shallow marsh zone meets deemed to comply criteria

Deep marsh zone meets deemed to comply criteria

Water level exceeded for 20% of time: 0.222 m

Water level exceeded for 50% of time: 0.116 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 62 below (refer to Appendix B for further design details and cross sections).

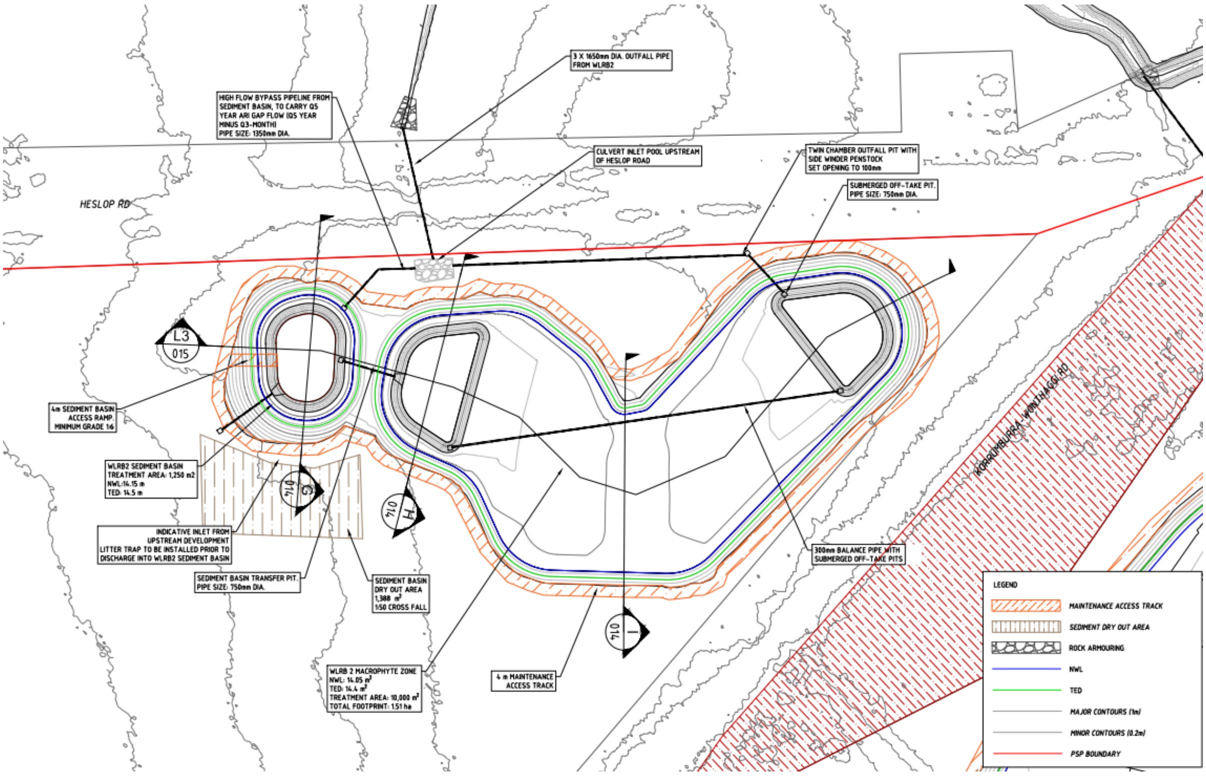


Figure 62. *Plan view of the designed wetland structure WLRB2 (DCP ref WL-02)*

15.1 Velocities

The area of the WLRB2 (DCP ref WL-02) macrophyte zone is proposed at 10,000 m^2 and 1,250 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 50 m in the macrophyte zone and 27 m 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 – WLRB2 (DCP ref WL-02)

	Parameter	4EY	20% AEP
Flow Conditions	Design flow (m^3/s)	0.91	5.05
	Flow depth (m)	0.35	0.35
Inlet pond	Width at NWL (m)	27	27
	Width at EDD (m)	31.2	31.2
	Average Width (m)	29.1	29.1
	Flow area (m^2)	10.2	10.2
	Flow velocity (m/s)	0.09	0.50
	Check	<0.5 OK	<0.5 OK
Macrophyte zone	Width at NWL (m)	50	50
	Width at EDD (m)	54.2	54.2
	Average Width (m)	52.1	52.1
	Flow area (m^2)	18.0	18.0
	Flow velocity (m/s)	0.05	0.28
	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 38. Inlet Pond design parameters and checks

	Parameter	Proposed design
Conditions	Contributing Catchment (ha)	73
	Area of Basin (m^2)	1,250
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	1.12
	Depth below permanent pool that is sufficient to retain sediment, d* (m)	0.50
	Design Discharge (m^3/s) [Q3-month]	0.91
	Capture Efficiency	95.0%
	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	694
	Available sediment storage volume	854
	Check (Available storage > required storage)	OK
Sediment dewatering	Depth for dewatering area (m)	0.50
	Area required for dewatering (m^2)	1,388

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 57 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 39. 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 63 shows the stage-storage-discharge relationship used in MUSIC for WLRB2 (DCP ref WL-02).

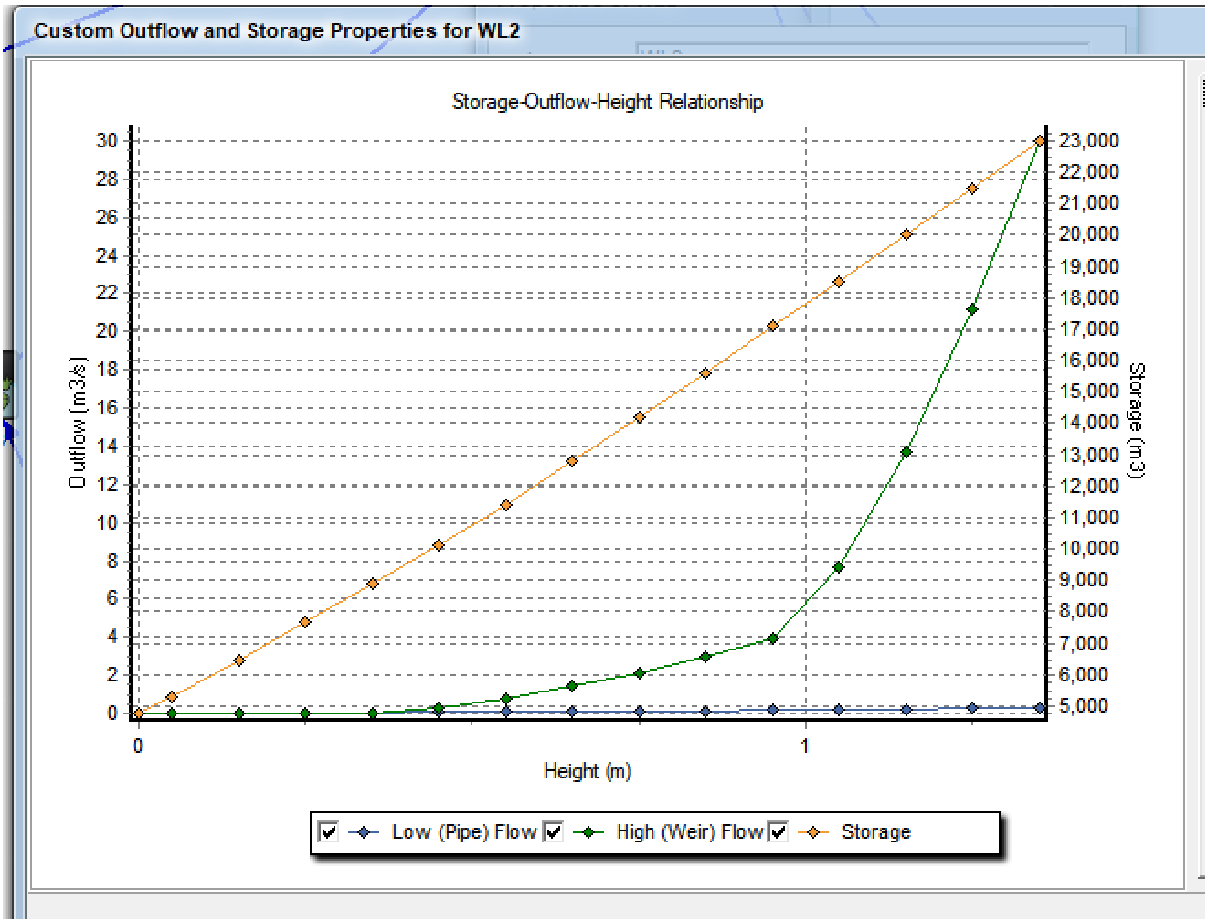


Figure 63. *Stage-storage-discharge relationship*

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.

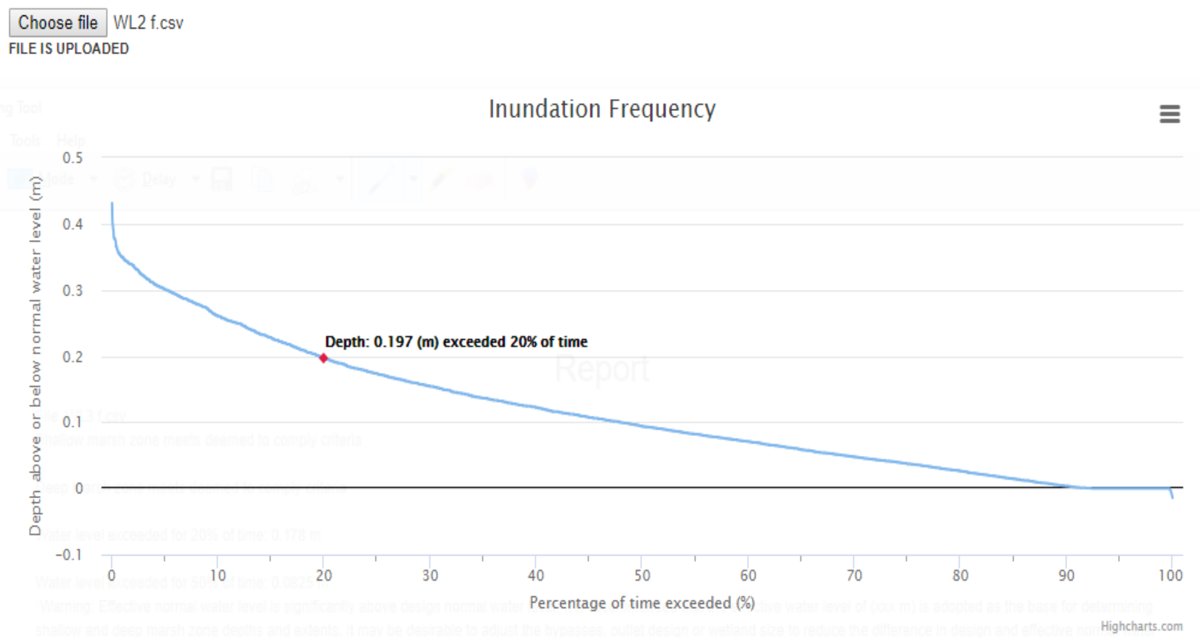
Sediment dewatering areas

A sediment dewatering area of 1,388m^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 59 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 f.csv
Shallow marsh zone meets deemed to comply criteria

Deep marsh zone meets deemed to comply criteria

Water level exceeded for 20% of time: 0.197 m

Water level exceeded for 50% of time: 0.0938 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 64 below (refer to Appendix B for further design details and cross sections).

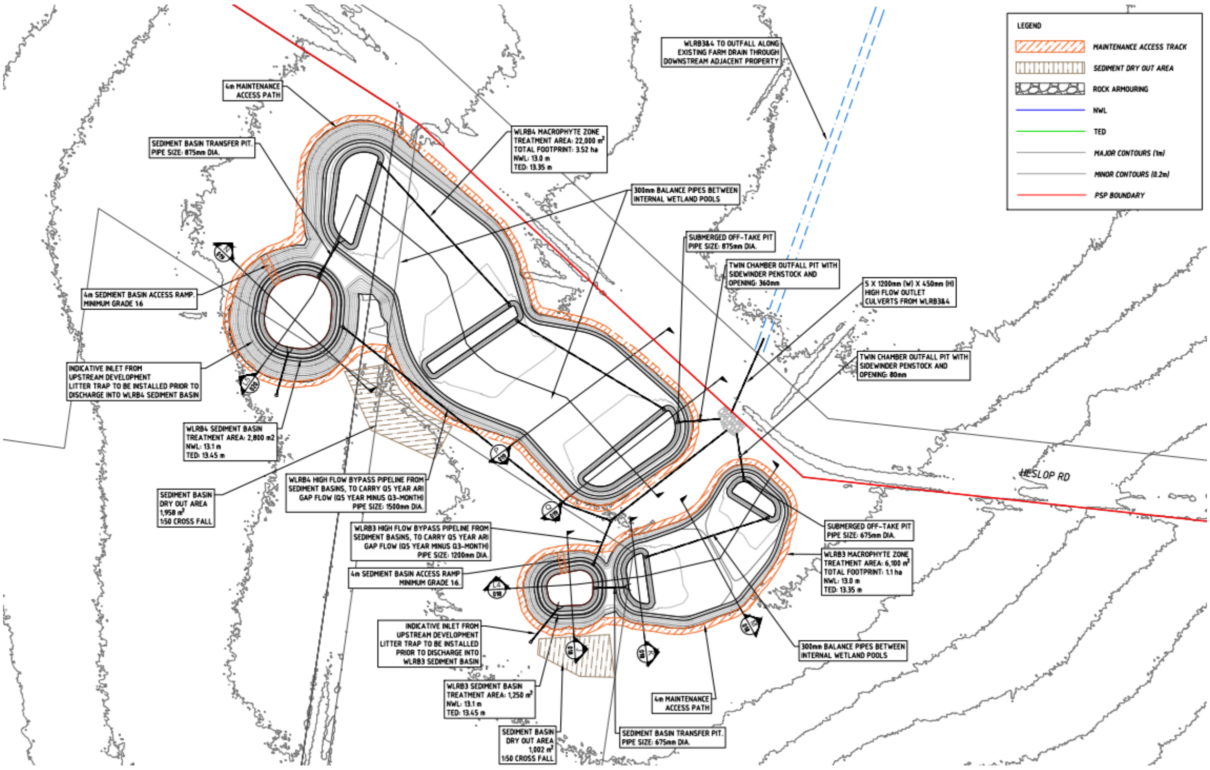


Figure 64. *Plan view of the designed wetland structure WLRB3 (DCP ref WL-03)*

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

	Parameter	4EY	20% AEP
Flow Conditions	Design flow (m^3/s)	0.68	3.76
	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)	0.09	0.49

	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	0.27
	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 41. Inlet Pond design parameters and checks

	Parameter	Proposed design
Conditions	Contributing Catchment (ha)	52
	Area of Basin (m^2)	1,250
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	1.12
	Depth below permanent pool that is sufficient to retain sediment, d* (m)	0.50
	Design Discharge (m^3/s) [Q3-month]	0.68
	Capture Efficiency	96.3%
	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	501
	Available sediment storage volume	854
	Check (Available storage > required storage)	OK
Sediment dewatering	Depth for dewatering area (m)	0.50
	Area required for dewatering (m^2)	1,002

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 57 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

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 65 shows the stage-storage-discharge relationship used in MUSIC for WLRB3 (DCP ref WL3).

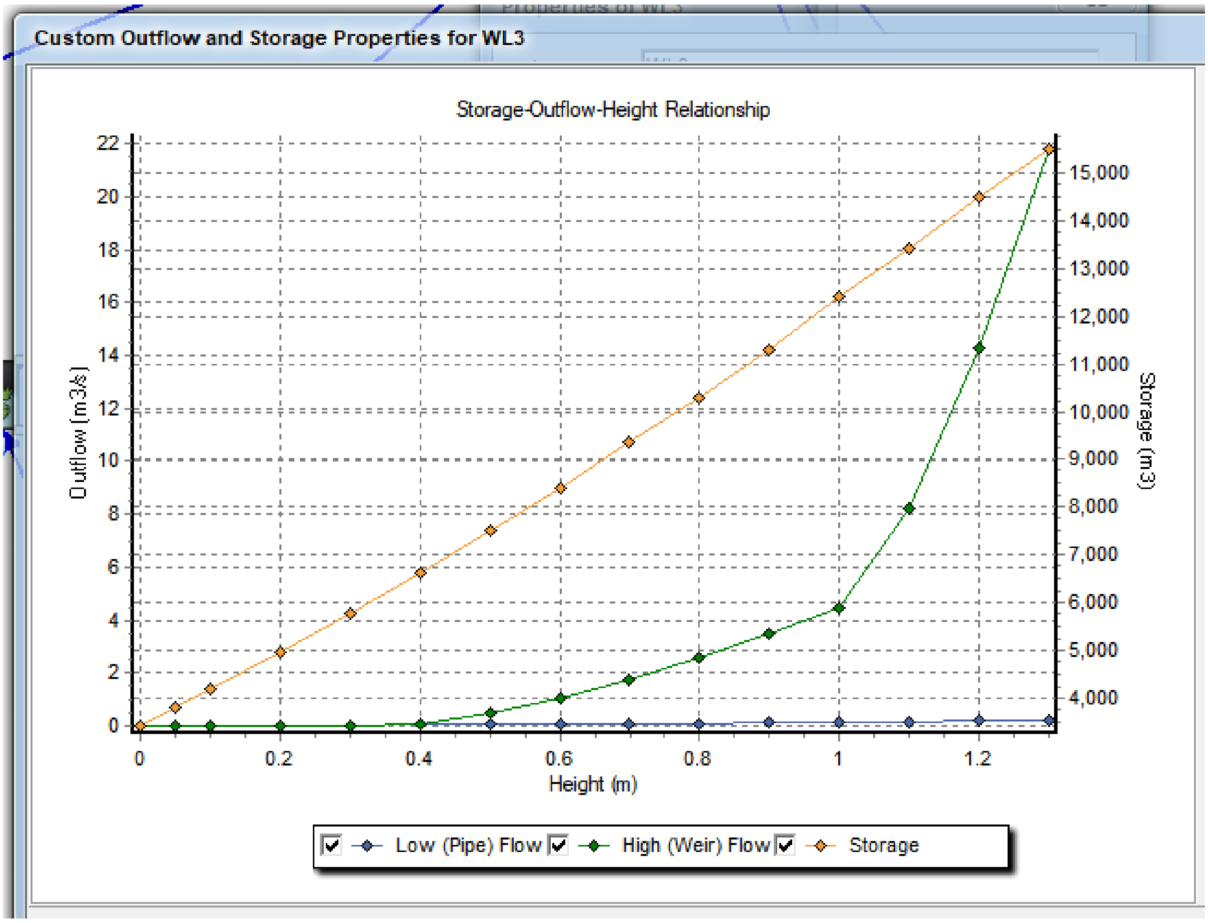


Figure 65. *Stage-storage-discharge relationship for WLRB3 (DCP ref WL-03)*

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 1,002m^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.

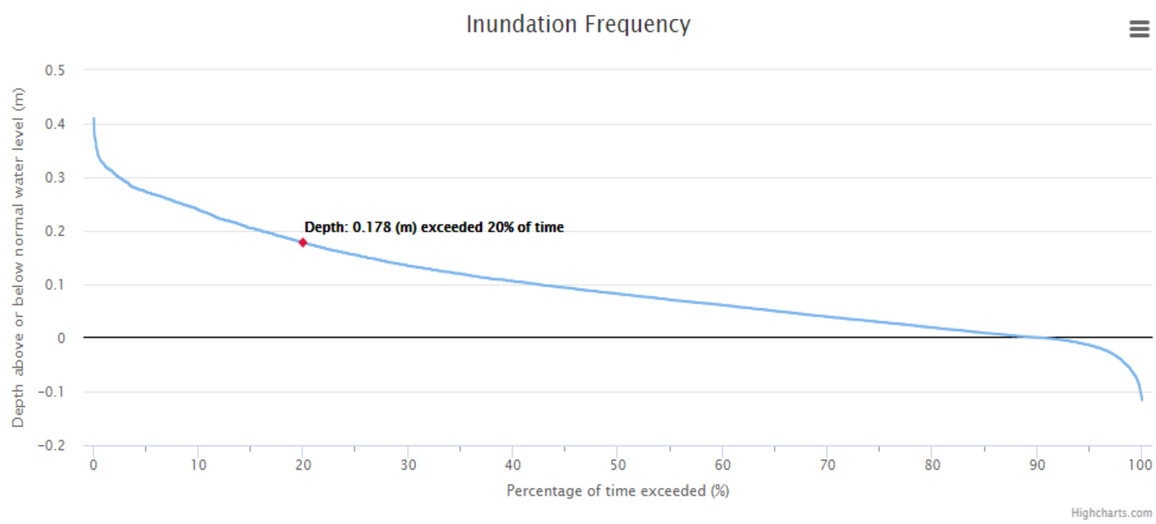
16.6 Vegetation

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 59 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 WL3 f.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: WL3 f.csv
Shallow marsh zone meets deemed to comply criteria

Deep marsh zone meets deemed to comply criteria

Water level exceeded for 20% of time: 0.178 m

Water level exceeded for 50% of time: 0.0825 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 66 below (refer to Appendix B for further design details and cross sections).

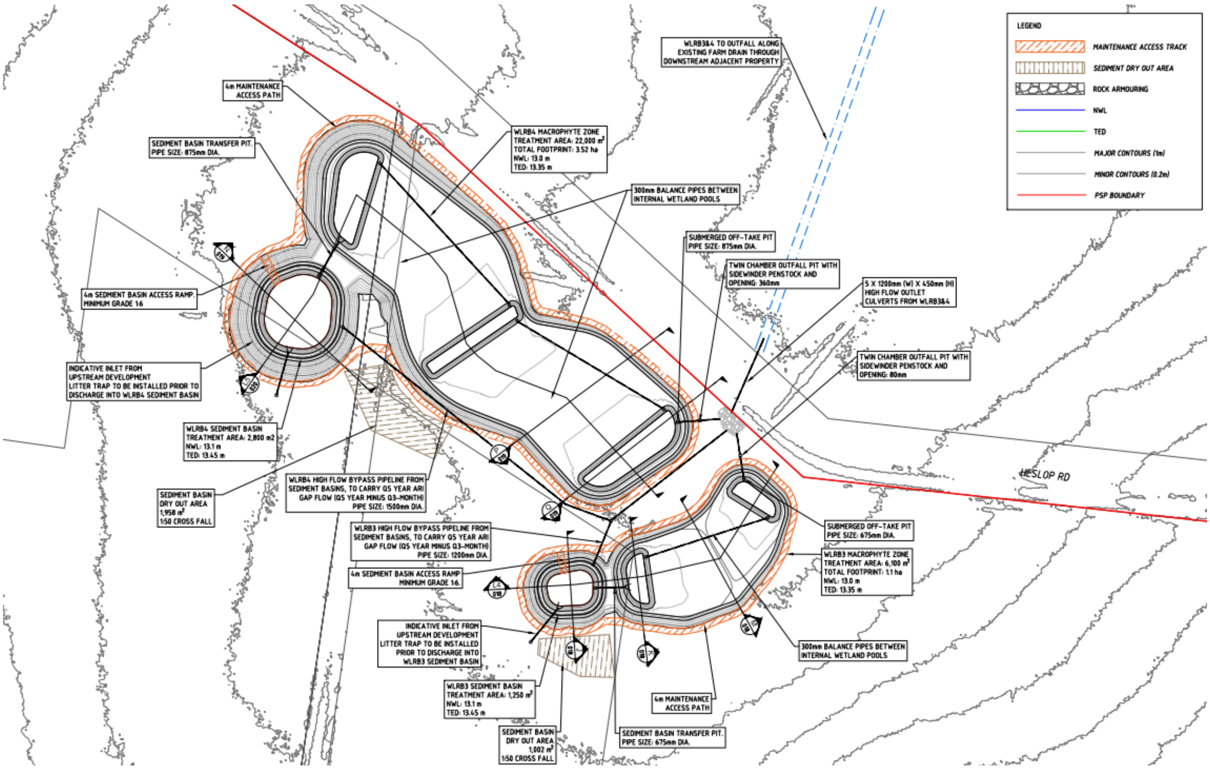


Figure 66. *Plan view of the designed wetland structure WLRB4 (DCP ref WL-04)*

17.1 Velocities

The area of the WLRB4 (DCP ref WL-04) macrophyte zone is proposed at 22,000 m^2 and 2,800 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 73 m in the macrophyte zone and 40 m in the inlet pond to meet velocity threshold requirements. Table 43 provides details on the minimum widths and velocities determined.

Table 43. System velocity calculations and design checks – WLRB4 (DCP ref WL-04)

	Parameter	4EY	20% AEP
Flow Conditions	Design flow (m^3/s)	1.31	7.25
	Flow depth (m)	0.35	0.35
Inlet pond	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)	14.7	14.7
	Flow velocity (m/s)	0.09	0.49

	Check	<0.5 OK	<0.5 OK
Macrophyte zone	Width at NWL (m)	73	73
	Width at EDD (m)	77.2	77.2
	Average Width (m)	75.1	75.1
	Flow area (m^2)	26.0	26.0
	Flow velocity (m/s)	0.05	0.28
	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 44. Inlet Pond design parameters and checks

	Parameter	Proposed design
Conditions	Contributing Catchment (ha)	101
	Area of Basin (m^2)	2,800
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	1.12
	Depth below permanent pool that is sufficient to retain sediment, d* (m)	0.50
	Design Discharge (m^3/s) [Q3-month]	1.31
	Capture Efficiency	96.9%
	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	979
	Available sediment storage volume	2,081
	Check (Available storage > required storage)	OK
Sediment dewatering	Depth for dewatering area (m)	0.50
	Area required for dewatering (m^2)	1,958

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 57 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	-0.7	-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 67 shows the stage-storage-discharge relationship used in MUSIC for WLRB4 (DCP ref WL-04).

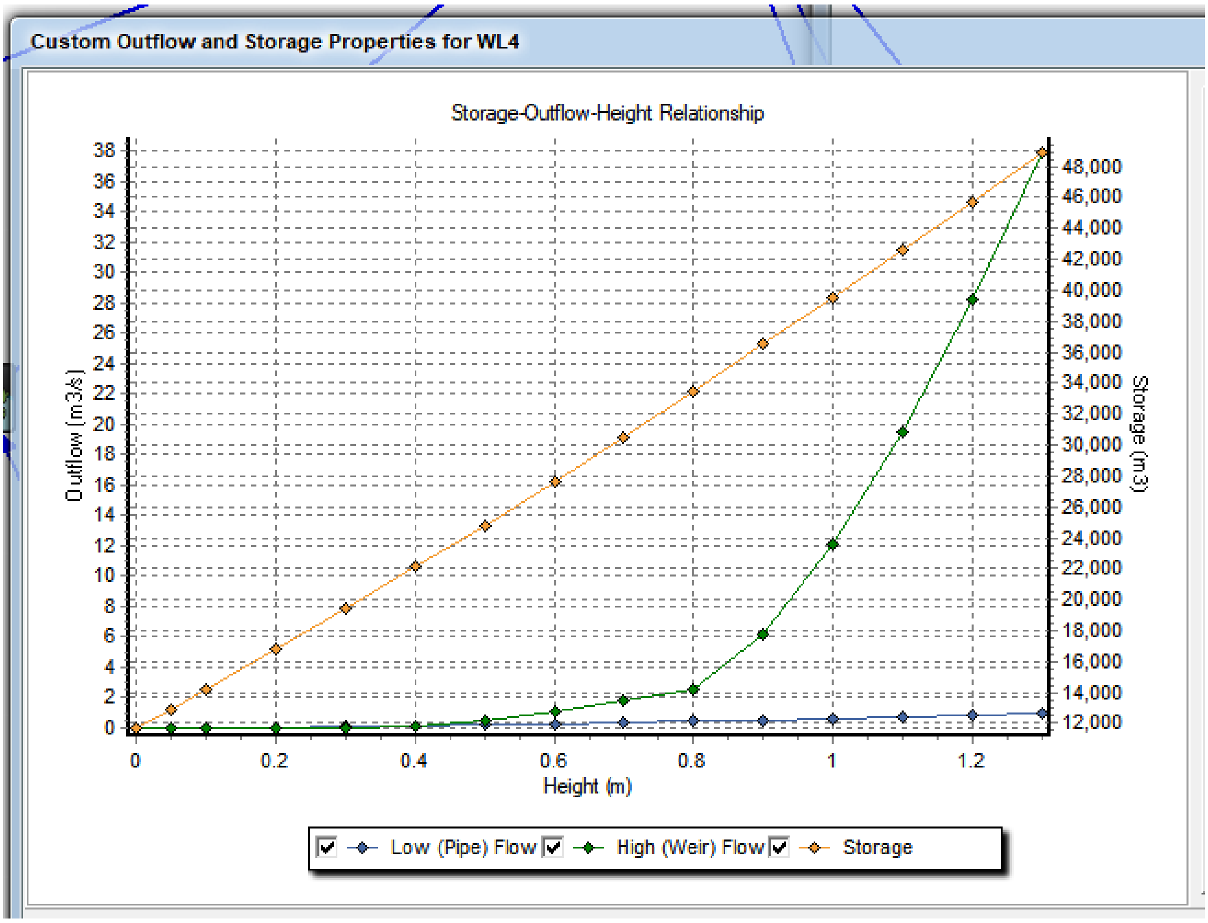


Figure 67. *Stage-storage-discharge relationship*

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

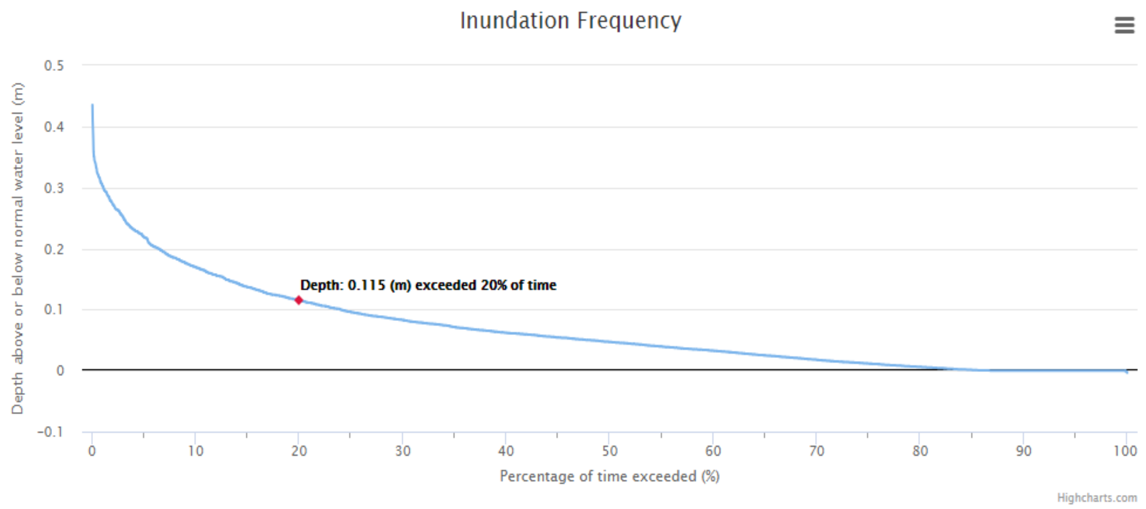
A sediment dewatering area of 1,958m^2 has been provided adjacent to the sediment pond. This area will allow accumulated sediment taken from the sediment basin to be dewatered on site before it is transported off site.

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 59 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 f.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
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	☐	☐	
Water Ribbons *Triglochin procerum*	1	☐	✓	
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 f.csv
Shallow marsh zone meets deemed to comply criteria

Deep marsh zone meets deemed to comply criteria

Water level exceeded for 20% of time: 0.115 m

Water level exceeded for 50% of time: 0.047 m
-Effective water level is within 50 mm of normal water level and is acceptable.

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 68 below. Refer to Appendix B for further design details and cross sections.

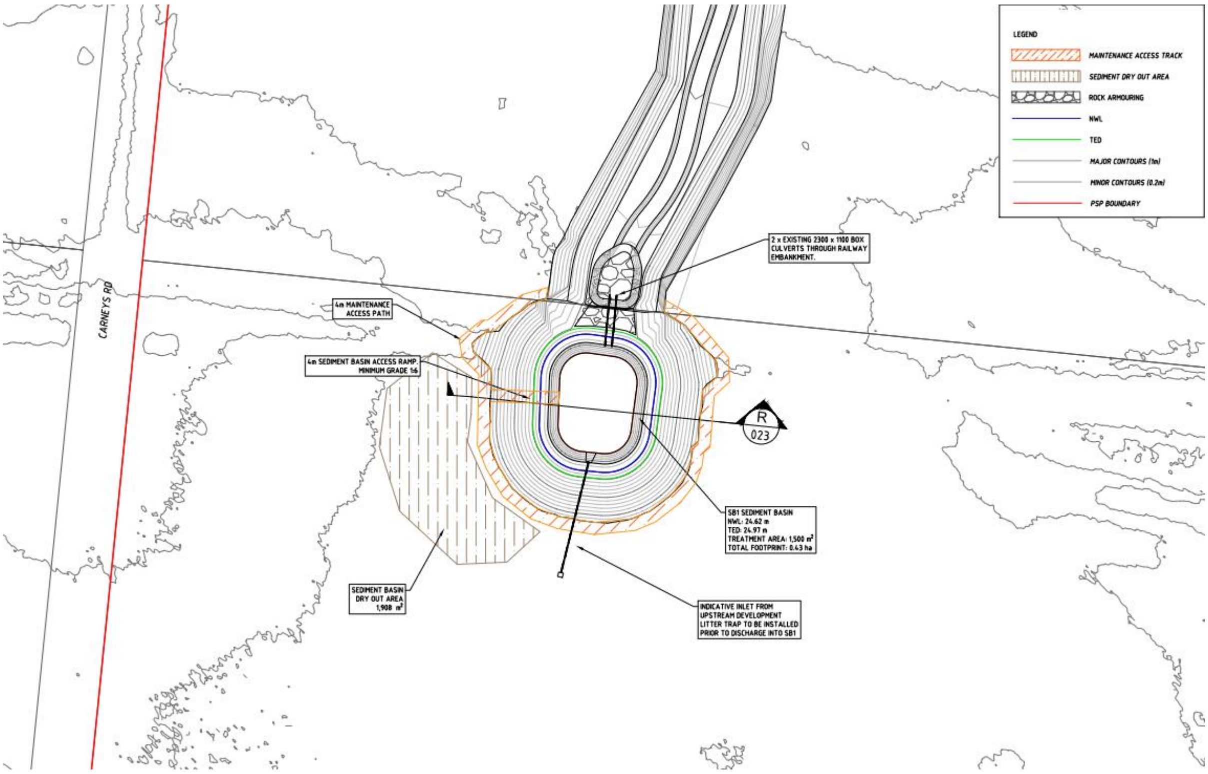


Figure 68. *Plan view of the designed wetland structure SB1(DCP ref SB3)*

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 46. 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 47. 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 2,000m^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 69 below. Refer to Appendix B for further design details and cross sections.

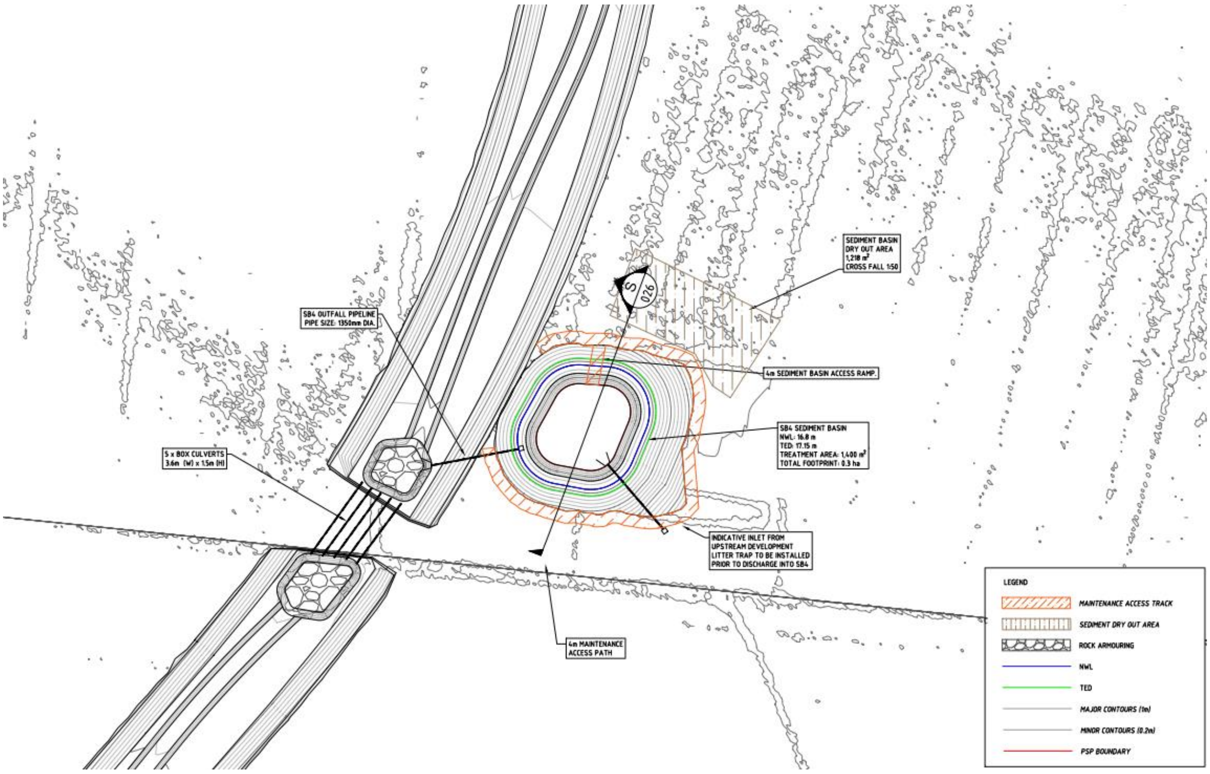


Figure 69. *Plan view of the designed wetland structure SB4 (DCP ref SB7)*

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 48. 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 49. 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 1,218m^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 70 below. Refer to Appendix B for further design details and cross sections.

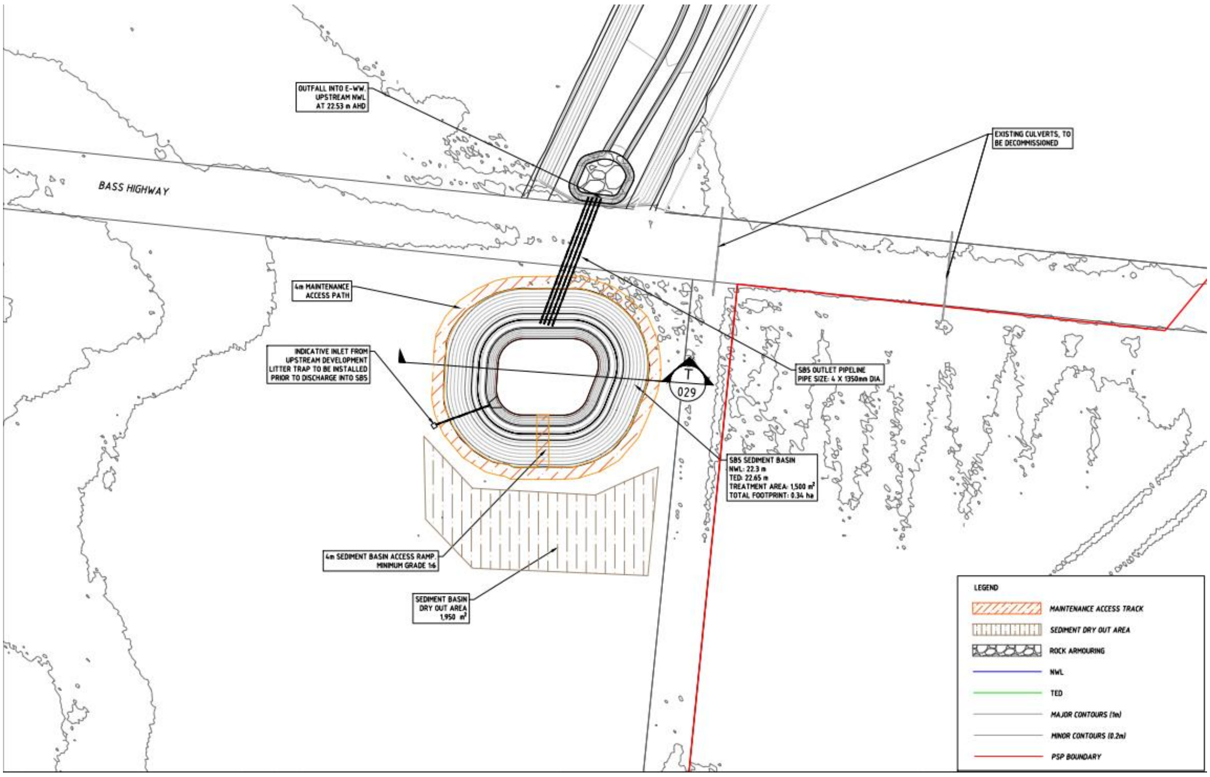


Figure 70. *Plan view of the designed wetland structure SB5 (DCP ref SB15)*

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 50. 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 51. 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 71 below. Refer to Appendix B for further design details and cross sections.

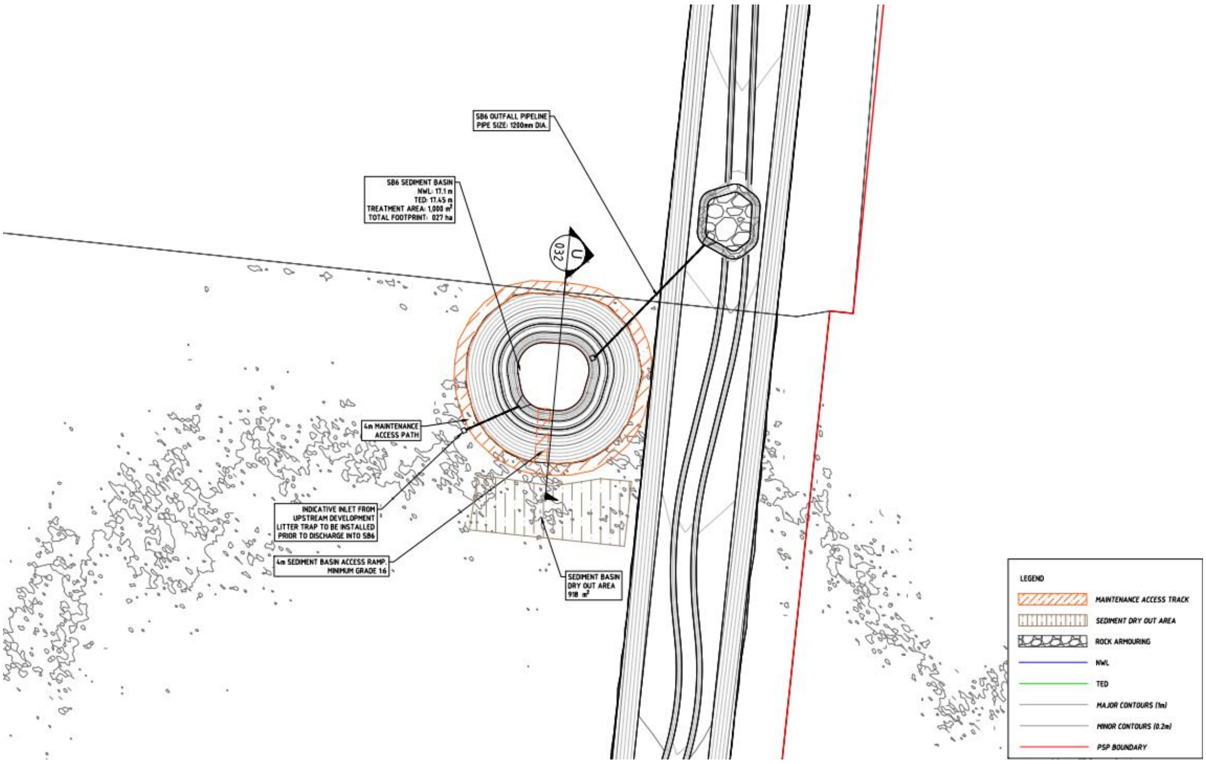


Figure 71. *Plan view of the designed wetland structure SB6*

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 52. 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 53. 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 919m^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 68 below. Refer to Appendix B for further design details and cross sections.

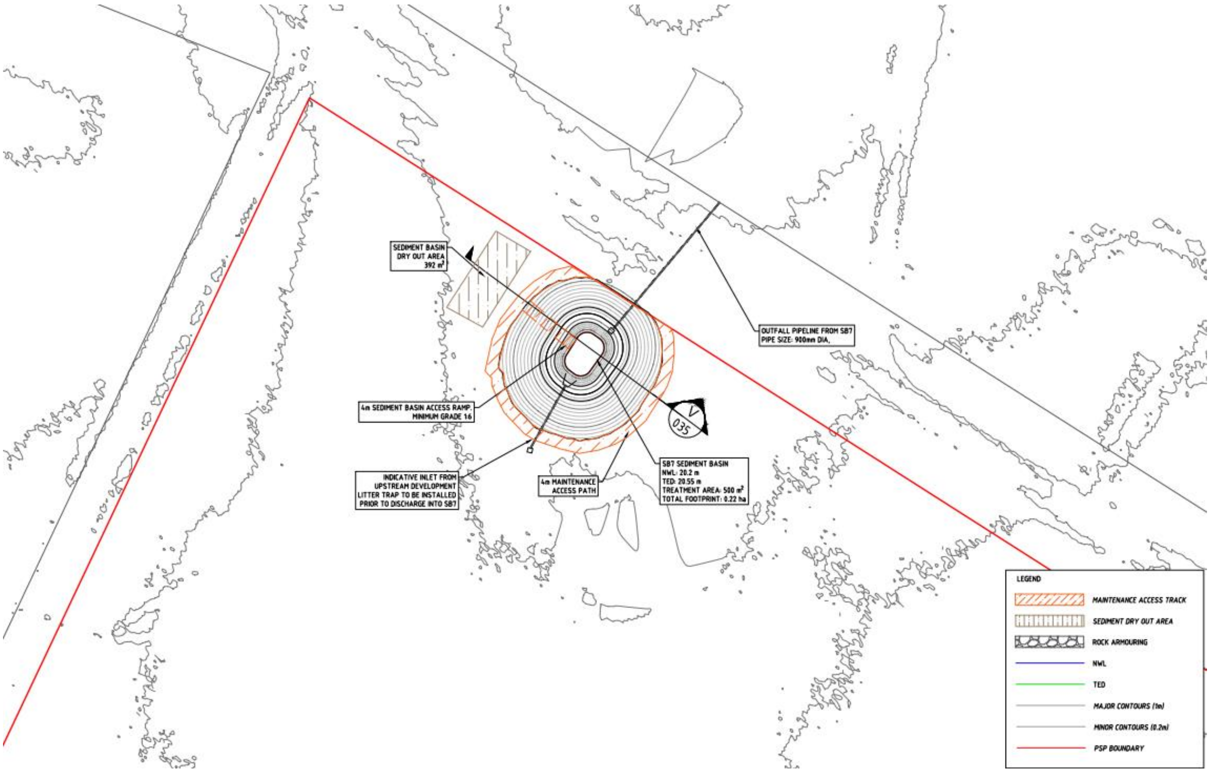


Figure 72. *Plan view of the designed wetland structure SB7*

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 54. 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 55. 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 391m^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. 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	WEST WATERWAY (W-WW)			$ 16,133,189
A2	EAST WATERWAY (E-WW)			$ 22,418,967
A3	MAIN OUTFALL TO POWLETT RIVER (MOP)			$ 3,640,606
A4	WETLAND RETARDING BASIN 1 (WLRB1A&B)			$ 37,043,490
A5	WETLAND RETARDING BASIN 2 (WLRB2)			$ 2,271,606
A6	WETLAND RETARDING BASIN 3 (WLRB3)			$ 2,131,136
A7	WETLAND RETARDING BASIN 4 (WLRB4)			$ 7,645,543
A8	SEDIMENT BASIN 1 (SB1)			$ 1,453,454
A9	SEDIMENT BASIN 4 (SB4)			$ 975,153
A10	SEDIMENT BASIN 5 (SB5)			$ 1,350,192
A11	SEDIMENT BASIN 6 (SB6)			$ 890,126
A12	SEDIMENT BASIN 7 (SB7)			$ 723,266
A13	INDUSTRIAL BOULVERAD CROSSING (LCT 16-17) (AS PER ENGENY STRATEGY)			$ 215,000
A14	CULVERT 1 BASS HIGHWAY CULVERTS (LCT 2-3) (AS PER ENGENY STRATEGY)			$ 255,000
A17	CULVERT 2 (3 x 1500mm dia PIPE CULVERTS)			$ 255,000
A15	CULVERT 3 (BASS HIGHWAY CULVERTS) (LCT 18-19) (AS PER ENGENY STRATEGY)			$ 255,000
A18	CULVERT 4 (5 x 3600mm x 1500mm BOX CULVERTS) (BASED ON ENGENY COST ESTIMATION)			$ 717,500
A19	CULVERT 5 (5 x 3600mm x 1500mm BOX CULVERTS) (BASED ON ENGENY COST ESTIMATION)			$ 717,500
A20	CULVERT 6 (5 x 3600mm x 1500mm BOX CULVERTS) (BASED ON ENGENY COST ESTIMATION)			$ 717,500
A25	CULVERT 7 (HESLOP ROAD) (LCT 45-46) (AS PER ENGENY STRATEGY) (ADDITIONAL COSTS OF $30k (WATER MAIN) FOR COMPLEXITIES ASSOCIATED WITH CROSSING OTHER AUTHORITY ASSETS)			$ 157,000
A21	CULVERT 8 (KORRUMBURRA - WONTHAGGI ROAD EMBANKMENT) (LCT 12-13) (AS PER ENGENY STRATEGY) (ADDITIONAL COSTS OF $30k (WATER MAIN) AND $50k (GAS MAIN) FOR COMPLEXITIES ASSOCIATED WITH CROSSING OTHER AUTHORITY ASSETS)			$ 975,000
A23	CULVERT 9 (HESLOP ROAD) (LCT 41-42) (AS PER ENGENY STRATEGY) (ADDITIONAL COSTS OF $30k (WATER MAIN) FOR COMPLEXITIES ASSOCIATED WITH CROSSING OTHER AUTHORITY ASSETS)			$ 456,000
A26	PIPELINE 1-2 (AS PER ENGENY STRATEGY)			$ 471,000
A27	PIPELINE 15-16 (AS PER ENGENY STRATEGY)			$ 472,000
A28	PIPELINE 14-16 (AS PER ENGENY STRATEGY)			$ 365,000
A29	PIPELINE 26-17 (AS PER ENGENY STRATEGY)			$ 233,000
A30	PIPELINE 27-28 (AS PER ENGENY STRATEGY)			$ 433,000
A31	PIPELINE 30-28 (AS PER ENGENY STRATEGY)			$ 26,000
A32	PIPELINE 28-29 (AS PER ENGENY STRATEGY)			$ 196,000
A33	PIPELINE 31-32 (AS PER ENGENY STRATEGY)			$ 569,000
A34	PIPELINE 33-34 (AS PER ENGENY STRATEGY)			$ 901,000
A35	PIPELINE 39A-39C (AS PER ENGENY STRATEGY)			$ 60,000
A36	PIPELINE 39C-40 (AS PER ENGENY STRATEGY)			$ 43,000

A37	PIPELINE 47-47A (AS PER ENGENY STRATEGY)			$ 53,000
A38	PIPELINE 47A-40 (AS PER ENGENY STRATEGY)			$ 127,000
A39	PIPELINE 40-48 (AS PER ENGENY STRATEGY)			$ 450,000
A40	PIPELINE 43-45 (AS PER ENGENY STRATEGY)			$ 58,000
A41	GROSS POLLUTANT TRAP 1			$ 24,000
A42	GROSS POLLUTANT TRAP 2			$ 24,000
A43	GROSS POLLUTANT TRAP 3			$ 24,000
			TOTAL	**$ 105,926,227**

24 References

BCSC & VPA, 2020. Wonthaggi North East Precinct Structure Plan

BCSC & VPA, 2020. Wonthaggi North East Development Contributions Plan

Bunurong Land Council Aboriginal Corporation website: https://www.bunuronglc.org/

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Engeny Water Management Pty Ltd, 2021. 465 Heslop Road Wonthaggi NE PSP Impact and Proposed Mitigation Works (March 2021)

Engeny Water Management Pty Ltd, 2021. Revised HECRAS and MUSIC Modelling for Wetlands 1 and 2 (13th August 2021)

Engeny Water Management Pty Ltd, 2021. Revised 12D Design for Wetland-Retarding Basins 1 & 2 (20th August 2021)

Engeny Water Management Pty Ltd, 2021. Revised Drainage Strategy for Wonthaggi North East PSP (25th August 2021)

Engeny Water Management Pty Ltd, 2021. (Final) Drainage Strategy for Wonthaggi North East PSP (September 2021)

Nature Advisory & BCSC, 2020. Wonthaggi North East Precinct Structure Plan Flora and Fauna Assessment

Triskel Heritage Consulting, 2017. Wonthaggi North East Growth Area: Aboriginal Cultural Heritage Survey

Victorian Planning Authority, 2021. Addendum to the Bushfire Development Report for the Wonthaggi North East Precinct Structure Plan.

APPENDICES

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

Table 56. 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	81,012	m2	$ 5	$ 405,060	
1.5	Excavation	122,988	m3	$ 38	$ 4,673,544	Includes over excavation for topsoil placement
1.6	Formation of batters	1,796	m3	$ 10	$ 17,960	
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.	240	m3	$ 200	$ 48,000	
2.1.2	Supply and install D50=400mm rock, 800 mm thick to form Bass Hwy Inlet Pool.	194	m3	$ 200	$ 38,880	
2.1.3	Supply and install D50=400mm rock, 800 mm thick to form Bass Hwy Outlet Pool.	194	m3	$ 200	$ 38,720	
2.1.4	Supply and install D50=400mm rock, 800 mm thick to form pool No 2.	328	m3	$ 200	$ 65,600	
2.1.5	Supply and install D50=400mm rock, 800 mm thick to form Culvert 4 Inlet Pool.	358	m3	$ 200	$ 71,520	
2.1.6	Supply and install D50=400mm rock, 800 mm thick to form Culvert 4 Outlet Pool.	260	m3	$ 200	$ 52,000	
2.1.7	Supply and install D50=400mm rock, 800 mm thick to form Culvert 5 Inlet Pool.	385	m3	$ 200	$ 76,960	
2.1.8	Supply and install D50=400mm rock, 800 mm thick to form Culvert 5 Outlet Pool.	259	m3	$ 200	$ 51,840	
2.1.9	Supply and install D50=400mm rock, 800 mm thick to form Culvert 6 Inlet Pool.	373	m3	$ 200	$ 74,560	
2.1.10	Supply and install 100mm minus quarry rock bedding layer for all rockwork	162	m3	$ 100	$ 16,190	
2.1.11	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	40,506	m2	$ 5.00	$ 202,530	
3.2	Additional topsoil to be imported for planting areas	40,506	m2	$ 80.00	$ 3,240,480	
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 temnporary erosion control.	2,604	LM	$ 20	$ 52,080	
4	**MISCELLANEOUS**					
4.1			Item			
4.2	Other *(Description)*		Item			
	SUB-TOTAL WORKS				$ 11,031,240	
5	**DELIVERY**					
5.1	Council Fees	3.25	%		$ 358,515	
5.2	VicRoads Fees	1	%		$ 110,312	
5.3	Traffic Management	5	%		$ 551,562	
5.4	Environmental Management	0.5	%		$ 55,156	
5.5	Survey & Design	5	%		$ 551,562	
5.6	Supervision & Project Management	9	%		$ 992,812	
5.7	Site Establishment	2.5	%		$ 275,781	
5.8	Contingency	20	%		$ 2,206,248	
	SUB-TOTAL DELIVERY				$ 5,101,949	
6	**TOTAL ESTIMATED COST**				$ 16,133,189	

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	117,522	m2	$ 5	$ 587,610	
1.5	Excavation	156,256	m3	$ 38	$ 5,937,713	Includes over excavation for topsoil placement
1.6	Formation of batters	3,133	m3	$ 10	$ 31,330	
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	236	m3	$ 200	$ 47,200	
2.1.2	Supply and install D50=400mm rock, 800 mm thick to form McGibbonys Rd Inlet Pool	303	m3	$ 200	$ 60,640	
2.1.3	Supply and install D50=400mm rock, 800 mm thick to form McGibbonys Rd Outlet Pool	253	m3	$ 200	$ 50,560	
2.1.4	Supply and install D50=400mm rock, 800 mm thick to form pool No 1.	397	m3	$ 200	$ 79,360	
2.1.5	Supply and install D50=400mm rock, 800 mm thick to form pool No 2.	330	m3	$ 200	$ 65,920	
2.1.6	Supply and install D50=400mm rock, 800 mm thick to form pool No 3.	414	m3	$ 200	$ 82,720	
2.1.7	Supply and install D50=400mm rock, 800 mm thick to form pool No 4.	369	m3	$ 200	$ 73,760	

2.1.8	Supply and install 100mm minus quarry rock bedding layer for all rockwork	144	m3	$ 200	$ 28,760	
2.1.9	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	58,761	m2	$ 5.00	$ 293,805	
3.2	Additional topsoil to be imported for planting areas	58,761	m2	$ 80.00	$ 4,700,880	
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 temnporary erosion control.	4,091	LM	$ 20	$ 81,810	
4	**MISCELLANEOUS**					
4.1			Item			
4.2	Other *(Description)*		Item			
	SUB-TOTAL WORKS				$ 15,329,208	
5	**<u>DELIVERY</u>**					
5.1	Council Fees	3.25	%		$ 498,199	
5.2	VicRoads Fees	1	%		$ 153,292	
5.3	Traffic Management	5	%		$ 766,460	
5.4	Environmental Management	0.5	%		$ 76,646	
5.5	Survey & Design	5	%		$ 766,460	
5.6	Supervision & Project Management	9	%		$ 1,379,629	
5.7	Site Establishment	2.5	%		$ 383,230	
5.8	Contingency	20	%		$ 3,065,842	
	SUB-TOTAL DELIVERY				$ 7,089,759	
6	**TOTAL ESTIMATED COST**				$ 22,418,967	

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	$ 38	$ 770,792	Includes over excavation for topsoil placement
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	486	m3	$ 200	$ 97,120	
2.1.2	Supply and install D50=400mm rock, 800 mm thick to form WLRB2 Outlet Pool	118	m3	$ 200	$ 23,680	
2.1.3	Supply and install D50=400mm rock, 800 mm thick to form connection to existing downstream drain	245	m3	$ 200	$ 48,960	
2.1.4	Supply and install 100mm minus quarry rock bedding layer for all rockwork	53	m3	$ 200	$ 10,610	
2.1.5	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	8,712	m2	$ 5.00	$ 43,560	
3.2	Additional topsoil to be imported for planting areas	8,712	m2	$ 80.00	$ 696,960	
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				$ 2,489,303	
5	**DELIVERY**					
5.1	Council Fees	3.25	%		$ 80,902	
5.2	VicRoads Fees	1	%		$ 24,893	
5.3	Traffic Management	5	%		$ 124,465	
5.4	Environmental Management	0.5	%		$ 12,447	
5.5	Survey & Design	5	%		$ 124,465	
5.6	Supervision & Project Management	9	%		$ 224,037	

5.7	Site Establishment	2.5	%		$ 62,233	
5.8	Contingency	20	%		$ 497,861	
	SUB-TOTAL DELIVERY				$ 1,151,303	
6	**TOTAL ESTIMATED COST**				$ 3,640,606	

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

Item	Description	Quantity	Unit	Rate $	Amount $	Comments
	WLRB1A&B WORKS					
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	28,058	m2	$ 5	$ 140,290	
1.5	Excavation	517,874	m3	$ 38	$ 19,679,212	Includes over excavation for topsoil placement
2	**DRAINAGE**					
2.1	Rockwork					
2.1.1	Supply and install D50=400mm rock, 800 mm thick to form WL1A Wetland inlet	670	m3	$ 200	$ 134,080	
2.1.2	Supply and install D50=400mm rock, 800 mm thick to form WL1A Wetland overflow spillway	501	m3	$ 200	$ 100,160	
2.1.3	Supply and install D50=400mm rock, 800 mm thick to form WL1B Wetland inlet channel	678	m3	$ 200	$ 135,680	
2.1.4	Supply and install D50=400mm rock, 800 mm thick to form WL1B Wetland overflow spillway	246	m3	$ 200	$ 49,120	
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	1,070	m3	$ 350	$ 374,500	
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	1,436	m3	$ 350	$ 502,600	
2.3	Drainage					
2.3.1	Supply and install D50=200mm with Class 2 FCR backfill to form 4m wide sediment pond maintenance access (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	40	m	$ 750	$ 30,000	
2.3.3	Supply and install submerged offtake pit	1	No.	$ 3,000	$ 3,000	
2.3.4	Supply and install 300 mm dia RCP balance pipes	298	m	$ 250	$ 74,500	
2.3.5	Supply and install submerged offtake pits for balance pipes	4	No.	$ 3,000	$ 12,000	
2.3.6	Supply and install 900 mm dia wetland outfall pipe incl excavation, crushed rock bedding and back fill	40	m	$ 750	$ 30,000	
2.3.7	Supply and install twin chamber outfall pit with penstock and concrete weir	1	No.	$ 15,000	$ 15,000	
2.3.8	Supply and install 10 x 300 mm dia retarding basin outfall pipes incl excavation, crushed rock bedding and back fill	600	m	$ 250	$ 150,000	

2.3.9	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	
2.3.10	Supply and install 900 mm dia sediment pond transfer pipe incl excavation, crushed rock bedding and back fill	80	m	$ 750	$ 60,000	
2.3.11	Supply and install submerged offtake pit	1	No.	$ 3,000	$ 3,000	
2.3.12	Supply and install 300 mm dia RCP balance pipes	342	m	$ 250	$ 85,500	
2.3.13	Supply and install submerged offtake pits for balance pipes	4	No.	$ 3,000	$ 12,000	
2.3.14	Supply and install 1050 mm dia wetland outfall pipe incl excavation, crushed rock bedding and back fill	40	m	$ 950	$ 38,000	
2.3.15	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	14,029	m2	$ 5.00	$ 70,145	
3.2	Additional topsoil to be imported for planting areas	14,029	m2	$ 80.00	$ 1,122,320	
3.3	Placement of 300 mm compacted clay liners for sedimentation basin and wetland (clay sourced onsite)	34,539	m3	$ 15.00	$ 518,085	
3.4	Supply and install submerged marsh planting (600cm3 tube, 1/m2).	11,063	No.	$ 5.00	$ 55,315	
3.5	Supply and install deep marsh planting (600cm3 tube, 2/m2).	67,426	No.	$ 5.00	$ 337,130	
3.6	Supply and install shallow marsh planting (600cm3 tube, 2/m2).	50,258	No.	$ 5.00	$ 251,290	
3.7	Supply and install wet ephemeral planting (90cm3 tube, 6/m2).	36,354	No.	$ 2.50	$ 90,885	
3.8	Supply and install dry ephemeral planting (90cm3 tube, 6/m2).	182,760	No.	$ 2.50	$ 456,900	
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				$ 25,328,882	
5	**<u>DELIVERY</u>**					
5.1	Council Fees	3.25	%		$ 823,189	
5.2	VicRoads Fees	1	%		$ 253,289	
5.3	Traffic Management	5	%		$ 1,266,444	
5.4	Environmental Management	0.5	%		$ 126,644	
5.5	Survey & Design	5	%		$ 1,266,444	
5.6	Supervision & Project Management	9	%		$ 2,279,599	
5.7	Site Establishment	2.5	%		$ 633,222	

5.8	Contingency	20	%		$ 5,065,776	
	SUB-TOTAL DELIVERY				$ 11,714,608	
6	**TOTAL ESTIMATED COST**				$ 37,043,490	

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	3,016	m2	$ 5	$ 15,080	
1.5	Excavation	19,610	m3	$ 38	$ 745,180	Includes over excavation for topsoil placement
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	73	m3	$ 350	$ 25,550	
2.3	Drainage					
2.3.1	Supply and install D50=200mm with Class 2 FCR backfill to form 4m wide sediment pond maintenance access (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	$ 400	$ 14,000	
2.3.3	Supply and install submerged offtake pit	1	No.	$ 3,000	$ 3,000	
2.3.4	Supply and install 300 mm dia RCP balance pipes	100	m	$ 250	$ 25,000	
2.3.5	Supply and install submerged offtake pits for balance pipes	2	No.	$ 3,000	$ 6,000	
2.3.6	Supply and install 1350 mm dia wetland high flow bypass pipeline	50	m	$ 1,400	$ 70,000	
2.3.7	Supply and install submerged offtake pit for high flow bypass	1	No.	$ 3,000	$ 3,000	
2.3.8	Supply and install 750 mm dia wetland outfall pipe incl excavation, crushed rock bedding and back fill	40	m	$ 575	$ 23,000	
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	1,508	m2	$ 5.00	$ 7,540	
3.2	Additional topsoil to be imported for planting areas	1,508	m2	$ 80.00	$ 120,640	
3.2	Placement of 300 mm compacted clay liners for sedimentation basin and wetland (clay sourced onsite)	4,081	m3	$ 15.00	$ 61,215	
3.3	Supply and install submerged marsh planting (600cm3 tube, 1/m2).	1,072	No.	$ 5.00	$ 5,360	
3.4	Supply and install deep marsh planting (600cm3 tube, 2/m2).	7,386	No.	$ 5.00	$ 36,930	

3.5	Supply and install shallow marsh planting (600cm3 tube, 2/m2).	7,874	No.	$ 5.00	$ 39,370	
3.6	Supply and install wet ephemeral planting (90cm3 tube, 6/m2).	7,650	No.	$ 2.50	$ 19,125	
3.7	Supply and install dry ephemeral planting (90cm3 tube, 6/m2).	15,678	No.	$ 2.50	$ 39,195	
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	4,832	m2	$ 10	$ 48,320	
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				$ 1,553,235	
5	**DELIVERY**					
5.1	Council Fees	3.25	%		$ 50,480	
5.2	VicRoads Fees	1	%		$ 15,532	
5.3	Traffic Management	5	%		$ 77,662	
5.4	Environmental Management	0.5	%		$ 7,766	
5.5	Survey & Design	5	%		$ 77,662	
5.6	Supervision & Project Management	9	%		$ 139,791	
5.7	Site Establishment	2.5	%		$ 38,831	
5.8	Contingency	20	%		$ 310,647	
	SUB-TOTAL DELIVERY				$ 718,371	
6	**TOTAL ESTIMATED COST**				$ 2,271,606	

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	2,193	m2	$ 5	$ 10,965	
1.5	Excavation	19,499	m3	$ 38	$ 740,962	Includes over excavation for topsoil placement
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	92	m3	$ 350	$ 32,200	
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	$ 400	$ 8,000	
2.3.2	Drainage: Supply and install submerged offtake pit	1	No.	$ 3,000	$ 3,000	
2.3.3	Drainage: Supply and install 300 mm dia RCP balance pipes	88	m	$ 250	$ 22,000	
2.3.4	Drainage: Supply and install submerged offtake pits for balance pipes	2	No.	$ 3,000	$ 6,000	
2.3.5	Drainage: Supply and install 1200 mm dia wetland high flow bypass pipeline	30	m	$ 1,200	$ 36,000	
2.3.6	Drainage: Supply and install submerged offtake pit for high flow bypass	1	No.	$ 3,000	$ 3,000	
2.3.7	Drainage: Supply and install 675 mm dia wetland outfall pipe incl excavation, crushed rock bedding and back fill	40	m	$ 500	$ 20,000	
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	$ 1,200	$ 60,000	
3	**OTHER WORKS**					
3.1	Re spread 200 mm topsoil for planting areas	1,097	m2	$ 5.00	$ 5,485	
3.2	Additional topsoil to be imported for planting areas	1,097	m2	$ 80.00	$ 87,760	
3.3	Placement of 300 mm compacted clay liners for sedimentation basin and wetland (clay sourced onsite)	2,833	m3	$ 15.00	$ 42,495	
3.4	Supply and install submerged marsh planting (600cm3 tube, 1/m2).	753	No.	$ 5.00	$ 3,765	
3.5	Supply and install deep marsh planting (600cm3 tube, 2/m2).	4,972	No.	$ 5.00	$ 24,860	
3.6	Supply and install shallow marsh planting (600cm3 tube, 2/m2).	4,790	No.	$ 5.00	$ 23,950	
3.7	Supply and install wet ephemeral planting (90cm3 tube, 6/m2).	5,838	No.	$ 2.50	$ 14,595	
3.8	Supply and install dry ephemeral planting (90cm3 tube, 6/m2).	14,400	No.	$ 2.50	$ 36,000	
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	3,677	m2	$ 10	$ 36,770	
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				$ 1,457,187	
5	**DELIVERY**					

5.1	Council Fees	3.25	%		$ 47,359	
5.2	VicRoads Fees	1	%		$ 14,572	
5.3	Traffic Management	5	%		$ 72,859	
5.4	Environmental Management	0.5	%		$ 7,286	
5.5	Survey & Design	5	%		$ 72,859	
5.6	Supervision & Project Management	9	%		$ 131,147	
5.7	Site Establishment	2.5	%		$ 36,430	
5.8	Contingency	20	%		$ 291,437	
	SUB-TOTAL DELIVERY				$ 673,949	
6	**TOTAL ESTIMATED COST**				$ 2,131,136	

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	7,035	m2	$ 5	$ 35,175	
1.5	Excavation	88,349	m3	$ 38	$ 3,357,262	Includes over excavation for topsoil placement
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	268	m3	$ 350	$ 93,800	
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	$ 650	$ 26,000	
2.3.3	Drainage: Supply and install submerged offtake pit	1	No.	$ 3,000	$ 3,000	
2.3.4	Drainage: Supply and install 300 mm dia RCP balance pipes	200	m	$ 450	$ 90,000	
2.3.5	Drainage: Supply and install submerged offtake pits for balance pipes	4	No.	$ 3,000	$ 12,000	
2.3.6	Drainage: Supply and install 1500 mm dia wetland high flow bypass pipeline	320	m	$ 1,500	$ 480,000	
2.3.7	Drainage: Supply and install submerged offtake pit for high flow bypass	1	No.	$ 3,000	$ 3,000	
2.3.8	Drainage: Supply and install 900 mm dia wetland outfall pipe incl excavation, crushed rock bedding and back fill	40	m	$ 750	$ 30,000	
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	3,518	m2	$ 5.00	$ 17,590	

3.2	Additional topsoil to be imported for planting areas	3,518	m2	$ 80.00	$ 281,440	
3.3	Placement of 300 mm compacted clay liners for sedimentation basin and wetland (clay sourced onsite)	8,616	m3	$ 15.00	$ 129,240	
3.4	Supply and install submerged marsh planting (600cm3 tube, 1/m2).	724	No.	$ 5.00	$ 3,620	
3.5	Supply and install deep marsh planting (600cm3 tube, 2/m2).	19,054	No.	$ 5.00	$ 95,270	
3.6	Supply and install shallow marsh planting (600cm3 tube, 2/m2).	18,026	No.	$ 5.00	$ 90,130	
3.7	Supply and install wet ephemeral planting (90cm3 tube, 6/m2).	11,580	No.	$ 2.50	$ 28,950	
3.8	Supply and install dry ephemeral planting (90cm3 tube, 6/m2).	48,948	No.	$ 2.50	$ 122,370	
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	7,338	m2	$ 10	$ 73,380	
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				$ 5,227,722	
5	**DELIVERY**					
5.1	Council Fees	3.25	%		$ 169,901	
5.2	VicRoads Fees	1	%		$ 52,277	
5.3	Traffic Management	5	%		$ 261,386	
5.4	Environmental Management	0.5	%		$ 26,139	
5.5	Survey & Design	5	%		$ 261,386	
5.6	Supervision & Project Management	9	%		$ 470,495	
5.7	Site Establishment	2.5	%		$ 130,693	
5.8	Contingency	20	%		$ 1,045,544	
	SUB-TOTAL DELIVERY				$ 2,417,821	
6	**TOTAL ESTIMATED COST**				$ 7,645,543	

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	865	m2	$ 5	$ 4,325	
1.5	Excavation	14,285	m3	$ 38	$ 542,830	Includes over excavation for topsoil placement
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	$ 1,500	$ 60,000	
2.3.3	Supply and install submerged offtake pit	1	No.	$ 3,000	$ 3,000	
3	OTHER WORKS					
3.1	Re spread 200 mm topsoil for planting areas	433	m2	$ 5.00	$ 2,165	
3.2	Additional topsoil to be imported for planting areas	433	m2	$ 80.00	$ 34,640	
3.3	Placement of 300 mm compacted clay liners for sedimentation basin and wetland (clay sourced onsite)	628	m3	$ 15.00	$ 9,420	
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				$ 993,815	
5	**DELIVERY**					
5.1	Council Fees	3.25	%		$ 32,299	
5.2	VicRoads Fees	1	%		$ 9,938	
5.3	Traffic Management	5	%		$ 49,691	
5.4	Environmental Management	0.5	%		$ 4,969	
5.5	Survey & Design	5	%		$ 49,691	
5.6	Supervision & Project Management	9	%		$ 89,443	
5.7	Site Establishment	2.5	%		$ 24,845	
5.8	Contingency	20	%		$ 198,763	
	SUB-TOTAL DELIVERY				$ 459,639	
6	**TOTAL ESTIMATED COST**				$ 1,453,454	

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	601	m2	$ 5	$ 3,005	
1.5	Excavation	6,992	m3	$ 38	$ 265,696	Includes over excavation for topsoil placement
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	$ 1,400	$ 56,000	
2.3.3	Supply and install submerged offtake pit	1	No.	$ 3,000	$ 3,000	
3	**OTHER WORKS**					
3.1	Re spread 200 mm topsoil for planting areas	301	m2	$ 5.00	$ 1,505	
3.2	Additional topsoil to be imported for planting areas	301	m2	$ 80.00	$ 24,080	

3.3	Placement of 300 mm compacted clay liners for sedimentation basin and wetland (clay sourced onsite)	597	m3	$ 15.00	$ 8,955	
3.4	Supply and install submerged marsh planting (600cm3 tube, 1/m2).	120	No.	$ 5.00	$ 600	
3.5	Supply and install shallow marsh planting (600cm3 tube, 2/m2).	708	No.	$ 5.00	$ 3,540	
3.6	Supply and install wet ephemeral planting (90cm3 tube, 6/m2).	1,782	No.	$ 2.50	$ 4,455	
3.7	Supply and install dry ephemeral planting (90cm3 tube, 6/m2).	7,776	No.	$ 2.50	$ 19,440	
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	1,115	m2	$ 10	$ 11,150	
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				$ 666,771	
5	**DELIVERY**					
5.1	Council Fees	3.25	%		$ 21,670	
5.2	VicRoads Fees	1	%		$ 6,668	
5.3	Traffic Management	5	%		$ 33,339	
5.4	Environmental Management	0.5	%		$ 3,334	
5.5	Survey & Design	5	%		$ 33,339	
5.6	Supervision & Project Management	9	%		$ 60,009	
5.7	Site Establishment	2.5	%		$ 16,669	
5.8	Contingency	20	%		$ 133,354	
	SUB-TOTAL DELIVERY				$ 308,382	
6	**TOTAL ESTIMATED COST**				$ 975,153	

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	680	m2	$ 5	$ 3,400	
1.5	Excavation	8,721	m3	$ 38	$ 331,398	Includes over excavation for topsoil placement
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 4 x 1350 mm dia sediment pond outfall pipe incl excavation, crushed rock bedding and back fill	160	m	$ 1,400	$ 224,000	
2.3.2	Supply and install submerged offtake pit	1	No.	$ 3,000	$ 3,000	
3	**OTHER WORKS**					
3.1	Re spread 200 mm topsoil for planting areas	340	m2	$ 5.00	$ 1,700	
3.2	Additional topsoil to be imported for planting areas	340	m2	$ 80.00	$ 27,200	
3.3	Placement of 300 mm compacted clay liners for sedimentation basin and wetland (clay sourced onsite)	629	m3	$ 15.00	$ 9,435	
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				$ 923,208	
5	**DELIVERY**					
5.1	Council Fees	3.25	%		$ 30,004	
5.2	VicRoads Fees	1	%		$ 9,232	
5.3	Traffic Management	5	%		$ 46,160	
5.4	Environmental Management	0.5	%		$ 4,616	
5.5	Survey & Design	5	%		$ 46,160	
5.6	Supervision & Project Management	9	%		$ 83,089	
5.7	Site Establishment	2.5	%		$ 23,080	

5.8	Contingency	20	%		$ 184,642	
	SUB-TOTAL DELIVERY				$ 426,984	
6	**TOTAL ESTIMATED COST**				$ 1,350,192	

<u>Sediment Basin 6 (SB6)</u>

Item	Description	Quantity	Unit	Rate $	Amount $	Comments
	<u>SB6 WORKS</u>					
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	533	m2	$ 5	$ 2,665	
1.5	Excavation	6,371	m3	$ 38	$ 242,098	Includes over excavation for topsoil placement
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	$ 1,200	$ 48,000	
2.3.2	Supply and install submerged offtake pit	1	No.	$ 3,000	$ 3,000	
3	**OTHER WORKS**					
3.1	Re spread 200 mm topsoil for planting areas	267	m2	$ 5.00	$ 1,335	
3.2	Additional topsoil to be imported for planting areas	267	m2	$ 80.00	$ 21,360	
3.3	Placement of 300 mm compacted clay liners for sedimentation basin and wetland (clay sourced onsite)	458	m3	$ 15.00	$ 6,870	
3.4	Supply and install submerged marsh planting (600cm3 tube, 1/m2).	98	No.	$ 5.00	$ 490	
3.5	Supply and install shallow marsh planting (600cm3 tube, 2/m2).	590	No.	$ 5.00	$ 2,950	
3.6	Supply and install wet ephemeral planting (90cm3 tube, 6/m2).	1,524	No.	$ 2.50	$ 3,810	
3.7	Supply and install dry ephemeral planting (90cm3 tube, 6/m2).	8,280	No.	$ 2.50	$ 20,700	
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	948	m2	$ 10	$ 9,480	
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				$ 608,633	
5	**DELIVERY**					
5.1	Council Fees	3.25	%		$ 19,781	
5.2	VicRoads Fees	1	%		$ 6,086	
5.3	Traffic Management	5	%		$ 30,432	
5.4	Environmental Management	0.5	%		$ 3,043	
5.5	Survey & Design	5	%		$ 30,432	
5.6	Supervision & Project Management	9	%		$ 54,777	
5.7	Site Establishment	2.5	%		$ 15,216	
5.8	Contingency	20	%		$ 121,727	
	SUB-TOTAL DELIVERY				$ 281,493	
6	**TOTAL ESTIMATED COST**				$ 890,126	

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	443	m2	$ 5	$ 2,215	
1.5	Excavation	4,767	m3	$ 38	$ 181,146	Includes over excavation for topsoil placement
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	$ 750	$ 30,000	
2.3.2	Supply and install submerged offtake pit	1	No.	$ 3,000	$ 3,000	
3	**OTHER WORKS**					
3.1	Re spread 200 mm topsoil for planting areas	222	m2	$ 5.00	$ 1,110	

3.2	Additional topsoil to be imported for planting areas	222	m2	$ 80.00	$ 17,760	
3.3	Placement of 300 mm compacted clay liners for sedimentation basin and wetland (clay sourced onsite)	261	m3	$ 15.00	$ 3,915	
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				$ 494,541	
5	**DELIVERY**					
5.1	Council Fees	3.25	%		$ 16,073	
5.2	VicRoads Fees	1	%		$ 4,945	
5.3	Traffic Management	5	%		$ 24,727	
5.4	Environmental Management	0.5	%		$ 2,473	
5.5	Survey & Design	5	%		$ 24,727	
5.6	Supervision & Project Management	9	%		$ 44,509	
5.7	Site Establishment	2.5	%		$ 12,364	
5.8	Contingency	20	%		$ 98,908	
	SUB-TOTAL DELIVERY				$ 228,725	
6	**TOTAL ESTIMATED COST**				$ 723,266	