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Beveridge Intermodal Precinct

Stage 1A Surface Water Modelling and Assessment

National Intermodal Corporation

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Executive Summary

This surface water assessment was undertaken to address the request for additional information (EPBC 2023/09693) including an assessment of the likely direct and indirect impacts to the environment of Herne Swamp wetland and the associated waterways during the construction, operational and maintenance components of the Beveridge Intermodal Precinct Stage 1A Project (Stage 1A). This assessment provides:

- An assessment of the likely duration of impacts to Herne Swamp wetland and the associated waterways, as a result of the Proposed Action.
- Discussion of whether the impacts are likely to be repeated, for example as part of maintenance.
- Discussion of whether any impacts are likely to be unknown, unpredictable or irreversible.

The assessment has been prepared with consideration to the EPBC Act Significant Impact Guidelines 1.2.

Project Site

Stage 1A occurs within rural lands within and adjacent to Herne Swamp in the upper Merri Creek catchment. Remnant Seasonal Herbaceous Wetland of the Temperate Lowland Plains (SHWTLP) occurs within the Herne Swamp and was mapped by ecological consultants in areas within and adjacent to Stage 1A. Agricultural practices have altered the local drainage regime but there are some areas of SHWTLP which remain or has recolonised.

The key surface water features of Herne Swamp within the study area are:

- A constructed, agricultural drain (Farm Drain 1) which flows from west to Merri Creek in the east. An external 440 Ha rural catchment enters Herne Swamp via Farm Drain 1 via culverts under the existing railway. Biosis mapped the upstream portion of Farm Drain 1 as containing SHWTLP vegetation community.
- The western portion of Herne Swamp was mapped as having SHWTLP and contains the highest quality stand of vegetation.
- The section of Herne Swamp to the North east of Stage 1A, between the project boundary and Merri Creek is very flat receiving direct rainfall with little runoff due to the flat surrounding topography. This area is part of the Merri Creek floodplain and is periodically inundated when Merri Creek breaks its banks. A potential SHWTLP community was also mapped North east of Stage 1A, between the project boundary and Merri Creek.
- Three farm dams within the study area are absent of SHWTLP but have characteristics that may provide habitat for Growling Grass Frog. No Growling Grass Frog were recorded during targeted surveys (Biosis, 2025).
- Drainage lines from the northeast flow into the study area downstream of Stage 1A and are not further considered in the assessment.
- Areas to the south of the study area contain a section of Stage 1A and Stage 1B of the future Intermodal development. These areas drain away from Herne Swamp towards a tributary of Merri Creek and are not considered further in this study.

The Project

Stage 1A of the Beveridge Intermodal Precinct comprises a footprint of approximately 67 hectares (ha) of a permanent rail connection to the existing Australian Rail Track Corporation (ARTC) rail freight corridor, together with sidings and a basic intermodal terminal and associated infrastructure for the initial stage of the Beveridge Intermodal Terminal.

Earthworks and a viaduct crossing associated with the rail infrastructure and temporary terminal hardstand and landscaping areas that will alter the drainage paths and runoff patterns from the local catchments that supply runoff and baseflow to the Herne Swamp.

Potential Construction Impacts

The key risks to Herne Swamp identified during the construction phase are from the potential impacts due to:

- Damage to vegetation associated with delivery of the earthworks, viaduct works and permanent access tracks. Removal of SHWTLP vegetation will be required to create drainage culverts beneath the access track crossing over the drainage channel (Farm Drain 1) which is reported (Biosis, 2025) to result in removal of 0.03 ha of SHWTLP.
- Temporary introduction of sediment and contaminants from land disturbance and exposure of potentially sodic soils that are prone to rapid erosion.

These risks can be managed through safeguards and controls around how, when and where construction activities are conducted.

Operational Impacts

Hydrologic and hydraulic modelling was undertaken to assess the potential changes to the seasonal wetting and drying regime and water level flux of the different zones of Herne Swamp. Water quality modelling was also undertaken to understand the potential changes in stormwater pollution loads associated with the land use change.

The key outcomes from this modelling and assessment include that because of the Beveridge Intermodal Precinct Stage 1A Project:

- Minor changes in the South-West Herne swamp catchment will have little to no impact on the most significant stand of SHWTLP within Herne Swamp mapped by Biosis (2024). The change in catchment associated with Stage 1A results in a negligible change to the water level flux in the South-East Herne Swamp or on the duration and number of times the wetland fills, overflows and completely dries.
- The proposed railway viaduct crossing and reduced areas of earthworks will preserve the hydrologic function of North-East Herne Swamp catchment. This section of the Swamp has been mapped as ‘Potential SHWTLP’ by Biosis (2024). The changes in this catchment are expected to have negligible impact to the wetting/drying regime of Herne Swamp during frequent events, as the impacted area is very flat and does not flow to the swamp during minor events, but instead pools in depressions and infiltrates. During intensive rainfall, runoff will flow south to Farm Drain 1.
- Areas of SHWTLP vegetation adjacent to the proposed viaduct crossing beneath Stage 1A will be directly impacted by the proposed works.
- The hydrology and wetting and drying characteristics of the existing farm dams in the South, North-East and South catchments will not be altered by Stage 1A. As such, no direct or indirect impacts are expected to any potential habitat value of the farm dams.
- Minor hydrological changes to Merri Creek will not alter the hydrologic and hydraulic conditions in Merri Creek at the confluence or downstream. As such, direct and indirect impacts to the stability and geomorphology of Merri Creek are so small as to be insignificant.

Water quality impacts to Herne Swamp and Merri Creek are shown to be small in average rainfall years and in the order of a very small increase in annual loads associated increases in stormwater runoff volumes. These changes are in the order of 5%. It is likely that the Beveridge Intermodal Precinct Stage 1A Project will achieve the BEPM criteria once the scheme is optimised and modelled in accordance with Melbourne Water’s standard practice.

National Intermodal has adapted the design from an earth embankment with culverts to a viaduct structure. The viaduct structure is constructed over the floodplain zone to maintain natural flood passage. This will allow the normal wetting and drying regimes for Herne Swamp to be maintained. In summary, potential changes in hydrologic function of the surrounding areas can be effectively mitigated through the implementation of shallow drainage swales designed to preserve the natural infiltration processes along the Stage 1A rail line.

1 Introduction

1.1 Background

National Intermodal Corporation (National Intermodal) are planning to develop a major freight and logistics hub at 2025 Merriang Road Beveridge, in Melbourne's north. The Beveridge Intermodal Precinct is being proposed in stages where Stage 1A is a standalone, operational intermodal freight terminal.

Due to potential direct or indirect impacts to Herne Swamp, Stage 1A of the Project was determined to be a Controlled Action under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC), with assessment to be undertaken by Preliminary Documentation.

A request for additional information (EPBC 2023/09693) was issued by the Department of Climate Change, Energy, the Environment and Water (DCCEEW) including an assessment of the likely direct and indirect impacts to the environment of Herne Swamp wetland and the associated waterways during the construction, operational and maintenance components of the project.

Aurecon has been engaged by National Intermodal Corporation to prepare a surface water technical report which will document the findings of modelling and respond to the request for additional information from DCCEEW.

1.2 Project Description

The proposed Beveridge Intermodal Precinct, which will cover approximately 915 ha of area will leverage its strategic location near key existing and planned arterial roads, freeways and the ARTC rail line that will support access to and from the site to local, regional, and national destinations

Within this overall development footprint, the Stage 1A Site comprises approximately 67 ha of largely cleared and relatively flat, rural land approximately 40 km north of Melbourne CBD and to the east of the township of Beveridge.

Herne Swamp is located within the north of the site and Merri Creek is located to the north-east and east. The Study Area is shown on Figure 1-1 which includes the mapped Herne Swamp extent and immediate surrounds.

1.2.1 Proposed Action

Stage 1A (Proposed Action) involves the construction and operation of a permanent rail connection to the existing Australian Rail Track Corporation (ARTC) rail freight corridor, together with sidings, a basic intermodal terminal and associated infrastructure for the initial stage of the Beveridge Intermodal Precinct.

The Stage 1A terminal will have the ability to operate 24 hours a day, 7 days a week, with up to two (2) 1,800-metre-long trains being processed per day in each 24-hour period (train shunting movements will be one 1,800 metre train at a time).

The operation of the Stage 1A Proposed Action will be predominately rail to rail. For the rail to road proportion, truck movements will be capped (through the use of a vehicle booking system) to four (4) truck movements per hour averaged over each 24-hour period, with a maximum of eight (8) truck movements in any one hour (unless otherwise agreed and approved).

The Stage 1A Proposed Action has been designed to provide rail infrastructure which will be utilised by future development of the broader Beveridge Intermodal Precinct, without pre-empting the further assessment and approval of the precinct planning and development. It comprises the following key components:

- Rail connection – rail connection (southern and northern lines) from the existing ARTC rail corridor to the terminal.

- Rail infrastructure – turnouts and sidings (adjacent to the terminal hardstand) to accommodate interstate trains up to 1,800 metres long. Rail infrastructure will include three sections of permanent hardstand and earthworks that would directly or indirectly drain to the Herne Swamp. Approximately 700 m of linear rail tracks will be provided on a viaduct elevated above the floodplain.
- Permanent maintenance access tracks - proposed for the viaduct alignment to provide ARTC with 24/7 access to signals. Access tracks adjacent to the rail will be constructed flush with the existing ground surface so as to not impede any surface flows across that area and will be constructed from locally sourced crushed and compacted basalt rock.
- Intermodal terminal – container handling and storage area (hardstand) for loading and unloading of trains. Manual handling only with reach stackers.
- Site access and internal roads – Beveridge Road intersection and internal access road for heavy and light vehicle movement within the site.
- Drainage infrastructure – drainage and stormwater quality treatment works and stormwater infrastructure to manage and control the stormwater runoff appropriately.
- Ancillary development – demountable administration facility (office, toilet, lunch room) and packaged equipment (inc. but not limited to refuelling, water storage and drainage, lighting, fencing, weighbridge, solar generation and power storage, signage).
- External roads – local road improvement works between the Hume Hwy and the subject site as agreed by the relevant parties.
- Utilities – connection and site lead in for electricity, telecommunications, sewer and potable water.
- Vegetation removal – removal of native vegetation within the project area boundary to the minimum extent required to facilitate the use and development.

1.2.2 Design Refinements

National Intermodal have adapted the design to minimise the impacts on Herne Swamp to address concerns from stakeholders.

The design has changed from an earth embankment with culverts to a viaduct structure. Sitting on concrete piers, the viaduct structure is designed to have a minimal footprint within and adjacent to Herne swamp, being constructed over the floodplain zone to maintain natural flood passage. This will allow the normal wetting and drying regimes for Herne Swamp to be maintained Additionally, once constructed the viaduct structure will promote the return of the SHWTLP along the farm drain through the Stage 1A project.

Critical changes to the proposal which will reduce the risk of alteration to Herne Swamp are as follows:

- Replacement of an earth embankment with a viaduct over the crossing of the mapped Herne Swamp
- Removal of the proposed drainage culverts beneath the rail crossing due to the bridge like function of the proposed viaduct
- Removal of proposed channel deepening works within the Farm Drain 1 which reduces disturbance to the mapped Herne Swamp area.

1.3 Project Objectives

This surface water assessment was undertaken to address the request for additional information (EPBC 2023/09693) including an assessment of the likely direct and indirect impacts to the environment of Herne Swamp wetland and the associated waterways during the construction, operational and maintenance components of the project.

The objectives of this project are to provide:

- An assessment of the likely duration of impacts to Herne Swamp wetland and the associated waterways, as a result of the Proposed Action.

- Discussion of whether the impacts are likely to be repeated, for example as part of maintenance.
- Discussion of whether any impacts are likely to be unknown, unpredictable or irreversible.

The assessment has been prepared with consideration to the EPBC Act Significant Impact Guidelines 1.2.

Figure 1-1. Location of Stage 1A Beveridge Intermodal and Study Area for the assessment

1.4 Assessment Approach

The scope of work for this surface water assessment and impact assessment involves the following:

- Background and data review - Civil and drainage designs for the Project and relevant studies have been reviewed including the flooding assessment report, aerial photography, ecological investigations and water sampling reports to identify data gaps and limitations.
- Conceptual site model – A conceptual model was prepared for existing conditions and proposed conditions including key levels (spill points, flood level, groundwater) and drainage connectivity across Herne swamp to Merri Creek.
- Hydrological and Water Quality Modelling - Baseline MUSIC hydrological and water quality modelling was undertaken. A statistical summary for comparison with proposed development results was prepared.
- Hydraulic Modelling – (undertaken by SMEC) the hydrology was modelled and peak flood depth, velocity and afflux maps produced to model potential changes in flood extent during a seasonal storm event.
- Assessment of impacts to Herne Swamp - The duration and severity of the potential hydrological and water quality impacts to Herne Swamp was assessed based on statistical analysis of the hydraulic, hydrological, water quality and water balance modelling results.
- Assessment of impacts to Merri Creek, drainage lines and farm dams - The duration and severity of the surface water impacts to Merri Creek, drainage lines and farm dams was assessed based on the hydraulic, hydrological, water quality and water balance modelling results and statistical analysis.
- Management and Mitigation - Proposed mitigation and avoidance measures (in the design) were summarised with respect to protection of the surface water environment and the need for any additional mitigation and management measures were assessed. Key gaps were identified for incorporation into management plans.

Limitations

The following limitations apply to this report:

- Hydrologic modelling has been carried out using industry standard MUSIC models in accordance with MUSIC guidance however these models are not calibrated to local hydrologic conditions and were established to assess changes in runoff resulting from directly connected impervious surfaces.
- Hydraulic modelling of the South West Herne Swamp catchment has been carried out using topographic survey.
- Water quality modelling was undertaken based on the reference design and will require refinement during detailed design development. Modelling results indicate that there is sufficient area within Stage 1A boundary to achieve BEPM targets and provide WSUD elements that can maintain existing runoff and infiltration processes.

2 Background Data and Document Review

2.1 Data Sources

Data sources for this assessment are outlined below in Table 2-1.

Table 2-1. Data Sources

Data	Source
Topography	Vicmap Elevation DEM 10m v3.0 (October 2020)
Survey	Site survey received 13th August 2024
Aerial Imagery	Nearmap, captured 28th May 2024
Land Use Planning Zones	VicPlan, accessed 8th August 2024
DELWP Wetland Extents	Victorian Wetland Inventory (Current) – Dataset – Data Vic
MUSIC Modelling Parameters	MUSIC Guideline (Melbourne Water, July 2024) NlimSW MUSIC Modelling Guidelines (BMT WBM, August 2015)
Daily Rainfall, Potential Evapotranspiration	SILO database https://www.longpaddock.qld.gov.au/silo/

2.2 Relevant Legislation, Policy and Guidelines

Table 2-2 summarises the current legislative requirements, policies and regional guidelines relevant to this study.

Table 2-2. Summary of key legislation, policies and guidelines applicable to the project.

Legislation / Policy/ Guideline	Brief Description and relevance
Commonwealth Legislation	
Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)	Commonwealth environmental legislation which protects matters of national environmental significance (MNES), including threatened flora and fauna. In Herne Swamp, Seasonal Herbaceous Wetland of the Temperate Lowland Plains (SHWTLP) is a listed ecological community. Further to this the Proposed Action is located on land that is defined as Commonwealth Land under the Act, requiring an assessment of impacts under Significant Impact Guidelines 1.2. **Commonwealth approval is required for controlled actions including the Beveridge Intermodal Precinct Stage 1A Project.**
Commonwealth Policies and Guidelines	
National Water Quality Management Strategy (NWQS)	The NWQMS (ANZECC and ARMCANZ) provides a nationally consistent approach to water quality management and the information and tools to help protect water resources. The main policy objective of the NWQMS is to achieve sustainable use of water resources, by protecting and enhancing their quality, while maintaining economic and social development. Consideration of NWQS should be included in environmental management plans.
Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC)	The ANZECC Water Quality Guidelines provide recommended trigger values for various levels of protection which have been considered when describing the existing water quality and key indicators of concern. This assessment considers the level of protection based on the Guidelines.

Legislation / Policy/ Guideline	Brief Description and relevance
State Legislation	
Planning and Environment Act 1987	The purpose of the act is to provide a framework for planning the use, development and protection of land in Victoria for the long-term interest of all Victorians. It also gives effect to planning schemes which includes Planning Policy Framework. The key clauses of PPF applicable to the development are Biodiversity (12.01), Water bodies and wetlands (12.03), Floodplains (13.03) and Natural Resource Management (14.02).
Water Act 1989	Provides the legal framework for managing Victoria's water resources. Key purposes of the act relevant to the development are floodplain and drainage management and waterway management. Under the *Water Act 1989*, the designated waterways, regional drainage and floodplain management authority for the Project area is Melbourne Water.
Environment Protection Act 2017 (general environmental duties)	The legislation provides the legal framework for Victoria's environmental protection laws. It focuses on preventing adverse impacts rather than managing them after they have occurred. The impact assessment would follow the principles outlined in the EP Act. The general environmental duty requires risks of harm to human health and the environment to be minimised 'so far as reasonably practical'.
State Policies and Guidelines	
Biodiversity Conservation Strategy (BCS) 2013	Outlines EPBC matters of national environmental significance within Melbourne's growth corridors. Conservation Area 34 in the Merri Creek corridor is specifically for the Growling Grass Frog.
Best Practice Environmental Management Guidelines for Urban Stormwater (BPEMG) 1999	Provides guidance in ten key areas with a focus on managing the quantity and quality of stormwater so that environmental performance is improved and receiving waters are protected. BPEMG would be considered in the assessment of the project. The targets specified in this guideline apply to the management of runoff from the Project: • 80% Total Suspended Solids • 45% Total Phosphorus • 45% Total Nitrogen • 70% Gross Pollutants or Litter
Regional Guidelines	
Healthy Waterways Strategy (2018-2028) – Melbourne Water 2018	Sets a long-term vision for managing the health of rivers, wetlands and estuaries in the Port Phillip and Westernport region. Outlines water quality targets for values and conditions of waterways across the Yarra catchment, informs implementation of actions in the plan and provides a basis for monitoring and reporting on outcomes. It is noted the HWS is a strategy not a statutory document and is understood to apply to the broader precinct rather than for Stage 1A. Herne Swamp: Investigate opportunities to further re-engage the natural wetlands in this area and to improve wetland water regime to meet ecological watering objectives, improve ecosystem services, cultural and social value. Merri Creek Upper: To prevent decline in stormwater condition, treat urban development upstream of Mount Ridley Road so directly connected imperviousness (DCI) remains below 1% throughout the upper Merri Creek catchment. For every ha of new impervious area, this requires harvesting around 4.2 ML/y and infiltrating 0.9 ML/y, which is about 110 ML/y and 25 ML/y for full development to the urban growth boundary.

Legislation / Policy/ Guideline	Brief Description and relevance
Co-designed catchment program for the Yarra Catchment 2018	The Healthy Waterways Strategy is supported by the co-designed Yarra Catchment Program. This includes a summary of key values and performance objectives to be achieved for Herne Swamp and Merri Creek.
Yarra Strategic Plan (Burndap Birraung burndap umarkoo) 2022	Outlines a 50-year vision for Birrarung - Yarra River and emphasises the importance of traditional owners and co-management of land. It includes a land use framework with actions and directions for future development which would be considered in the impact assessment. Objective 1 – Action 6: - Investigate options to restore billabongs and wetlands on private and public land by using water for the environment to mimic natural water cycles and undertaking complementary land and water management works. Opportunities to include rehabilitated wetlands and reintroduced zones of vegetation into Merri Creek (a tributary of Birrarung – Yarra River) should be considered in the landscaping of Stage 1A and the intermodal masterplan.
Melbourne Water MUSIC modelling guidelines 2024	This provides guidance on modelling approaches and input parameters for MUSIC models that are submitted to Melbourne Water. MUSIC modelling for the assessment will be conducted with consideration to the guidelines.

2.3 Relevant Studies

The following documents and studies of the study area were reviewed for their relevance to the Beveridge Intermodal Precinct Stage 1A Project.

Table 2-3. Relevant studies

Document	Description and how study impacts the Project
Stormwater Management Strategy - Preliminary Context (SMEC, 27 May 2020)	▪ This technical memo describes the proposed preliminary high-level concept stormwater management strategy for the Beveridge Intermodal Precinct Stage 1A Project. ▪ This study has been used to understand the initial hydrological context for the Project and forms the basis of the EPBC assessment presented in this document.
Preliminary Site Investigation – Beveridge Intermodal Precinct Stage 1A (Arcadis Australia Pacific, October 2023)	▪ The purpose of the Preliminary Site Investigation is to assess potential contamination risks posed by the current and historical land use, as well as to identify potential risks to human and ecological health. ▪ This study has been used to understand the environmental setting of the study area.
Geotechnical Investigation Factual Report – Beveridge Intermodal Freight Terminal (BIFT) (Tonkin & Taylor Pty Ltd, 6 October 2023)	▪ This report provides a factual report on the ground and groundwater conditions at the proposed site. ▪ This study has been used to inform soil and groundwater conditions for the study area.
Flora and Fauna Assessment (Biosis, February 2025)	▪ Biosis Pty Ltd was commissioned by National Intermodal Corporation (National Intermodal) to undertake a flora and fauna assessment of the proposed Beveridge Intermodal Precinct, specifically to detail the impacts of early works being undertaken for Stage 1A of the Precinct. ▪ This report provides an assessment of the flora and fauna undertaken for the Beveridge Stage 1A Precinct, which reviewed EPH and Arcadis field study and also results of targeted survey for matters of national environmental significance (MNES) listed under the EPBC Act. ▪ This study has been used to define the extent of the Seasonal Herbaceous Wetland of the Temperate Lowland Plains (SHWTLP) ecological community identified on the site.

Document	Description and how study impacts the Project
Technical Memorandum – BIFT Stage 1A – Flood Modelling, Rev C (SMEC, 17 April 2024)	▪ The main purposes of this technical memo are: flood assessments of existing and development conditions; identifying non-compliant items as per technical specification; proposing mitigation options to address non-compliant items; and highlighting departure items (if any) and key risks (if any) for the next stage ▪ This study has been used to understand flooding at the site and proposed works around the Hearne Swamp that may alter the local hydrology.
Stormwater Management Strategy – BIFT Stage 1A Reference Design (SMEC, 18 April 2024)	▪ The Stormwater Management Strategy (SWMS) includes: Review of existing site topography and how surface water flows will be conveyed; Flow calculations for a 10% Annual Exceedance Probability (AEP) storm for Stage 1A development site; Flow calculation for a 1% AEP storm for the Stage 1A development site; Consideration of flood retardation requirements; and Stormwater Quality modelling to achieve Best Practice Environmental Management Guidelines (BPEMG) for the Stage 1A development site. ▪ This study has been used to understand the site hydrological context and proposed stormwater infrastructure that may alter the local hydrology.
Beveridge Intermodal Precinct Stage 1A – Baseline Contamination Assessment (Aurecon Australasia Pty Ltd, 31 May 2024)	▪ The baseline soil contamination assessment objectives of the SAQP were as follows: ▪ Provide an indication of the potential risks that soils may have on human health (i.e. construction workers) and sensitive ecological receptors during construction. ▪ Assess on-site reusability of spoil generated during the construction phase of the project. ▪ Provide an indicative waste classification of the spoil likely to be generated during the construction phase of the project.
Beveridge Intermodal Precinct Stage 1A – Baseline Contamination Assessment Addendum (Aurecon Australasia Pty Ltd, 23 October 2024)	▪ This report provides a description and findings of the surface water and groundwater assessment as part of the baseline contamination investigation conducted at the Site between 1 – 31 May 2024. This report is to be read in conjunction with the findings from the soil assessment, which are reported in the Baseline Contamination Assessment produced by Aurecon (2024) on 31 May 2024. ▪ This study has been used to inform groundwater levels at the study area.
Reference Design Drawings (SMEC, 14 June 2024)	▪ The civil reference design drawings for the Stage 1A have been used to understand the design, including hardstand areas and proposed swales and other drainage infrastructure.

2.4 Climate

The study area has a temperate climate classification. It is located on the border of Melbourne Water's "Melbourne Airport" and "Melbourne Regional" rainfall distribution areas, which have an annual rainfall range of 500 to 650 mm and 650 to 750 mm respectively. It is considered a Priority Stormwater Area (Melbourne Water, 2024).

Climate data for the site was sourced from SILO, a "database of Australian climate data from 1889 to the present". Point climate data for daily rainfall and Potential Evapotranspiration (Morton's PET) were obtained at -37.45 latitude, 145.00 longitude. The full data set back to 1889 was reviewed for patterns and data reliability; this review indicates pan evapotranspiration data quality improved after 1970. Data analysis was therefore undertaken for the 34-year period between 1990 to 2023.

During the 34-year period reviewed, the site has an average annual rainfall of 651.5mm (1990 to 2023), compared to an average of 675.10mm for the full record (1889 to 2023). Further analysis on climate data undertaken for modelling input is described in Section 4.1 and Appendix A.

2.5 Topography

The study area is situated in the Upper Merri Creek catchment. The overall Stage 1A site topography can be described as relatively well graded slopes surrounded by the Upper Merri Creek floodplain to the north and east. The Site is divided by a high point, forming two separate catchments in the southwest, and northeast.

The topography of Herne Swamp (shown in Figure 2-1) is generally flat. There is a farm drain (hereafter referred to as Farm Drain 1) that runs east-west through Herne Swamp with a grade of less than 0.05%. North of the Farm Drain, the topography is very flat with similar grades. South of Farm Drain 1 there are small localised hills with flat areas at the bottom between the hill and Farm Drain 1.

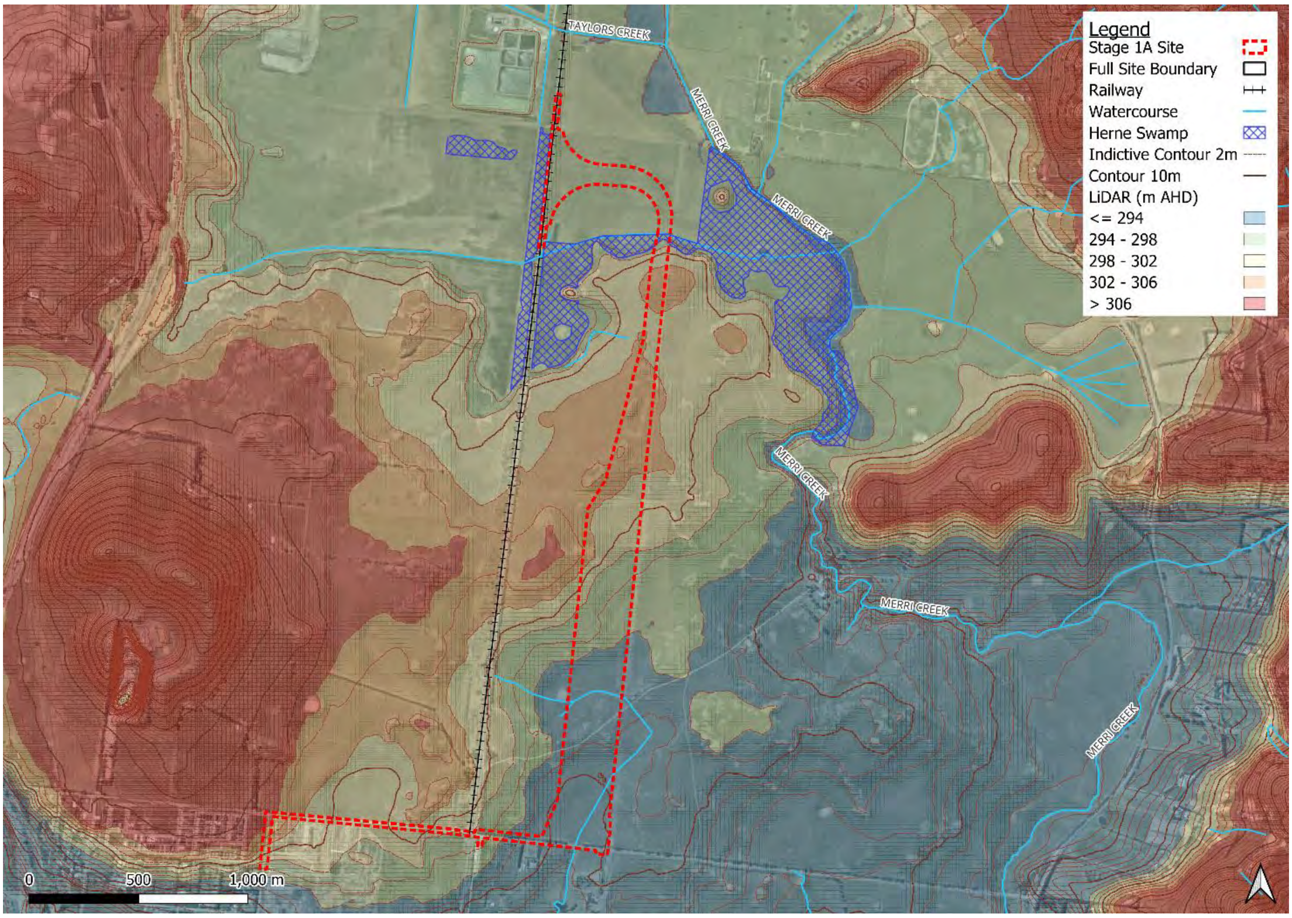


Figure 2-1. Site Topography

2.6 Surface Water

2.6.1 Catchment Overview

The study area is located in the upper Merri Creek catchment which drains an area of 396 km^2 southwards through Melbourne's northern suburbs to the Yarra River. It has many major tributary systems including Edgars, Merlynston, Central, Curly Sedge, Aitken and Malcolm Creeks and in the upper reaches, Wallan, Mittagong, Taylors and Strathaird Creeks are also important tributaries (Merri Creek Management Committee, 2024). The Merri Creek catchment is shown in Figure 2-2.

The Merri Creek catchment is predominantly rural, changing along the course of the creek from pastoral to industrial and then urban to residential. The rural reaches have retained some natural stream form and feature despite a history of land clearing and agricultural development (Melbourne Water, 2016).

2.6.2 Merri Creek

From aerial imagery, it can be observed that Merri Creek has been channelised, north of study area before it becomes a natural reach. Within the study area Merri Creek generally flows from north to south, meandering along the eastern boundary of Herne Swamp catchment (see Figure 2-2).

Biosis observed that whilst patches of Tall Marsh vegetation persist along Merri Creek and emergent vegetation is present in some areas, the majority of the creek banks within proximity to the study area have been severely trampled by livestock (Biosis, 2025).

Taylors Creek is a tributary of Merri Creek and meets its confluence with Merri Creek, north of the defined study area. It is channelised and conveys flows from Wallan Treatment Plant. In the early 2000s it was identified that the Wallan East Sewage Treatment Plant was generating overland flow within the lower Taylors Creek. After the upgrades and operation of the plant was taken over by Yarra Valley Water, the risk of overland flows has reduced. Merri Creek Management Committee states that sewerage infrastructure will impact Taylors Creek significantly over time (Taylors Creek Strategic Plan, 2009). The most recent storage capacity upgrades are scheduled for completion in 2021 which will require periodic discharging of any excess water under controlled conditions to Merri Creek via Taylors Creek (Yarra Valley Water, n.d.).

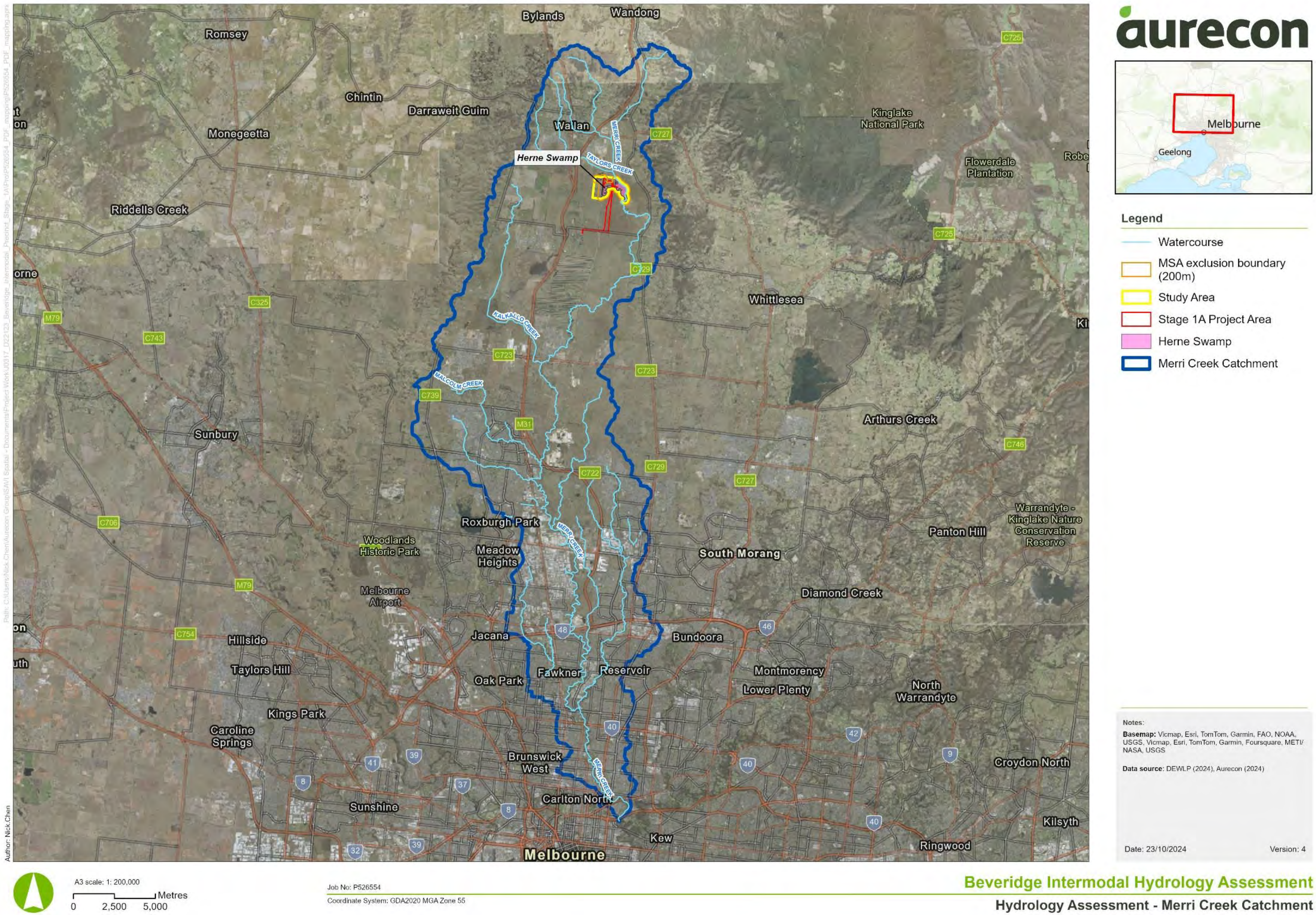


Figure 2-2. Merri Creek catchment

2.6.3 Herne Swamp

Herne Swamp (as shown in Figure 1-1) has an irregular shape with two connected main sections which are located against the railway tracks on the western Site boundary and a larger section towards the north-west bounded by Merri Creek. Herne Swamp forms part of the EPBC Act listed threatened community Seasonal Herbaceous Wetland (Freshwater) of the Temperate Lowland Plains (SHWTLP) and is a Department of Environment, Land, Water and Planning (DELWP) (now Department of Energy, Environment and Climate Action (DEECA)) mapped wetland (DELWP mapped wetland zone).

The extent of Herrne Swamp subject to this assessment is located in the southern most extent of a larger area known as 'Greater Herne Swamp' identified and mapped indicatively by Alluvium (2021) and presented below in Figure 2-3. Alluvium mapped this as the original extent prior to artificial drainage and based on topographic data.

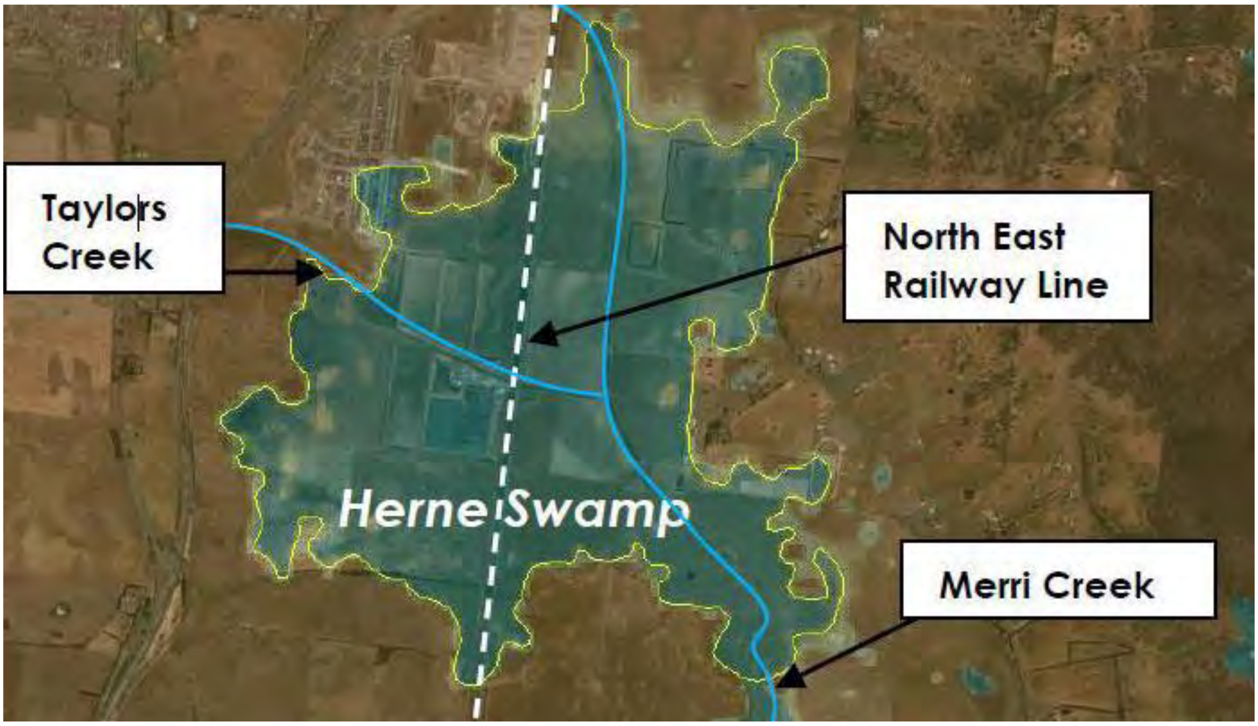


Figure 2-3 - Greater Herne Swamp mapped by Alluvium (2021)

Seasonal Herbaceous Wetlands (Freshwater) of the Temperate Lowland Plains ecological community (hereafter referred to as SHWTLP) are described as temporary freshwater wetlands, located on isolated drainage lines or depressions that are seasonally inundated, typically filling after winter-spring rains, and then drying out (DCCEEW, 2012). Their main water source is rainfall, and they are not dependant on overbank flooding from riverine systems. The vegetation is generally treeless and dominated by an herbaceous ground layer (DCCEEW, 2012). Seasonal herbaceous wetlands water is fresh to slightly brackish (Rakali Ecological Consulting, 2017). The depth, duration and frequency of inundation is variable, however typically they are inundated by up to 1 m for months and then dry out, sometimes for several years (Rakali Ecological Consulting, 2017).

Current land uses within Herne Swamp include livestock grazing and rural conservation. For the purposes of this study, Herne Swamp is considered to comprise the DELWP mapped wetland zone as shown in Figure 2-4 below.

Biosis ecologists mapped a portion of the DELWP mapped wetland zone to have the EPBC Act listed SHWTLP community present with a localised zone also mapped as Potential SHWTLP. These areas are shown in Figure 2-4 below.

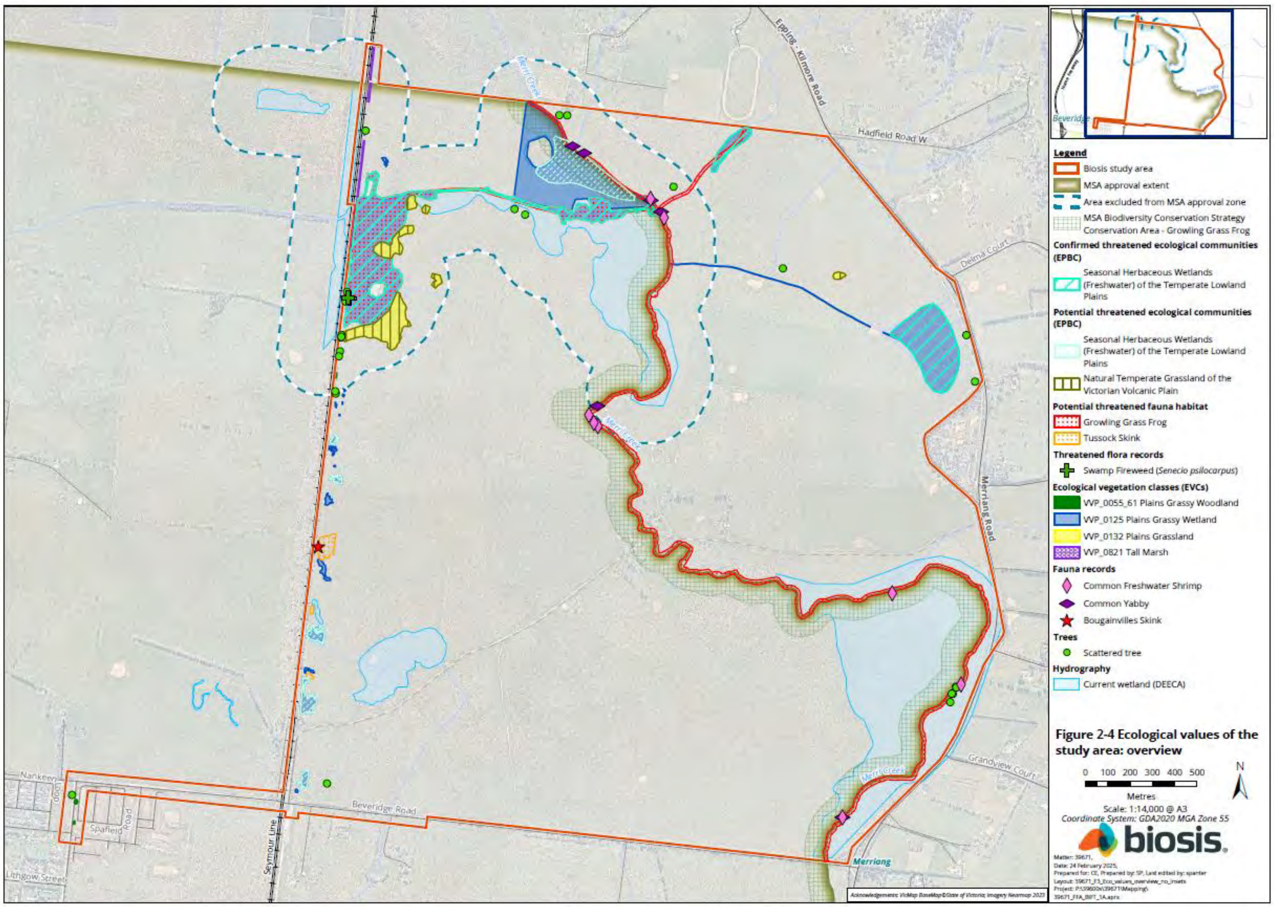


Figure 2-4. Ecological values of the study area (Biosis, 2025)

The areas that Biosis mapped as SHWTLP correlate with flatter expanses of Herne Swamp and local drainage lines, with a majority of the SHWTLP community occurring between the existing railway and Stage 1A of the Project. The SHWTLP was also mapped by Biosis within the constructed agricultural drain (Farm Drain 1) previously proposed to be deepened as part of the Project for flood management/drainage improvement works. The mapped SHWTLP extends within Farm Drain 1 to the existing railway to the west and Merri Creek to the east with some mapped either side of the drain as well including Farm Dam 2. A potential SHWTLP community was also mapped north east of Stage 1A, between the project boundary, Farm Drain 1 and Merri Creek. No other areas of the Herne Swamp land was mapped with SHWTLP across the areas comprising the graded hill slopes towards Merri Creek.

Aerial photos indicate the historical inundation patterns in the swamp showing green vegetation up until November, drying out in December, very dry conditions in the summer months from January to March, and wet conditions in winter. During heavy rainfall events, the extent of the swamp is discernible from aerial imagery and flows concentrate on the west site of the swamp against the existing rail line.

2.6.4 Herne Swamp surface water features

The key surface water features of Herne Swamp are identified in Figure 2-5.

- There is one unnamed, constructed agricultural drain (Farm Drain 1) within the study area which flows from west to east. An external 440 Ha catchment enters the site boundary via Farm Drain 1 from the northwest, through culverts under the existing railway.

Farm Drain 1 passes through Herne Swamp to Merri Creek. Biosis mapped Farm Drain 1 within the Stage 1A impact area as having the SHWTLP community present. There are three farm dams within the study area (refer Dam 1, Dam 2, Dam 3 in Figure 2-5).

- The farm dams are turkey nest dams with embankments raised above the surrounding land.
- Survey indicates flow within Farm Drain 1 would drain into Dam 2 and Dam 3 with overflows continuing east towards Merri Creek.

  - Dam 1 is located within the southwestern part of Herne Swamp.
- There are two other drainage lines coming from the northeast which flow into the study area. Since these are downstream of the Herne Swamp study area, they are not further considered in the assessment.

Figure 2-5. Herne Swamp Surface Water Features

2.6.5 Water Users, Ecology and Heritage

Both Merri Creek and Herne Swamp have been mapped (Biosis, 2020) as being areas of cultural heritage importance. Merri Creek is an environmental, cultural, heritage and recreation corridor, with its tributaries playing an important role in linking these areas and their values (Merri Creek Management Committee, 2024). Herne Swamp, although not an ideal camping place, would have provided an abundance of game and other resources (Biosis, 2020).

Merri Creek is remnant habitat for threatened flora and fauna and locally valued vegetation communities (Merri Creek Management Committee, 2024). An important aquatic species associated with Merri Creek is the EPBC Act listed Growling Grass Frog, which has a recorded population within Merri Creek (Biosis, 2025). Herne Swamp was also identified to provide suitable habitat for a range of threatened flora and fauna, including the Growling Grass Frog (GGF), although no GGF were recorded during targeted surveys in 2020 (Biosis 2025).

Three farm dams and farm drain that occur in the study area have historically been used for agricultural purposes, specifically stock watering. It is noted that growling grass frogs are known to utilise fam dams or “turkey nest” dams of this type for habitat where specific conditions are present (DELWP, 2017). However, it is noted that the farm dams are potential habitat as the GGF were not recorded during targeted surveys.

2.6.6 Summary

A summary of the key characteristics of the local surface water features within the study area is provided in Table 2-4.

Table 2-4 Summary of characteristics of the water features within study area

Water Feature	Water Feature Type	ANZG (2018) Ecosystem Type	Flow Regime	Key features	Catchment description	Water users
Merri Creek	Watercourse – creek – partially modified	Upland River	Intermittent	Merri Creek is a meandering creek which flows from north to south. Channelised upstream of study area but follows natural path within study area. Eroded banks impacted by livestock.	Catchment topography varies. Local topography can be described as relatively well graded slopes surrounded by the Upper Merri Creek floodplain to the north and east.	Aquatic ecosystems Stock watering Cultural value
Herne Swamp	Swamp - seasonal herbaceous wetland – partially modified	Wetland	Intermittent - seasonal herbaceous wetlands are naturally isolated freshwater wetlands that are seasonally inundated in the winter – spring and generally dry out by late summer. The Herne Swamp drainage regime is now impacted by the presence of agricultural drains however some localised depressions and isolated drainage lines remain.	Herne Swamp forms part of the EPBC Act listed threatened community Seasonal Herbaceous Wetland (Freshwater) of the Temperate Lowland Plains (SHWTLP).	Merri Creek catchment. Current land use primarily comprises livestock grazing. Topography is mix of flat terrain and gentle hillslopes.	Aquatic ecosystems Cultural value
Farm Drain 1	Watercourse – artificial drainage line	Wetland within Herne Swamp	Ephemeral	Artificial drain which runs through Herne Swamp. Connected / supplies water to Farm Dam 2 and 3.	Merri Creek catchment. Local catchment land use primarily comprises livestock grazing. Topography is mix of flat terrain and gentle hillslopes.	Aquatic ecosystems Stock watering
Farm Dam 1	Artificial dam	Freshwater reservoir	Ephemeral	Slightly perched. The water levels vary between being filled and empty during the year and does not reflect the levels within the swamp		Stock watering Potential frog habitat

Farm Dam 2	Artificial dam	Freshwater reservoir	Ephemeral	Slightly perched dam connected to Farm Drain 1. The water levels are consistent with the swamp. It has denser vegetation nearing the water body which becomes sparser further.	Limited overland catchment. Receives flow from Farm Drain 1	Stock watering Potential frog habitat
Farm Dam 3	Artificial dam	Freshwater reservoir	Ephemeral	Slightly perched dam connected to Farm Drain 1. The water levels vary between being filled and empty during the year and does not reflect the levels within the swamp (based on aerial imagery).	Limited overland catchment. Receives flow from Farm Drain 1	Stock watering Potential frog habitat

2.7 Soils

The study area comprises two distinct geological units, including “quaternary age newer volcanics comprising alkaline to tholeiitic basalt (Type 1)” and “quaternary age alluvial terrace deposits comprising gravel, sand and silt (Type 2)”, refer Figure 2-6 below. The other two geological units identified in the area – “Devonian age Humevale siltstone” (Type 3) and “Quaternary age colluvium comprising Diamictite, gravel, sand, silt, clay rubble” (Type 4) – are only found east and south outside of the study area and are therefore not considered in this assessment. The site is potentially underlain by sodic soils, which can inhibit water penetration. These landscapes are often susceptible to erosion when top soil is removed and underlying sodic soil is exposed to rainfall.

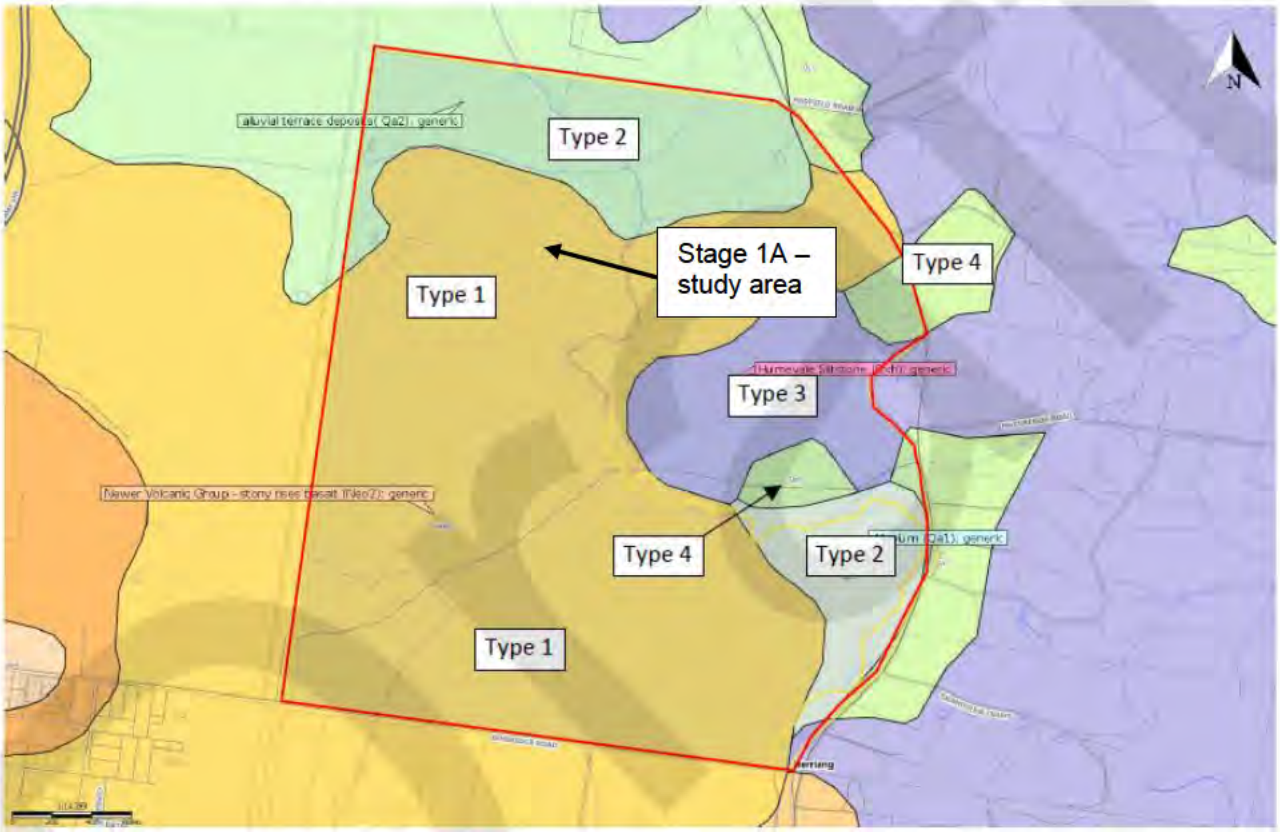


Figure 2-6. Site Geological Setting (Source: GeoVic from Tonkin & Taylor, 2023)

Geotechnical site investigation undertaken by Tonkin & Taylor in October 2023 further identified:

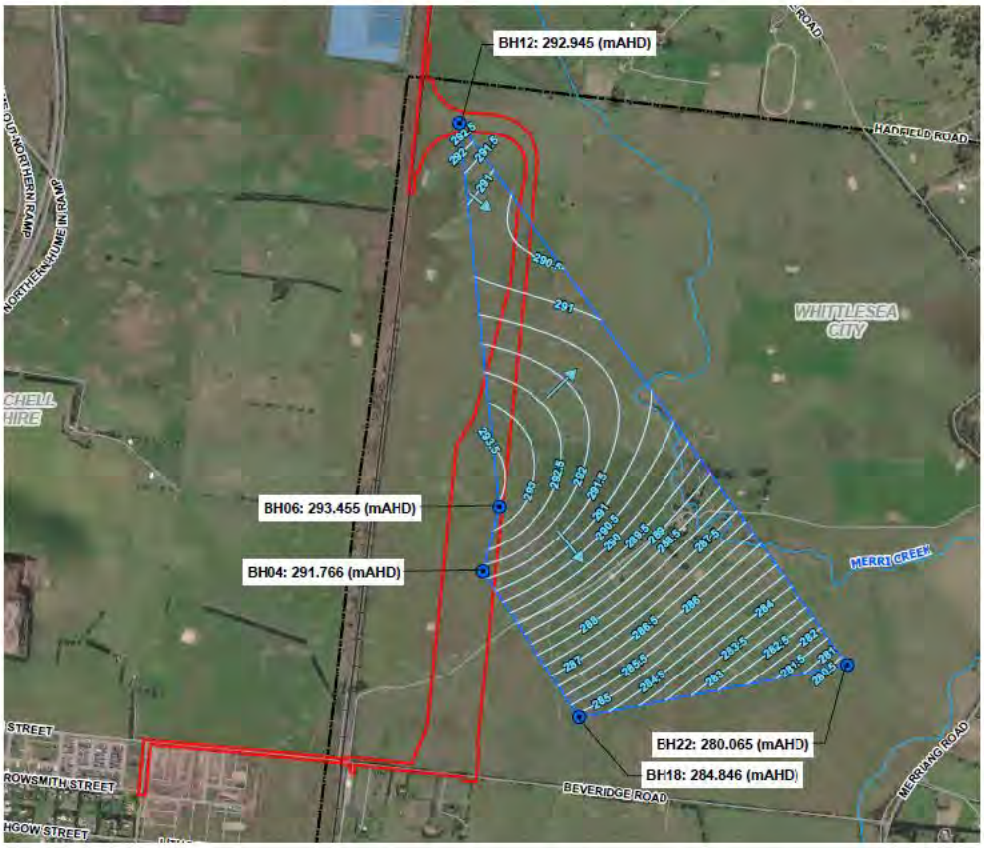
- Silt was identified at all test locations at ground surface and generally extends to depths between 0.05 m and 0.30 m. This unit was generally described as clayey silt, dark grey, low plasticity, moist and firm to stiff.
- Clay (newer volcanics) was identified at depths between 0.25 m to 3.80 metres below ground level (m bgl), typically described as brown, high plasticity, moist and stiff to very stiff.

This indicates the soils near the study area are comprised largely of silt and clay. There is some sand present however this is largely south of the study area and will not be considered in the assessment.

2.8 Groundwater

A review of available groundwater information relevant to the study area is summarised below.

Table 2-5. Review of groundwater information

Report	Information relevant to the project
Baseline Contamination Assessment Addendum (Aurecon, 24 June 2024)	▪ Depth to groundwater gauged at on- and off-Site monitoring wells ranged between 1.7 – 4.0 metres below ground level (mbgl) and is inferred to generally flow radially from the centre of the Site, except for groundwater in the north-western portion of the Site, which is indicated to flow south easternly. ▪ The closest borehole to the study area (BH12) recorded a depth to water of 1.884mbgl. 
Geotechnical Investigation Factual Report (Tonkin & Taylor, October 2023)	▪ The Visualising Victoria's Groundwater database indicates that groundwater is likely to be present at less than 5 mbgl within the study area. ▪ The closest borehole to the study area (BH12) recorded a depth to water of 1.64 – 1.73 mbgl. Groundwater levels to the south of the study area at investigated boreholes ranged between 3.99 – 4.48 mbgl (BH06) and 1.84 mbgl (BH04). ▪ In addition, near the study area perched water was observed at 0.3 mbgl (TP04) and surface water was observed near BH13.

The above review of groundwater information indicates that regional groundwater is at a depth that it is not likely to have a significant impact on the study. It is therefore not further considered in the assessment.

A review of the Potential Groundwater Dependent Ecosystem (GDE) Mapping for the Port Phillip and Westernport Catchment Management Area (DEECA, 2024) indicated no GDEs within the study area.

Notwithstanding, it is possible that surface water becomes shallow, perched groundwater as indicated at BH13, which may play a role in sustaining Herne Swamp. The location of BH13 is shown below in Figure 3-2.

2.9 Flooding

The northern portion of the Beveridge Intermodal Precinct Stage 1A Project site is subject to flooding and is located within the flood planning scheme overlay.

Flood modelling and assessments for the broader study areas beyond Stage 1A have been undertaken, with the most recent 1% Annual Exceedance Probability (AEP) flood with climate change shown to extend onto Stage 1A are presented in Figure 2-7.

For the purposes of this study, the local 20% AEP event has been used to contextualise the more frequent flood behaviour at Stage 1A. 20% AEP flood mapping for the broader study area is shown in Figure 2-8 and shows water depths within Herne Swamp are shallow, predominantly under 0.1 m and spread across a large area, primarily north of Farm Drain 1. This project area and Herne Swamp has been mapped with a flood hazard of H1 within Farm Drain 1. Some localised higher flood hazards are experienced within the farm dams and the farm drain where depths are greater. The H1 category correlates to velocities of under 2.0 m/s and depths under 0.3 m.

In order to mitigate afflux, prevent blockage of flood flow, and achieve project compliance from a flooding perspective, culverts extending the full width of the new railways, compensatory storage basins, and vegetated swales/drains have been proposed, refer SMEC Stormwater Management Strategy (April 2024) for details.

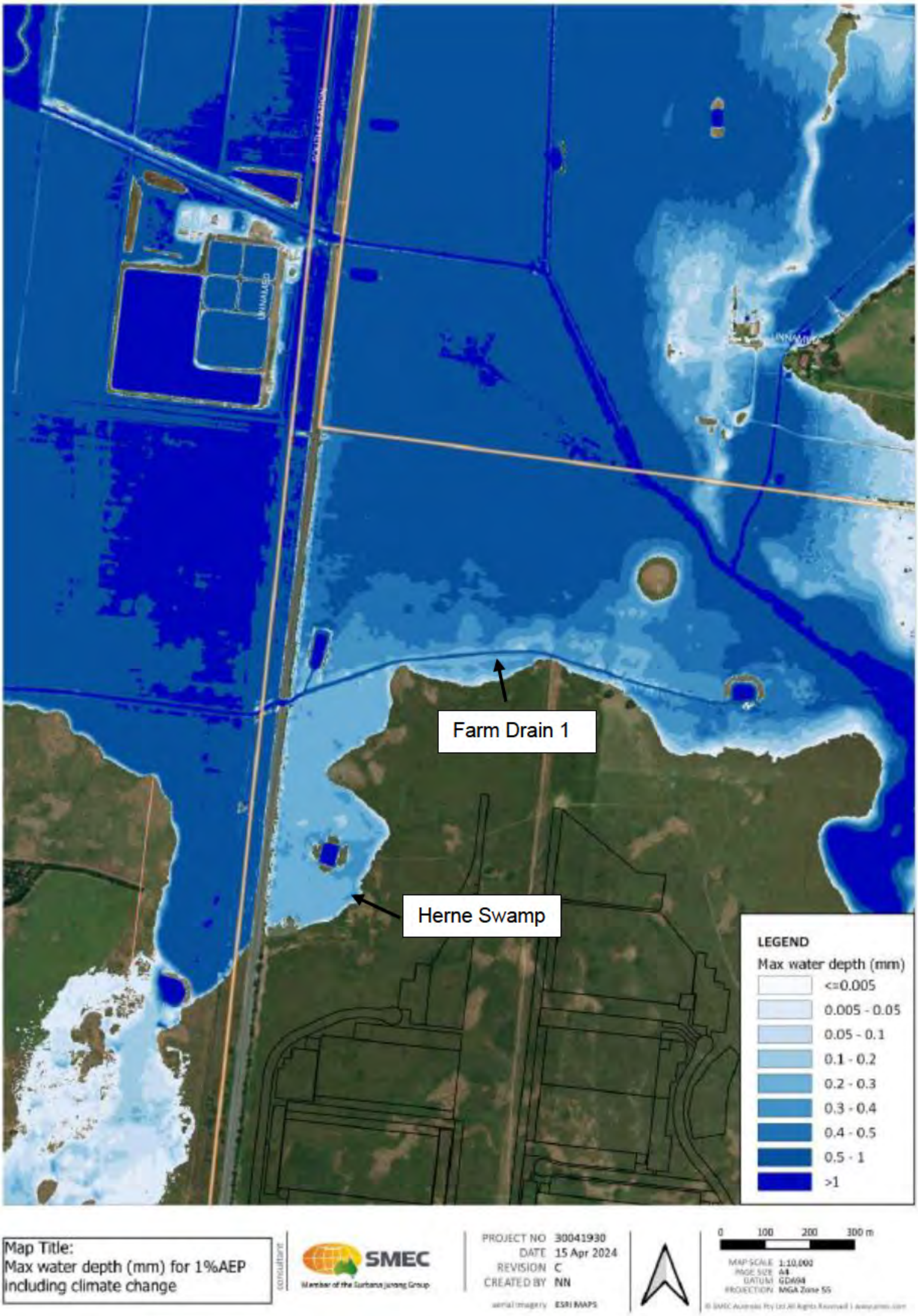


Figure 2-7. 1% AEP with climate change flood extent (SMEC, 2024)

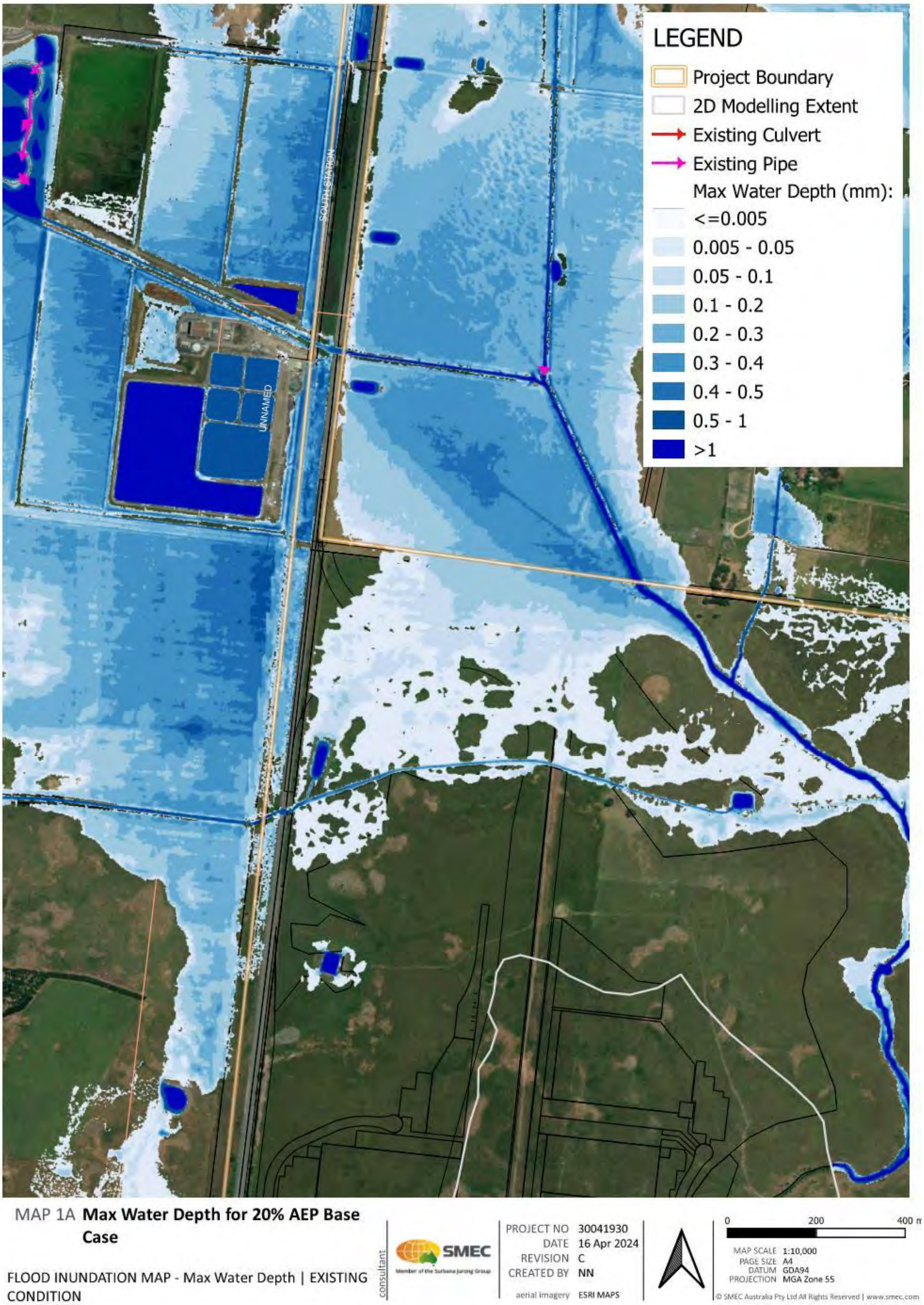


Figure 2-8 20% AEP flood max water depth (SMEC, 2024)

3 Conceptual Site Model

A Conceptual Site Model has been developed for the pre and post development cases to define the hydrologic characteristics of the sub-catchments, storage volumes and depressions across Herne Swamp. The model is based on a desktop analysis of aerial photography, topographic survey of drainage paths and spill points, and published groundwater depths. The Conceptual Site Model explains how the drainage features of the study area create the wetting and drying processes that sustain the protected plant communities of Herne Swamp.

The Herne Swamp catchment forms the project study area shown in Figure 3-1 below. Stage 1A of the Project extends south of the Herne Swamp catchment boundary, however this section is not part of the Herne Swamp assessment. Drainage flow directions are shown as solid black arrows. Uncertain drainage flow directions (due to very flat terrain) are shown as waved arrows with question marks.

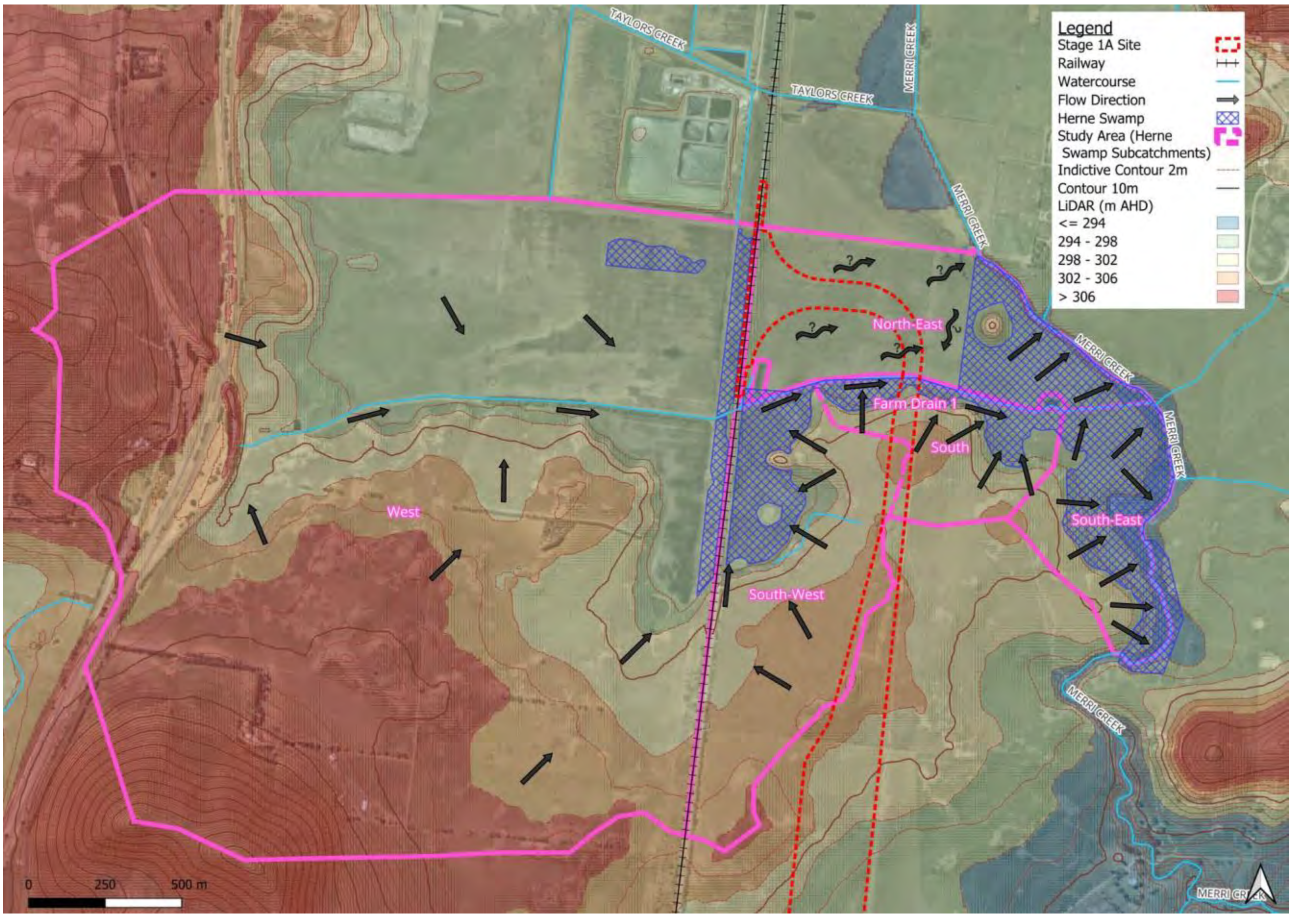


Figure 3-1. Herne Swamp Study Area and Catchments

3.1 Pre-Development

The Conceptual Site Model (CSM) for the site in the pre-development case is shown on Figure 3-2 with reference to both the mapped areas of SHWTLP and DEECA current wetland layer. Key hydrological features include:

- The West catchment drains to Farm Drain 1 through culverts under the existing railway. This catchment is hydrologically connected to Dam 3 via a diversion weir that has been constructed across Farm Drain 1 diverting lower, frequent flows to the north and a small section of SHWTLP mapped by Biosis. This catchment is not affected by the Beveridge Intermodal Precinct Stage 1A Project.
- The South-West catchment includes the main section of SHWTLP of Herne Swamp and an area of hillslope that grades towards the Swamp. The area of SHWTLP occurs within a natural depression that

stores direct rainfall and runoff from the adjacent hill slope. Rainfall and runoff from within this section of the Swamp is the dominant source of water that sustains the wetting and drying processes within the mapped SHWTLP. Review of available LIDAR survey shows this South-West catchment is slightly perched above agricultural Farm Drain 1, overtopping into the drain once the water level in the natural depression exceeds 295 m AHD. Section 3.1.1 discusses the storage and overtopping in more detail.

- The South catchment has no storage component, rainfall drains north into Farm Drain 1.
- Depression storage within Dam 2 and Farm Drain 1 is relatively small. Farm Drain 1 has a very shallow grade of less than 0.05% that promotes the ponding of water. Biosis (2024) mapped SHWTLP communities in Farm Drain 1 within the Stage 1A boundary, extending to Merri Creek as well as Dam 2. The area of SHWTLP within Farm Drain 1 inside the Stage 1A project land is proposed to be disturbed for flood management works. Biosis indicated that the SHWTLP community within the Farm Drain is on the "*periphery of the patch extent*".
- The North East catchment section of Herne Swamp mapped by DEECA sits between Merri Creek and a modified agricultural property to the west. Potential SHWTLP was mapped within this section by Biosis.
- The North-East catchment is very flat with average grades less than 0.05%. There is a distinct zone of Herne Swamp mapping within the eastern section of this catchment that is bounded by Merri Creek to the east. The hydrology of this section of Swamp would be dominated by direct rainfall and very occasional inundation by floodwater from Merri Creek and the Northern catchment.
- The North catchment is similarly very flat and has been modified by agricultural practices. Aerial photos show a subtle network of furrows that collect rainfall and shallow groundwater. Runoff during more intense storms would flow south, east and north east towards Merri Creek and the North Eastern section of Herne Swamp.
- The South-East catchment drains East to Merri Creek. This area does not include any area mapped as SHWTLP and is not affected by the Beveridge Intermodal Precinct Stage 1A Project.
- At times, floodwaters from Merri Creek may enter the swamp from the east, but this is not expected to be frequently enough to contribute to the wetting and drying regime that sustains the swamp.
- As mentioned above, regional groundwater is at a depth that does not interact with the Swamp and no references indicate the role of deeper groundwater on the swamp.

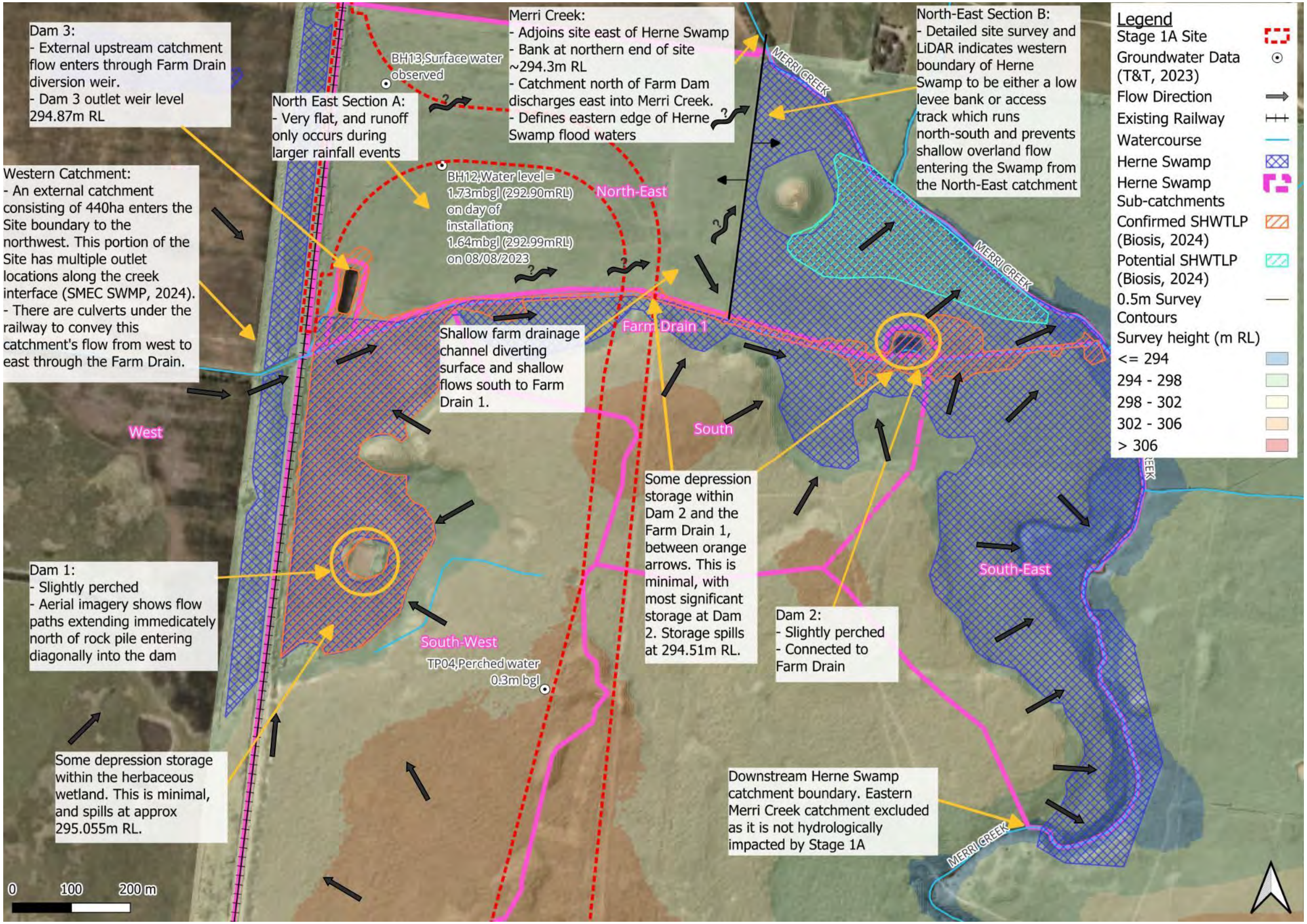


Figure 3-2. Conceptual Site Model of Herne Swamp – Pre-Development

3.1.1 Storage Volumes

The storage curve and spill points for the depression storage zone in the SHWTLP in the South-West catchment is shown below on Figure 3-3.The storage curve was created using the site survey to understand the storage capacity within this part of the study area. The storage curve shows the increase in volume of water stored in the wetland as water level increases, until it reaches a spill point, after which additional water entering this catchment discharges into Farm Drain 1. The depression storage zone depth is only around 100 mm deep.

This information has been incorporated in the development of the water balance model to incorporate the spilling process of the swamp when assessing water level flux. The storage curve also relates back to surface area and therefore has been used to calculate infiltration and evapotranspiration rates.

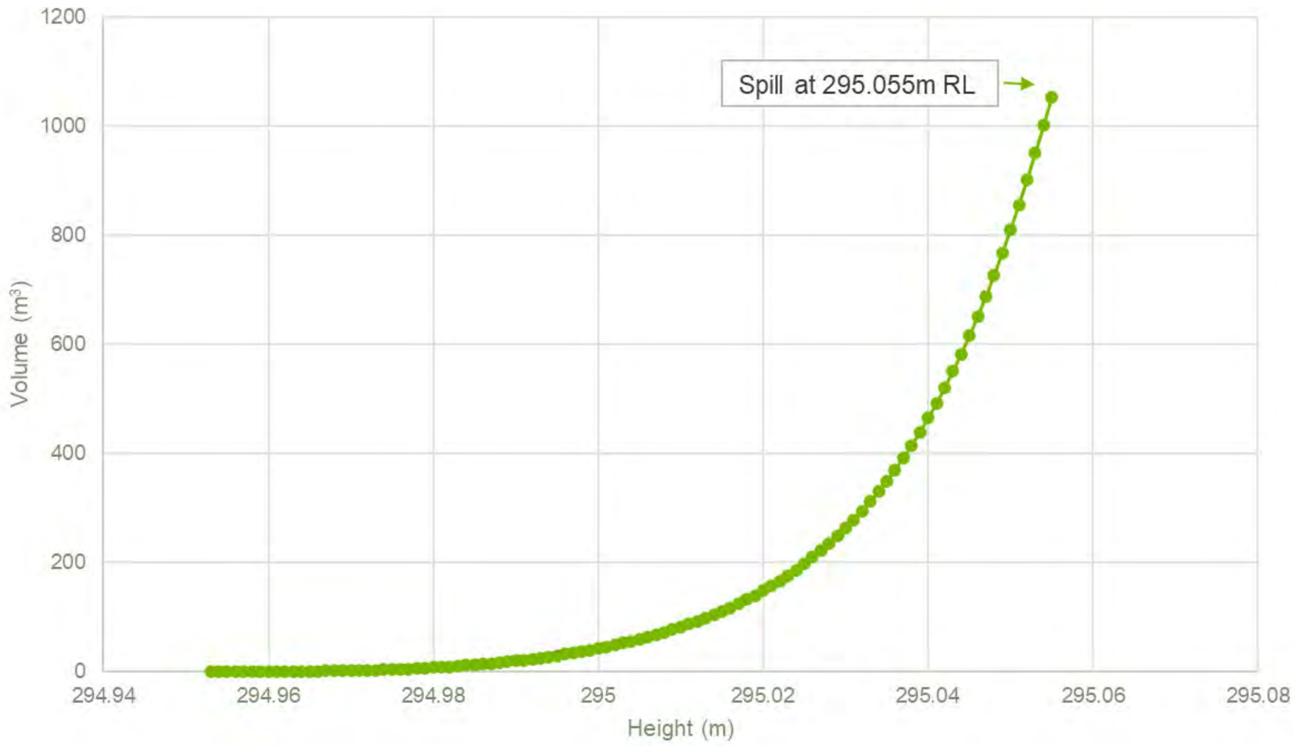


Figure 3-3. Storage Curve for South-west catchment, Seasonal Herbaceous Wetland

3.2 Post-Development

The post-development Conceptual Site Model is shown in Figure 3-4 with the proposed changes in surface water drainage shown.

These changes are associated with drainage infrastructure that will capture runoff and manage flooding and stormwater pollutants from the Beveridge Intermodal Precinct Stage 1A Project. The summary below should be considered in conjunction with the descriptions of how the Beveridge Intermodal Precinct Stage 1A Project will alter drainage which are provided in Section 3.1.3 and 3.1.4 below, Table 9-7 in Appendix A, and summarised here:

- The West catchment is to remain unchanged ensuring the majority of natural flows arriving at Farm Drain 1 are preserved.
- The South-West catchment is also largely unchanged as catchment areas and levels of the swamp will remain unchanged and will function as they currently do. Figure 3-4 shows the small changes in catchment area that are proposed to protect the mapped SHWTLP community from direct impacts of poor water quality.
- The North-East catchment is also largely unchanged and continues to deliver overland flow and groundwater to the Merri Creek (shown in blue) and south with minimal interruption to existing groundwater and surface water flow patterns, 0.712 Ha of new earthworks and hardstand will be introduced at the western extent of the catchment and approximately 2.452 Ha of viaduct located above

the floodplain on concrete piers. Runoff from these areas will be managed by shallow, water sensitive urban design measures designed to remove pollutants from the runoff prior to entering Farm drain 1 and mimic local hydrologic processes.

- The South catchment is unchanged 5.27 Ha of earthworks and hardstand will be introduced at the southern extent of the catchment. This will drain directly to Herne Swamp and Farm Drain 1. Runoff from these areas will also be managed by shallow, water sensitive urban design measures designed to remove pollutants from the runoff prior to entering Farm drain 1 and mimic local hydrologic processes.
- The South-East catchment does not include any sections of the Beveridge Intermodal Precinct Stage 1A Project.
- Impacts of the Beveridge Intermodal Precinct Stage 1A Project will be assessed at the two locations circled: Downstream of the Stage 1A boundary rail culverts (location 1), and downstream of the confluence of Farm Drain 1 and Merri Creek (location 2).

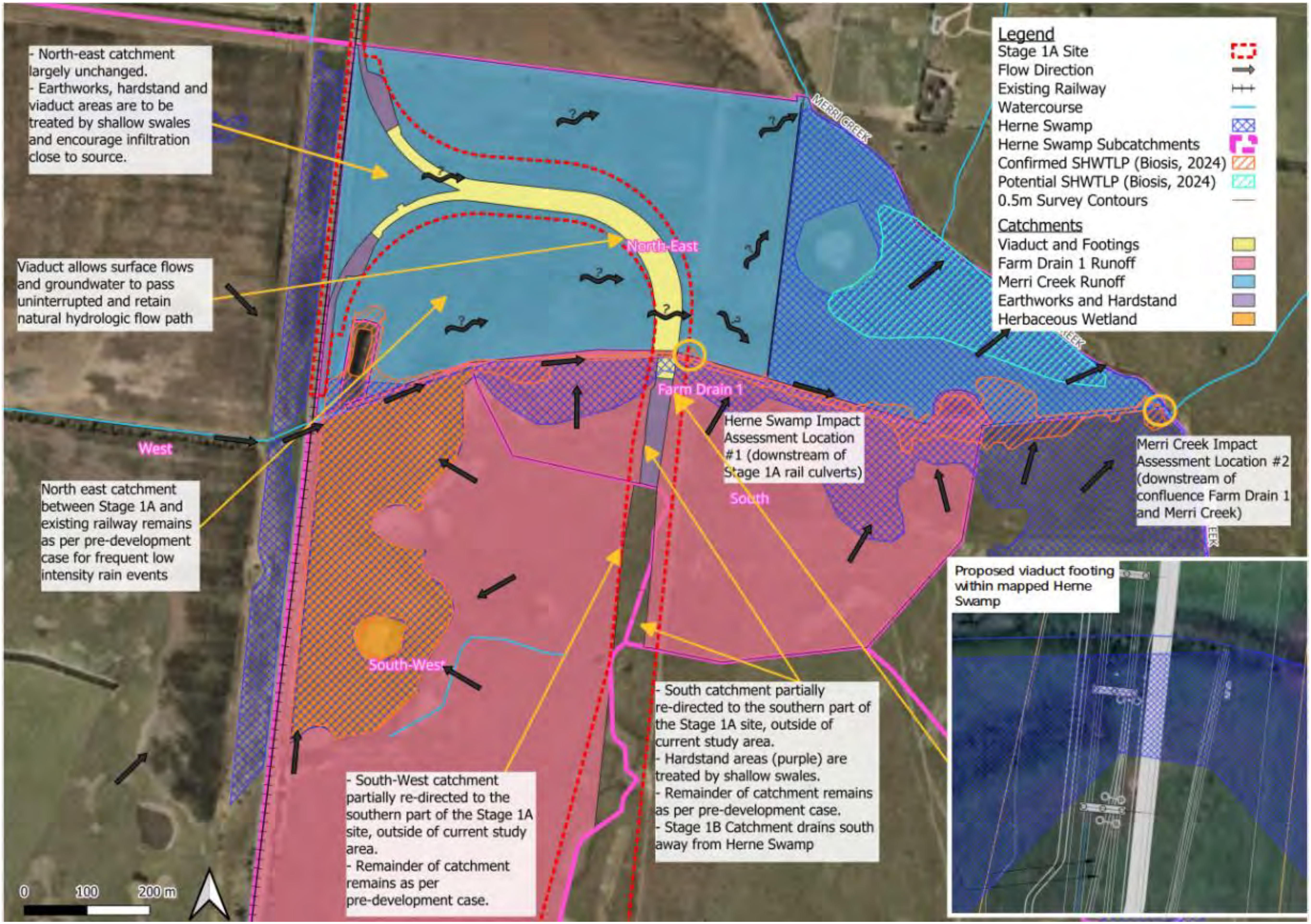


Figure 3-4. Conceptual Site Model of Herne Swamp – Post Development

4 Hydrological and Water Quality Modelling

Baseline hydrological and water quality modelling (MUSIC software) was undertaken to determine whether the Beveridge Intermodal Precinct Stage 1A Project is likely to cause changes to the wetting, drying and water quality processes outlined in above.

4.1 Hydrologic Modelling

4.1.1 Overview

A hydrological model of the study area was developed using eWater's software package MUSIC 'Model for Urban Stormwater Improvement Conceptualisation' (v6.3.0, eWater). MUSIC is a continuous simulation modelling software that uses water balance and mass balance calculations to model water and contaminant transport.

Existing and post-development flows and contaminant loading to Merri Creek and Herne Swamp were simulated to understand the potential change in hydrological regime in Herne Swamp as a result of the Beveridge Intermodal Precinct Stage 1A Project. Three separate climate periods were selected to represent dry, average, and wet rainfall years.

Modelling has been undertaken in accordance with the Melbourne Water MUSIC Guidelines (July, 2024). Insufficient data is available to calibrate the models to local soil and groundwater conditions, however sensitivity analysis has been included to provide certainty that the modelled impacts reflect the potential changes in hydrology and hydraulics under a range of possible underlying soil conditions.

The MUSIC model input parameters, catchment areas, and schematic are described in Section 4.1.2 below, with further detail provided in Appendix A.

4.1.2 Model Development & Parameters

Climate data

Climate data was sourced from SILO, a "database of Australian climate data from 1889 to the present". Point climate data for daily rainfall and Potential Evapotranspiration (Morton's PET) were obtained.

Rainfall

A percentile analysis of the total annual rainfall over the chosen 34-year period (1990-2023, 651.5 mm average total annual rainfall) was undertaken to determine a representative dry (10^{th} percentile), average (50^{th} percentile), and wet (90^{th} percentile) rainfall year for use in modelling. The two years with annual rainfall totals closest to each percentile were identified and the annual number of days with daily rainfall totals >1 mm, >5 mm, >10 mm, >25 mm, >50 mm, and >100 mm were compared to determine the most representative. Refer Appendix A. Based on this analysis, the following years were selected for modelling:

- 2006 as a representative "dry" year (467.6 mm total annual rainfall);
- 2013 as a representative "average" year (634.4 mm total annual rainfall); and
- 1996 as a representative "wet" year (842.2 mm total annual rainfall).

For each year, rainfall was modelled on a daily timestep.

Potential evapotranspiration (PET)

Monthly average Potential Evapotranspiration for the 34-year period was calculated from the SILO data (total annual PET 1456mm). It was compared against the “Melbourne Regional” MUSIC template values (total annual PET 990mm) (Melbourne Water, 2024). The difference between the datasets is shown on Figure 4-1 below. It is noted that PET values from the SILO data are 50% higher.

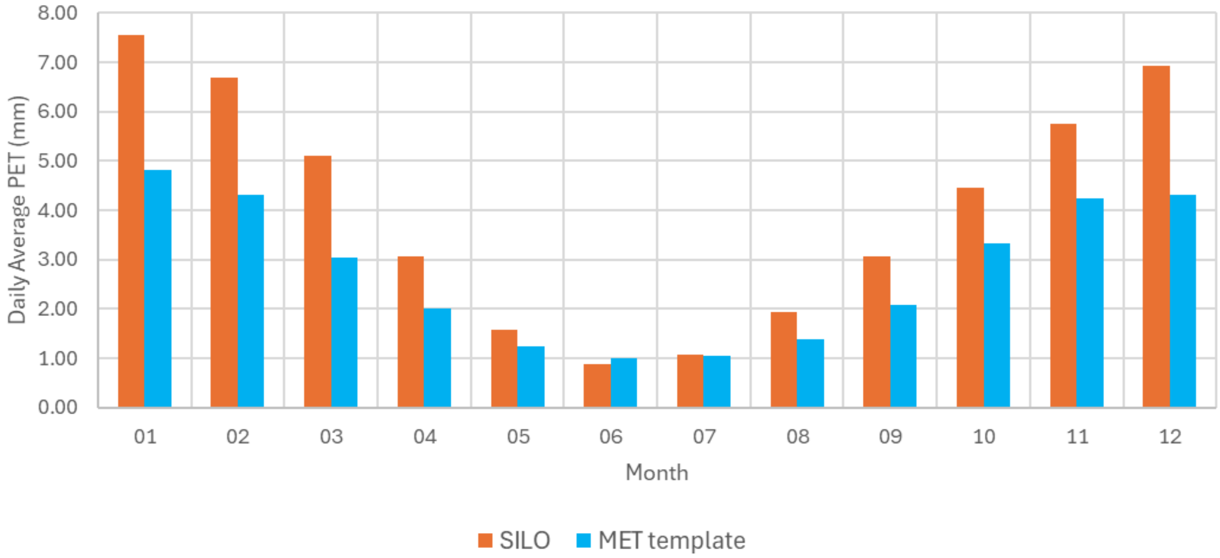


Figure 4-1. Daily Average Potential Evapotranspiration Comparison

The SILO data has been used in the MUSIC modelling as it is taken from the data source closest to the site, therefore considered more representative of the site conditions. Refer Appendix A for adopted daily values.

Rainfall runoff parameters

Pervious area rainfall runoff parameters for input into MUSIC have been based on Melbourne Water MUSIC Guidelines (Melbourne Water, July 2024). The adopted Rainfall runoff parameters are based primarily on the Melbourne Water MUSIC Guidelines (Melbourne Water, July 2024). This recommends adopting 120 mm for soil storage capacity and 50 mm for field capacity in combination with the default MUSIC parameters.

To more specifically reflect characteristics of the silt and clay soils found in the study area, sensitivity parameters have been sourced from the NSW MUSIC Modelling Guidelines (BMT WBM, August 2015).

Pollutant parameters

The MUSIC default stormwater pollutant concentrations were adopted in the MUSIC modelling as per Melbourne Water MUSIC Guidelines (July, 2024). These are presented in Appendix A.

MUSIC model schematisation

The MUSIC model schematisation is shown in Appendix A.

4.1.3 Merri Creek Modelling

Figure 4-2. shows the Merri Creek MUSIC model catchment boundary. Note:

- The larger Merri Creek catchment was broken into 4 sub-catchments. Each sub-catchment was modelled with a mixed urban and agricultural source node.
- The land planning zone codes shown below were used to allocate areas and impervious percentages to each MUSIC node, based on the Melbourne Water MUSIC Guidelines (July, 2024).
- The downstream boundary of the Merri Creek MUSIC model is at the confluence of Merri Creek with Farm Drain 1.

- The Herne Swamp sub-catchment, indicated below as the 'Study Area', was excluded from the Merri Creek model and modelled separately (described in Section 4.1.4).Therefore, since there are no changes within the Merri Creek catchment boundary between the pre and post development cases, there is only one case modelled for Merri Creek to estimate flow and pollutant loading.

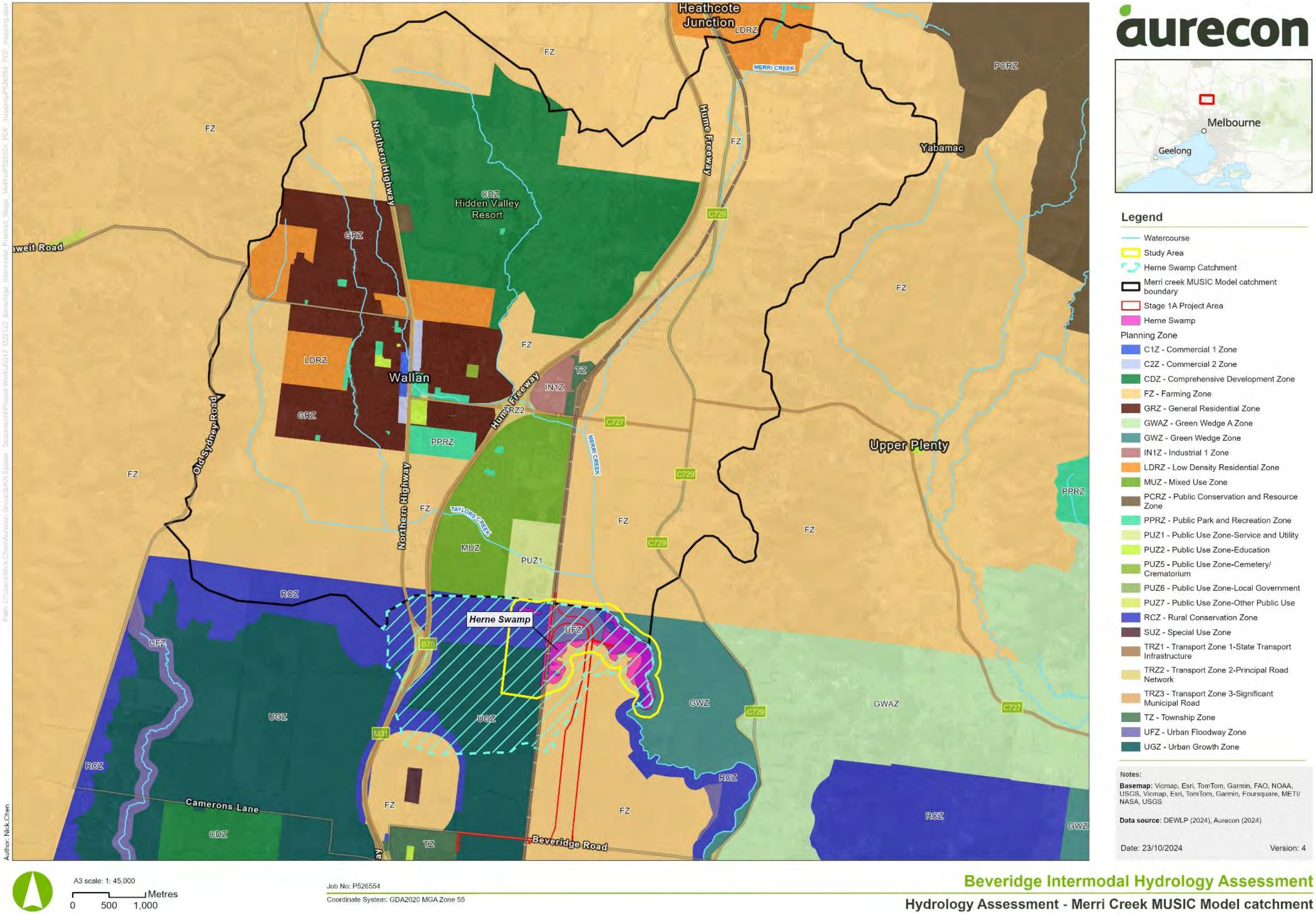


Figure 4-2. Merri Creek MUSIC Model catchment boundary

4.1.4 Herne Swamp Catchment Changes

The South-West, North-East, and South/Farm Drain 1 catchments contain SHWTLP mapped by Biosis (2024). These catchments include Beveridge Intermodal Precinct Stage 1A Project (SMEC, 2024) however the largest risk of impact is associated with works in the south western catchment, as described in Table 9-7 in Appendix B.

Earthworks and hardstand areas are proposed within the South/Farm Drain 1 catchment at the southern edge of the proposed viaduct and study area. Runoff from this area will be redirected to Farm Drain 1 through formal drainage. The proposed development will increase the imperviousness of the Farm Drain 1 catchment by 0.53 Ha which accounts for approximately 0.1% of its upstream catchment. As such, an incremental increase in flow to Farm Drain 1 is anticipated, but the impact is likely to be insignificant due to broader catchment inflows to Farm Drain 1 from the west. The section of the rail corridor within the Southern catchment will require drainage swales and stormwater treatment prior to discharging to the Farm Drain 1. Treatment options may include vegetated swales and the effectiveness of these will be further assessed in the detailed design phase to meet water quality objectives or if additional measures are required.

For the South-West and North-East catchments, changes in effective imperviousness will be effectively zero since no drainage works will collect, concentrate and discharge runoff into the Herne Swamp or its feeding waterways. To quantify potential stormwater pollutant loads, areas of imperviousness and new changes in land use associated with the Stage 1A reference design were modelled as mixed urban nodes in MUSIC.

The West and South-East catchments will not be altered by Stage 1A and have been assessed without any changes between the pre and post development case.

The South-East catchment was excluded from the modelling as there are no areas that will be impacted by the Beveridge Intermodal Precinct Stage 1A Project and this catchment is downstream of the confluence of Merri Creek with Farm Drain 1 which is where impacts are assessed.

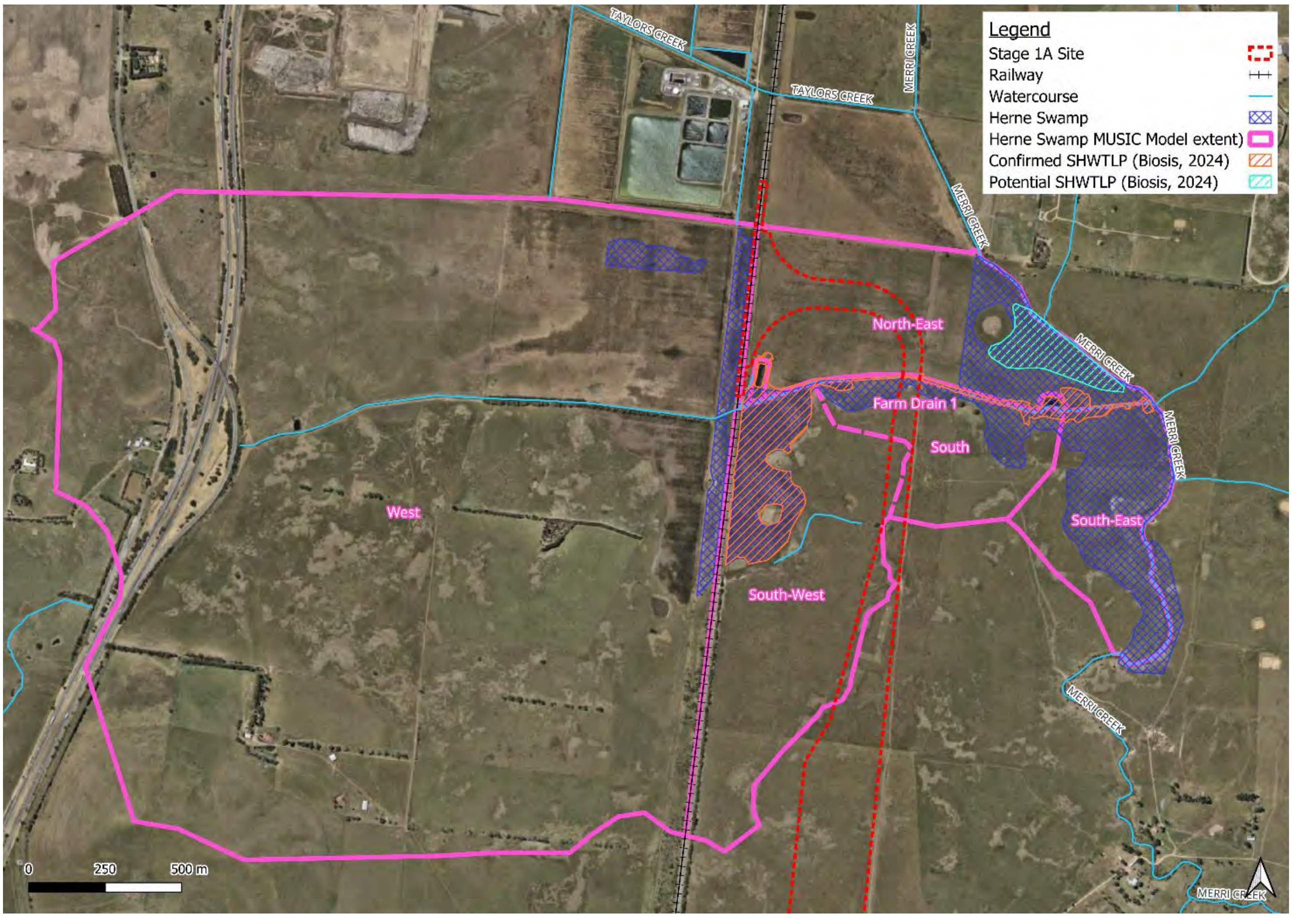


Figure 4-3. Herne Swamp MUSIC Model catchment boundary

4.2 Herne Swamp Water Balance

4.2.1 Overview

Water balance models were developed to understand the impact of the Beveridge Intermodal Precinct Stage 1A Project on wetting and drying processes within Herne Swamp.

This assessment is undertaken for each of the three catchments (South-West, North-East, and South) identified in the post-development Conceptual Site model in Section 3.2, Figure 3-4.

Hydrological inputs from the MUSIC modelling described in Section 4.1.4 were used.

Water balance models were developed for a representative dry, average, and wet rainfall year.

4.2.2 Water Balance Development

Table 4-1 Herne Swamp Water Balance Development

<table>
<tr><th>Catchment</th><th>Water Balance Development</th></tr>
<tr><td>South-West</td><td>
A spreadsheet water balance was set up using the following equation:
V(i) = V(i-1) + (Qhs + Psw) - (E + I) - L
<table>
<tr><th>Where</th><th>Description</th><th>Unit</th><th>Source/formula</th></tr>
<tr><td>V(i)</td><td>Storage volume at timestep i</td><td>m3</td><td>Calculated in excel</td></tr>
<tr><td>V(i-1)</td><td>Storage volume at previous timestep i-1</td><td>m3</td><td>Calculated in excel</td></tr>
<tr><td>Qhs</td><td>Flow from hillside catchment</td><td>m3</td><td>Daily flow from catchment from MUSIC model</td></tr>
<tr><td>Psw</td><td>Precipitation on swamp</td><td>m3</td><td>Daily rainfall x swamp catchment footprint area</td></tr>
<tr><td>E</td><td>Evapotranspiration</td><td>m3</td><td>SILO Evaporation depth for relevant month x swamp water surface area</td></tr>
<tr><td>I</td><td>Infiltration</td><td>m3</td><td>Infiltration depth (constant) x swamp water surface area</td></tr>
<tr><td>L</td><td>Spill to Drain 1</td><td>m3</td><td>If swamp storage capacity is reached, remaining volume spills to Drain 1</td></tr>
</table>
The water balance model was set up with the following assumptions:

Daily flow for the hillside catchment was extracted from MUSIC
Daily flow in the herbaceous swamp component of the catchment was calculated by multiplying daily rainfall by catchment area
Evapotranspiration and infiltration values were based on swamp surface area from the previous day
Evapotranspiration values from SILO were used
An infiltration rate of 1mm/day was assumed. Sensitivity testing of the outcome to this assumption was undertaken with an infiltration rate of 5mm/day.
If swamp storage capacity is reached, it is assumed everything above capacity drains within that timestep and volume at end of timestep is equal to the swamp storage capacity.
Storage volume, surface area, and height in the swamp are related with the storage curve in Section 3.1.1

</td></tr>
<tr><td>North-East</td><td>Assessed in terms of potential for flow redistribution and new imperviousness that is directly connected to Herne Swamp</td></tr>
<tr><td>South</td><td>Assessed in terms of potential for flow redistribution and new imperviousness that is directly connected to Herne Swamp</td></tr>
</table>

4.3 Hydrologic Assessment

4.3.1 Herne Swamp – South-West catchment

There is negligible change in water level in South-West Herne swamp throughout the year as a result of the Beveridge Intermodal Precinct Stage 1A Project for all three rainfall years assessed. This is shown on the water level (Figure 4-4 to Figure 4-6) and water level duration (Figure 4-7) curves below. These results were produced with a low infiltration rate (1 mm /day) applied across the inundated surface of the Swamp to estimate the volume lost to infiltration. A higher rate of infiltration (5mm/day) sensitivity was also tested to assess the sensitivity of water level to this uncalibrated value. The sensitivity testing shows that the impacts of Stage 1A will be insignificant whether the soil infiltration rate is low or high. This modelling is presented in Appendix B.

Figure 4-4. South-West Herne Swamp – Water Level variation (average rainfall year) (1mm infiltration)

Figure 4-5. South-West Herne Swamp – Water Level variation (dry rainfall year) (1mm infiltration)

Figure 4-6. South-West Herne Swamp – Water Level variation (wet rainfall year) (1mm infiltration)

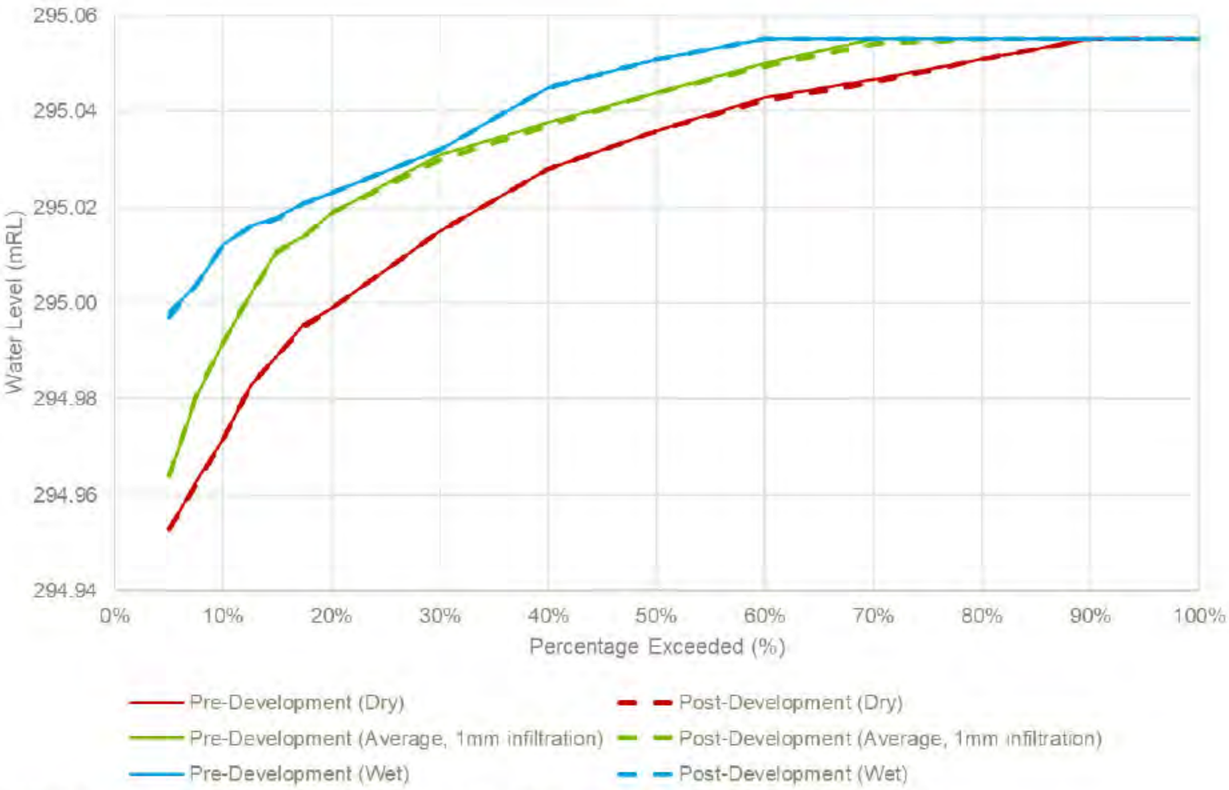


Figure 4-7. South-West Herne Swamp – Water level duration curve (1mm infiltration)

Figure 4-7 shows that as a results of the Beveridge Intermodal Precinct Stage 1A Project, there is:

- A 0.3% to 1.6% reduction in mean annual runoff volume (MARV) for the South-West catchment.
- A negligible reduction in number of annual spills from the swamp modelled storage.
- No change in "dry" conditions (defined as less than 1 m^3 volume within swamp).

Table 4-2. South-West Herne Swamp – water balance results

Parameter	Dry rainfall year			Average rainfall year			Wet rainfall year		
	Pre-Dev	Post-Dev	% Change	Pre-Dev	Post-Dev	% Change	Pre-Dev	Post-Dev	% Change
MARV (ML/year)	52.7	52.6	-0.3	91.8	90.8	-1.1	154.5	151.9	-1.6
Number of spills	46	45	-2.0	101	99	-2.0	142	142	0
Number of dry days	33	33	0	24	24	0	8	8	0

4.3.2 Herne Swamp – North-East catchment

The proposed viaduct crossing and access track across the North Eastern catchment will minimise changes in surface drainage patterns. Small, localised drainage changes may be expected around viaduct footings and along a section of new rail, earthworks and hardstand (0.712 ha) at the junction with the existing rail line.

Rainfall and runoff generated from the earthworks area, new hardstand, access track and viaduct in this catchment will be managed by shallow, informal swales to capture runoff, provide pollution reductions and infiltrate that water as close to its source as possible. Swales will not be constructed to concentrate and convey stormwater or significantly redistribute surface flows within Herne Swamp. The swales will preserve the existing flow paths, infiltration and hydrology of the North-east catchment.

As such new hardstand will not be directly connected to the Farm Drain 1 and areas of mapped Herne Swamp. No change in the effective imperviousness, infiltration capacity or drainage patterns will result from the Stage 1A works in this catchment.

The combined effect of the earthworks and viaduct will be minimised and will not result in any significant redistribution of flows or alteration of the hydrologic function of the North East catchment.

4.3.3 Herne Swamp – South / Farm Drain 1 catchment

The proposed viaduct crossing over the South catchment and Farm Drain 1 will not result in any significant changes in surface drainage patterns within Farm Drain 1 within Herne Swamp.

Minor, localised drainage changes may be expected around viaduct footings within the mapped Herne Swamp.

Areas of proposed hardstand and earthworks (0.527 ha) within the South catchment will modify the local catchment discharging to Farm Drain 1, however relative to the entire catchment discharging to the waterway (570.6 Ha), the additional impervious area accounts for a small incremental change (0.1% of the catchment).

The relative change in imperviousness in the Farm Drain 1 catchment has not been modelled as there is a low risk of this additional area impacting on the waterways.

Hydrologic function of the Farm Drain 1 will remain effectively unchanged.

4.3.4 Herne Swamp Operational Water Quality

Pollutant loads resulting from the Beveridge Intermodal Precinct Stage 1A Project have the potential to increase sediment, litter, metals and nutrients in stormwater runoff.

Runoff from paved areas and new earthworks will be intercepted by vegetated swales and biofiltration to encourage stormwater infiltration. The removal efficiency of swales is dependent on the density and height of the vegetation in the channel. For MUSIC modelling undertaken in this assessment, a vegetation height of 20 mm was adopted to reflect the swale design by SMEC (2024).

The proposed viaduct crossing, access track and footings will not generate concentrated stormwater runoff as it is a suspended structure, and the concrete footings have no direct connection to waterways. Runoff from the structure can be allowed to be drained to the ground below without being collected and diverted away from the source. Sediment, litter, metals and nutrients in stormwater can be captured at ground below within informal, managed vegetated swales adjacent to the access track. These informal swales would be designed to facilitate infiltration rather than collect and redistribute runoff. Further discussion and recommendations on the vegetated swale design is provided in Section 7.2.1

Table 4-3 indicates the treatment effectiveness of the notional swales in treating runoff from hardstand areas and viaduct surfaces directed into them. These values represent the pollution capture efficiency for the extent of potential works in Stage 1A only.

Table 4-3. Herne Swamp – Treatment effectiveness of swales – % Reduction at Stage 1A project boundary

Parameter	Performance Objective[1]	Dry rainfall year	Average rainfall year	Wet rainfall year	Target Met?
Total Suspended Solids (TSS)	-80%	-91.2%	-91.2%	-91.1%	Yes
Total Phosphorus (TP)	-45%	-63.2%	-63.3%	-63.0%	Yes
Total Nitrogen (TN)	-45%	-43.7%	-42.8%	-40.9%	No
Gross Pollutants (GP) / Litter	-70%	-100%	-100%	-100%	Yes
Flow (water volume)	-72% / -9%[2]	0%	0%	0%	No

[1]BPEM 1739.1

[2]72% (harvest/evapotranspiration) and 9% (infiltrate) of mean annual impervious run-off

Table 4-4 demonstrates overall modelled change in pollutant loads generated from the Herne Swamp catchment by comparing the pre and post development stormwater pollutant loads at the downstream end of Herne Swamp, prior to its confluence with Merri Creek. This shows that across average rainfall periods, the contribution of urban runoff from the Beveridge Intermodal Precinct Stage 1A Project is small generating a small incremental increase in phosphorous and nitrogen associated with the additional volume of runoff produced from hardstand areas. Mitigation measures are discussed in Section 7.

Table 4-4. Herne Swamp Impacts at Merri Creek Confluence – % Change from pre-development to post-development (treated)

Parameter	Dry rainfall year	Average rainfall year	Wet rainfall year
Total Suspended Solids (TSS)	+13.7%	+1.8%	0%
Total Phosphorus (TP)	+25.5%	+5.4%	+2.5%
Total Nitrogen (TN)	+32.9%	+7.4%	+4.2%
Gross Pollutants (GP) / Litter	0%	0%	0%
Flow (water volume)	+25.7%	+5.3%	+2.3%

4.3.5 Merri Creek Impacts

Table 4-5 shows the changes between pre and post development pollutant loads downstream of the confluence of the Farm Drain 1 and Merri Creek; which forms part of the Herne Swamp southern catchment. This demonstrates the overall impact in Merri Creek can be mitigated through a combination managed, informal swales. The total Herne Swamp catchment area is only 9% of the total combined Herne Swamp and Merri Creek area. The are no changes between pre and post development for TSS, TP, and GP. There are expected to be minor changes between pre and post development for TN and flow. The Beveridge Intermodal Precinct Stage 1A presents very small changes within the Herne Swamp catchment, overall pollutant load changes associated with the land use are small and manageable with swales, and if required, pollutant removal could be improved through the use of leaky biofiltration that discharges to groundwater.

Table 4-5. Combined Impacts from Herne Swamp and Merri Creek catchments at Merri Creek Confluence – % Change from pre-development to post-development (treated)

Parameter	Dry rainfall year	Average rainfall year	Wet rainfall year
Total Suspended Solids (TSS)	0%	0%	0%
Total Phosphorus (TP)	0%	0%	0%
Total Nitrogen (TN)	0%	+0.4%	+0.3%
Gross Pollutants (GP) / Litter	0%	0%	0%
Flow (water volume)	+0.2%	+0.2%	0%

5 Construction Impact Assessment

5.1 Impact Assessment

An impact assessment for the construction and the operational phases of this proposal are outlined in this section and Section 6, respectively. The potential and residual impact are based on modelling provided in Section 4 and risk definitions set out below and in Table 5-1.

- **Low**: Potential adverse impact could result in a minimal/not noticeable decline in the resource in the study area.
- **Medium**: Potential adverse impact could result in a decline in the resource/quality of a resource in the study area. Impact can often be managed through standard safeguards.
- **High**: Potential adverse impact could result in a decline in the resource/quality of a resource to lower than-baseline/worse-than-baseline. Impacts would require specific management as impact could have large community/environmental issues.
- **Extreme**: Potential adverse impact could result in significant decline in the resource/quality of a resource to significantly lower-than-baseline/worse-than-baseline condition. Impacts would require specific management as impact would have significant community/environmental issues.

Table 5-1 Qualitative risk assessment

Risk Assessment		Most credible consequence level				
		Insignificant	Minor	Moderate	Major	Severe
Likelihood	Almost Certain	Medium	High	High	Extreme	Extreme
	Likely	Medium	Medium	High	High	Extreme
	Possible	Low	Medium	Medium	High	High
	Unlikely	Low	Low	Medium	Medium	High
	Rare	Low	Low	Low	Medium	Medium

5.2 Summary of Construction Impacts

If not managed correctly, the following construction activities could potentially lead to adverse impacts to the surface water and groundwater environment:

- Construction across waterways such as the farm drain flowing into farm dams and Merri Creek
- Vegetation removal and earthworks along the entire extent of the proposal area
- Leaks and spills within construction areas within the proposal areas
- Construction and operation of ancillary facilities
- Stockpiles
- Transportation of materials

A summary of the potential impacts to the environment and the assessed residual impact with the proposed management measures in place is provided in Table 5-2.

Table 5-2. Construction impact summary

Activity	Potential Impacts	Potential effect in receiving environment	Assessed potential impact	Management measures	Assessed residual impact
Clearing / removal of vegetation including native vegetation.	Loss or damage to ecological community Notably 0.03 Ha of SHWTLP as identified by ecological survey (Biosis, 2025)	Loss of ecological habitat in Herne Swamp, Farm Drain 1 species and community habitat	High	Delineate critical vegetation communities such as SHWTLP on site and establish exclusion zones no work zones. A Construction Environmental Management Plan (CEMP) has been recommended to be put in place prior and during site development, ensuring appropriate environmental management. A Site Environmental Implementation Plan (SEIP) is also required to be prepared by the Contractor. This should identify locations and nature of key environmental controls and pre-construction works for mitigation of environmental risks. Identify areas for potential regeneration of threatened ecological community footprint	Low
Earthworks, permanent and temporary landscaping	Discharge of sediment-laden runoff from cleared areas to Herne Swamp, Farm Drain 1 and Merri Creek	Sedimentation, water quality impacts and habitat degradation within the receiving waterways.	Medium	The Construction Environmental Management Plan (CEMP) prepared by the Contractor must include the approach to erosion and sediment control to prevent sediment laden water entering Herne Swamp or Merri Creek. Erosion and sediment controls designed and implemented in accordance with EPA Victoria construction guidelines (Publications 275, 1834 and 1896) will be implemented for works in the vicinity of waterways and wetlands such that water quality of waterways and wetlands that intersect the Project are maintained at preconstruction levels. Sediment runoff during construction is to be directed away from Herne Swamp and Merri Creek. A Site Environmental Implementation Plan (SEIP) is required to be prepared by the Contractor. This should identify locations and nature of key environmental controls and pre-construction works for mitigation of environmental risks, including sediment controls.	Low

Activity	Potential Impacts	Potential effect in receiving environment	Assessed potential impact	Management measures	Assessed residual impact
	Earthworks into groundwater table leading to groundwater intrusion in excavations. This could lead to leaching of pollutants to groundwater and localised interference to groundwater flow.	Localised disruption of groundwater flow and groundwater quality impacts which could potentially impact groundwater dependant ecosystems	Low	A Construction Environmental Management Plan (CEMP) has been recommended to be put in place prior and during site development, ensuring appropriate environmental management. This must include measures that outline the approach to groundwater management.	Low
Disturbance of contaminated land	Contaminant laden runoff discharging directly to Herne Swamp and Farm Drain 1 which may ultimately enter Merri Creek.	Water quality impacts and habitat degradation within the receiving waterways.	Low	A Sampling Analysis Quality Plan (SAQP) has been completed and preliminary Stage 1A environmental testing has been undertaken (Aurecon, 2024) which indicated Contaminants of Potential Concern analysed in soil were reported to be below the adopted screening criteria for the protection of human and ecological health. Based on the limited assessment undertaken, risk to construction workers, future site occupiers and ecological receptors is considered to be low and acceptable. This report outlines further recommendations which should be assessed prior to construction. A Construction Environmental Management Plan (CEMP) has been recommended to be put in place prior and during site development, ensuring appropriate environmental management. This must include the identification of any exposure of contaminated or hazardous material during construction and the management and control measures to be put in place.	Low
Dewatering of excavations and sediment basins and discharge of runoff	Direct release of sediment and contaminant laden waters to Herne Swamp and Merri Creek.	Sedimentation, water quality impacts and habitat degradation within the receiving waterways.	Medium	Sediment controls and dewatering management measures are be included in the Construction Environmental Management Plan (CEMP). A Site Environmental Implementation Plan (SEIP) is required to be prepared by the Contractor. This should identify pre-construction works for mitigation of environmental risks, including sediment controls.	Low

Activity	Potential Impacts	Potential effect in receiving environment	Assessed potential impact	Management measures	Assessed residual impact
Construction of access track and low-level culvert crossing across Farm Drain 1	Temporary interfere / divert existing flow paths during construction. Temporary disturbance to soils and potential to cause localised erosion impacts.	Increased potential for localised scour and erosion which could lead to water quality impacts within Merri Creek downstream. Creation of a barrier which may lead to increased overtopping of Farm Drain 1 into Herne Swamp.	Medium	A Construction Environmental Management Plan (CEMP) has been recommended to be put in place prior and during site development, ensuring appropriate environmental management. Erosion and sediment controls designed and implemented in accordance with EPA Victoria construction guidelines (Publications 275, 1834 and 1896) will be implemented for works in the vicinity of waterways and wetlands such that water quality of waterways and wetlands that intersect the Project are maintained at preconstruction levels A Working on Waterways Permit from Melbourne Water is likely required for works within or adjacent to Merri Creek and / or existing Melbourne Water drainage assets. The Contractor will be responsible for obtaining this Permit prior to construction commencing.	Low
Carrying out earthworks in sodic soils within the vicinity of watercourses (Farm Drain 1)	Interfere / divert existing flow paths.	Increased potential for localised erosion which could lead to water quality impacts within Merri Creek downstream.	Medium	A Construction Environmental Management Plan (CEMP) has been recommended to be put in place prior and during site development, ensuring appropriate environmental management. Erosion and sediment controls designed and implemented in accordance with EPA Victoria construction guidelines (Publications 275, 1834 and 1896) will be implemented for works in the vicinity of waterways and wetlands such that water quality of waterways and wetlands that intersect the Project are maintained at preconstruction levels A Working on Waterways Permit from Melbourne Water is likely required for works within or adjacent to Merri Creek and / or existing Melbourne Water drainage assets. The Contractor will be responsible for obtaining this Permit prior to construction commencing.	Low

Activity	Potential Impacts	Potential effect in receiving environment	Assessed potential impact	Management measures	Assessed residual impact
	Disturbance of the bed and banks of Farm Drain 1.	Expose erosive soils leading to sediment loads, water quality impacts and habitat degradation in Merri Creek.	Medium	A Construction Environmental Management Plan (CEMP) has been recommended to be put in place prior and during site development, ensuring appropriate environmental management. Special consideration will be given to the management of sodic soils. Erosion and sediment controls designed and implemented in accordance with EPA Victoria construction guidelines (Publications 275, 1834 and 1896) will be implemented for works in the vicinity of waterways and wetlands such that water quality of waterways and wetlands that intersect the Project are maintained at preconstruction levels. A Working on Waterways Permit from Melbourne Water is likely required for works within or adjacent to Merri Creek and / or existing Melbourne Water drainage assets. The Contractor will be responsible for obtaining this Permit prior to construction commencing.	Low
	Disturbance of the flood conditions and wetting and drying regime of Herne Swamp.	Loss or damage to ecological communities.	Low	Utilising a viaduct crossing over the Herne Swamp has a low impact on the existing hydrology of the Herne Swamp.	Low
Construction of ancillary facilities	Cement laden runoff or concrete wash water entering soils and local waterways.	Water quality impacts in surface water and groundwater.	Medium	Measures to manage concrete wash water will be included within the CEMP prepared by the contractor.	Low
Leaks and spills	Potentially harmful chemicals and substances accidentally released during construction spills or as result of maintenance works, refuelling and inappropriate storage or handling.	Water quality impacts in Farm Drain 1 and Herne Swamp.	Medium	Measures to minimise the potential impacts associated with accidental leaks and spills during construction will be incorporated in the CEMP prepared by the contractor.	Low

Activity	Potential Impacts	Potential effect in receiving environment	Assessed potential impact	Management measures	Assessed residual impact
	Leakage from amenity facilities or wastewater collection points with subsequent runoff into receiving watercourses.	Nutrient and microbiological water impacts in Farm Drain 1 and Herne Swamp.	Low	Measures to minimise the potential impacts associated with accidental leaks during construction will be incorporated in the CEMP prepared by the contractor.	Low
Stockpiling and removal of spoil	Loose material stored within the floodplain and overland flow paths mobilised to drainage lines during rainfall.	Sedimentation, water quality impacts and habitat degradation within Farm Drain 1 and Herne Swamp.	Medium	Stockpiles site locations would be confirmed during detailed designed within the ancillary facilities and managed in accordance with EPA Victoria construction guidelines (Publications 1895 – Managing stockpiles. Construction stockpiles should be placed within the approved Project area only and away from waterways and outside of areas mapped as high flood risk.	Low
	Stockpiles located within the floodplain would reduce floodplain storage and obstruct flows.	Disruption of overland flow and localised flood impacts in Merri Creek.	Low	A Construction Environmental Management Plan (CEMP) has been recommended to be put in place prior and during site development, ensuring appropriate environmental management, including waste classification for any spoil generated at the Site. Construction stockpiles should be placed within the approved Project area only and away from waterways.	Low
Transportation of materials	Waste materials such as concrete, plasterboard, timber, asbestos and contaminated soil spreading via surface run-off to Farm Drain 1.	Sedimentation, water quality impacts and habitat degradation within Farm Drain 1.	Low	A Construction Environmental Management Plan (CEMP) has been recommended to be put in place prior and during site development, ensuring appropriate environmental management. This must include the identification of any exposure of contaminated or hazardous material during construction and the management and control measures to be put in place.	Low

5.3 Overall Construction Impact Assessment

The key construction impacts are summarised below for Herne Swamp and for Merri Creek. The potential impacts to Herne Swamp, Farm Drain 1, and Merri Creek are expected to be managed by the Contractor through the implementation of the CEMP and SEIP.

5.3.1 Herne Swamp and Farm Drain 1

The key risks to Herne Swamp during the construction phase are from the potential impacts due to:

1. Potential damage of vegetation for works within mapped areas of SHWTLP vegetation associated with constructing an access track crossing over Farm Dam 1;
2. The introduction of sediment and contaminants from land disturbance; and
3. Exposure of potentially sodic soils that are prone to rapid erosion.

These risks can be managed through safeguards and controls around how, when and where construction activities are conducted.

During construction, it is expected that the potential impacts to Herne Swamp can largely be managed through the Construction Environmental Management Plan (CEMP) which will be put in place by the Contractor. Importantly, this document should specify the approach to erosion and sediment control and management and control measures for the potential exposure of contaminated and hazardous materials and establish no work zones to avoid SHWTLP vegetation communities.

Another important management measure for Herne Swamp will be the Site Environmental Implementation Plan (SEIP), prepared by the Contractor. This should identify locations and nature of key environmental controls and pre-construction works for mitigation environmental risks, including sediment controls and appropriate flow management around Herne Swamp, with particular attention to minimising impacts to the SHWTLP mapped areas.

The potential impact to Herne Swamp varies across the sub-catchments. The key risk areas are identified to be in the South, North East and South-East catchment, which contain the majority of the earthworks and hardstand construction within Stage 1A.

The south-west catchment of Herne Swamp contains the majority of the SHWTLP mapped by Biosis and this location is likely to have a lower construction risk, as it largely sits upstream of the Stage 1A footprint.

The Farm Drain 1 area will be crossed by a low level access track, viaduct works with one viaduct footing proposed within the DEECA mapped area but not within an area of mapped SHWTLP. Additionally, Biosis (2024) recommended that mitigation measures for the Growling Grass Frog should be addressed in the CEMP.

5.3.2 Merri Creek

The key risks to Merri Creek during the construction phase are from the potential impacts due to the introduction of sediment and contaminants. This is a potential impact from construction activities including earthworks, vegetation clearing and stockpiling.

During construction, it is expected that the potential impacts to Merri Creek can largely be managed through the Construction Environmental Management Plan (CEMP) which will be put in place by the Contractor. This document should specify the approach to

- excavating, handling and stabilising earthworks in sodic soils
- erosion and sediment control and management and
- control measures for the potential exposure of contaminated and hazardous materials and
- placement of stockpiled material and construction equipment in areas that present no loss of significant vegetation.

6 Operational Impact Assessment

6.1 Flow and Water Levels

A flow assessment of Herne Swamp has been carried out including a continuous simulation modelling and analysis of the seasonal wetting and drying patterns and water level flux within parts of Herne Swamp. In the following section, this information will help to:

- Define the frequency and duration of hydrological impacts.
- Contextualise and assess the severity of any water quality and hydrological impacts on Herne swamp and Merri Creek.
- Discuss whether impacts are likely to be repeated, for example as part of maintenance.
- Discuss whether any impacts are likely to be unknown, unpredictable, or irreversible.

6.1.1 Herne Swamp

The operational impacts to Herne Swamp were assessed on both a sub-catchment and overall basis. Impacts are described below:

- South-West catchment
  - There is a minor decrease in size of this catchment (3%) as a result of the Beveridge Intermodal Precinct Stage 1A Project. As a result, there is negligible change to the water level flux in the South-East Herne Swamp (reduction of up to 1.6% in mean annual runoff volume (wet rainfall year)).
  - The SHWTLP identified in this catchment was modelled with a water balance tool which demonstrates that no change in water level fluctuation is associated with the Beveridge Intermodal Precinct Stage 1A Project changes in the south-west catchment. The number of spills and number of dry days during the dry and wet rainfall years shows no change after delivery of Stage 1A. The average and dry rainfall years show a reduction up to 2% in spills to the adjacent farm drain. This change is so small that it is expected to have negligible impacts on the SHWTLP community.
  - Negligible changes are expected to the filling, wetting and drying characteristics of the South West farm dam and the associated potential habitat of the farm dam remains unchanged for Stage 1A.
- North-east catchment
  - The proposed construction of a viaduct crossing over the Swamp and North-east catchment will minimise impacts on natural hydrologic function of this area.
  - The earthworks and hardstand area at the intersection with the existing rail line will potentially generate runoff from a relatively small area of catchment to be managed with vegetated, informal swales along the access track. These swales would mimic natural evaporation and infiltration processes to minimise changes in surface water groundwater and generation that reaches the downstream Herne Swamp and Meri Creek areas.
  - Due to the flat grade of this catchment trending east to its original outlet to Merri Creek, it is expected that rain falling on the access track, viaduct structure and footings will continue to the ground to be managed within the proposed informal swales to remove pollutants and preserve natural hydrologic function of areas beneath the viaduct structure.
  - The viaduct and footings present a minimal disruption to the existing, natural hydrologic function of the north-east catchment. Runoff and shallow infiltration within the north-east catchment will continue to flow in its current patterns.
  - Negligible changes are expected to the filling, wetting and drying characteristics of the North East farm dam and the associated potential habitat of the farm dam remains unchanged for Stage 1A.
- South catchment

- The proposed viaduct and footings present an insignificant amount of change (0.1%) to Farm Drain 1 catchment and will have negligible impact on the existing hydrology. This minor overall catchment change is unlikely to impact habitat value of this area.

- West catchment
  - The West catchment is to remain unchanged ensuring the majority of natural flows arriving at Farm Drain 1 are preserved.
- South-East catchment
  - The South-East catchment is not affected by the Beveridge Intermodal Precinct Stage 1A Project.
- Overall Herne Swamp
  - The proposed viaduct and footings will result in a negligible change in the mean annual runoff and groundwater volumes at the Merri Creek outlet of Herne Swamp.
  - Negligible impacts will occur to the natural flow regime within the north-east and south catchments during the operational phase of the Beveridge Intermodal Precinct Stage 1A Project. Maintenance or other operational activities will not alter this impact or introduce additional impacts on the flow regime of Herne Swamp.
  - The assessment in this report is undertaken using best available data and using uncalibrated desktop modelling. If modelling does underestimate the actual impacts on the local hydrology of the Swamp, there are ways to further alter and improve the way surface water flows enter different zones of the wetland.

6.1.2 Merri Creek

No cumulative change will result in Merri Creek surface and groundwater flows rates as a result of the Beveridge Intermodal Precinct Stage 1A Project.

Runoff from the relatively small increase in impervious surfaces within the North-east and south catchments will be allowed to locally infiltrate. Localised changes in overland flow path or groundwater recharge are minimised.

Changes in tributary flows from the Herne Swamp catchment will be negligible. As such, direct and indirect impacts to the stability and geomorphology of Merri Creek are so small as to be insignificant.

6.2 Water quality

6.2.1 Herne Swamp

Pollutant loads resulting from the Beveridge Intermodal Precinct Stage 1A Project have the potential to increase sediment, litter, metals and nutrients in stormwater within the area immediately adjacent to track works and beneath the viaduct. Swales with formalised infiltration zones will manage urban runoff from the Stage 1A earthworks and improve water quality discharges.

Managed vegetation within informal swales will be provided under the viaduct to capture sediments, metals, hydrocarbons and nutrients that are washed off the viaduct structure. These will minimise the risk of increased stormwater pollutants while preserving the natural hydrologic function of the North-east catchment.

Based on the climate data adopted for this study, modelling indicates that the BPEM targets for TSS, TP, and GP (litter) are likely to be achieved for both Farm Dam 1 and Merri Creek.

Further design refinement may be required to achieve the BPEM targets for TN. These changes can be achieved by implementing small adjustments in the proposed swale arrangements which is discussed in Section 7. The model should also be verified with the Melbourne Water defined climate data to confirm whether the BPEM targets can be achieved.

Swale designs can be included in rehabilitation plan for the project area that compliments the revegetation and sodic soil management associated with earthworks and footing construction.

6.2.2 Merri Creek

Combined water quality impacts downstream of the Merri Creek confluence show:

- There is a no change in TSS, TP, and GP expected in Merri Creek.
- There is a minor increase in TN of up to 0.4% expected in Merri Creek.

These minor water quality changes are unlikely to have an impact on the ecosystems within Merri Creek.

7 Management and Mitigation

The impact assessment provided above is contingent on the delivery of water quality improvement swales and ensuring that temporary and permanent flow management works do not alter the arrival or drainage of zones in the Swamp, particularly areas of mapped vegetation.

The following mitigations are recommended as ways of managing any unforeseen impacts.

7.1 Construction

During the construction phase, there are potential impacts to Herne Swamp and Merri Creek due to activities including the clearing and removal of vegetation, earthworks, land disturbance and discharge of construction runoff.

It is expected that the potential impacts to Herne Swamp and Merri Creek can be managed by the Contractor through the implementation of the:

- Construction Environmental Management Plan (CEMP)
- Site Environmental Implementation Plan (SEIP)

These documents will establish the locations and nature of key environmental controls and pre-construction works for mitigating environmental risks around Herne Swamp and Merri Creek, with particular attention to the SHWTLP mapped areas and the management of sodic soils. This will include the approach and location of erosion and sediment control, controls for the potential exposure of erosive soils, management of contaminated and hazardous materials, and the establishment of no work zones to avoid SHWTLP vegetation communities.

7.2 Operation

7.2.1 Informal Swales

The notional pollution reduction performance shown in Section 6.2.1 requires small improvements in TN removal which can be provided through biofiltration and optimisation of WSUD measures to achieve the BPEM water quality target for nitrogen removal during detailed design. It is noted that this should be confirmed with the Melbourne Water defined climate data.

The following mitigation measures are recommended to achieve compliance with the targets:

- Appropriate revegetation and low-nutrient landscaping are required on the outer batters of all works and within the swales.
- Native grasses of 100 mm long are required in the swale.
- Informal swales or biofiltration must be shallow and include infiltration zones to encourage captured, filtered runoff to enter the groundwater as close as possible to its source.
- Informal swales must be designed to fill and spill in a similar manner to existing local flow patterns.

Areas of biofiltration may be included within the swale footprints to improve pollutant removal from runoff from new pavement or intensified landscaping treatments. and facilitate infiltration.Table 7-1 shows the improved nitrogen reduction performance of the treatment system with increased vegetation height.

Table 7-1. Herne Swamp – Treatment effectiveness of swales – % Reduction at Stage 1A project boundary

Parameter	Performance Objective[1]	Average rainfall year – swale as designed	Target Met?	Average rainfall year – swale modified (150mm vegetation height)	Target Met?
Total Nitrogen (TN)	-45%	-43%	No	-45%	Yes

[1]BPEM 1739.1

7.2.2 Flow and Water Level Management

This study uses hydrologic metrics to assess the potential changes to the hydrology associated with the Beveridge Intermodal Precinct Stage 1A Project.

Where swales are required to capture and filter stormwater runoff, every effort should be made to ensure that the swales protect the local hydrologic patterns. This will preclude any swales being designed and constructed to divert runoff away from where it currently flows.

Swales can be incorporated into rehabilitation works and should be designed by an appropriate specialist experienced in designing water sensitive urban design elements to preserve natural hydrologic function.

7.2.3 Recovery Potential

The recovery potential of the DEECA mapped Herne Swamp and the greater Herne Swamp is not altered by the proposed Stage 1A works. With the exception of the relatively small area of earthworks and viaduct footings, the natural hydrologic regime of the site is largely protected by the current viaduct design. Furthermore, it is entirely possible that the stormwater management swales proposed in this study complements the rehabilitation of the Herne Swamp.

8 Conclusions

This surface water assessment was undertaken to address the request for additional information (EPBC 2023/09693) including an assessment of the likely direct and indirect impacts to the environment of Herne Swamp wetland and the associated waterways during the construction, operational and maintenance components of the Beveridge Intermodal Precinct Stage 1A Project (Stage 1A). This assessment provides:

- An assessment of the likely duration of impacts to Herne Swamp wetland and the associated waterways, as a result of the Proposed Action.
- Discussion of whether the impacts are likely to be repeated, for example as part of maintenance.
- Discussion of whether any impacts are likely to be unknown, unpredictable or irreversible.

The assessment has been prepared with consideration to the EPBC Act Significant Impact Guidelines 1.2.

Potential Construction Impacts

The key risks to Herne Swamp identified during the construction phase are from the potential impacts due to:

- Potential damage of vegetation if works are not excluded from mapped areas of SHWTLP vegetation
- The introduction of sediment and contaminants from land disturbance
- Exposure of potentially sodic soils that are prone to rapid erosion.

During Construction, it is expected that the potential impacts can largely be mitigated through the implementation of the CEMP and SEIP. This should include identification of locations and nature of key environmental controls and pre-construction works for mitigating environmental risks, with particular indication for the controls for the SHWTLP mapped areas and the mitigation measures for the Growling Grass Frog.

Operational Impacts

A hydrologic assessment has been undertaken which includes hydrologic and hydraulic modelling of the potential changes to the seasonal wetting and drying regime and water level flux of Herne Swamp. Water quality modelling was also undertaken to understand the potential changes in stormwater pollution loads associated with the land use change.

The key outcomes from this modelling and assessment include that as a result of the Beveridge Intermodal Precinct Stage 1A Project:

- There is a minor decrease in size of the South-West Herne swamp catchment which contains the most significant stand of SHWTLP communities mapped by Biosis (2024). The change in catchment results in a negligible change to the water level flux in the South-West Herne Swamp. The changes in the duration and number of times the wetland fills, overflows and completely dries is negligible.
- The proposed viaduct crossing over the north-east and southern catchments presents a minimal disruption to natural hydrologic processes or disruption to the passage of flood waters, surface runoff and groundwater.
- There is a small change in impervious surfaces associated with the track works at the junction with the existing rail line. Stormwater runoff will be captured, filtered and infiltrated as close as possible to the source to protect the natural groundwater and hydrology of that area.
- There is a small change in impervious surfaces associated with the viaduct and footings but these surfaces are not directly connected to waterways and do not pose a significant risk of altered flows. Any runoff generated from the viaduct and footings will be captured within informal vegetated swales that will encourage infiltration as close as possible to the source.
- The hydrology and wetting and drying characteristics of the existing farm dams in the South, North East and South catchments will not be altered by Stage 1A. As such, no direct or indirect impacts is expected to any potential habitat value of the farm dams.

- Stage 1A works will not alter the hydrologic and hydraulic conditions in Merri Creek at the confluence or downstream. As such, no direct or indirect impacts will result to the stability and geomorphology of Merri Creek.
- Water quality impacts to Herne Swamp and Merri Creek are shown to be small in average rainfall years and in the order of a very small increase in annual loads associated with increases in stormwater runoff volumes. These changes are in the order of 5%. It is likely that the Beveridge Intermodal Precinct Stage 1A Project will achieve the BEPM criteria once the scheme is optimised and modelled in accordance with Melbourne Water's standard practice.

The following mitigations could be considered through design development to further complement the rehabilitation of Herne Swamp:

- Minor works associated with drainage culverts beneath the access track crossing at Farm Drain 1 and the proposed stormwater swales will not alter wetting and drying regimes in the South and North-Eastern zones of the Swamp. The wetting and drying regimes in the north-east and south catchments are expected to remain constant throughout the operation of the Beveridge Intermodal Precinct Stage 1A Project. Impacts are not expected to change over time however there are potential flow managements and flow interventions that could be implemented to improve or adjust flow impacts that are found and should be reversed. These can include changed culvert design and incorporation of leaky drains and flow spreaders associated with the proposed maintenance access track.
- Small improvements which can be provided through swale design optimisation to achieve the BPEM water quality target for nitrogen removal. It is noted that this should be confirmed with the Melbourne Water defined climate data.
- Optimised swale dimensions or additional areas of stormwater management, such as biofiltration, may be incorporated into the stormwater management assets if additional stormwater treatment is needed to improve water quality outcomes in the South catchment or accommodate additional pavement or intensified landscaping treatments are delivered beyond what is proposed for Stage 1A.
- To facilitate the reestablishment of SHWTLP vegetation within this East catchment or other areas where SHWTLP is absent, then there is potential to further refine or improve the hydrologic characteristics by providing small diversions, French drains and flow spreaders.

Outcome

National Intermodal has adapted the design to minimise the impacts on Herne Swamp to address concerns from stakeholders.

The design has further changed from an earth embankment with culverts to a viaduct structure. Sitting on concrete piers, the viaduct structure is designed to have a minimal footprint within and adjacent to Herne Swamp, being constructed over the floodplain zone to maintain natural flood passage. This will retain the SHWTLP along Farm Drain 1 and preserve the normal wetting and drying regimes for Herne Swamp.

The findings of this report demonstrate that the viaduct design will have minimal ongoing impacts to Herne Swamp and surrounding area and promote future conservation efforts.

9 References

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Appendix A – MUSIC Model parameters

Rainfall

The percentile analysis and comparison of daily rainfall totals to determine the years selected for modelling are shown on Table 9-1 and in Figure 9-1, with the selected years in bold. Annual rainfall totals for both years assessed for each scenario were within 5 mm of the percentile. Therefore, the representative rainfall years selected were based primarily on daily rainfall distributions.

Table 9-1. Rainfall analysis

Rainfall Scenario	Percentile	Percentile Rainfall total (mm)	Years assessed & Annual rainfall
Dry	10th	469.52	**2006** (467.6mm) & 1994 (474mm)
Average	50th	633.95	2005 (633.5mm) & **2013** (634.4mm)
Wet	90th	843.67	**1996** (842.2mm) & 1993 (844.3mm)

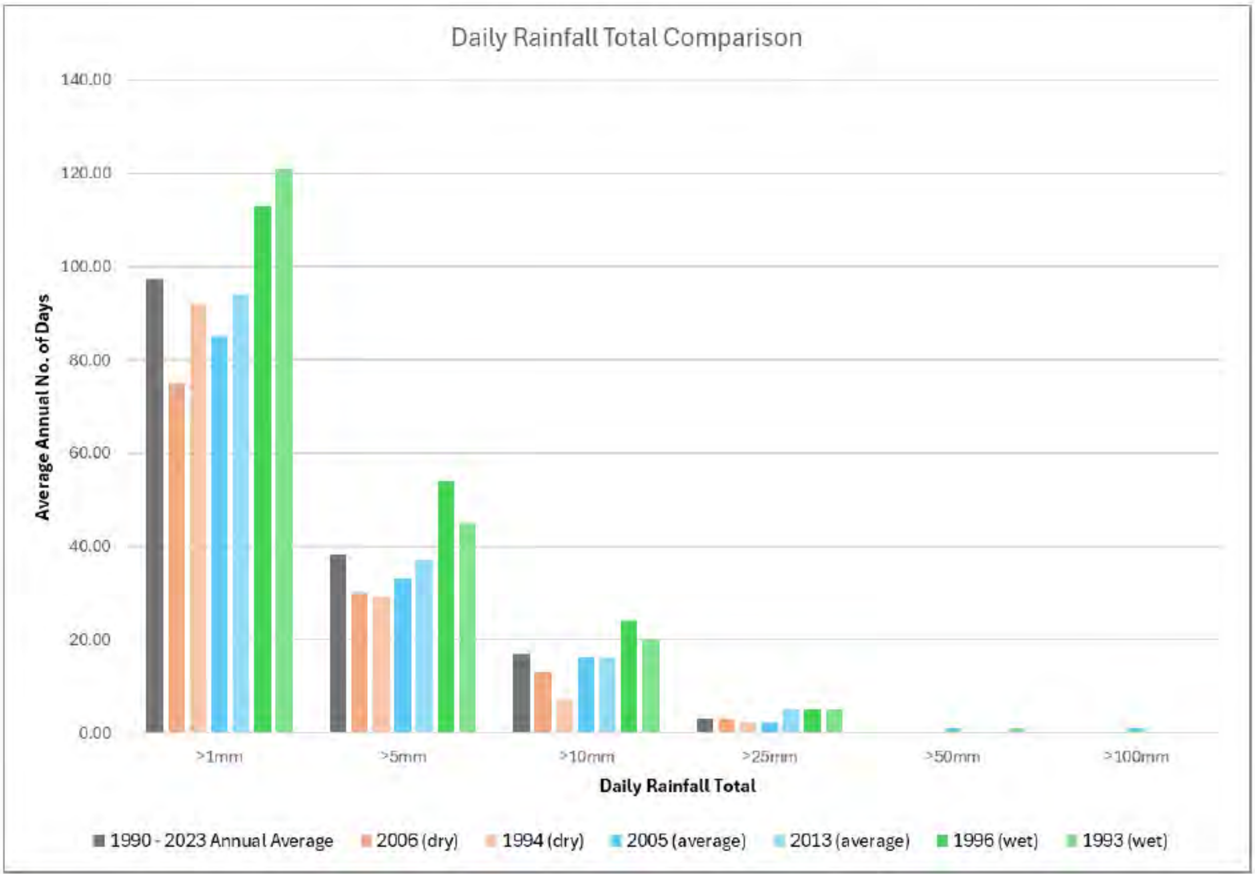


Figure 9-1. Daily Total Rainfall Comparison (Source: SILO)

Potential Evapotranspiration (PET)

Potential evapotranspiration values were obtained from SILO. PET was applied as a consistent value for each day in a month. The average PET per day was calculated as the average from the 34-year record.

Table 9-2. MUSIC –PET input values

Month	Average PET per day (mm)
January	7.54
February	6.69

Month	Average PET per day (mm)
March	5.10
April	3.07
May	1.57
June	0.88
July	1.06
August	1.93
September	3.06
October	4.44
November	5.74
December	6.94

Rainfall runoff parameters

Pervious area rainfall runoff parameters for input into MUSIC have been based on Melbourne Water MUSIC Guidelines (Melbourne Water, July 2024). The adopted[3] Rainfall runoff parameters are based on the Melbourne Water MUSIC Guidelines (Melbourne Water, July 2024). This recommends adopting 120 mm for soil storage capacity and 50 mm for field capacity[2] in combination with the default MUSIC parameters[1].

To more specifically reflect characteristics of the silt and clay soils found in the study area, sensitivity parameters[4] have been sourced from the NSW MUSIC Modelling Guidelines (BMT WBM, August 2015).

Table 9-3. MUSIC Rainfall runoff parameters

Parameter	MUSIC Default[1]	Melbourne Water Parameters[2]	Adopted[3]	Sensitivity[4]	Unit
Impervious area properties					
Rainfall Threshold	1	-	1	1	mm/day
Pervious area properties					
Soil storage capacity	120	120	120	54	mm
Initial storage	25	-	25	25	% of capacity
Field capacity	80	50	50	51	mm
Infiltration capacity coefficient - a	200	-	200	180	-
Infiltration capacity coefficient – b	1.0	-	1.0	3.0	-
Groundwater properties					
Initial depth	10	-	10	10	mm
Daily recharge rate	25	-	25	25	%
Daily baseflow rate	5	-	5	25	%
Daily deep seepage rate	0	-	0	0	%

Pollutant parameters

Default MUSIC pollutant parameters were applied as per the Melbourne Water MUSIC Guidelines. The mean pollutant estimation method was run due to stochastic estimation resulting in high pollutant load variability.

Table 9-4. MUSIC pollutant parameters

Pollutant Parameter	Agricultural	Mixed Urban	Forest
Total Suspended Solids - Base Flow Concentration - Mean (log mg/L)	1.4	1.1	0.9
Total Suspended Solids - Base Flow Concentration - Std Dev (log mg/L)	0.13	0.17	0.13
Total Suspended Solids - Base Flow Concentration - Estimation	1	1	1
Total Suspended Solids - Base Flow Concentration - Serial Correlation (R^2)	0	0	0
Total Suspended Solids - Storm Flow Concentration - Mean (log mg/L)	2.3	2.2	1.9
Total Suspended Solids - Storm Flow Concentration - Std Dev (log mg/L)	0.31	0.32	0.2
Total Suspended Solids - Storm Flow Concentration - Estimation	1	1	1
Total Suspended Solids - Storm Flow Concentration - Serial Correlation (R^2)	0	0	0
Total Phosphorus - Base Flow Concentration - Mean (log mg/L)	-0.88	-0.82	-1.5
Total Phosphorus - Base Flow Concentration - Std Dev (log mg/L)	0.13	0.19	0.13
Total Phosphorus - Base Flow Concentration - Estimation	1	1	1
Total Phosphorus - Base Flow Concentration - Serial Correlation (R^2)	0	0	0
Total Phosphorus - Storm Flow Concentration - Mean (log mg/L)	-0.27	-0.45	-1.1
Total Phosphorus - Storm Flow Concentration - Std Dev (log mg/L)	0.3	0.25	0.22
Total Phosphorus - Storm Flow Concentration - Estimation	1	1	1
Total Phosphorus - Storm Flow Concentration - Serial Correlation (R^2)	0	0	0
Total Nitrogen - Base Flow Concentration - Mean (log mg/L)	0.074	0.32	-0.14
Total Nitrogen - Base Flow Concentration - Std Dev (log mg/L)	0.13	0.12	0.13
Total Nitrogen - Base Flow Concentration - Estimation	1	1	1
Total Nitrogen - Base Flow Concentration - Serial Correlation (R^2)	0	0	0
Total Nitrogen - Storm Flow Concentration - Mean (log mg/L)	0.59	0.42	-0.075
Total Nitrogen - Storm Flow Concentration - Std Dev (log mg/L)	0.26	0.19	0.24
Total Nitrogen - Storm Flow Concentration - Estimation	1	1	1
Total Nitrogen - Storm Flow Concentration - Serial Correlation (R^2)	0	0	0

MUSIC model inputs – Merri Creek

The Merri Creek catchment was modelled in 4 sub-catchments in MUSIC.

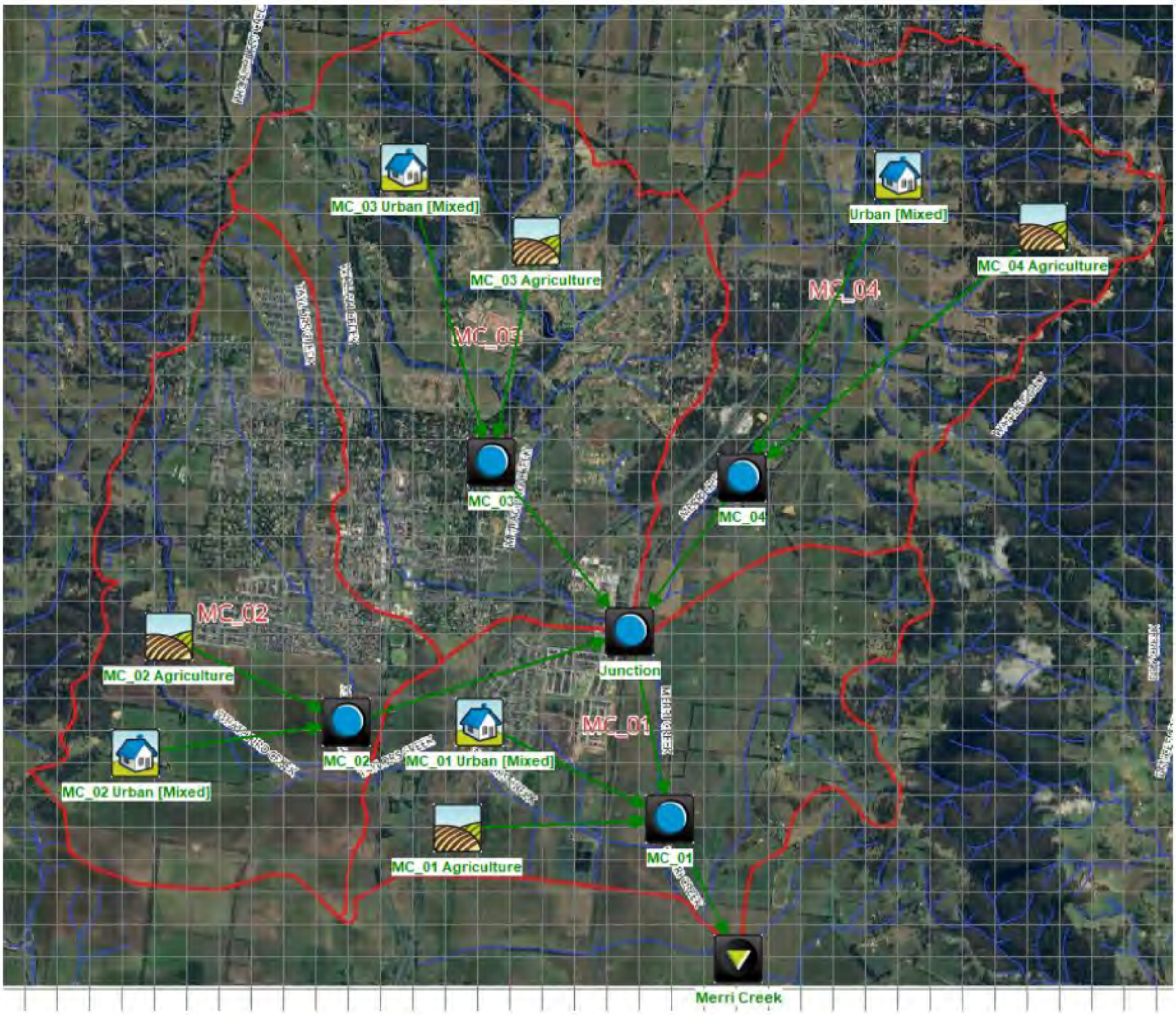


Figure 9-2. MUSIC Model Schematisation – Merri Creek

The total area for each MUSIC node and its associated impervious percentage is shown in Table 9-6.

Table 9-5. MUSIC Catchment Input Parameters – Merri Creek

Sub-Catchment Name	MUSIC Node Type	Total Area (ha)	Impervious %
MC_01	Mixed Urban	459.1	44%
MC_01	Agriculture	737.9	10%
MC_02	Mixed Urban	611.0	40%
MC_02	Agriculture	748.1	10%
MC_03	Mixed Urban	1347.8	39%
MC_03	Agriculture	395.8	10%
MC_04	Mixed Urban	282.8	44%
MC_04	Agriculture	1140.4	10%

To develop the Merri Creek MUSIC Model catchment input parameters above, the following land zoning codes, impervious percentage and MUSIC node types were used (based on Melbourne's MUSIC guidelines).

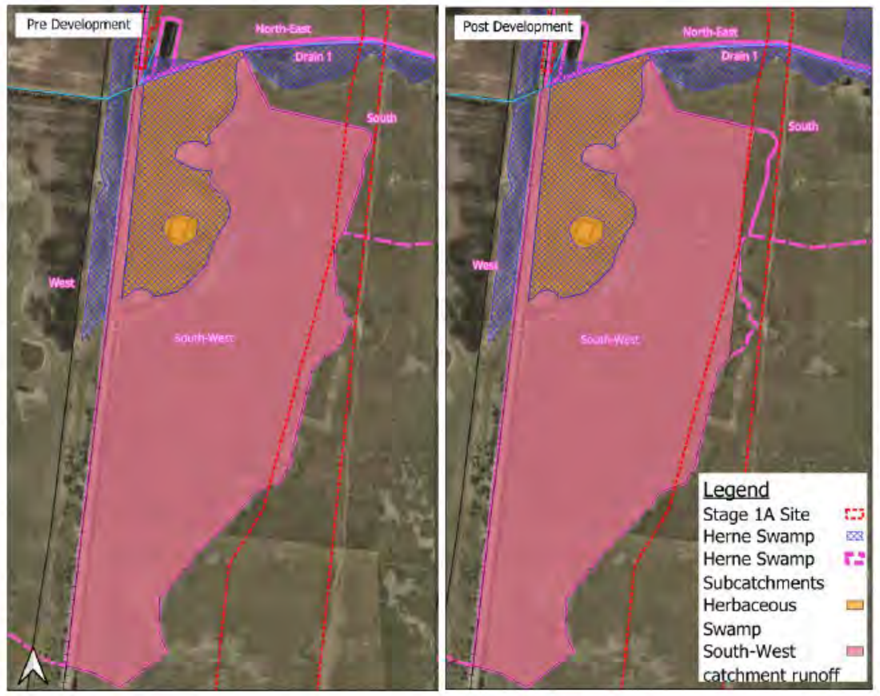
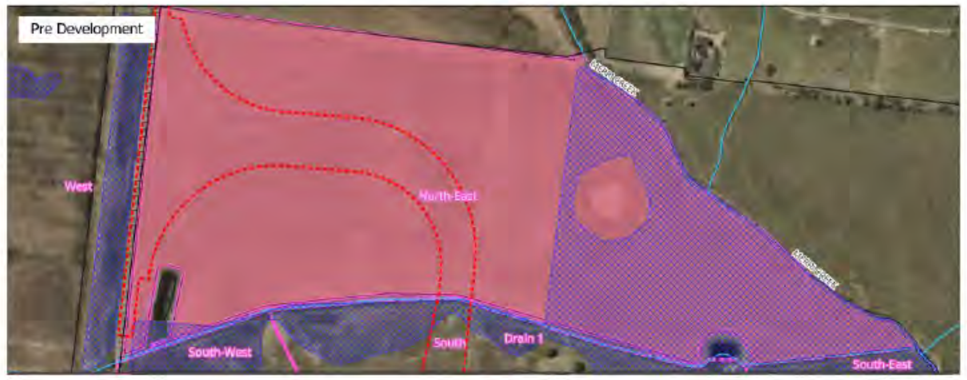
Table 9-6. Land Zoning and MUSIC nodes – Merri Creek

Zone Code	Zone Description	Impervious %	Music Node
C1Z	C1Z - Commercial 1 Zone	90%	Mixed Urban
C2Z	C2Z - Commercial 2 Zone	90%	Mixed Urban
CDZ	CDZ - Comprehensive Development Zone	30%	Mixed Urban
FZ	FZ - Farming Zone	10%	Agriculture
GRZ	GRZ - General Residential Zone	60%	Mixed Urban
IN1Z	IN1Z - Industrial 1 Zone	90%	Mixed Urban
LDRZ	LDRZ - Low Density Residential Zone	20%	Mixed Urban
MUZ	MUZ - Mixed Use Zone	75%	Mixed Urban
PCRZ	PCRZ - Public Conservation and Resource Zone	0%	Mixed Urban
PPRZ	PPRZ - Public Park and Recreation Zone	10%	Mixed Urban
PUZ1	PUZ1 - Public Use Zone-Service and Utility	5%	Mixed Urban
PUZ2	PUZ2 - Public Use Zone-Education	70%	Mixed Urban
PUZ5	PUZ5 - Public Use Zone-Cemetery/Crematorium	60%	Mixed Urban
PUZ6	PUZ6 - Public Use Zone-Local Government	70%	Mixed Urban
TRZ1	TRZ1 - Transport Zone 1-State Transport Infrastructure	70%	Mixed Urban
TRZ2	TRZ2 - Transport Zone 2-Principal Road Network	70%	Mixed Urban
TRZ3	TRZ3 - Transport Zone 3-Significant Municipal Road	70%	Mixed Urban
TZ	TZ - Township Zone	55%	Mixed Urban
GWZ	GWZ - Green Wedge Zone	0%	Mixed Urban
RCZ	RCZ - Rural Conservation Zone	0%	Mixed Urban
UFZ	UFZ - Urban Floodway Zone	0%	Mixed Urban
UGZ	UGZ - Urban Growth Zone	60%	Mixed Urban
RCZ	RCZ - Rural Conservation Zone	0%	Mixed Urban
GWAZ	GWAZ - Green Wedge A Zone	0%	Mixed Urban

MUSIC model inputs – Herne Swamp

The modelling methodology for Herne Swamp per sub-catchment is detailed in Table 9-7 below.

Table 9-7. Herne Swamp Modelling Methodology – details per sub-catchment

Catchment	South-West	North-East	South / Drain 1
Pre and post development catchment extent	 **Figure 9-3. Pre & Post Development catchments – South-West Herne Swamp**	 **Figure 9-4. Pre & Post Development catchments– Stage 1A does not alter the North-East Herne Swamp catchment**	 **Figure 9-5. Pre & Post Development catchments – Stage 1A does not alter the South Herne Swamp catchment**
Catchment outlet	▪ Pre-development: Farm Drain 1 ▪ Post-development: Farm Drain 1	▪ Pre-development: Merri Creek ▪ Post-development: Farm Drain 1	▪ Pre-development: Farm Drain 1 ▪ Post-development: Farm Drain 1
Change in catchment	▪ There is a 3% reduction in the south west catchment size in the post-development case. This is because a section of catchment is intercepted and redirected further south as part of the Beveridge Intermodal Precinct Stage 1A Project, through swales included in Stage 1A that convey flow to the Farm Drain 1 adjacent to the rai corridor.	▪ There is a small area of impervious hardstand and earthworks introduced (0.712 Ha) in that would runoff to shallow swales designed to treat and infiltrate runoff ▪ Approximately 24.52 Ha of viaduct surface that is not directly connected to waterways but will drain to an area beneath the viaduct that is managed to capture pollutants in runoff. ▪ No drainage swales are proposed to redirect flows into Farm Drain 1. ▪	▪ There is 0.53 Ha of impervious hardstand and earthworks introduced in that would runoff. ▪ The catchment draining to this point includes the West and South-West catchments. Considering these, the overall catchment increase is 3.3%.
Modelling methodology	▪ The hydraulic impact of water level fluctuations in the Herne Swamp has been modelled through an excel water balance model to account for wetting and drying processes in the swamp. ▪ Runoff processes in south west catchment have been modelled in MUSIC.	▪ The full catchment has been modelled in MUSIC. ▪ Proposed swales have been modelled as 80% of their designed length	▪ The full catchment has been modelled in MUSIC. ▪ Minimal storage identified in Farm Drain 1 and Dam 2 has not been modelled as impacts are assessed at the project boundary which is upstream of this storage. ▪ Proposed swales have been modelled as 80% of their designed length
How impacts have been assessed	▪ Impacts from the Beveridge Intermodal Precinct Stage 1A Project have been assessed by analysing: – Change in the catchment size – Change in <u>water level</u> in the swamp – Change in <u>wetting and drying</u> patterns in the swamp	▪ Impacts from the Beveridge Intermodal Precinct Stage 1A Project have been assessed by analysing: – Change in the catchment imperviousness – Change in <u>flow</u> to Merri Creek – Change in <u>flow</u> to Farm Drain 1 – <u>Treatment effectiveness</u> of proposed swales	▪ Impacts from the Beveridge Intermodal Precinct Stage 1A Project have been assessed by analysing: – Change in <u>flow</u> to Farm Drain 1

Based on the above, the Herne Swamp catchment was modelled in 4 sub-catchments in MUSIC, see Figure 9-6 for the pre-development model and Figure 9-7 for the post-development model.

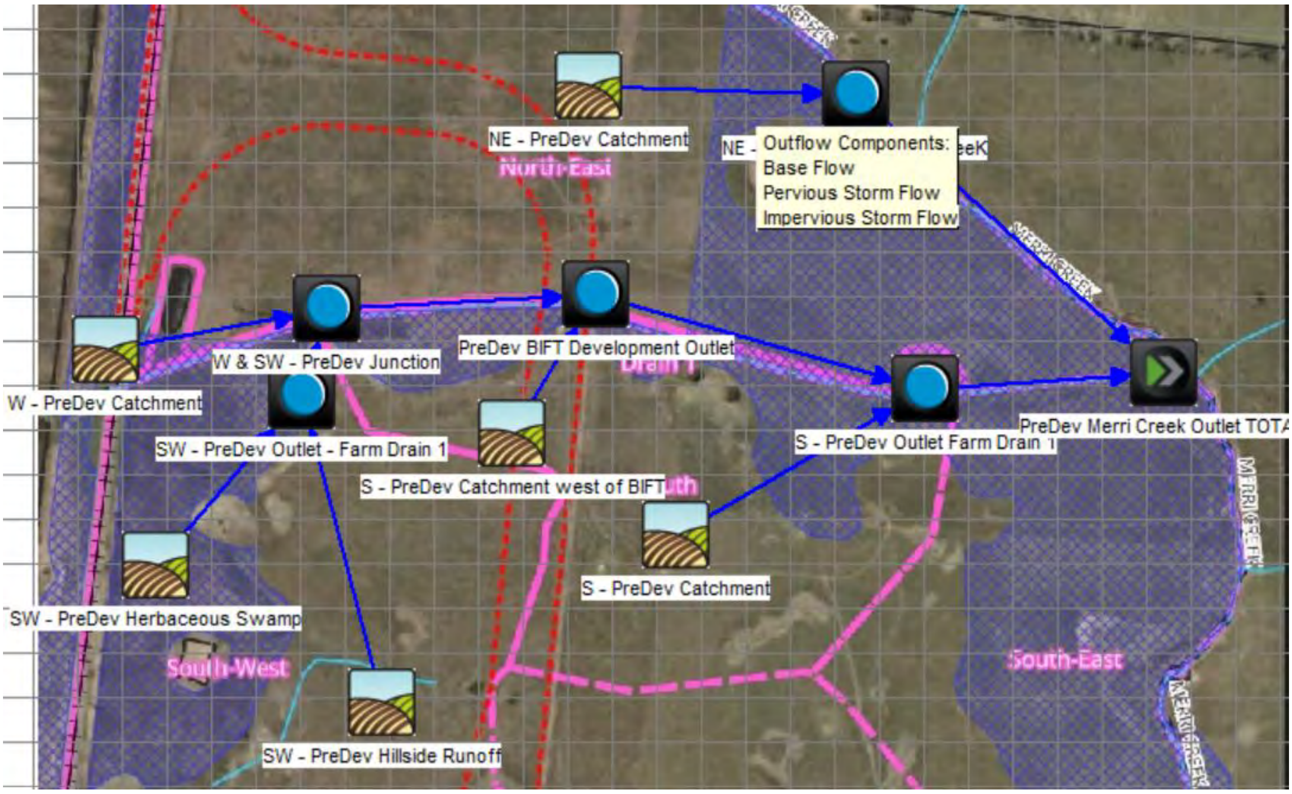


Figure 9-6. MUSIC Model Schematisation – Herne Swamp – pre-development

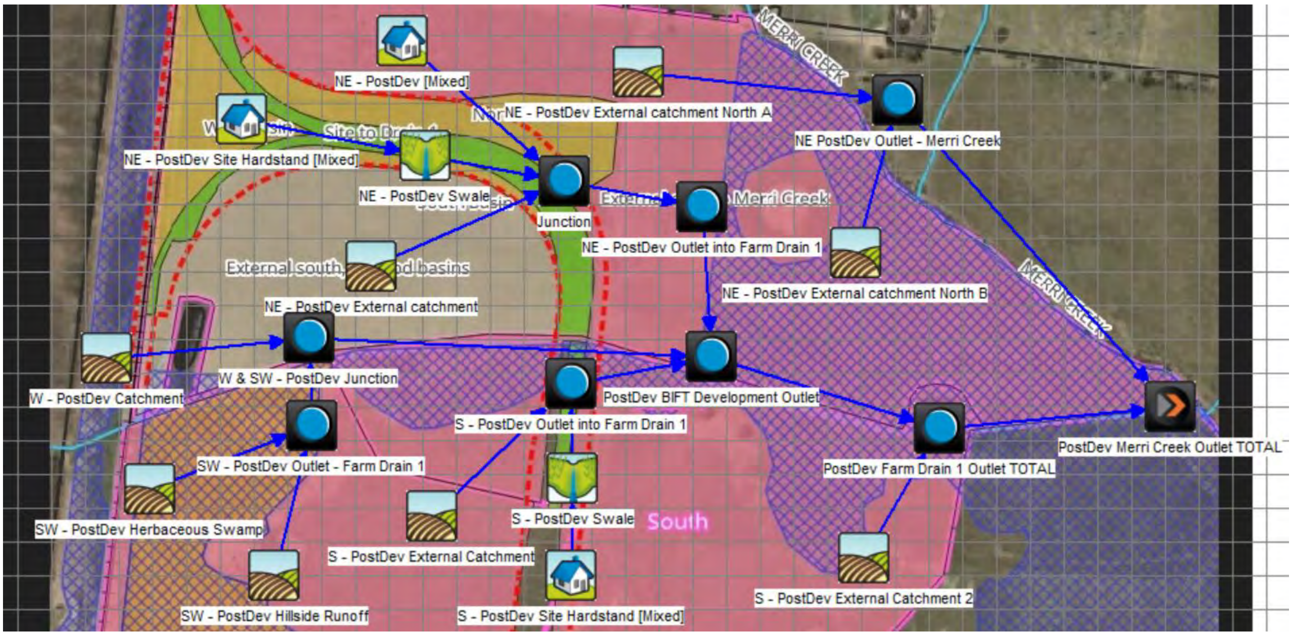


Figure 9-7. MUSIC Model Schematisation – Herne Swamp– post-development

The Herne Swamp model input parameters are detailed below.

Table 9-8. MUSIC Catchment Input Parameters – Herne Swamp – Pre-development

Sub-Catchment Name	MUSIC Node Type	Total Area (ha)	Directly Connected Impervious %
W - PreDev Catchment	Agricultural	436.6	0
SW - PreDev Herbaceous Swamp	Agricultural	10.4	0
SW - PreDev Hillside Runoff	Agricultural	52.6	0
S - PreDev Catchment west of BIFT	Agricultural	6.0	0
S - PreDev Catchment east of BIFT	Agricultural	19.3	0
NE - PreDev Catchment	Agricultural	47.7	0
	Total area (ha)	**572.6**	

Table 9-9. MUSIC Catchment Input Parameters – Herne Swamp – Post-development

Sub-Catchment Name	MUSIC Node Type	Total Area (ha)	Directly Connected Impervious %
W - PostDev Catchment	Agricultural	436.6	0
SW - PostDev Herbaceous Swamp	Agricultural	10.4	0
SW - PostDev Hillside Runoff	Agricultural	50.6	0
S - PostDev Undeveloped Catchment	Agricultural	20.03	0
S - PostDev Site Hardstand	Urban (Mixed)	0.527	(50% total imperv.)
NE - PostDev Undeveloped Catchment	Agricultural	16.06	0
NE - PostDev Eathworks and Hardstand	Agricultural	0.712	(50% total imperv.)
NE - PostDev Viaduct	Urban (Mixed)	24.52	0
	Total area (ha)	**570.6**	

Table 9-10.MUSIC Swales Input Parameters

Swale	NE – PostDev Swale	S – PostDev Swale
Inlet Properties - Low Flow By-pass (cubic metres per sec)	0	0
Storage Properties - Length (metres)	1280	184
Storage Properties - Bed Slope (%)	0.05* (would be effectively 0% in design)	0.05* (would be effectively 0% in design)
Storage Properties - Base Width (metres)	0.3	0.3
Storage Properties - Top Width (metres)	0.6	0.6
Storage Properties - Depth (metres)	0.02	0.02
Storage Properties - Vegetation Height (metres)	0.02	0.02
Storage Properties - Exfiltration Rate (mm/hr)	0.1	0.1

Appendix B – Modelling Results

South-West catchment – 5 mm infiltration sensitivity

A sensitivity assessment was undertaken to compare the 1mm infiltration assumption in the model with a 5mm infiltration assumption to assess the validity of the outcome with uncalibrated soil parameters. The outcome of this sensitivity assessment is shown below and indicates that whilst water levels, number of spills, number of dry days, and the water level duration curve are different, there is negligible difference between the pre and post development cases.

Figure 9-8. Water Level variation in South-West Herne Swamp (average rainfall year) (5mm infiltration)

Table 9-11. South-West Herne Swamp – water balance results – 1mm vs 5mm infiltration

Parameter	Average rainfall year, 1mm infiltration			Average rainfall year, 5mm infiltration		
	Pre-Dev	Post-Dev	% Change	Pre-Dev	Post-Dev	% Change
MARV (ML/year)	91.8	90.8	-1.1	91.8	90.8	-1.1
Number of spills	101	99	-2.0	51	49	-4.0
Number of dry days	24	24	0	37	37	0

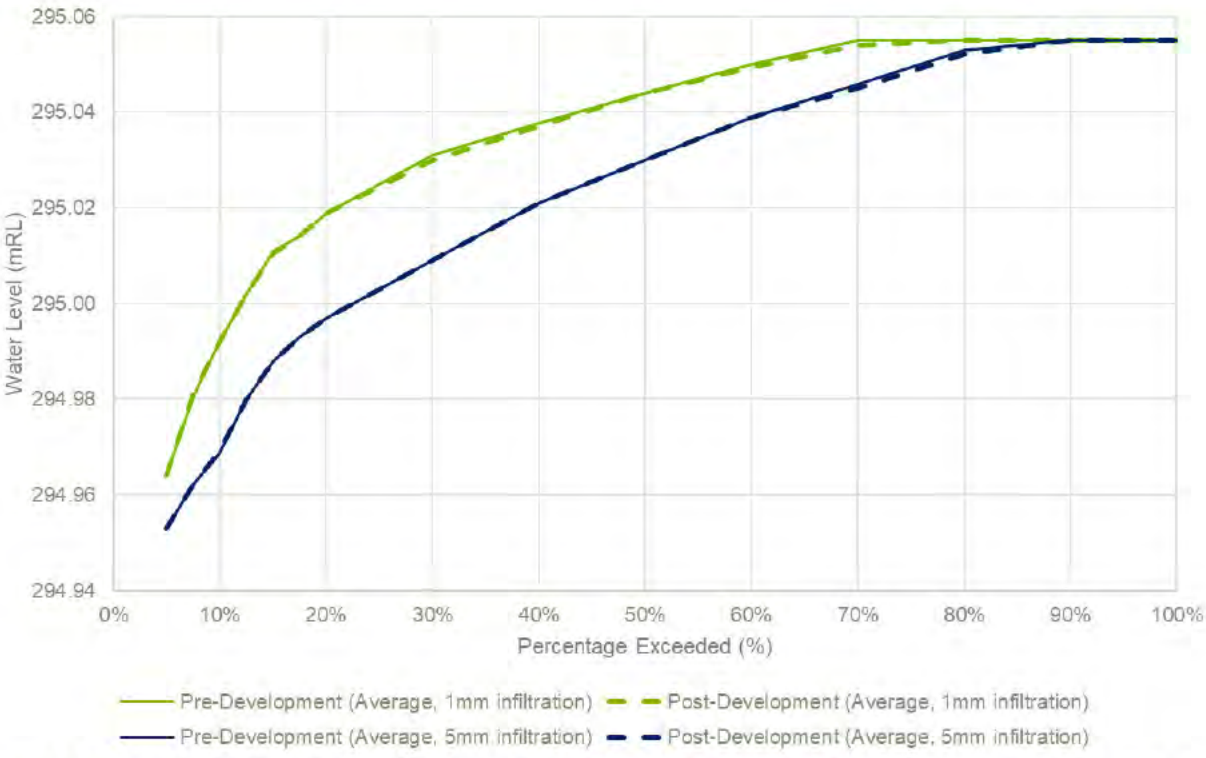


Figure 9-9. South-West Herne Swamp – Water Level variation (average rainfall year) (1mm vs 5mm infiltration)

North-East catchment – MUSIC soil parameters sensitivity

Figure 9-10 shows the flow duration curve for North-East Herne Swamp comparing the Adopted (Melbourne Water recommended) versus the sensitivity parameters (NSW MUSIC Guidelines “Silty-Clay” parameters).

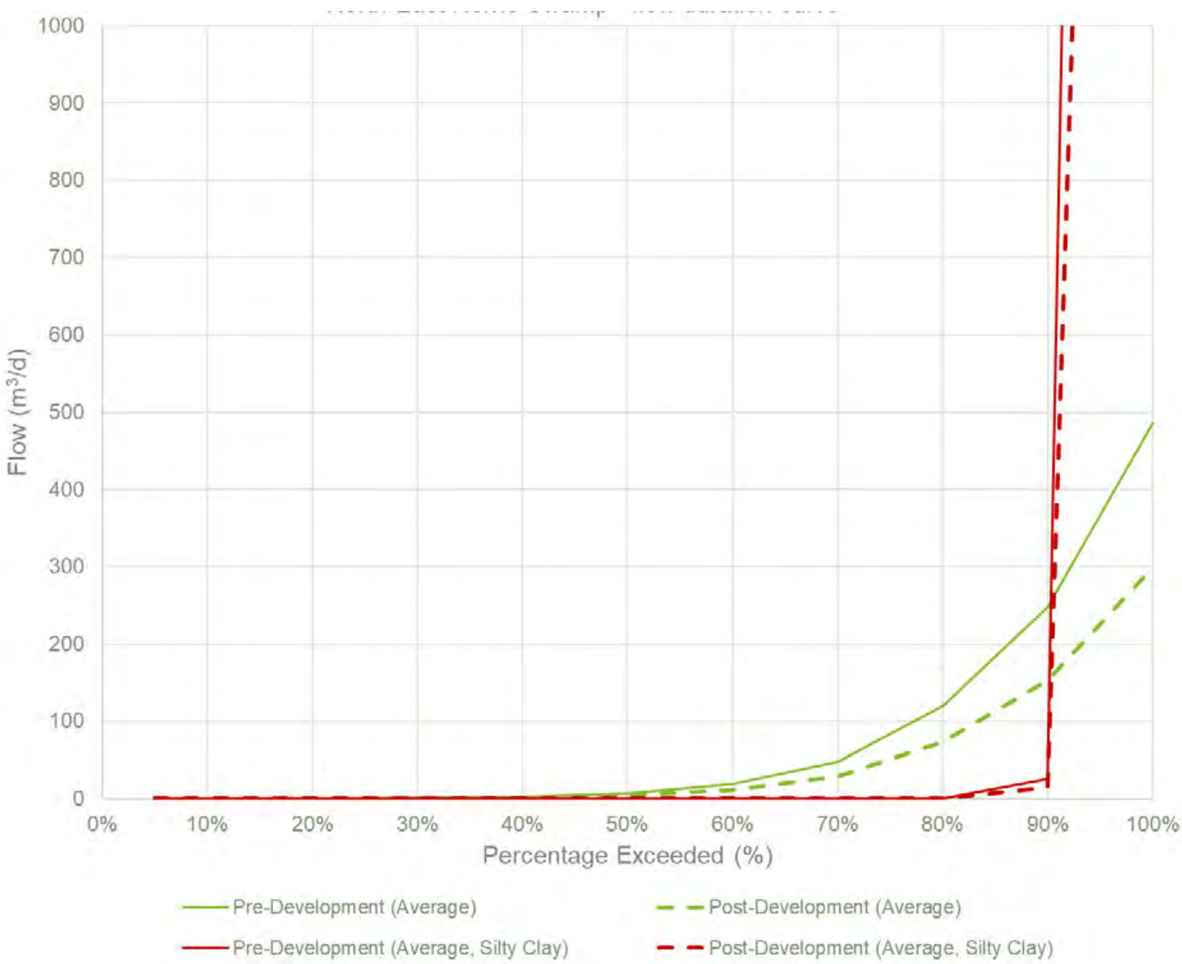


Figure 9-10. North-East Herne Swamp – flow duration curve – soil parameters sensitivity

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