

**Merrifield North Employment and Beveridge
South West Precinct Structure Plans**

Geomorphology and vegetation
assessments – Final

April 2024

alluvium

 **EcoFutures**

Document control:

Project Title	Merrifield North Employment and Beveridge South West Precinct Structure Plans Background Investigations	Job number: 0122188.10		
Document Title	Geomorphology and vegetation assessments	File Reference		
Document Ref				
Version	Date			
1. Draft.	02 June 2023	Filename	Geomorphology and vegetation assessments	
		Description	Draft. Submitted to Andrew Marshall and Carolina Balagtas, Melbourne Water	
			Prepared by	Checked by Approved By
		Initials	CC, JB, DF, AM, AS	AS AS
		Signature		
2. Final.	02 October 2023	File Name	Geomorphology and vegetation assessments	
		Description	Final. Submitted to Seb McRae, Carolina Balagtas and Van Le, Melbourne Water	
			Prepared by	Checked by Approved by
		Initials	CC, JB, DF, AM, HC, AS	AS AS
		Signature		
3. Final – revised.	30 April 2024	File Name	Geomorphology and vegetation assessments	
		Description	Final – revised. Submitted to Alia Abid and Carolina Balagtas, Melbourne Water	
			Prepared by	Checked by Approved by
		Initials	CC, JB DF, AM, HC, AS	AS AS
		Signature		

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An aerial photograph of a dry, cracked landscape, possibly a salt flat or a desert. The ground is covered in a complex network of dark, winding cracks that form a honeycomb-like pattern. The overall tone is dark and monochromatic. A semi-transparent rectangular box is overlaid on the right side of the image, containing the text "Summary of assessment".

Summary of assessment

Summary

Alluvium Consulting Australia was engaged by Melbourne Water to conduct background investigations for the Merrifield North Employment and Beveridge South West Precinct Structure Plan areas.

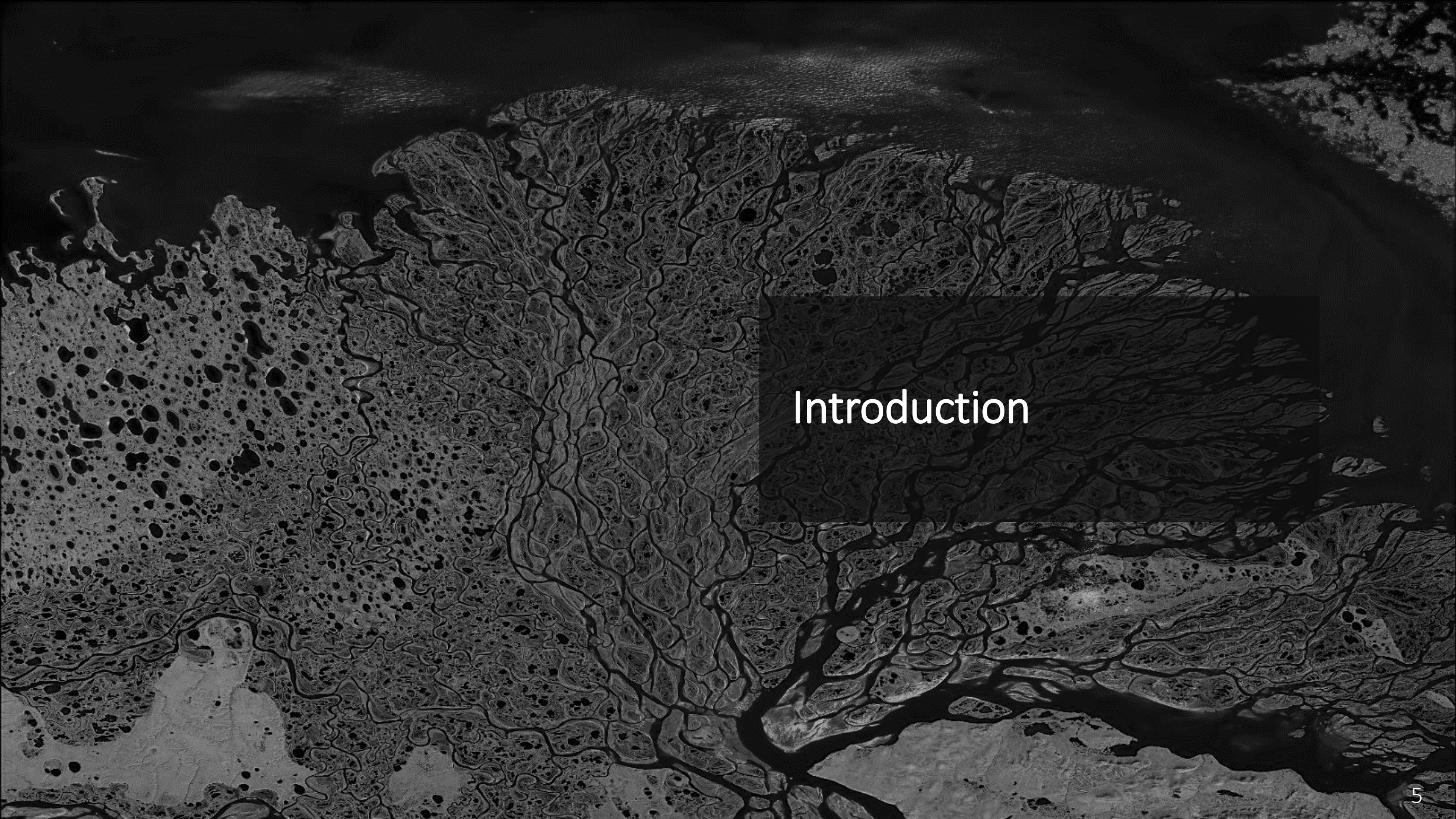
The following services were sought by Melbourne Water:

- Data collection and desktop assessment (geomorphology and ecology)
- Field investigations (geomorphology and vegetation assessments, geotechnical and soils analysis)
- Hydrogeological assessment
- Pre-European wetland assessment
- High-level plan of DSS assets
- Flood mapping
- Analysis and reporting

This report includes a desktop assessment of the two PSP areas, as well as field-based geomorphology and ecological assessments of both areas. It provides a high-level discussion of the possible impacts of proposed development at the Merrifield North Employment and Beveridge South West sites. Results of the investigation may inform the preparation of the PSP (preliminary urban & infrastructure layouts) and will provide the necessary early guidance on the development of Melbourne Water's Development Services Schemes (DSS).



Aerial image of PSP area. Source: Alex Sims

An aerial photograph of a dry, cracked landscape, possibly a salt flat or a desert. The ground is covered in a complex network of dark, winding cracks that form a honeycomb-like pattern. The overall tone is dark and monochromatic. A semi-transparent rectangular box is overlaid on the right side of the image, containing the word "Introduction" in white text.

Introduction

Introduction

Melbourne Water is in the process of developing a Development Services Scheme (DSS) for the Merrifield and Beveridge areas.

The DSS is a plan for the drainage, waterways and water quality treatment works required to provide effective environmentally robust and sound management of stormwater. The objectives of management is to protect the health of waterways from changes in stormwater runoff that result from urban and other forms of development, and to manage local and downstream flood protection.

As a part of the DSS development, Melbourne Water engaged Alluvium Consulting Australia (Alluvium) to assess the riparian vegetation and geomorphic values that would be impacted by development.

This baseline assessment provides Melbourne Water with a high-level inventory of geomorphic and ecological values and processes that can inform the site's Precinct Structure Plan (PSP) and aid the protection of important values and processes and to plan for future connectivity.

This report covers two PSP boundaries. These are the Beveridge South West PSP in the north of the study areas and the Merrifield North Employment PSP area to the south.

The Merrifield North Employment PSP is located approximately 35 km north of Melbourne, with an area of over 988 ha (Figure 1). The PSP is currently in its pre-commencement stage. The neighbouring Beveridge South West PSP covers an area of 1265 ha. The PSP is at an investigative stage.

The combined study area is a wide, flat and low-gradient valley floor where the presence of shallow groundwater, sodic soils and significant wetlands combine to present challenges to the management of stormwater and design and maintenance of future DSS assets. A legacy of past channelisation of waterways and a history of grazing are superimposed on this sensitive environment.

A combined vegetation and geomorphology assessment has been conducted by Alluvium in February and March 2023 for the two PSP areas. Further vegetation assessments were performed in July 2023. The methods, results and recommendations for the two PSP areas are described in detail in this report.

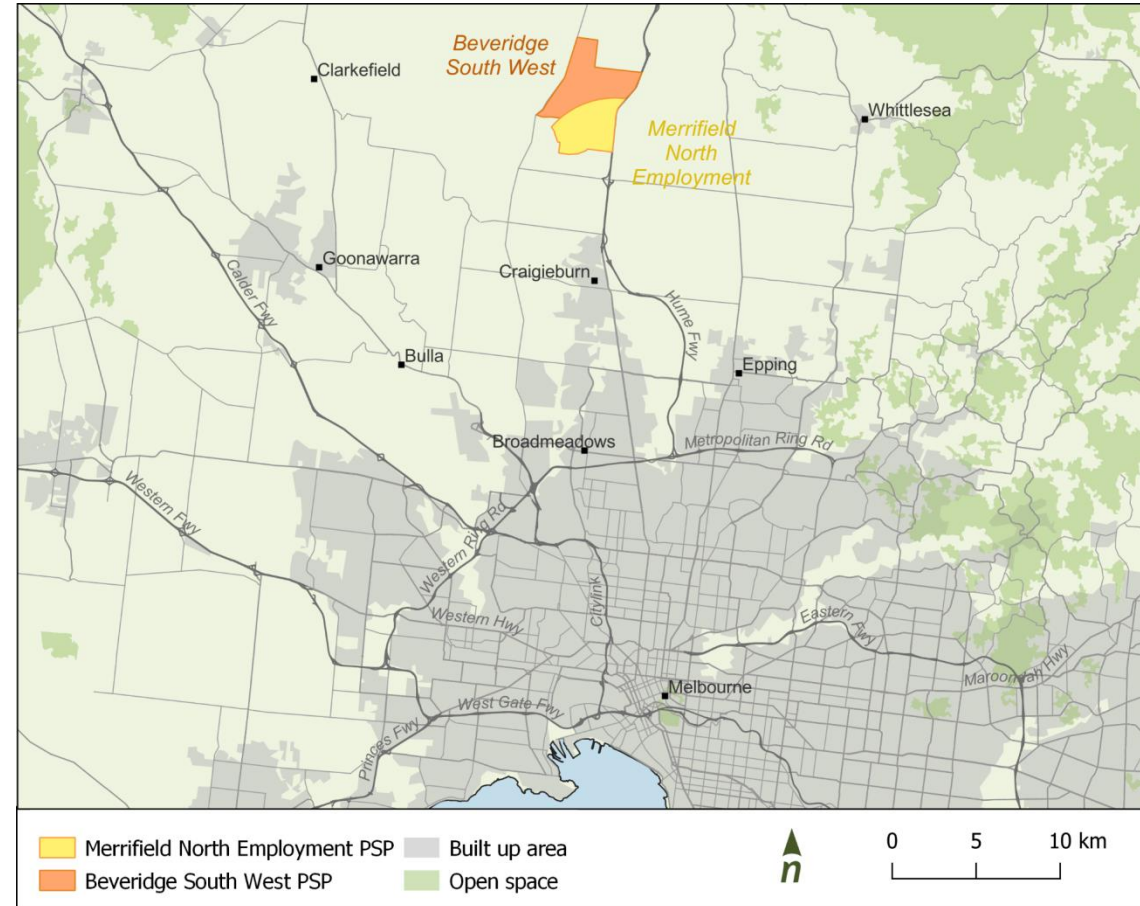


Figure 1. Map showing the location of the Merrifield North Employment and Beveridge South West PSP study areas

An aerial photograph of a dry, cracked landscape, possibly a salt flat or a desert. The ground is covered in a complex network of dark, winding cracks that form a honeycomb-like pattern. The overall tone is dark and monochromatic. A semi-transparent rectangular box is overlaid on the right side of the image, containing the text "Background Assessment".

Background Assessment

Applicable Healthy Waterways Strategy performance objectives

Healthy Waterway Strategy Performance Objectives

Melbourne Water Healthy Waterway Strategy (2018) Performance Objectives (POs) apply to broader catchments of the two PSP areas.

The POs for relevant catchments and waterways in or near the study area are provided below:

Kalkallo Creek

- 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.
- Improve wetland buffer to 50 per cent of the wetland perimeter.

Merri Creek Upper

- Establish a continuous riparian vegetated buffer (53 km, 213 ha) and maintain existing vegetation (12 km, 46 ha) along priority reaches (using EVC benchmarks to at least a level 3 vegetation quality).
- Maintain or achieve high and very high-quality vegetation (Vegetation Quality data level 4 and 5 - currently 10 km) through effective monitoring and management of threats including protection of endangered EVCs in these reaches. Fill data gaps and ensure additional high-quality reaches are also protected.
- To prevent decline in stormwater condition, treat urban development so directly connected imperviousness (DCI) remains below 2% on the Merri Creek at Summerhill Road (Wollert). For every hectare of new impervious area, this requires harvesting around 4.5 ML/y and infiltrating 1.1 ML/y, which is about 21.4 GL/y and 5.2 GL/y for full development to the urban growth boundary.
- 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 Malcolm Creek catchment. For every hectare 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.

- Investigate and mitigate threats to physical form and other high values (including impacts of urbanisation).
- Increase participation rates from low to high; support community groups, connect with growth area communities and build capacity of landowners through rural programs. Increase support for community/environment groups that undertake waterway improvement projects (e.g., Merri Creek Management Committee).
- Improve water quality for environmental values and Port Phillip Bay by reducing sedimentation from run-off associated with construction for urban development. Identify and mitigate sources of sedimentation from development construction activities. This can be through education programs or enforcement actions.

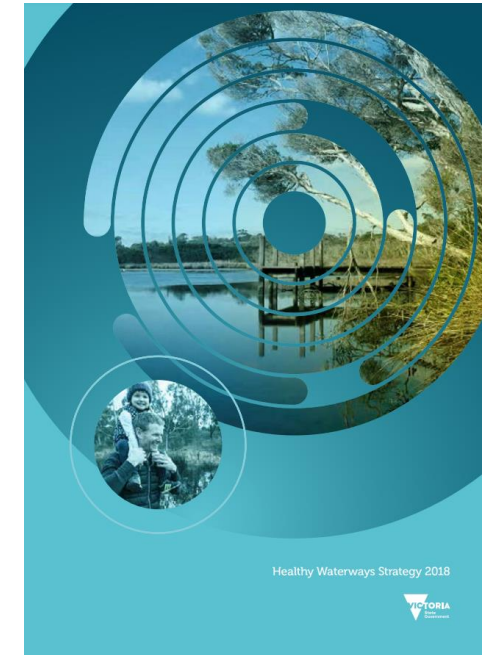


Figure 2. Cover of Healthy Waterways Strategy 2018. Source: Melbourne Water

Geology

The Merrifield and Beveridge areas feature three major and three minor inferred geological units¹.

Major Geological Units:

Alluvial Terrace Deposits (Qa2)

Most watercourses of the PSP lie on Alluvial Terrace Deposits, which are described as gravel, sand, silt: variably sorted and rounded, generally unconsolidated deposits from the Quaternary period. Alluvial terrace deposits usually are perched above the channel or alluvial floodplain and may be separated from these features via a steep slope.

Newer Volcanic Group—basalt flows (Neo)

Tholeiitic to alkaline basalt formed during the Miocene to Holocene periods via a lava flow process at volcanic eruption centre; This unit includes sheet flows and valley flows, and intercalated gravel, sand, clay. Minor proportions of pyroclastic products (scoria and ash) and fluvial sediments are found in basalt flows.

Newer Volcanic Group – Stony rises basalt (Neo2)

Stony rises basalt consists of tholeiitic to alkalic basalt, and basanite of Miocene to Holocene age, formed via a lava flow process at the volcanic eruption centre: Stony rises basalt are formed from youngest flows with little weathering or soil development.

Minor Geological Units

Incised colluvium (Nc1)

Silt, sand, gravel: generally poorly sorted and poorly rounded, except within channels cut into colluvium (material transported via gravity or earth flow process). Formed during the Pliocene to Holocene period.

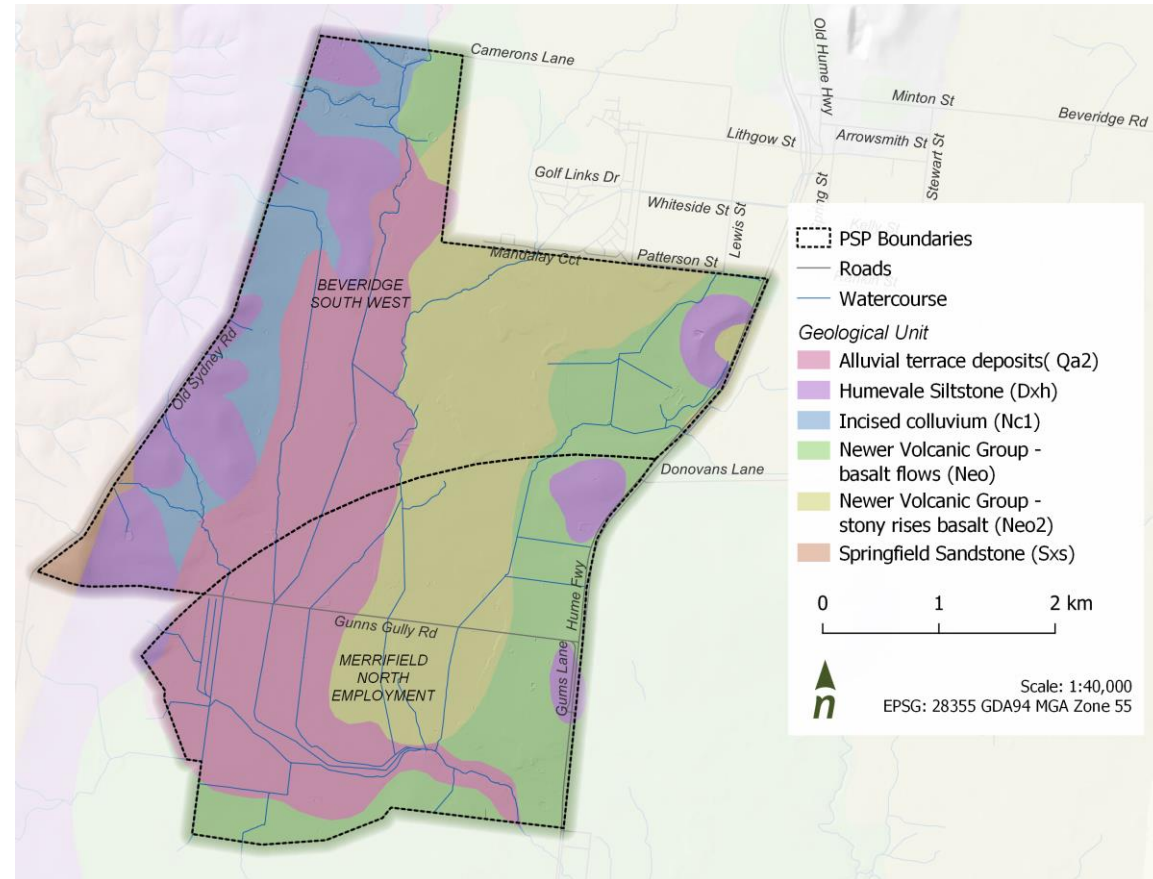


Figure 3. Geology of the study area.

Humevale Siltstone (Dxh)

Siltstone: brown, laminated; minor very fine- to fine-grained sandstone laminae and thin beds towards the top of the formation; distal shelf and hemipelagic deposits.

Springfield Sandstone (Sxs)

Sandstone, siltstone and conglomerate: medium to thick bedded, lithic quartz sandstone alternating with grey-green shaly siltstone and thin-bedded sandstone; variably bioturbated, occasional graptolites; deep-marine turbidite fan deposits.

¹ Geological unit information available via tabulated view of sg_geological_unit_250k spatial dataset at <https://earthresources.vic.gov.au/geology-exploration/maps-reports-data/geovic>. Shapefile is also available for download from <https://datashare.maps.vic.gov.au/>

Soils

Across the Beveridge South West PSP area, soils are almost exclusively classified as grey sodosols². Sodosols are soils that have a strong texture contrast between the A (topsoil) and B (subsoil) horizons with the upper 0.2 m of the B2 horizon being sodic (exchangeable sodium percentage > 6) and not strongly acidic (CSIRO 2016). Sodosols are dispersive, and if exposed to erosional forces are prone to piping/tunnel erosion and gully formation (Ford et al. 1993). In the field, sodic soils are likely to possess a bleached A2 horizon with an abrupt change to a B2 horizon which has columnar or prismatic structures (CSIRO 2016). The grey colour of subsoil suggests that the soil is not well-drained and may experience prolonged periods of saturation (VRO 2020)³.

The Merrifield North Employment PSP area consists of grey sodosols (described above), brown sodosols (texture-contrast sodic soils, where the brown colour of the subsoil suggests improved drainage and absence of prolonged saturation) and black vertosols. Vertosols are soils with clayey field texture (>35% clay) that crack strongly when dry and have high shrink-swell properties. Slickensides (smooth, shiny surfaces) and lenticular (lens shaped) soil units are features of vertosols. The black colouring of subsoil is suggestive of high levels of organic matter (Qld Government, 2023)⁴.

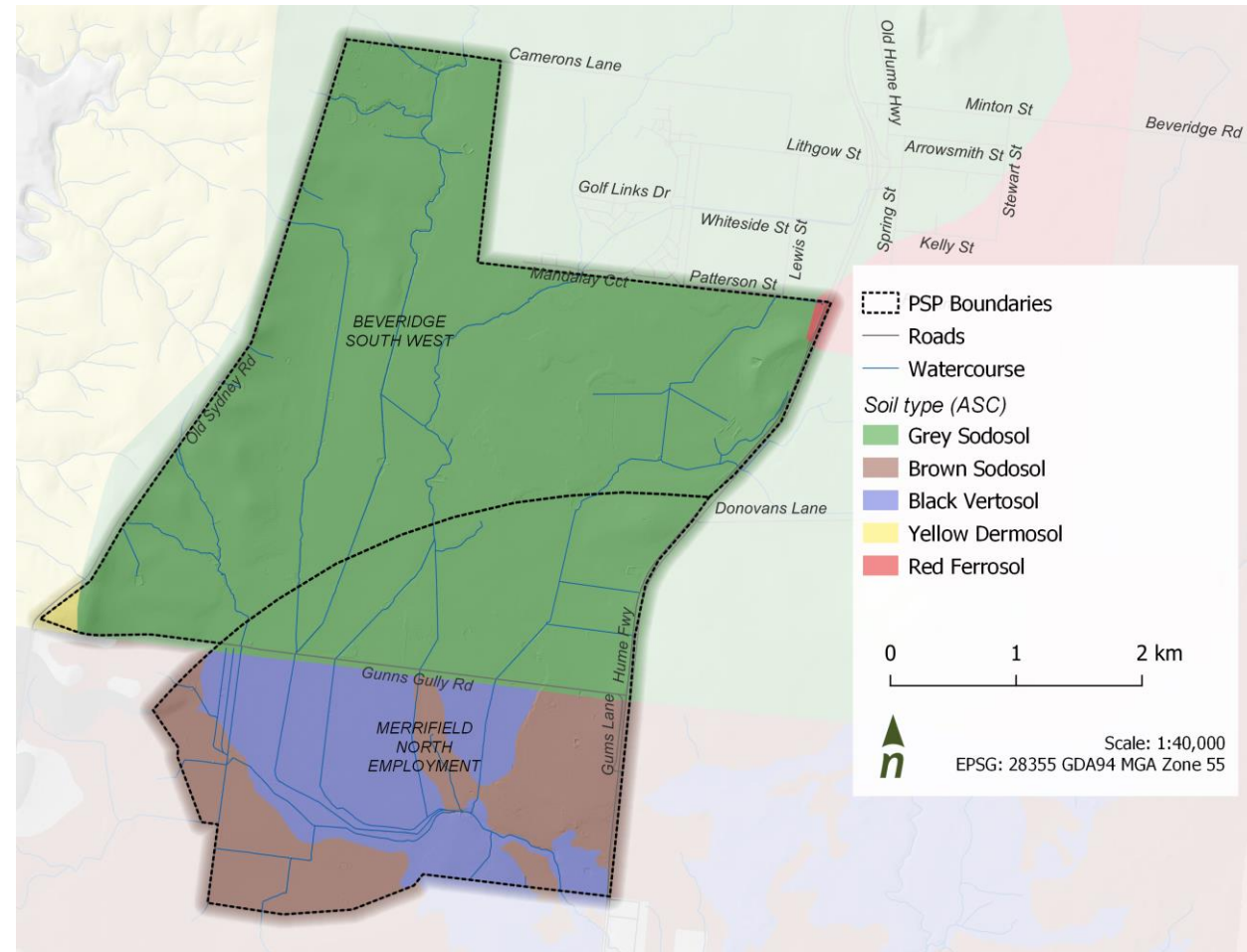


Figure 4. Soil types across the study area

² Australian Soil Classification soil_type dataset available from <https://datashare.maps.vic.gov.au/>

³ VRO 2020. https://vro.agriculture.vic.gov.au/dpi/vro/vrosite.nsf/pages/soilhealth_interpret_colour

⁴ Qld Government 2023: <https://www.qld.gov.au/environment/land/management/soil/soil-properties/colour>

Geomorphological management units

The project study area is comprised of two distinct geomorphological management units⁵.

2.1.1 Ridges, escarpments, mountains on non-granitic Palaeozoic rocks of the Western Uplands, Dissected Uplands (VRO 2018)⁶

This geomorphological unit occupies the western half of the study area. It is comprised of sedimentary rocks and characterised by low undulating hills. Texture contrast soils with well-developed, bleached subsurface horizons are common. Sodosols, in particular, occur in lower parts of the landscape in areas with low rainfall.

6.1.2 Stony Rises of the Western Plains, Volcanic Plains⁶

This geomorphological unit in the east of the study area is comprised of young stony rises lava flows from recent volcanic activity. Little to no soil development may occur on this unit. Over time stony rises have developed into plains with poorly developed drainage. Dark-coloured self-mulching vertosols are commonly associated with Stony Rises.

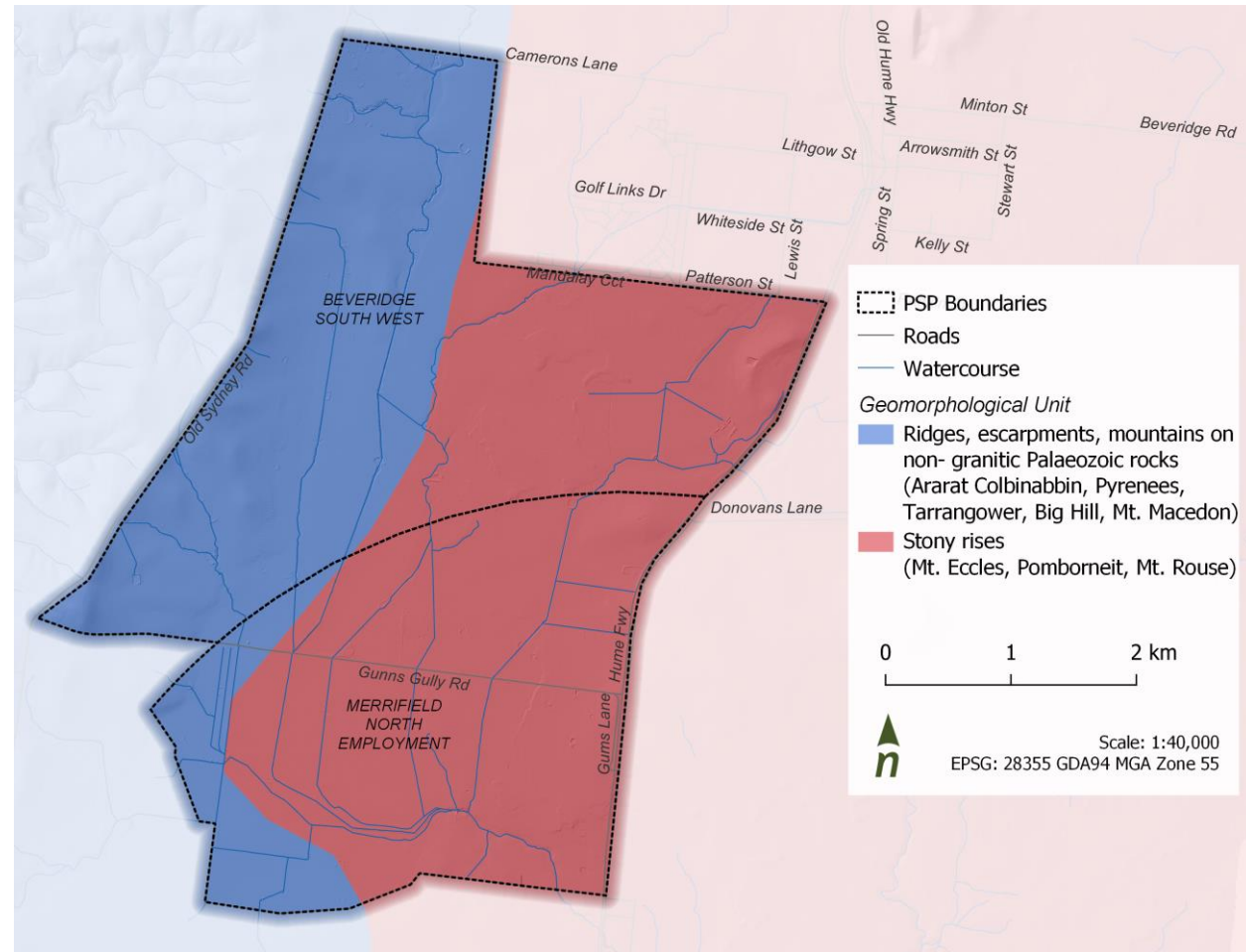


Figure 5. Geomorphological management units of the study area.

⁵ gmu250 spatial dataset available from <https://datashare.maps.vic.gov.au/>

⁶ Geomorphological unit descriptions available via https://vro.agriculture.vic.gov.au/dpi/vro/portreg.nsf/pages/ppw_gmu and links therein.

Wetlands, dams and water area spatial layers

Several spatial layers are available via DataShare (DEECA 2023a)⁷ showing wetlands, dams and other water features at the site.

The most current wetland layer (**Wetland_Current**) shows two wetlands at the site (70700 and 70753) (panel a).

The **VM_Hydro_Water_Area_Polygon** spatial layer contains polygon features representing hydrological features such as lakes, flats (subject to inundation), wetlands, pondages and dams⁷. In the study area, the spatial layer shows the location of dams and a central polygon that largely overlays the 1994 and pre-European wetland 70700 (panel b).

The modelled pre-European wetland layer (**Wetland_Pre_European**) shows a large polygon for wetland 70700, and a small polygon for wetland 70753 (panel c).

The 1994 wetland layer (**Wetland_1994**) shows a considerably larger area for wetland 70700 and does not include a polygon at the location of wetland 70753 (panel d).

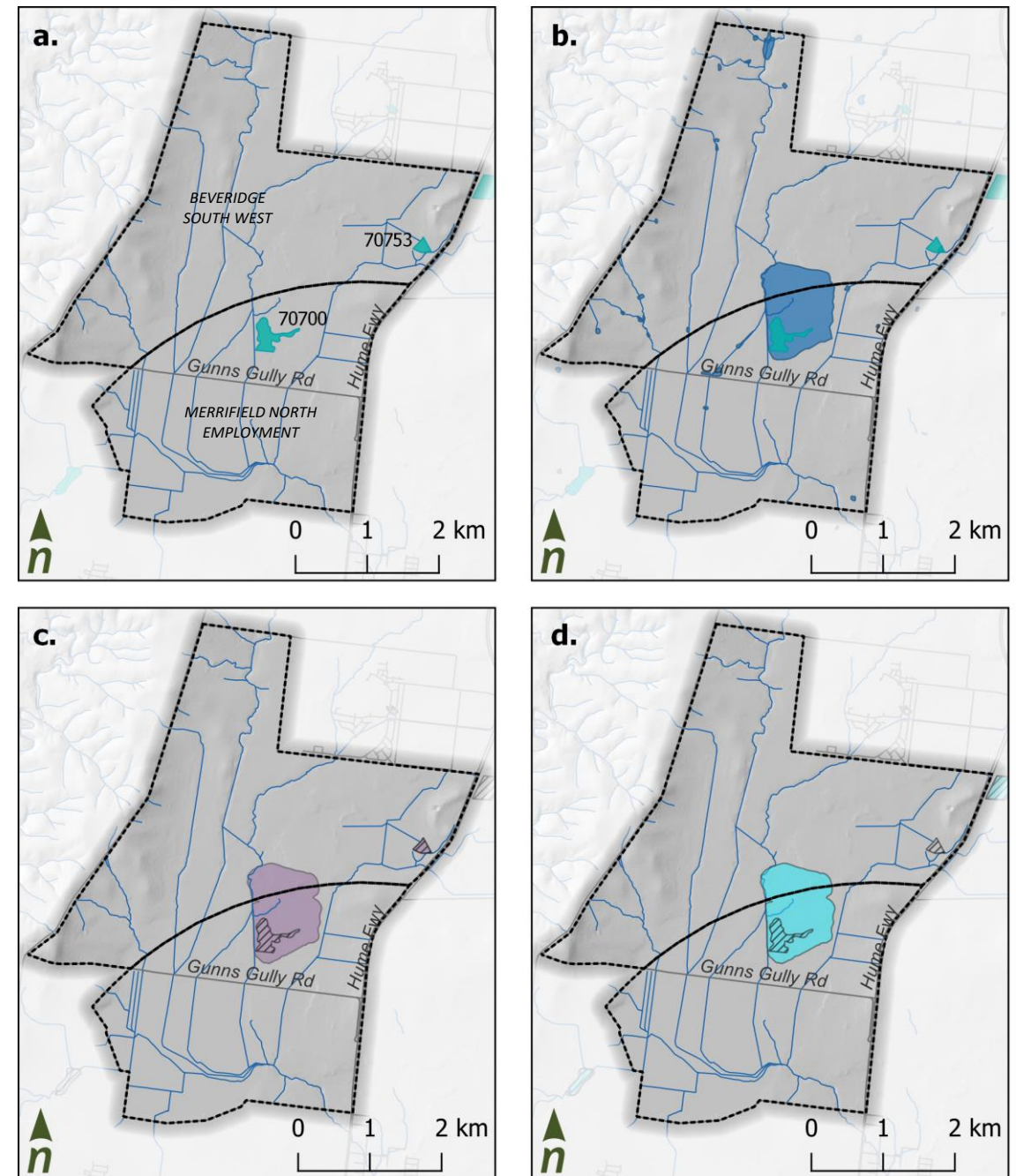
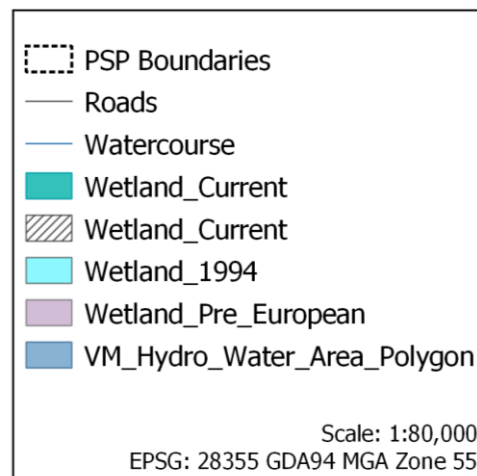


Figure 6. Wetland and Waterbody spatial layers for the study area.

⁷ DEECA 2023a. <https://datashare.maps.vic.gov.au/>

Wetlands and dams – spatial layers for this report

Given the inconsistencies between the different wetland and water area spatial layers, and the wetland extents observed in the field, we have elected to present the following water areas on maps:

- Wetlands 70700 and 70753 from Wetland_Current (DEECA 2023a)⁸.
- Dams from VM_Hydro_Water_Area_Polygon⁸.

The large central water area of VM_Hydro_Water_Area_Polygon has been removed for map accuracy.

The Pre-European wetland is investigated in the accompanying report titled “Merrifield North Employment and Beveridge South West PSP Pre-European Wetland Investigation” and is not further addressed here.

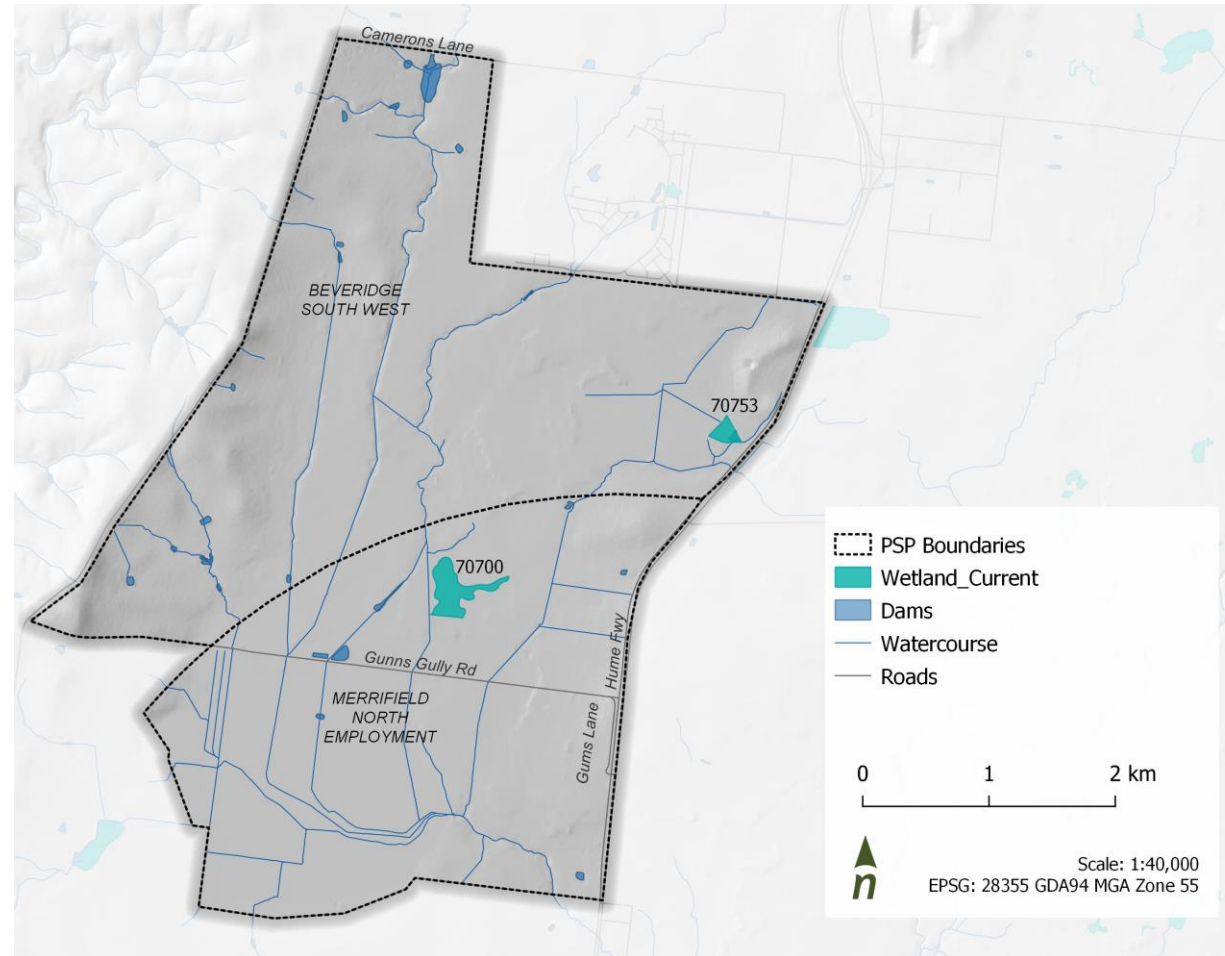


Figure 7. Wetlands and dams in the study area.

⁸ DEECA 2023a. Spatial layers available from <https://datashare.maps.vic.gov.au/>

Wetlands - observed

Two wetlands were assessed within the study area:

- Wetland 70700, located within the Merrifield North Employment PSP area – assessed in February 2023.
- Wetland 70753, located within the Beveridge South West PSP area – assessed in July 2023.

Further descriptions of wetland types, significance and the modifications that have occurred to these values are provided in the wetland assessment components of the vegetation assessment ([pages 55 - 57](#)).



Wetland 70700, February 2023.



Figure 8. Wetland locations and indicative images.



Wetland 70753, July 2023.

RiverStyles, waterbodies and watercourses

The RiverStyles framework is a consistent, documented and tested methodology used for categorising stream type (Macquarie University 2023)⁹. The framework provides a set of procedures that allow for the integration of catchment-scale geomorphic understanding of river forms, processes and linkages.

The main Kalkallo Creek channel and some anthropogenic channels in the drainage basin (south of Gunns Gully Road) had been mapped using the River Styles Framework¹⁰. Under the framework, the northern-most reach of Kalkallo Creek is an **alluvial, continuous low-sinuosity boulder bed**. The sinuous southern part of Kalkallo Creek contains **confined floodplain pockets**. Intervening reaches consist of straight, **anthropogenic shaped channel**, of varying depth.

We have further categorised streams into ten reaches based on our field observations (see Page 21).

Several in-channel waterbodies (dams) occur throughout the study area. The large waterbody (likely the historic extension of the mapped wetland) located in the centre of the study area was dry at the time of field assessment and was being used for cropping operations.

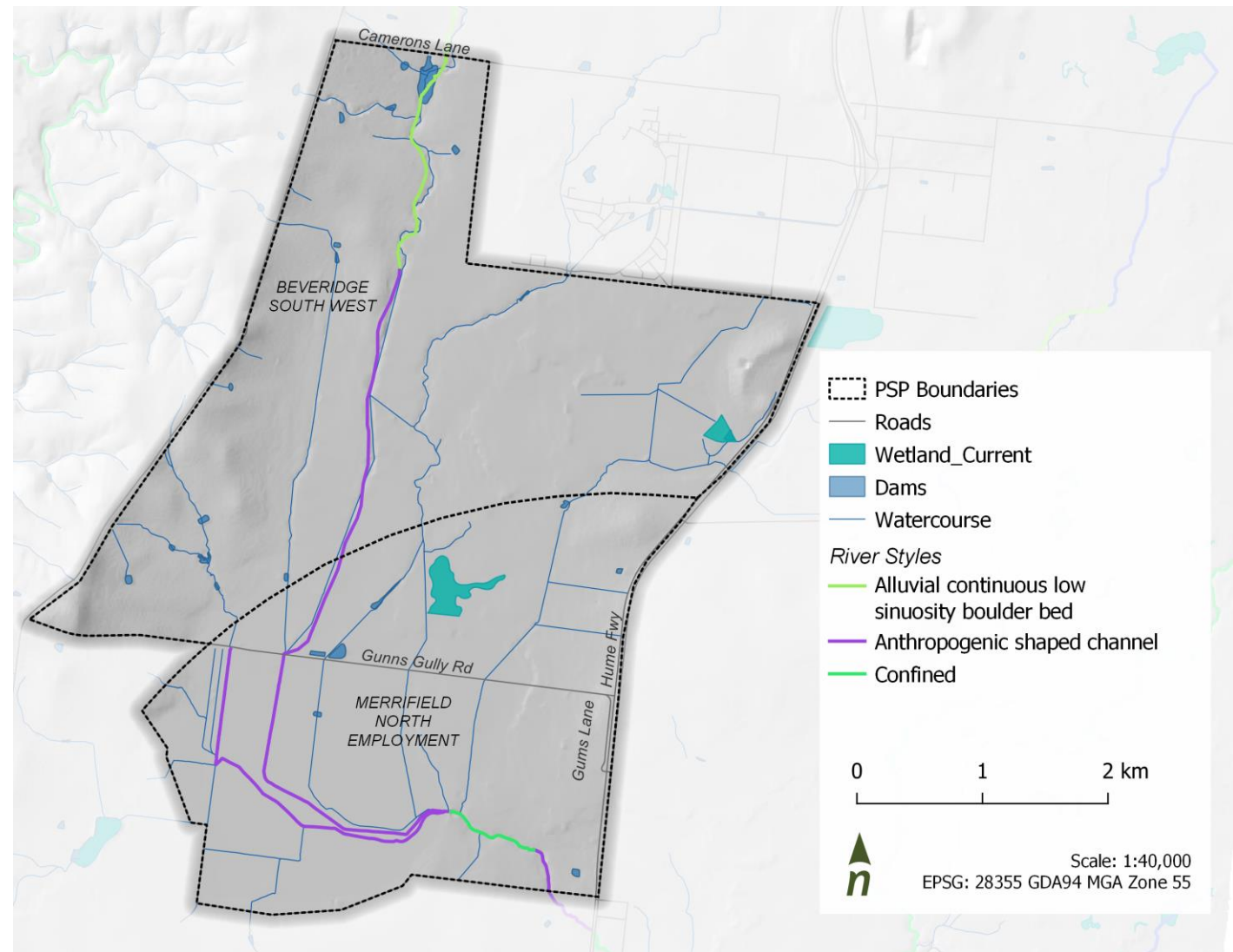


Figure 9. RiverStyles of the study area.

⁹ Macquarie University (2023) River Styles webpage <https://riverstyles.com/river-styles-framework/>

¹⁰ All_MW_River_Styles_polyline spatial dataset supplied by Melbourne Water

EVC benchmarks overview

Seven Ecological Vegetation Classes (EVCs) have been identified in the study area.

Modelled 1750 (pre-European) Communities¹¹ mapped within the PSP areas include;

- Grassy Dry Forest (EVC 22).
- Grassy Woodland (EVC 175).
- Plains Grassland (EVC 132).
- Plains Grassy Wetland (EVC 125).
- Plains Grassy Woodland (EVC 55).
- Riparian Scrub (EVC 191).
- Valley Grassy Forest (EVC 47).

Little native vegetation is modelled to have persisted within the study area (in 2005¹¹), with most remnant communities (particularly Grassy Plains Wetland, Plains Grassland, Plains Grassy Woodland and Riparian Scrub) occurring in the south east region of the Merrifield North Employment PSP area.

Small areas of native EVCs persist in the north west of the Beveridge South West PSP area.

We note the existence of a 2010 Native vegetation time stamping dataset. This dataset is described on [page 40](#).

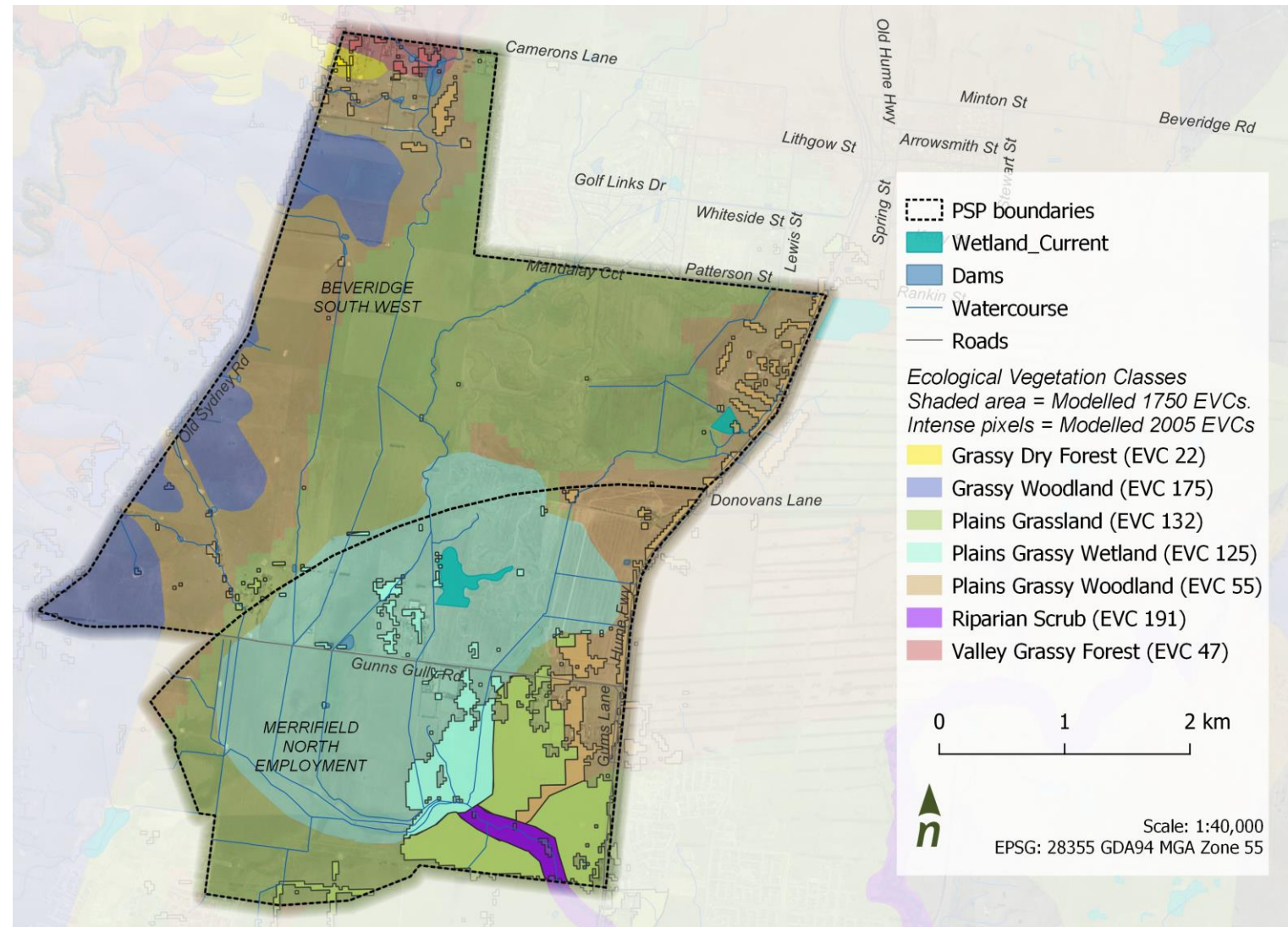


Figure 10. Modelled Ecological Vegetation Classes in the study area

¹¹ 2005 Native Vegetation EVCs (nv2005_EVCBCS) and modelled 1750 EVC (nv1750_EVCBCS) spatial datasets obtained from <https://datashare.maps.vic.gov.au/>

Victorian biogeographic regions (bioregions)

The Merrifield North Employment PSP area is located wholly within the Victorian Volcanic Plain bioregion¹².

The Beveridge South West PSP is mostly located within the Victorian Volcanic Plain bioregion, with elevated western areas situated within the Central Victorian Uplands bioregion¹².

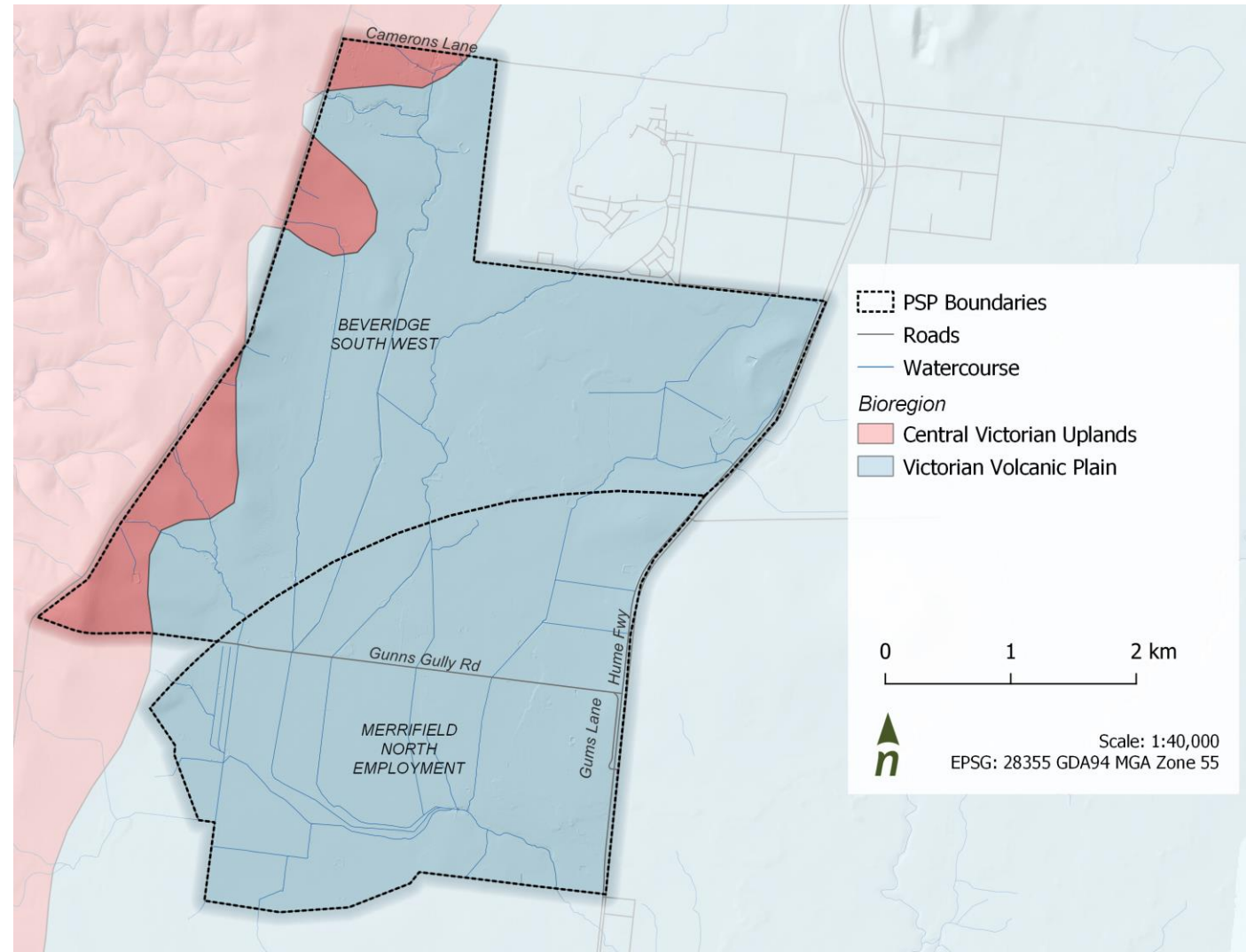


Figure 11. Victorian Bioregions within the study area

¹² Bioregion spatial dataset (VBIOREG100) obtained from <https://datashare.maps.vic.gov.au/>

Flood modelling

Updated flood modelling for events with annual exceedance probabilities that range from 63 % to 1 % was completed for the Merrifield and Beveridge South West PSP areas (Alluvium 2023)¹³. The extent and depth of inundation varies according to the event size, and the extent and depth of the 1 % AEP event is shown below. Additional model results and detailed methods are available in the accompanying flood modelling report titled “*Merrifield North and Beveridge Southwest PSP Flood Assessment Modelling Report*”.

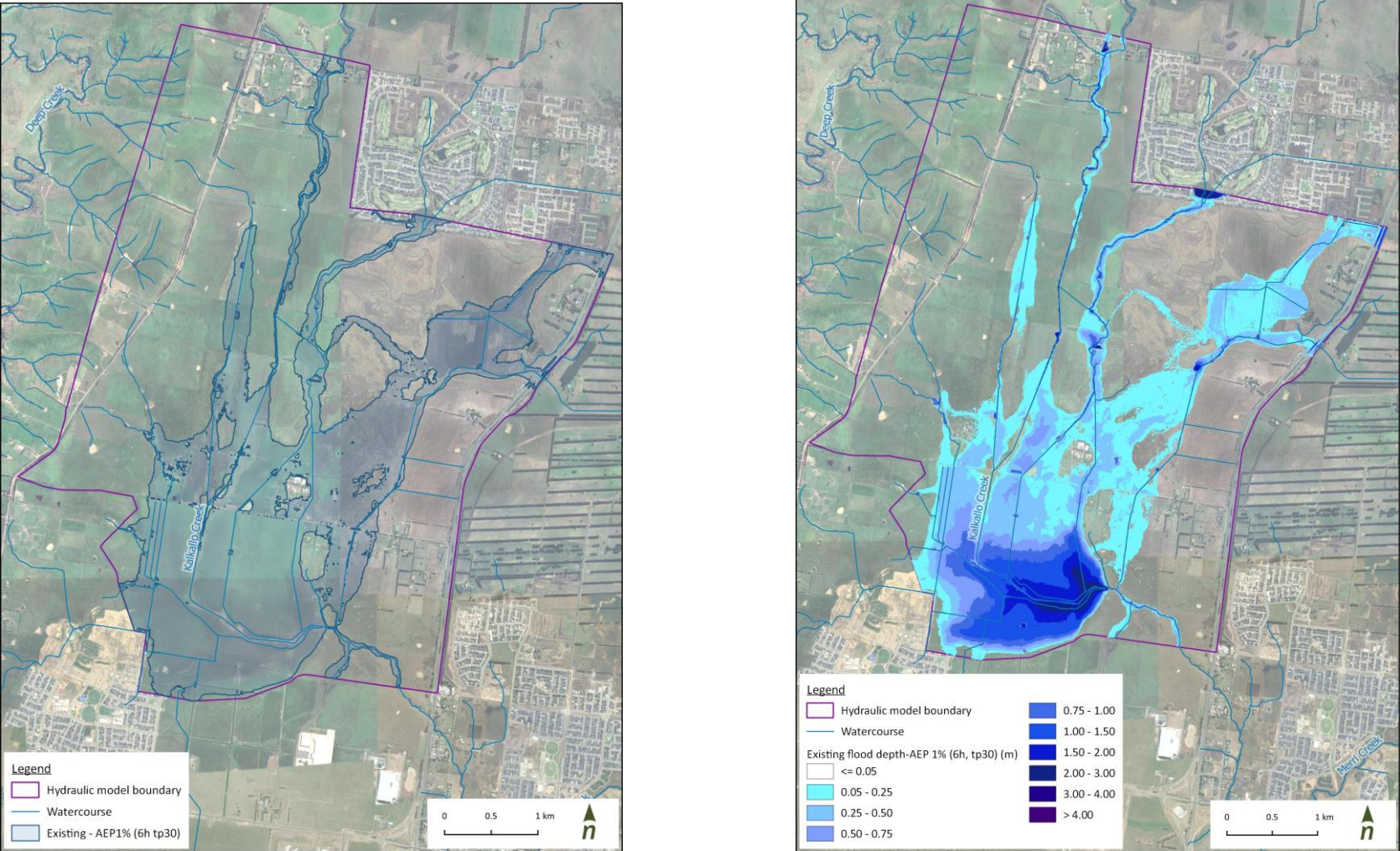
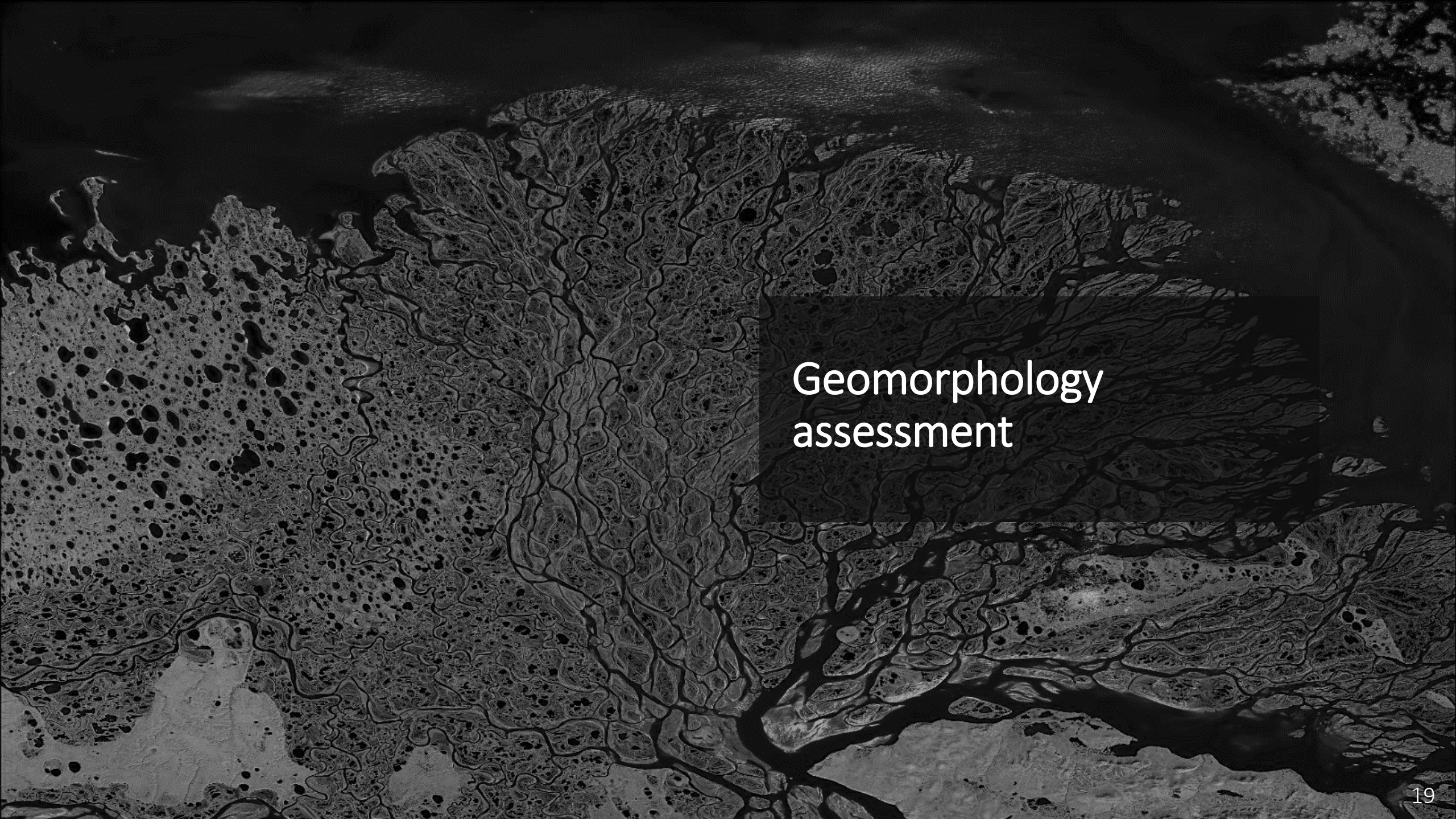


Figure 12. Flood extent (left) and depth (right) of 1% Annual Exceedance Probability (AEP) event

¹³ Alluvium 2023. Merrifield North and Beveridge Southwest PSP Flood Assessment Modelling Report

An aerial photograph of a karst landscape, showing a dense network of sinkholes and a complex drainage system. The terrain is characterized by numerous small, dark, circular features (sinkholes) and a series of interconnected, winding lines representing the drainage network. The overall appearance is highly textured and intricate.

Geomorphology assessment

Geomorphology Assessment Method

The field assessment component of these investigations has relied on inspection of waterways in order to:

- Classify the type of waterway.
- Document the channel form, the composition of the bed and banks and the presence of riparian and instream vegetation.

The waterways in the study area have been separated into reaches. Reaches vary in length and were defined based on the waterway form and expected response to the altered flow regime generated by development. Where several separate waterways were of similar form (for example artificial drainage channels), those waterways were grouped into a single 'reach' type. Where multiple sections of different waterways were classified as the same reach type, each of those segments was described separately for completeness.

Reaches were defined using a combination of aerial imagery, field observations and soil types.

The reaches described in this report form the basis of an assessment of hydrologic sensitivity of each waterway reach, the results of which are summarised on [Page 87](#) of this report.

Images used in this geomorphology assessment report were captured by Alluvium and Ecofutures assessors during assessments in February 2023 and March 2023.



Aerial image of waterway and instream dams. Source: Alex Sims

Geomorphic reaches

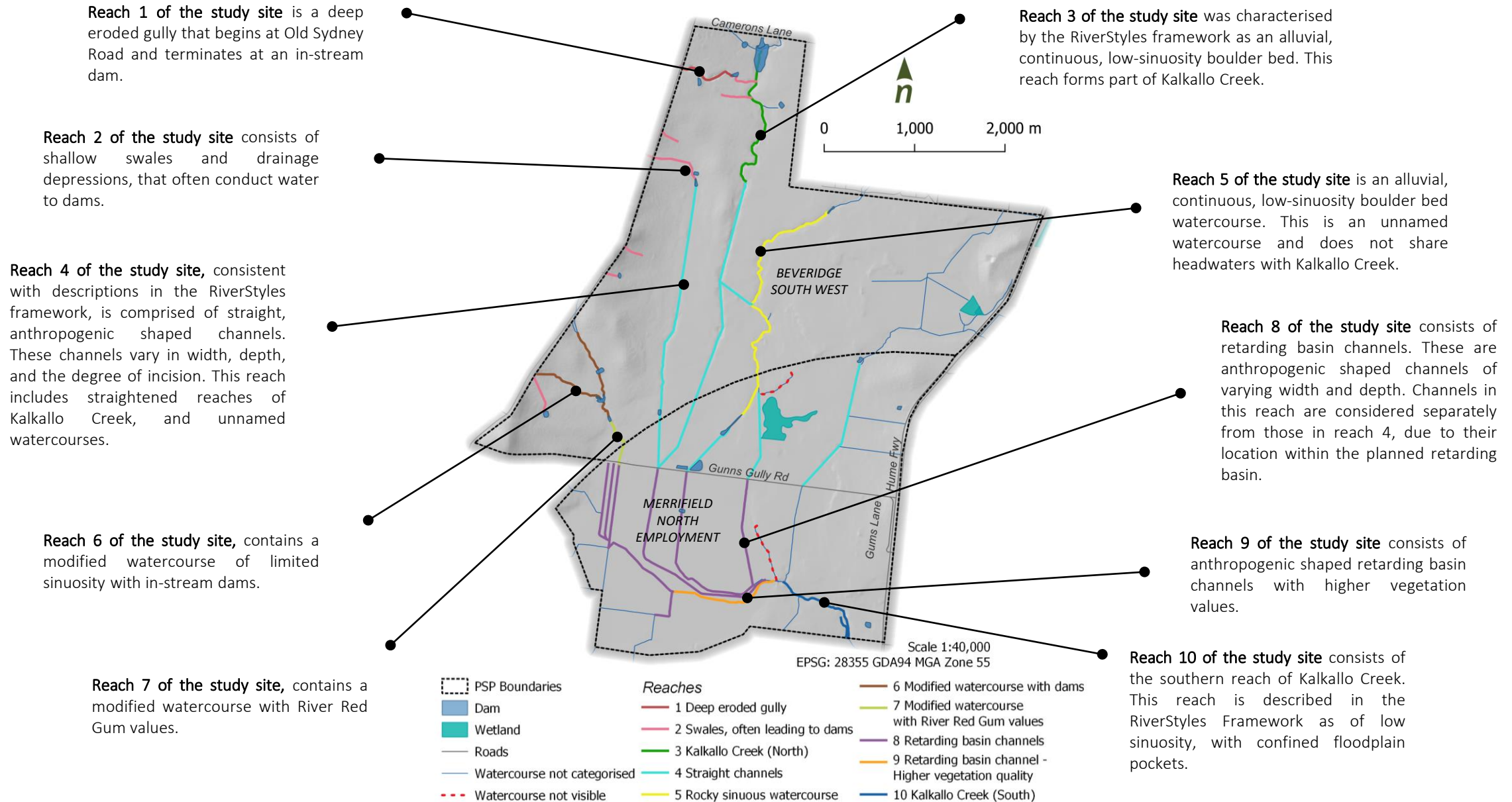


Figure 13. Geomorphic reaches within the study area

Reach #1

This reach consists of a 720 metre long deep eroded creek (a gully). The channel begins at Old Sydney Road and terminates at an in-stream waterbody (dam). Throughout this reach there is evidence of erosion processes associated with dispersive subsoils including tunnel erosion and gully erosion.

Parameter	Description
Channel	Single, continuous channel.
Bank/valley sides	Channel confined by steep eroded banks. Exposed sodic subsoils are present at locations along the reach. Banks consist of silts and clay with exposed gravels. Representative cross- sections are shown.
Bed	Typical longitudinal slope of first 420m of the reach is - 2.06%. The last 300m of the reach has a longitudinal slope of -0.78%. Bed material is predominantly a mixture of small gravels, silts and clays eroded from the upstream banks.
Planform	Low sinuosity channel confined by steep, eroded banks.
Geology	Incised colluvium (Nc1).
Land use	Reach 1 was fenced to prevent stock access to the gully. Agricultural land use occurs beyond the fence line.
Soil type	Grey Sodosol – sodic and non-acid B2 horizon with a strong texture contrast between A horizon and B horizon.
Sediment load	Ephemeral stream. No streamflow at the time of field inspection.
Riparian vegetation	Mixed eucalyptus and exotic (pine) overstorey.
In stream vegetation	Narrow sections with sparse vegetation or unvegetated (leaf litter). Wider eastern region dominated with exotic grasses.

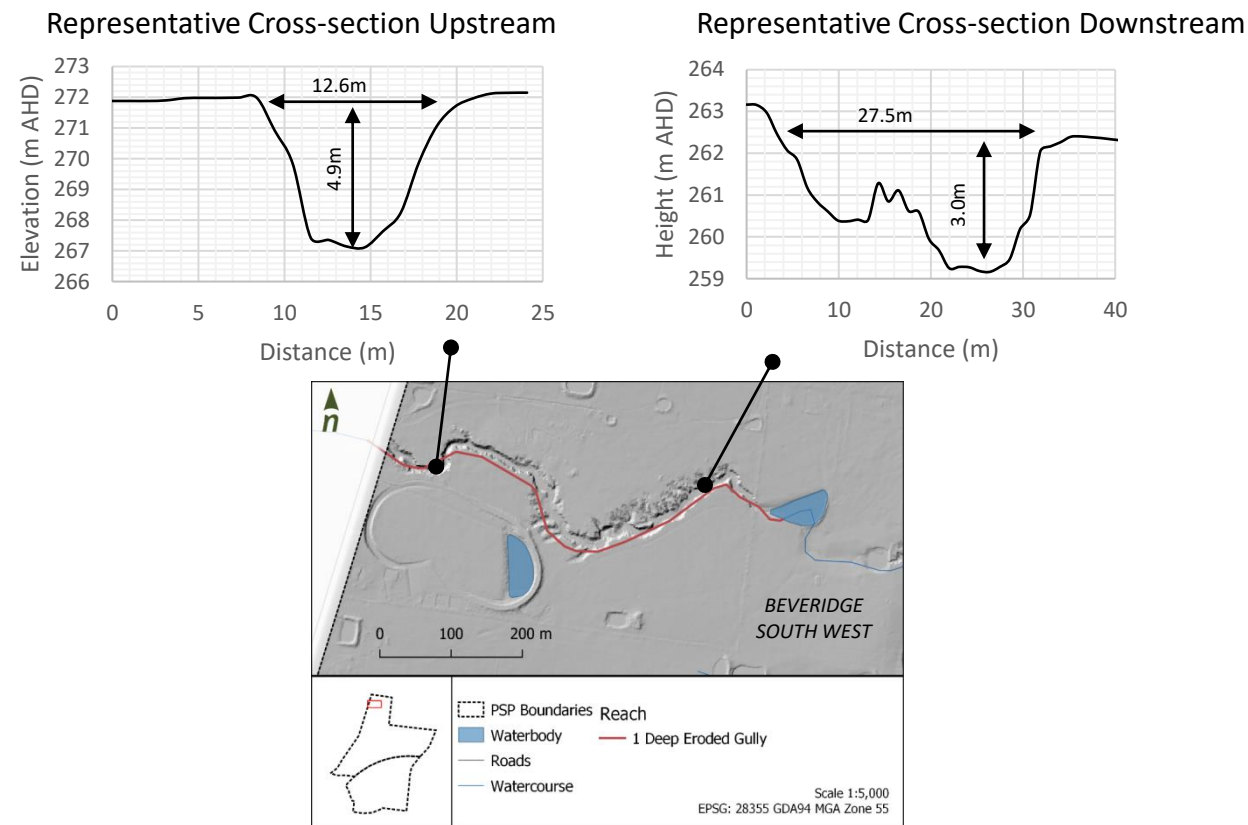
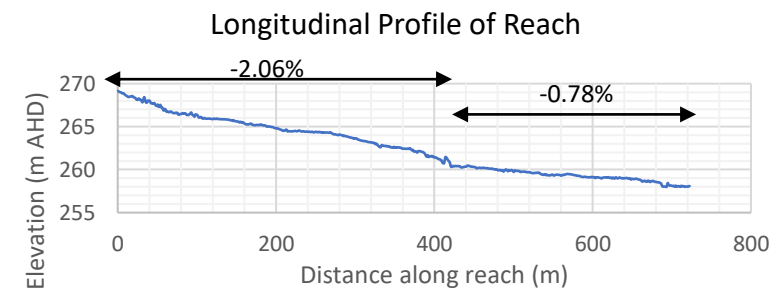


Figure 14. Reach 1.



Reach #1

Reach 1 consists of a 720 metre long deep eroded creek. The channel begins at Old Sydney Road and terminates at an in-stream waterbody (dam). Throughout this reach there is evidence of erosion processes associated with dispersive subsoils.



Tunnel erosion on reach banks



Narrow, deep, eroded channel of upstream sections of reach 1



Wider, open laterally eroding channel in downstream reach 1

Reach #2

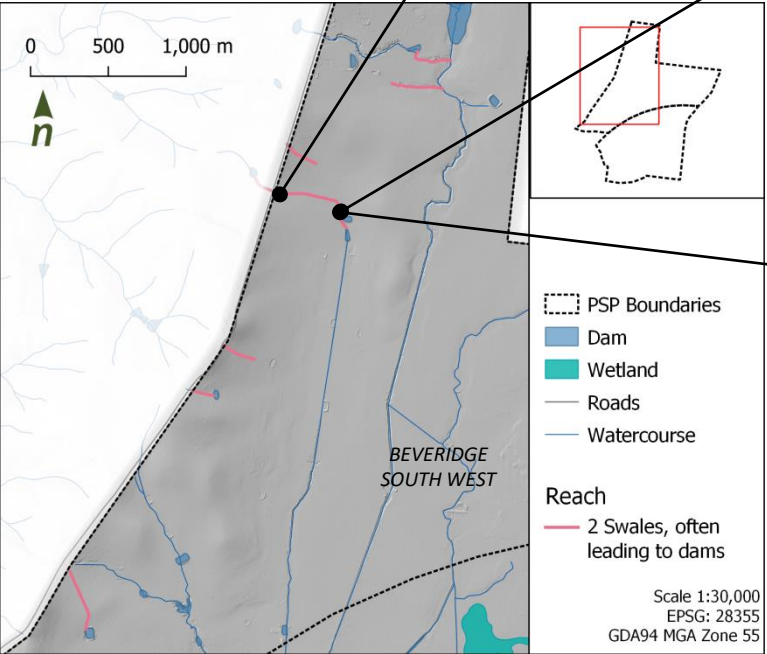
This reach consists of swales in agricultural paddocks, which often lead to dams. The combined length of swales is approximately 2.17 km.

Parameter	Description
Channel	Swales and drainage lines of varied width, depth and distinctiveness.
Bank/valley sides	Swales in grazed paddocks. Banks poorly discernible.
Bed	Swale beds are vegetated with grazed pasture. Swales follow local topography with longitudinal slopes from 2.3%-10.8%.
Planform	Shallow swales and drainage depressions in grazed paddocks.
Geology	Incised colluvium (Nc1) Humevale Siltstone (Dxh) Springfield Sandstone (Sxs)
Land use	Agriculture.
Soil type	Grey Sodosol – sodic and non-acid B2 horizon with a strong texture contrast between A horizon and B horizon.
Sediment load	No streamflow at the time of field inspection.
Riparian vegetation	Grazed perennial pasture grasses (<i>Phalaris aquatica</i> , <i>Dactylis glomerata</i>) with occasional rushes.
In stream vegetation	Grazed perennial pasture grasses (<i>Phalaris aquatica</i> , <i>Dactylis glomerata</i>) with occasional rushes.

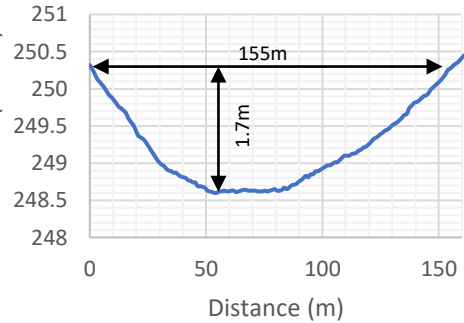


Some swales were barely perceptible

Wide swale in paddock



Wide swale cross section



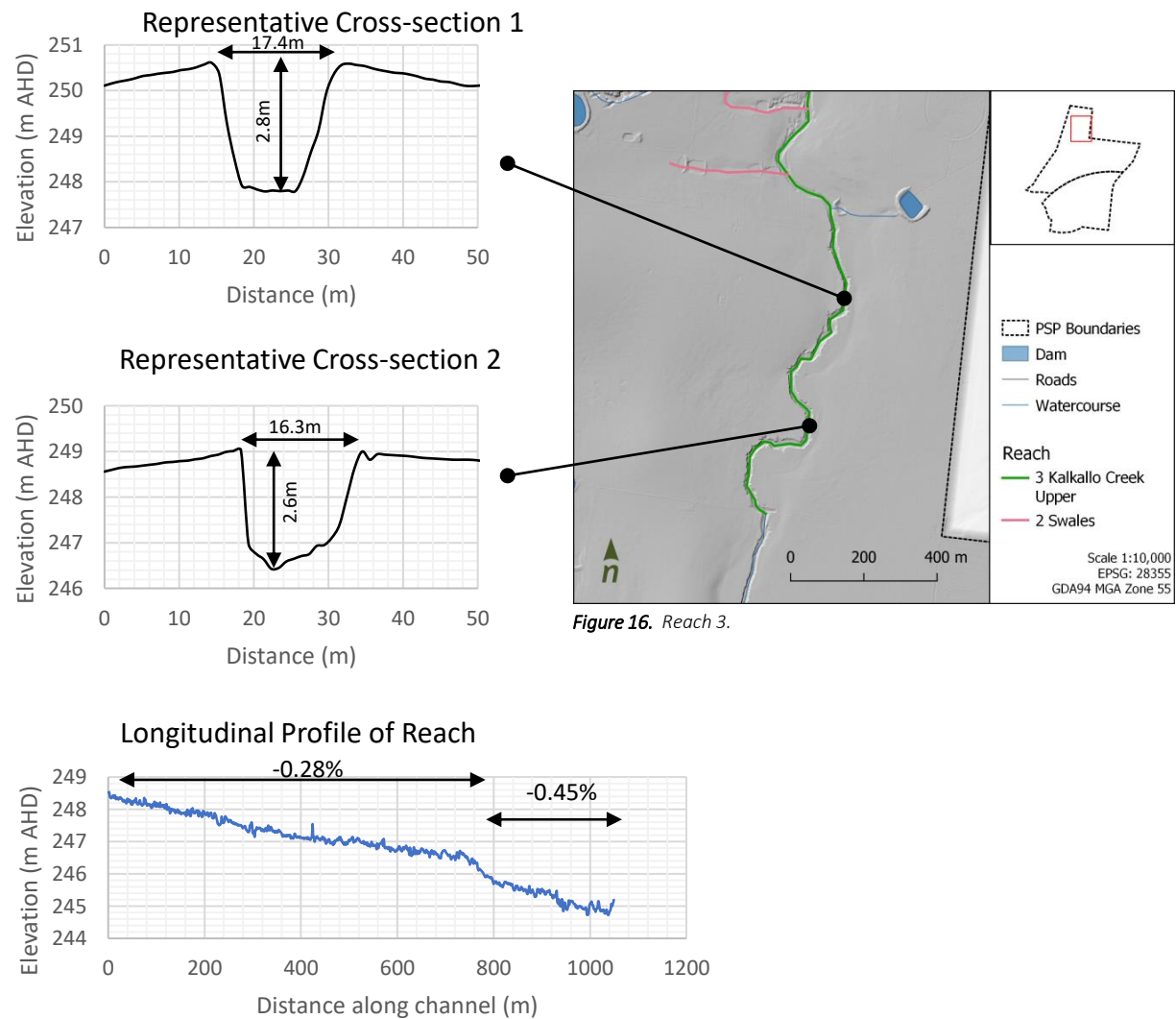
*Note, this cross section is of a defined, wide swale. Cross sections could not be generated for barely perceptible swales

Figure 15. Reach 2.

Reach #3

Reach 3 of the study site was characterised by the RiverStyles framework as an alluvial , continuous, low-sinuosity boulder bed. This reach forms part of Kalkallo Creek and approximately 1.1 km in length.

Parameter	Description
Channel	Single, continuous meandering watercourse.
Bank/valley sides	Channel confined by steep eroded banks. Exposed sodic subsoils are present at locations along the reach.
Bed	Typical longitudinal slope of the upper reach is -0.28%. The lower reach has a longitudinal slope of -0.45%. Bed material predominantly comprises silts, clays and minor gravels with occasional basalt rocks and white nodules (presumed calcareous), which are a product of natural weathering and groundwater movement that mobilises and then precipitates calcite.
Planform	Low sinuosity channel confined by steep, eroded banks.
Geology	Alluvial terrace deposits (Qa2).
Land use	Agriculture.
Soil type	Grey Sodosol – sodic and non-acid B2 horizon with a strong texture contrast between A horizon and B horizon.
Sediment load	Ephemeral stream. No streamflow at the time of field inspection.
Riparian vegetation	Grazed perennial pasture grasses (<i>Dactylis glomerata</i>).
In stream vegetation	Central channel dominated by Spiny rush (<i>Juncus acutus</i>). Grazed pasture grasses on in-stream benches.



Reach #3



Perennial pastures in riparian zone. Rushes visible in central channel



Perennial pastures in in-channel benches. Rushes visible in central channel

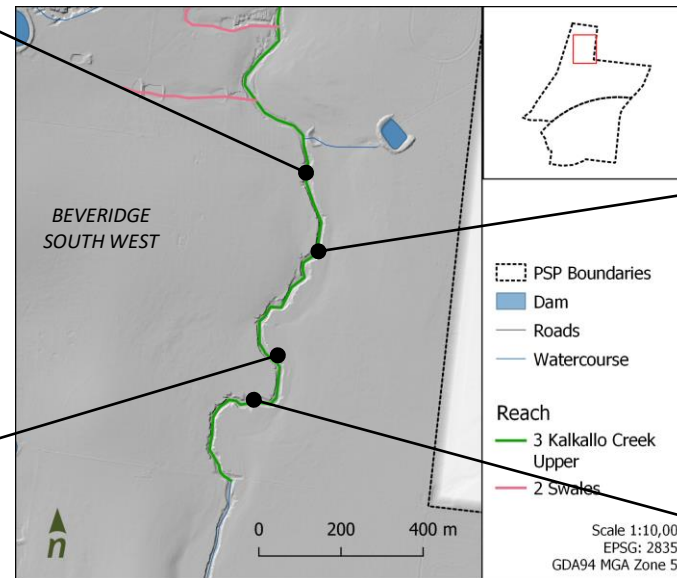


Figure 17. Reach 3 cont..



Steep eroded bank. Topsoil lighter in colour than subsoil. Suspected buried soil: Buried dark horizon, bleached horizon and grey also subsoil visible.

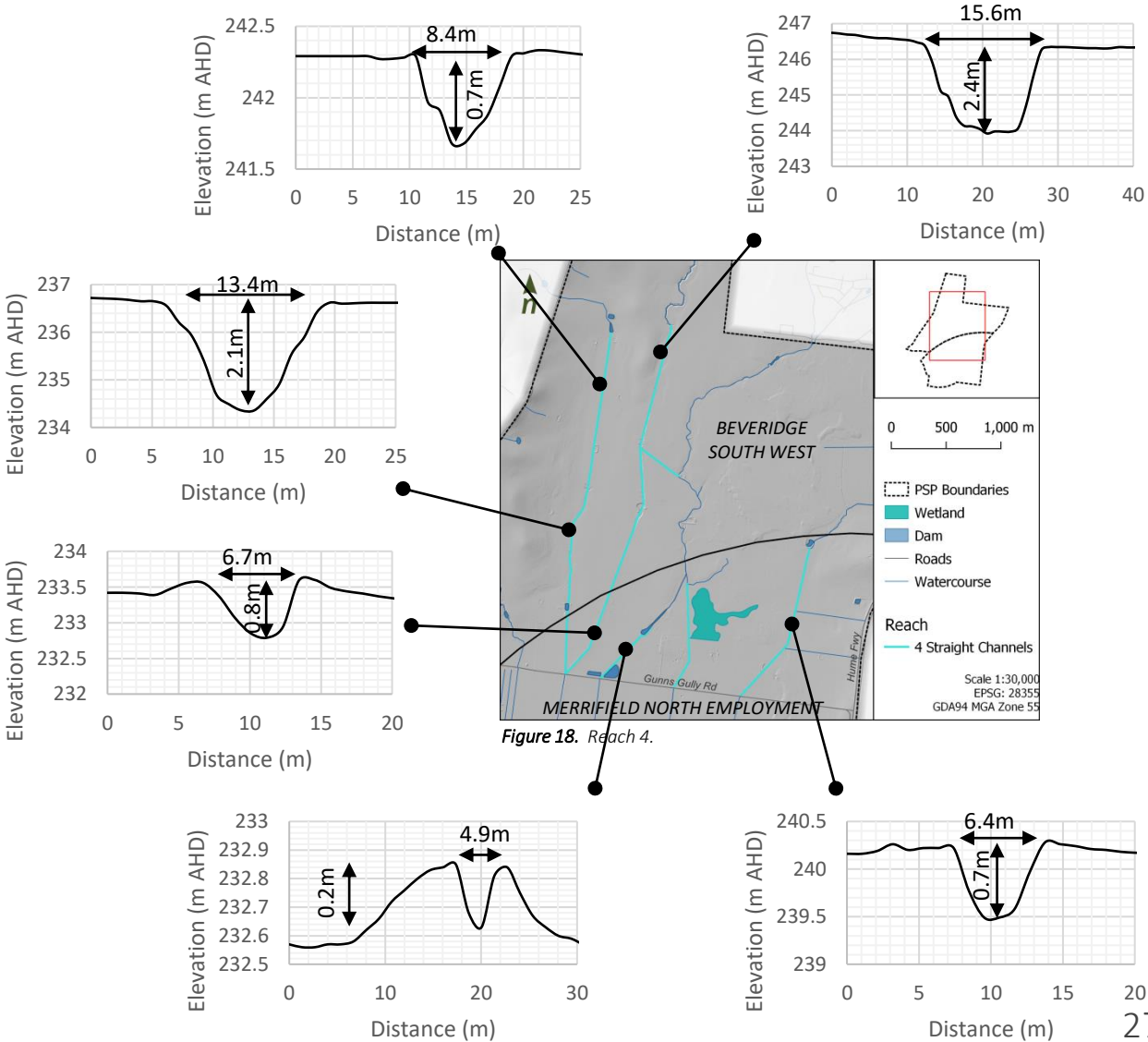


Exposed basalt rocks in channel

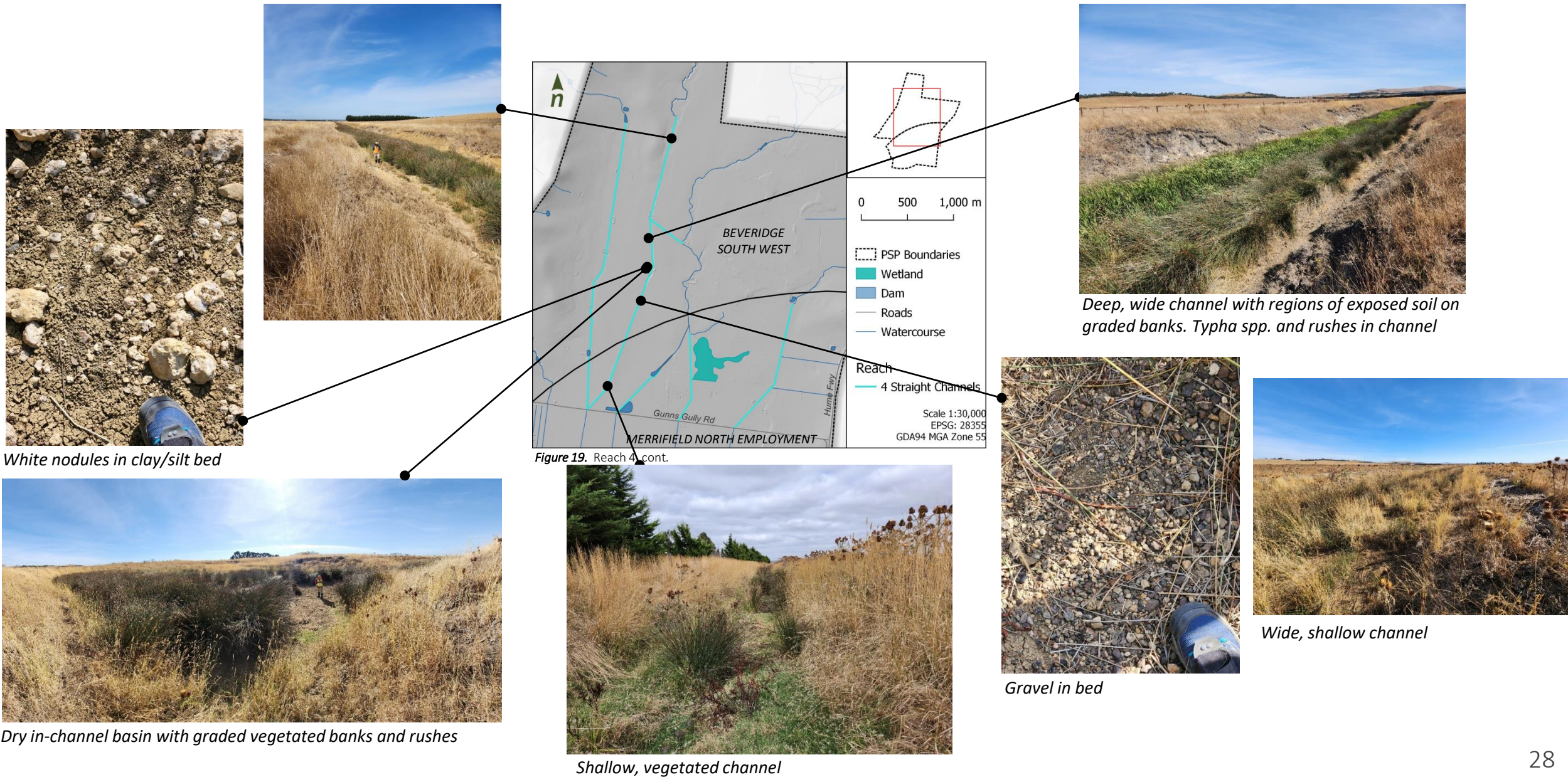
Reach #4

Reach 4 of the study site, consistent with descriptions in the RiverStyles framework, is comprised of straight, anthropogenic shaped channels. These channels vary in width, depth, and the degree of incision but all are straight and largely free of instream features such as pools and bars. This reach includes straightened reaches of Kalkallo Creek and unnamed watercourses. Marked reaches have a combined length of 10.13 km.

Parameter	Description
Channel	Single, continuous channel.
Bank/valley sides	Channel confined by steep or graded banks. Exposed sodic subsoils are occasionally present along the reach. Channels vary in depth and width (see cross-sections).
Bed	Typical longitudinal slopes vary from approximately -0.3% to -0.7%. Western and central channel bed material comprises silts, clays and gravels with occasional basalt rocks and boulders/cobbles (when on stony rises geology), and white nodular material (presumed calcareous). The Eastern-most channel (basalt flows geology) has regions of basalt boulder bed.
Planform	Straight anthropogenic channel, generally confined by graded banks.
Geology	Alluvial terrace deposits (Qa2). Newer volcanic group – basalt flows (Neo). Newer volcanic group – stony rises basalt (Neo2).
Land use	Agriculture.
Soil type	Grey Sodosol – sodic and non-acid B2 horizon with a strong texture contrast between A horizon and B horizon. Occasional cracking clays in easternmost channels.
Sediment load	Ephemeral stream. No streamflow at the time of field inspection.
Riparian vegetation	Perennial pasture grasses (<i>Phalaris aquatica</i> , <i>Dactylis glomerata</i>) surrounding western channel and Kalkallo Creek channel. Eastern channels have cropped canola in riparian zones.
In stream vegetation	Western and Kalkallo Ck channels dominated by spiny rush. Patches of Cumbungi (<i>Typha</i> spp.) in wetted regions. Pasture grasses and thistles on banks of eastern channels, with instream dominated by water couch (<i>Paspalum</i>) where not bare boulders.



Reach #4 – central channel



Reach #4 – Eastern and western channels



Straight channels of varied depth and width with graded, banks. Banks typically vegetated with perennial pasture grasses and thistles. Channel vegetation varies from bare trampled soil, to rushes, to perennial grasses.

Basalt boulder bed in eastern-most channel

Reach #5

Reach 5 of the study site is a sinuous watercourse. This is an unnamed watercourse that is adjacent to a large (dried) waterbody and wetland, and does not share headwaters with Kalkallo Creek. The marked reach has a length of 3.12 km.

Parameter	Description
Channel	Single, continuous channel.
Bank/valley sides	Channel confined by gently graded banks.
Bed	Average longitudinal slope is -0.4%. Bed material comprises grey silts and clays. Basalt rocks, and basalt boulder bed apparent when channel is on the stony rises geomorphological management unit.
Planform	Low sinuosity channel confined by gentle graded banks.
Geology	Alluvial terrace deposits (Qa2). Newer Volcanic group – stony rises basalt (Neo2).
Land use	Agriculture.
Soil type	Grey Sodosol – sodic and non-acid B2 horizon with a strong texture contrast between A horizon and B horizon.
Sediment load	Ephemeral stream. No streamflow at the time of field inspection.
Riparian vegetation	Perennial pasture grasses (<i>Phalaris aquatica</i>) and fringing spiny rush.
In stream vegetation	Instream vegetation predominantly consist of spiny rush and perennial pasture grasses. Common Reed (<i>Phragmites australis</i>) was present in section near the mapped waterbody.

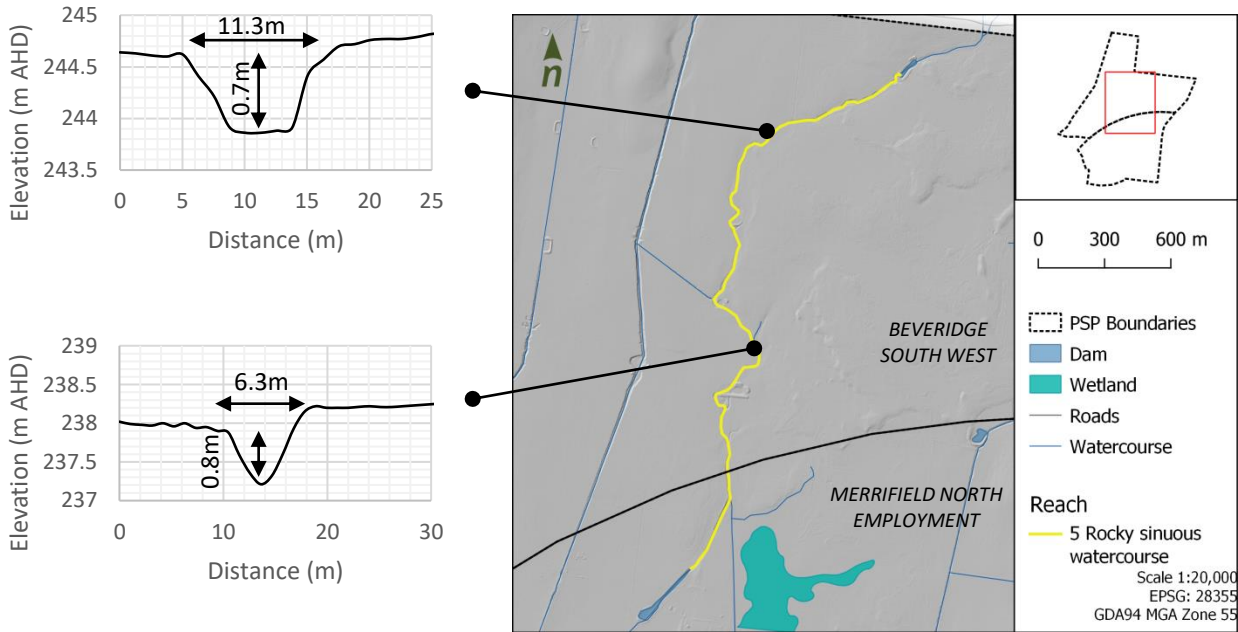
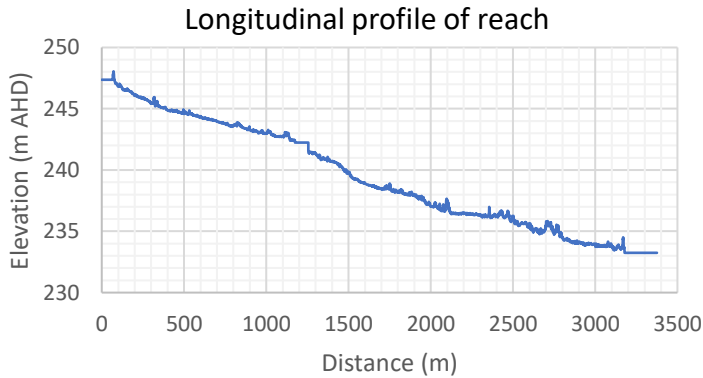


Figure 21. Reach 5.



Reach #5



Open channel with patchy grass cover, bordered by rushes

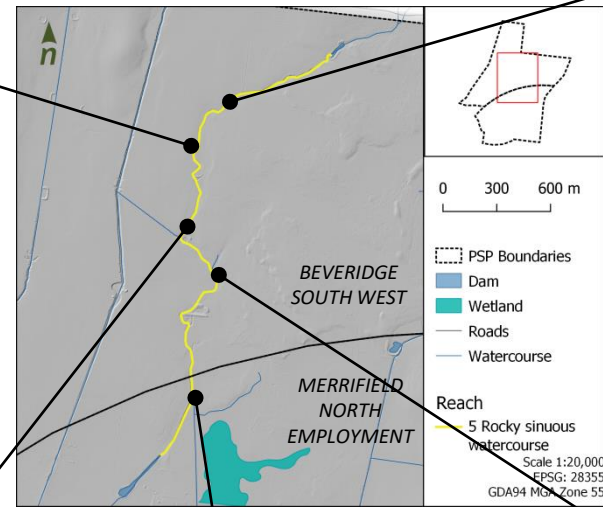


Figure 22. Reach 5. cont.



Rushes in watercourse. Shallow, sinuous watercourse with shallow banks



Stony rises (basalt rocks) in watercourse bed and banks



Exposed basalt boulder bed



Interspersed Phragmites and rushes in watercourse

Reach #6

Reach 6 of the study site, contains a modified watercourse of limited sinuosity with in-stream dams. Marked watercourses have a combined length of 1.68 km.

Parameter	Description
Channel	Channel consists of swales and drainage lines linked by in-stream dams. Western-most part of channel contains a revegetated, previously eroding gully.
Bank/valley sides	Broad swales and drainage lines with gentle slopes. Gully near Old Sydney Road with moderate, vegetated banks.
Bed	Typical longitudinal slope of swales and drainage lines ranges from -1.9% to -3.5%. Bed of swales typically vegetated with pasture grasses. Bed of gully consists of silt/clay with patchy vegetation.
Planform	Asymmetric swales with low sinuosity.
Geology	Alluvial terrace deposits (Qa2). Humevale siltstone (Dxh). Incised colluvium (Nc1). Springfield Sandstone (Sxs).
Land use	Agriculture.
Soil type	Grey Sodosol – sodic and non-acid B2 horizon with a strong texture contrast between A horizon and B horizon.
Sediment load	Ephemeral stream. No streamflow at the time of field inspection.
Riparian vegetation	Open Eucalyptus, Acacia and Casuarina overstorey in gully. Swales vegetated with perennial pasture grasses.
In stream vegetation	Gully channel contains perennial sedges and pasture grasses. Swales vegetated with perennial pasture grasses.

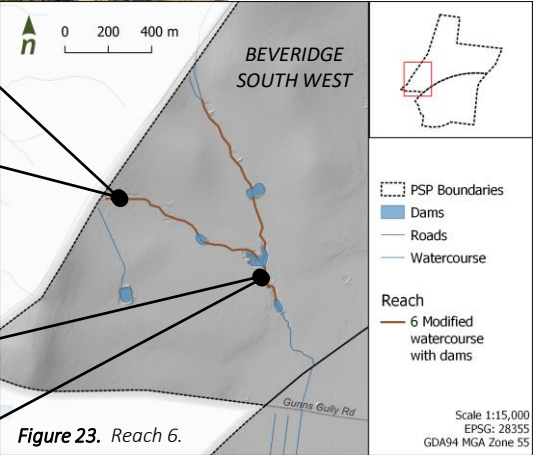


Figure 23. Reach 6.



Reach #7

Reach 7 of the study site, contains a ~500m long modified watercourse with River Red Gum values. Watercourse morphology is similar to that of Reach 6. The marked reach is 570 m in length.

Parameter	Description
Channel	Indistinct drainage lines.
Bank/valley sides	Indistinct drainage lines and broad swales. Banks vegetated with perennial pasture grasses.
Bed	Longitudinal slope varies from -0.4% to -0.9%. Bed is typically vegetated with perennial pasture grasses.
Planform	Modified very low sinuosity to straight channel.
Geology	Alluvial terrace deposit (Qa2).
Land use	Agriculture.
Soil type	Grey Sodosol – sodic and non-acid B2 horizon with a strong texture contrast between A horizon and B horizon.
Sediment load	Ephemeral stream. No streamflow at the time of field inspection.
Riparian vegetation	Perennial pasture grasses, with sparse old-growth River Red Gums (<i>Eucalyptus camaldulensis</i>).
In stream vegetation	Perennial pasture grasses, with sparse River Red Gum (<i>Eucalyptus camaldulensis</i>) overstorey.

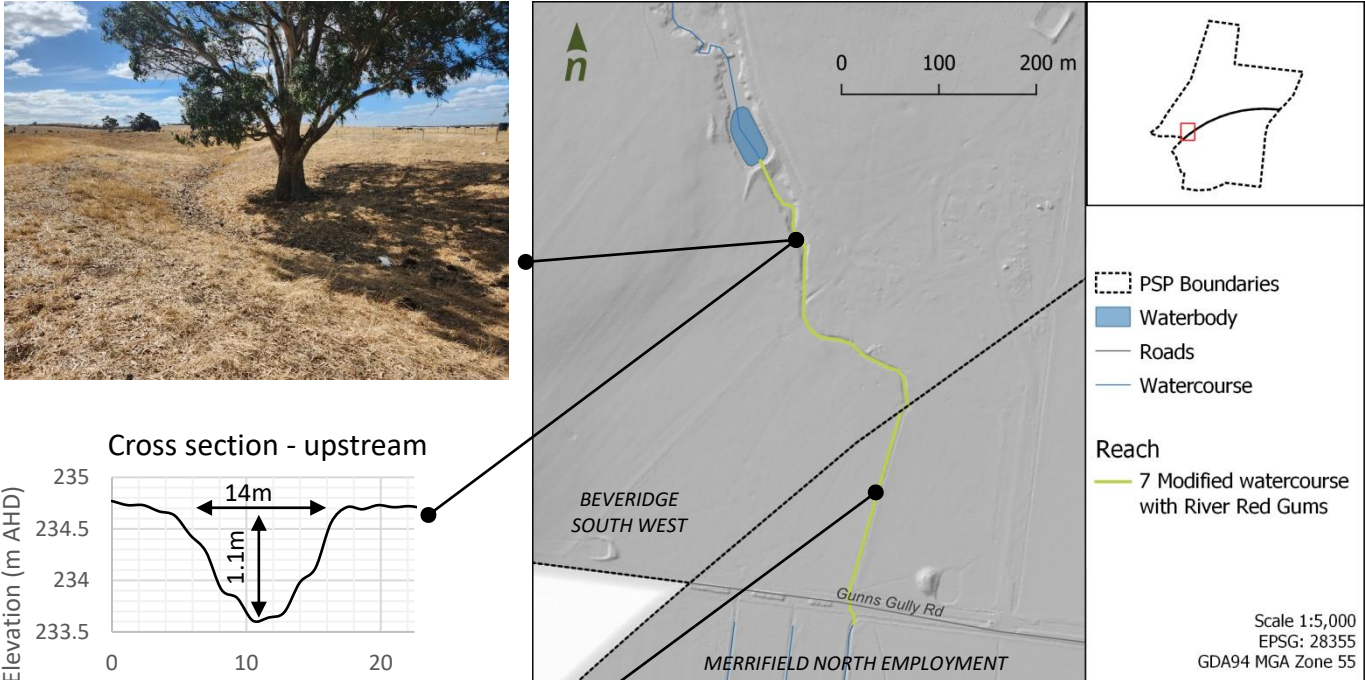
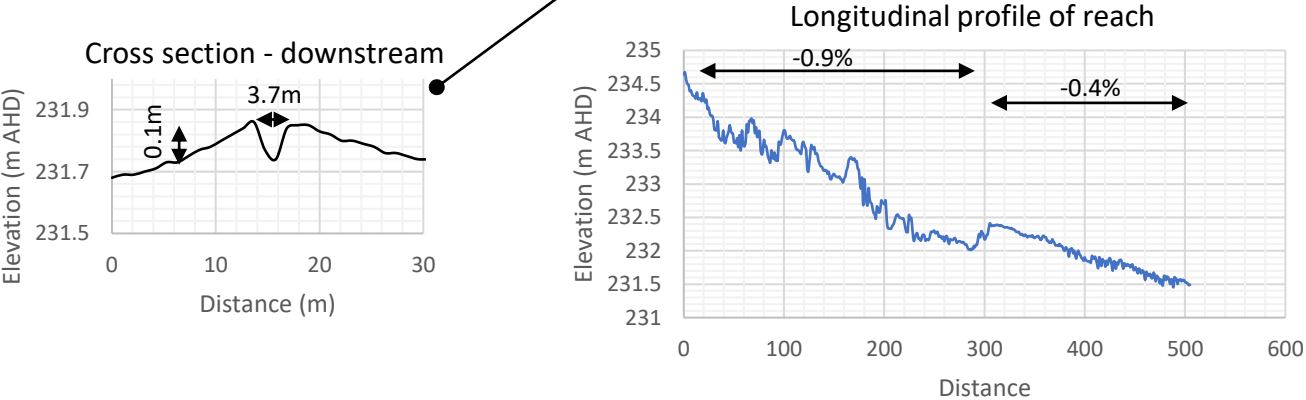


Figure 24 Reach 7.



Reach #8

Reach 8 of the study site consists of retarding basin channels. These are anthropogenic shaped channels of varying width and depth. Channels in this reach are considered separately from those in reach 4, due to their location within the planned retarding basin. The marked reaches have a combined length of 9.84 km.

Parameter	Description
Channel	Continuous channels.
Bank/valley sides	Channel confined by gently sloped banks. Small levees often present on one or both sides of the channel. Channels vary in width and depths. All deliver flows to Kalkallo Creek (Reach 10). Channel cross sections are shown.
Bed	Typical longitudinal slope ranges from -0.01% to -0.24%. Bed material comprises cracking clays that are usually vegetated.
Planform	Low sinuosity channel confined by steep banks.
Geology	Alluvial terrace deposits (Qa2).
Land use	Drainage / retarding basin.
Soil type	Black Vertosol – cracking clay soil (>35% clay throughout solum) with shrink/swell properties.
Sediment load	Ephemeral stream. No streamflow at the time of field inspection.
Riparian vegetation	Riparian vegetation dominated by perennial pasture grasses (<i>Phalaris aquatica</i>).
In stream vegetation	Northern regions of channels have high cover of Water Couch (<i>Paspalum distichum</i>). Other channels contain rushes (<i>Juncus</i> spp.), sedges (<i>Eleocharis</i> spp.) and pasture grasses and other wetland species.

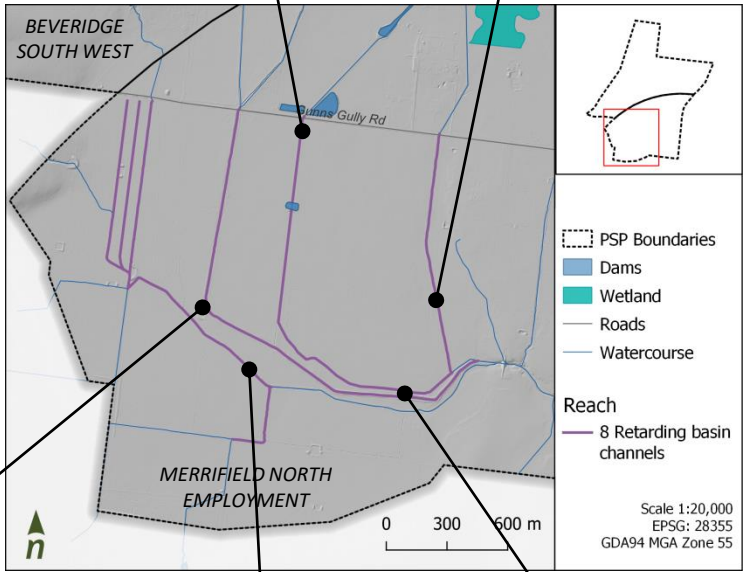
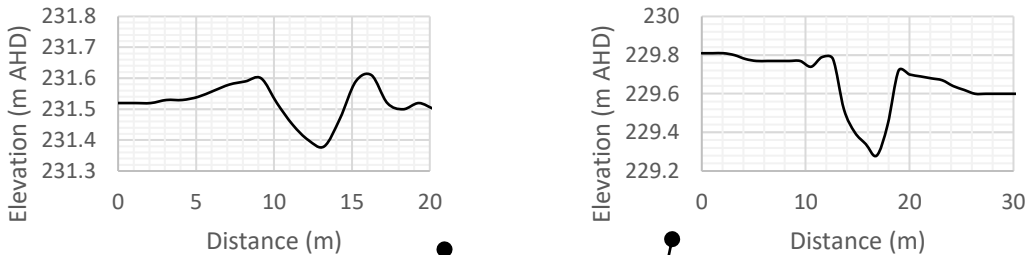
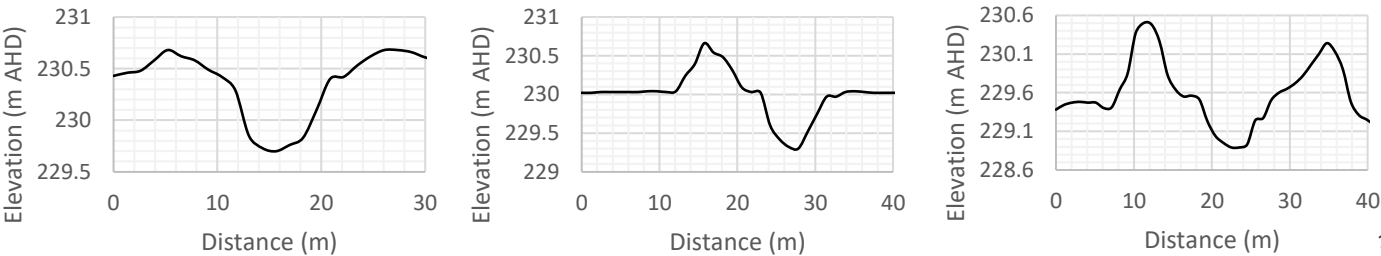


Figure 25. Reach 8.



Reach #8

Anthropogenic shaped channels of varying width and depth. Channels typically vegetated with perennial pasture grasses (Phalaris).

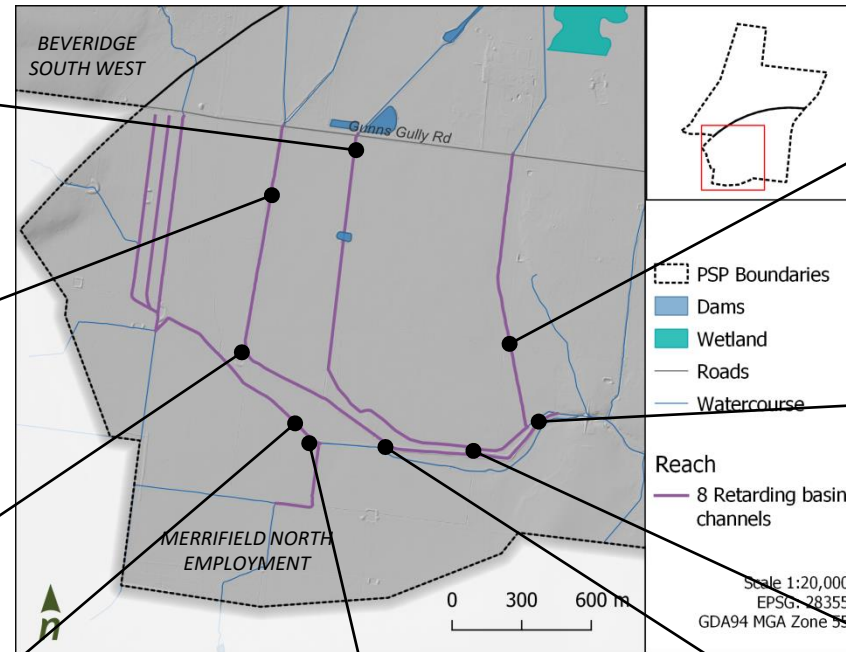


Figure 26. Reach 8 cont.

Reach #9

Reach 9 of the study site consists of anthropogenic shaped retarding basin channels with higher vegetation values. The marked channel is 1.24 km in length.

Parameter	Description
Channel	Continuous channels.
Bank/valley sides	Channel confined by gently sloped banks. Channels vary in width and depths with occasional pools. All channels deliver flows to Kalkallo Creek.
Bed	Typical longitudinal slope is -0.04%, with a steeper -2.3% gradient occurring over the last 40m of the reach. Bed material comprises vegetated silts and clays.
Planform	Straight anthropogenic channels.
Geology	Alluvial terrace deposits (Qa2).
Land use	Drainage / retarding basin.
Soil type	Black Vertosol – cracking clay soil (>35% clay throughout solum) with shrink/swell properties.
Sediment load	Ephemeral stream. No streamflow at the time of field inspection although standing water observed at some locations.
Riparian vegetation	Creekline Tussock Grassland in the eastern region of the reach, with prevalent Common Tussock-grass (<i>Poa labillardierei</i>), and native sedges. Western riparian regions dominated by pasture grasses.
In stream vegetation	Instream vegetation includes Water Couch <i>Paspalum distichum</i> , rushes (<i>Juncus</i> spp.) and Common Spike-sedge (<i>Eleocharis acuta</i>).

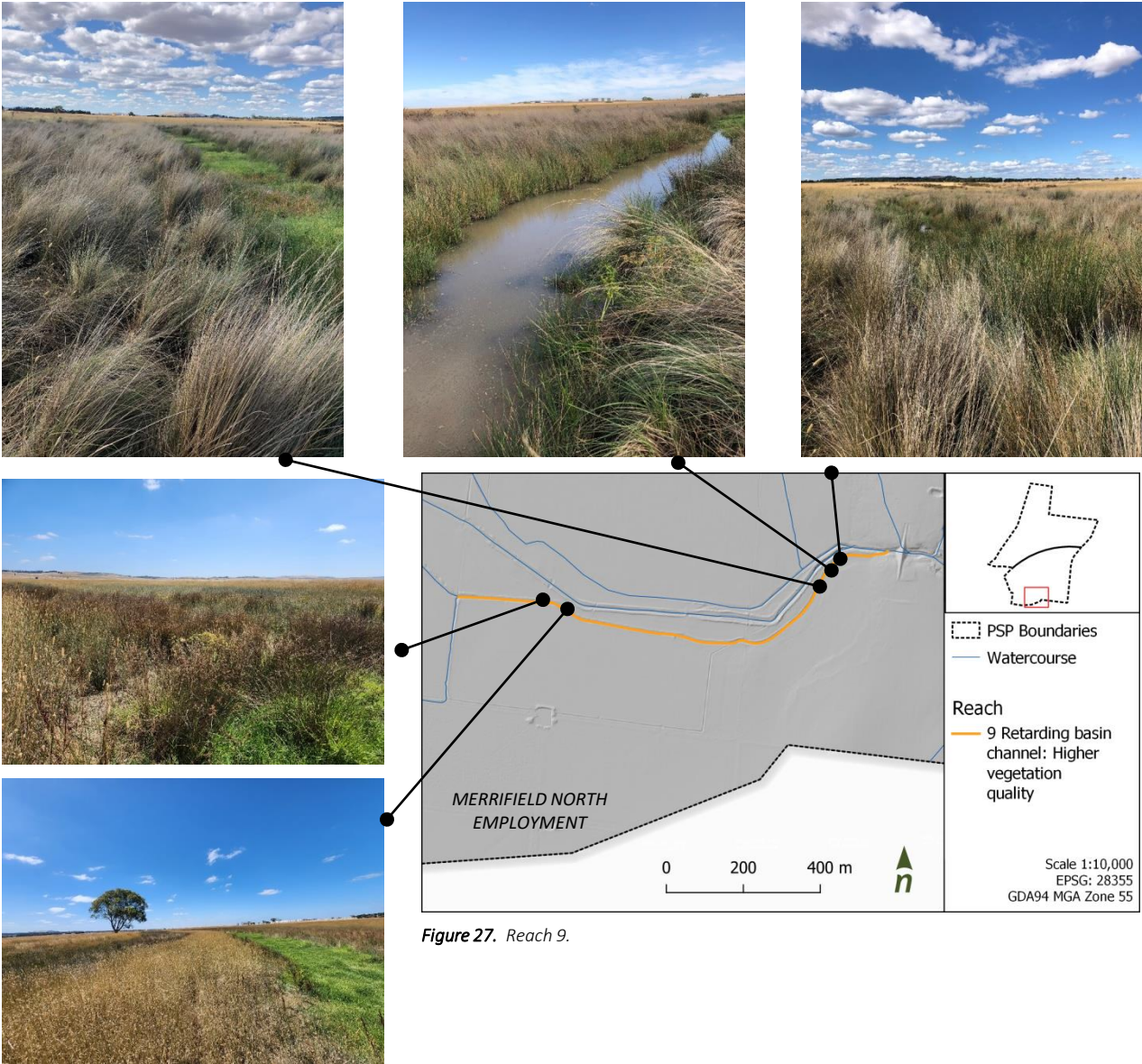
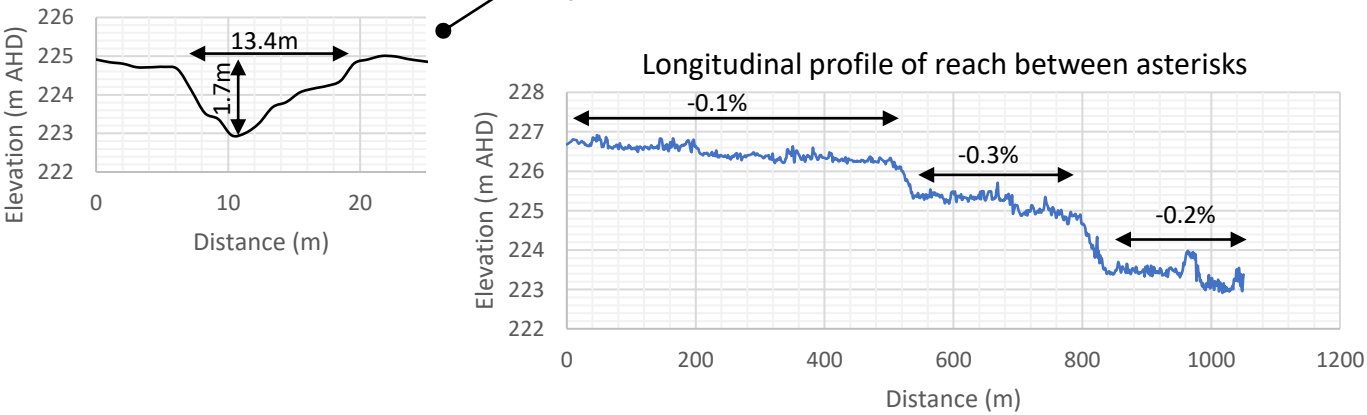
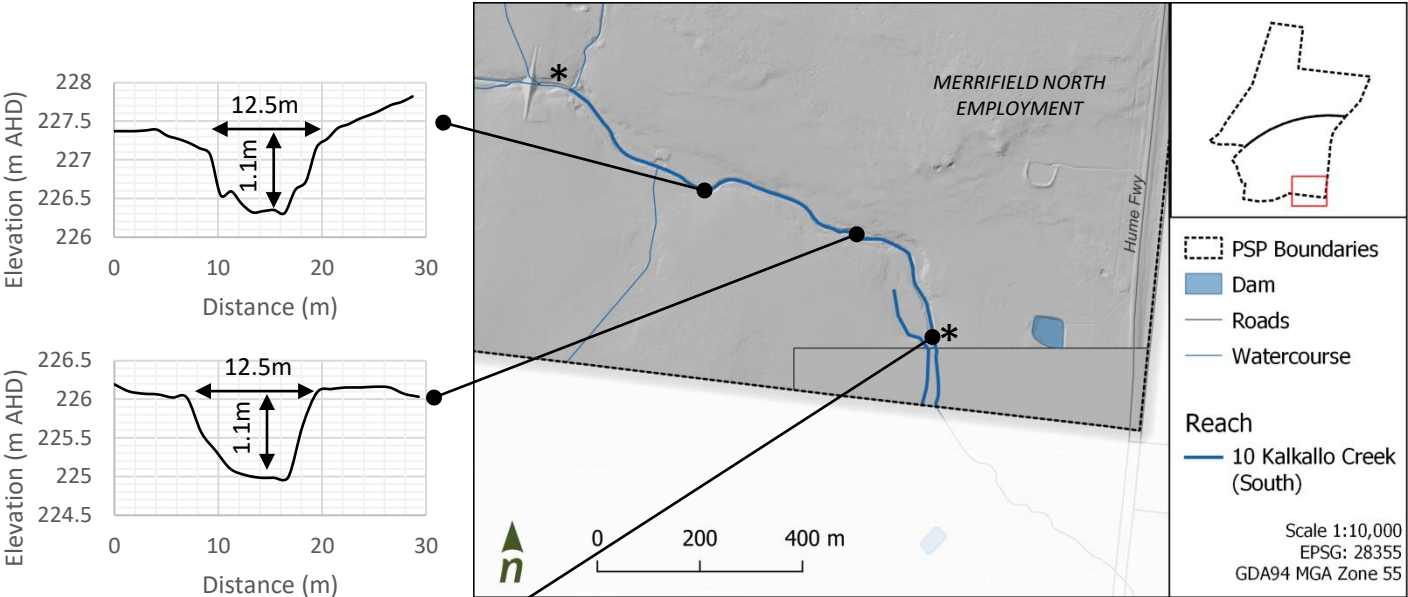


Figure 27. Reach 9.

Reach #10

Reach 10 of the study site consists of the southern reach of Kalkallo Creek. This reach is described in the RiverStyles Framework as of low sinuosity, with confined floodplain pockets. The marked reach within the Merrifield North Employment PSP area is 1.35 km in length.

Parameter	Description
Channel	Single, continuous channel, with standing pools.
Bank/valley sides	Channel confined by graded banks, and rocky extrusions.
Bed	Clear steps in elevation are visible in longitudinal profile. Longitudinal slope between steps ranges from -0.1% to -0.3%. Bed material comprises clays and lenses of sand that are generally vegetated or inundated with occasional bedrock outcrops.
Planform	Low sinuosity channel with confined floodplain pockets.
Geology	Alluvial terrace deposits (Qa2).
Land use	Agriculture and conservation area.
Soil type	Black Vertosol – cracking clay soil (>35% clay throughout solum) with shrink/swell properties.
Sediment load	Ephemeral stream. Little to no streamflow at the time of field inspection, although standing pools were observed.
Riparian vegetation	Mixed native and exotic grasses, rushes and sedges.
In stream vegetation	Rocky extrusions with interspersed exotic and native grasses and rushes (e.g. spiny rush).



Reach #10

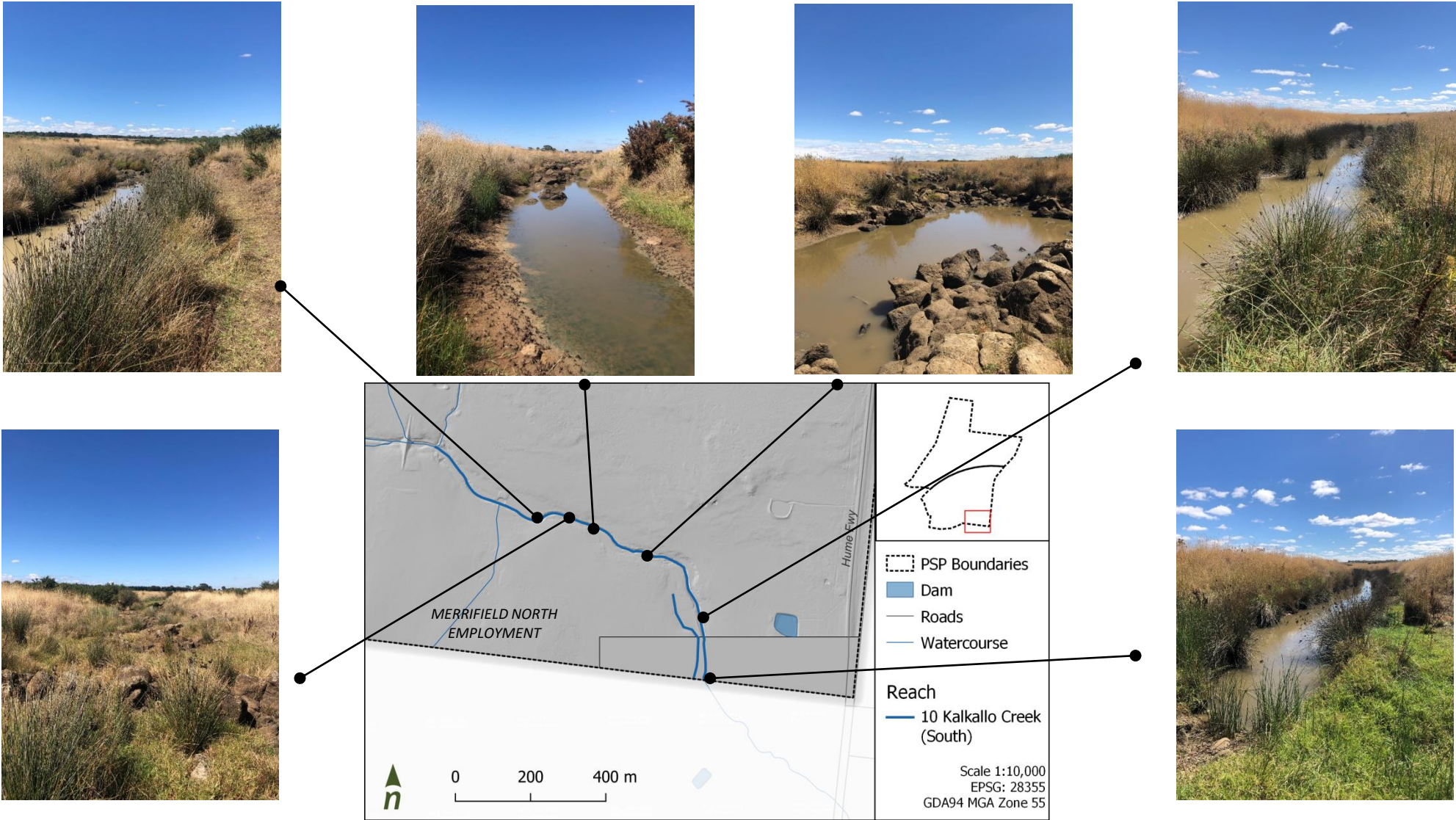
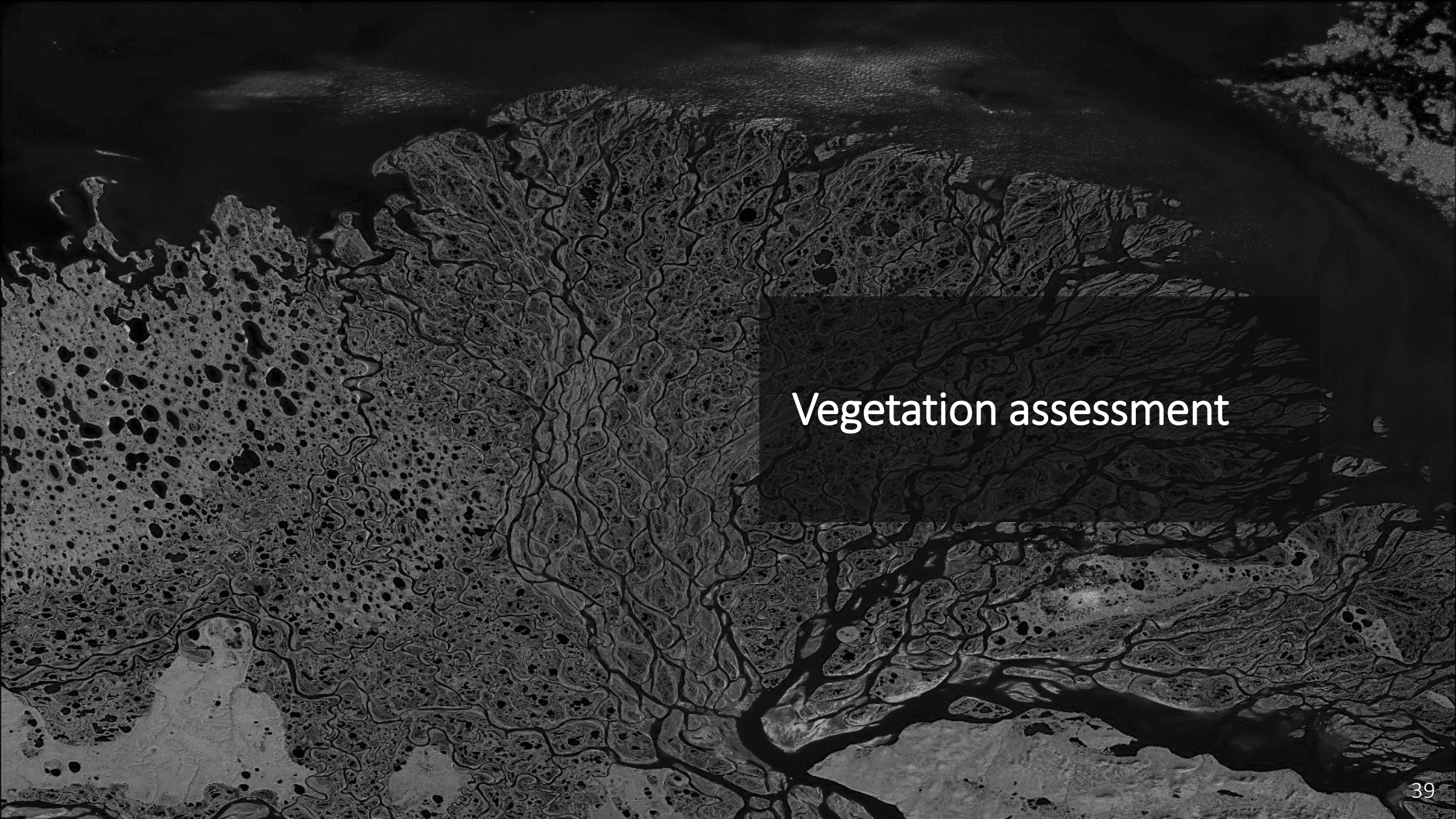


Figure 29. Reach 10 cont.

An aerial photograph of a dry, cracked landscape, likely a salt flat or a desert. The ground is covered in a complex network of dark, winding cracks that form a honeycomb-like pattern. The overall tone is dark and monochromatic. A semi-transparent rectangular box is overlaid on the right side of the image, containing the text "Vegetation assessment".

Vegetation assessment

Vegetation desktop assessment

A desktop review was conducted prior to field work to highlight potential and known significant species, communities and flora diversity. This provided a historical insight to help build a picture of how the flora has changed over time. Aerial imagery, HWS spatial layers including vegetation quality, timestamped vegetation data overlay (MSA), EVC mapping and species records from the Victorian Biodiversity Atlas, NatureKit and Matters of National Significance Protected Matters Search Tool were reviewed. Available wetland investigations in the surrounding area and the Biodiversity Conservation Strategy for urban growth areas were also reviewed to understand landscape connectivity and biodiversity. A full list of species from the database searches is found in Appendix A.

Given the site's landscape features and the significance of remnant vegetation on the Victorian Volcanic Plain bioregion there was an expectation that significant species and/or communities may be identified, potentially including groundwater dependent wetlands.

A desktop assessment of significant flora records was conducted for the study area. Records from the Victorian Biodiversity Atlas (VBA), *Environment Protection and Biodiversity Conservation (EPBC) Act 1999* Protected Matters Search and previous reports were reviewed and collated.

The results of the VBA search showed 2 listed flora species within the Merrifield North PSP and none within the Beveridge SW PSP with both records dating to 2008.

- 1 x Matted Flax Lily *Dianella amoena* record (EPBC listed)
- 1 x Tough Scurf-pea *Cullen tenax* record (listed under the Victorian *Flora and Fauna Guarantee Act 1988* (FFG Act)).

However, both listed species were derived from the VBA dataset with a spatial accuracy of between +/-500m to +/-10km therefore they have **not** been mapped.

Table 1 on the following page lists all listed flora species recorded either within VBA and/or in an EPBC protected matters search and their likelihood of present occurrence.

Figure 10 (in the background assessment) highlights the 1750 benchmark vegetation within both PSP's. This benchmark is a modelled estimate of the vegetation community's extent prior to European colonisation. The most recent assessment of ecological vegetation classes within the PSP borders was updated in 2012 as part of the Melbourne Strategic Assessments Biodiversity Conservation Strategy. Because both PSP's sit within Melbourne's urban growth corridor the areas were re-modelled with some ground truthing to determine an updated extent of EVC's within the urban growth corridor. Figure 30 includes all EVC's within the PSP boundaries that were modelled in 2012.

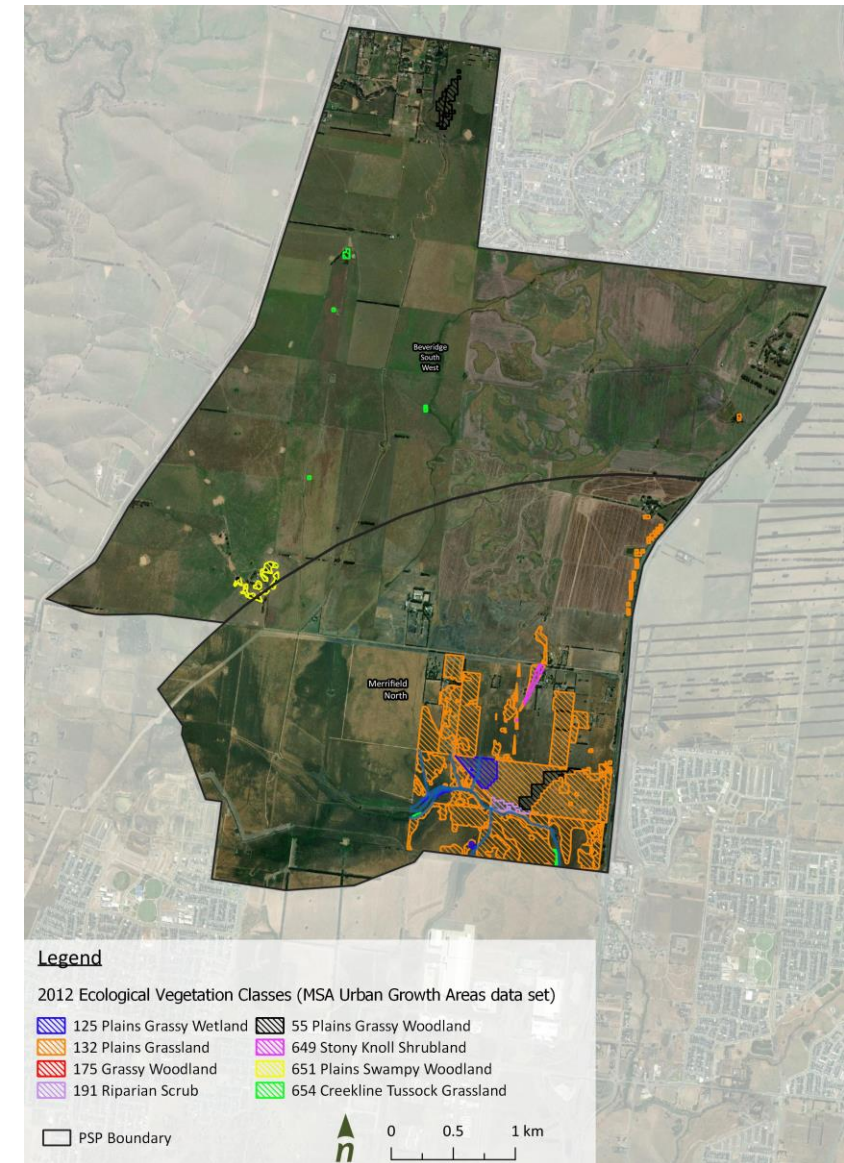


Figure 30. Ecological Vegetation Classes extent as modelled in 2012.

Significant flora and their conservation status – desktop assessment and field additions.

Table 1 Significant flora and their EPBC &FFG Act status. Species list compiled from VBA data and a protected matters search within the PSP study area and the nearby Craigieburn grasslands. Species in darker shading were opportunistically observed in the field.

Scientific Name	Common Name (s)	FFG	EPBC	Last Recorded on site	Likelihood of Occurrence
<i>Amphibromus fluitans</i>	River Swamp Wallaby-grass		Vulnerable	2023	High/ present - 2 individuals were tentatively identified within a patch of seasonal herbaceous wetland within reach 8.
<i>Amphibromus pithogastrus</i>	Plump Swamp Wallaby-grass	Critically Endangered			Moderate - Possibly present in marginal wetlands and damp sites if not displaced by management.
<i>Carex tasmanica</i>	Curly Sedge	Endangered		2011	High - <i>Carex tasmanica</i> recorded along Mandalay Creek (Reach 5).
<i>Comesperma polygaloides</i>	Small Milkwort	Critically endangered			Low – unlikely to have persisted due to management history (grazing sensitive).
<i>Cullen tenax</i>	Tough-scurf pea	Endangered		2023	High/ present - 2 individuals found in stony knoll grassland/shrubland vegetation in proximity to the mapped Wetland 70700.
<i>Dianella amoena</i>	Matted Flax-lily	Critically Endangered	Endangered	2008	High - Recorded during 2008 surveys.
<i>Diuris fragrantissima</i>	Sunshine Diuris	Critically Endangered	Endangered		Low - extremely unlikely due to habitat quality and management history.
<i>Dodonaea procumbens</i>	Trailing Hop-bush		Vulnerable		Low - highly unlikely due to lack of suitable habitat and management history (the nearest record is from 60km as the crow flies in a different habitat at the White Elephant reserve).
<i>Glycine latrobeana</i>	Clover Glycine	Vulnerable	Vulnerable		Moderate - possibly present in very localised more intact remnants of grassland or prior woodland e.g. red soil within conservation area 23.
<i>Lachnagrostis adamsonii</i>	Adamson's Blown-grass	Endangered	Endangered		Moderate - possibly present due to relevant brackish grassland habitat present.
<i>Lachnagrostis semibarbata</i> var. <i>semibarbata</i>	Purple Blown Grass	Endangered			Moderate - possibly present in marginal wetlands and damp sites if not displaced by management.
<i>Lepidium aschersonii</i>	Spiny Pepper-cress	Endangered	Vulnerable		Low - highly unlikely due to sensitivity to grazing and availability of suitable refugia.
<i>Lepidium hyssopifolium</i> s.s.	Basalt Pepper-cress	Endangered	Endangered		Low –unlikely to have persisted due to management history (grazing sensitive).
<i>Leucochrysum albicans</i> subsp. <i>tricolor</i>	White Sunray	Endangered	Endangered		Low - extremely unlikely due to habitat quality and management history.
<i>Pimelea spinescens</i> subsp. <i>spinescens</i>	Spiny Rice-flower	Critically Endangered	Critically Endangered		Low - unlikely due to habitat considerations.
<i>Pterostylis chlorogramma</i>	Green-striped Greenhood	Endangered	Vulnerable		Low - highly unlikely due to lack of suitable habitat and management history.
<i>Ranunculus diminutus</i>	Brackish Plains Buttercup	Endangered		2023	High/ present - present within margins of Wetland 70753.
<i>Rutidosis leptorhynchoides</i>	Button Wrinklewort	Endangered	Endangered		Low - extremely unlikely due to management history.
<i>Senecio macrocarpus</i>	Large headed Fireweed	Critically endangered	Vulnerable		Low - highly unlikely due to lack of suitably intact habitat and management history. Found in high quality remnants such as linear reserves only.
<i>Senecio psilocarpus</i>	Swamp Fireweed		Vulnerable		Moderate - possibly present in Plains Grassy Wetland but probably unlikely due to management history.
<i>Xerochrysum palustre</i>	Swamp Everlasting	Critically Endangered	Vulnerable		Moderate - possibly present in Plains Grassy Wetland but highly unlikely due to management history.

Vegetation field assessment method

Field survey - waterways. This study drew upon Melbourne Water's *Inventory of values and threats* and *Vegetation Visions* rapid riparian condition methodologies for waterway assessments (see vegetation quality categories used for waterways and riparian areas to right). The same reaches were adopted for assessment as for the geomorphology assessment (see Figure on next page).

Exotic species of management concern (i.e. those species which are a high threat to waterway function and riparian biodiversity) were recorded, noting which are most amenable to management. Also noted was the presence of species which were of low management priority i.e. those with less biodiversity or waterway function impact.

Table 2: Melbourne Water's Vegetation Visions categories

Vegetation Visions Score	Vegetation Quality
1	Very low
2	Low
3	Medium
4	High
5	Very high

Field survey - wetlands. In addition to mapping riparian vegetation quality, we also reviewed the presence of natural wetlands as these features are a priority listed in the Healthy Waterways Strategy and may be hydrologically impacted by future drainage response.

The method for assessment of wetland values and condition was informed by methodologies developed by the Arthur Rylah Institute to document values and threats for wetlands and the Index of Wetland Condition (IWC) method of Papas and Moloney, 2012. An overall summary of a wetlands' value or sub-units within a site follow the shown in the below table (Peters et al 2015). Potential for Seasonal Herbaceous Wetlands (SHW) was considered.

A IWC assessment was conducted for the two mapped wetlands. The remnant Seasonal Herbaceous Wetland flora along the drains (Reach 8) was not assessed by this method. The categories in Table 3 can be used for purposes of a rapid assessment.

Species conventions within the report

To increase the accessibility of the report scientific and common names of species were provided and symbology was used to denote the species origin:

- Where common names for species exist, they have been listed first with the scientific name in brackets

after it (note not all species have conventionally used common names).

Species conventions within the report cont.

- An asterisk (*) before a scientific name indicates a non-indigenous introduced species.
- An up arrow (^) before a scientific name indicates a cosmopolitan species with uncertain establishment means.
- No symbol before a scientific species names indicates an indigenous species.

Table 3: Wetland assessment categories

Condition category	Description
Category 1 (Excellent)	No major identifiable impacts on vegetation condition; vegetation apparently ecologically stable (temporal and spatial variation remaining within the spectrum of possibilities anticipated for unmodified examples of the relevant system); bio-diversity losses minimal if any; serious environmental weeds absent; and relatively unmodified in terms of ecological processes.
Category 2 (Good)	Some biodiversity losses within the EVC reasonably presumed or weeds invasions impacting on the indigenous vegetation, but system apparently remaining ecologically stable; and only minor modifications to critical ecological processes.
Category 3 (Moderate)	EVC disturbed but still readily identifiable; extinction-prone species mostly displaced but a substantial component of indigenous flora persisting (at least at low levels); serious environmental weeds often present or otherwise significant ecological invasions occurring; and substantial modifications to critical ecological processes.
Category 4 (Poor)	EVC degraded, with only a minor component of original flora persisting; structure of the vegetation substantially modified; serious environmental weeds often prevalent within at least part of the system or significant ecological invasions advanced; and system substantially disrupted due to loss of critical ecological processes.
Category 5 (Very Poor)	Indigenous vegetation displaced (throughout wetting and drying cycles); introduced species or mixtures including indigenous species from adjacent non-wetland habitats dominated vegetation; and system effectively displaced due to complete loss of all ecological processes associated with the original ecosystem.

Vegetation reaches and mapped wetlands assessed

Vegetation field assessment was conducted for waterways and wetlands where access was available, adopting wetland numbering from the Victorian current wetland spatial layer (Figure 7) and the same waterway reaches used in the geomorphology assessment. Each reach was subsequently given a corresponding Ecological Vegetation Class (EVC code displayed in Figure 31) and a vegetation visions assessment was undertaken at each reach.

Mapped wetlands assessed:

- 70700.
- 70753.

Waterway reaches assessed:

- Reach 1 (deep eroded gully).
- Reach 2 (swales leading to dams) – limited access.
- Reach 3 (upper Kalkallo Creek).
- Reach 4 (straight channelised channels) – limited access.
- Reach 5 (rocky sinuous watercourse).
- Reach 6 (modified watercourses with dams).
- Reach 7 (modified watercourse with river red gums).
- Reach 8 (retarding basin channels, some including seasonal herbaceous wetland flora).
- Reach 9 (high quality remnant Creekline Tussock Grassland).
- Reach 10 (Kalkallo Creek south).

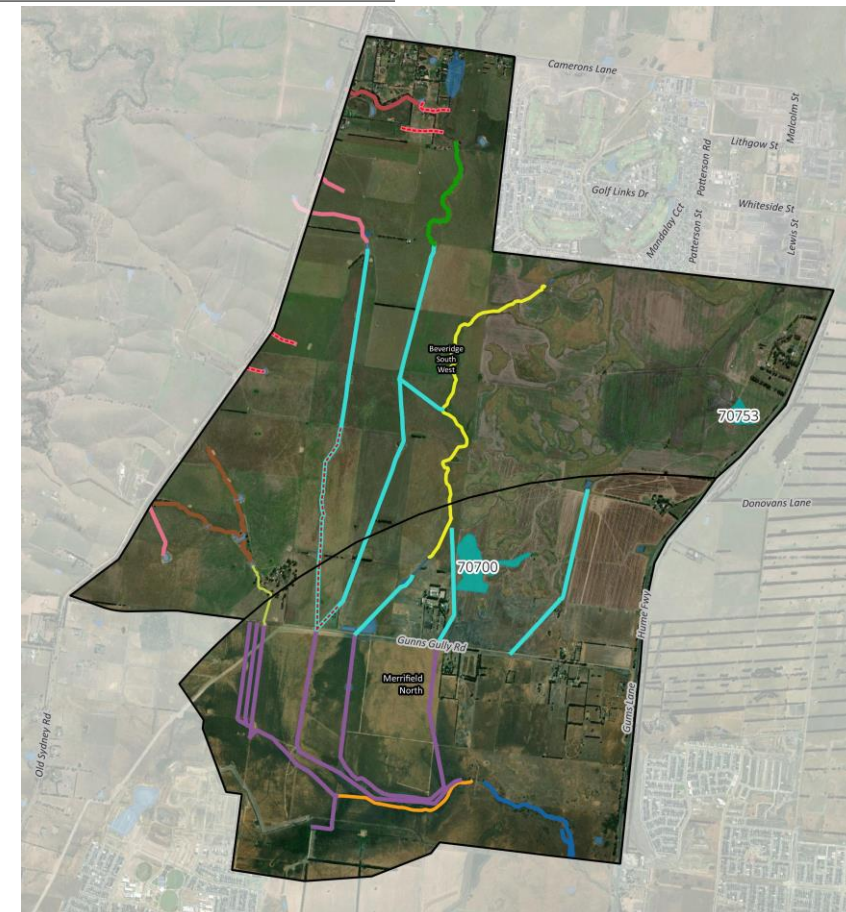
Other areas noted (field):

- Native grassland vegetation within BCS conservation areas 23 and 34.
- Incidental observations of threatened plants within rocky knolls north of wetland 70700.

Other areas (desktop):

- 2012 (Alluvium) Curly Sedge records in a small depression coming off reach 5.
- NB: * proceeding species name denotes the species as introduced in Victoria.

Limitations. This assessment applies to riparian and wetland areas only where access was available (see map) with some incidental observations of nearby terrestrial areas. While a list of species observed in the field is appended, a comprehensive inventory of flora was not undertaken as this assessment was intended to provide an overview of values which can be used as a basis to conduct further detailed assessments. Several areas were not accessed as permission was not given by landowners or they could not be contacted. These sites were reviewed via desktop but require further review and ground truthing. Some data sources were not available and should be incorporated into future investigation, including Birdlife Australia records and any relevant Melbourne Water species records not yet on the VBA .



Legend

Reaches

- 1 Deep Eroded Gully (EVC 88)
- 2 Swales Leading to Dams (EVC 999)
- 3 Kalkallo Creek Upper (EVC 654)
- 4 Straight Channels (EVC 999)
- 5 Rocky sinuous watercourse (EVC 124)
- 6 Modified watercourse with dams (EVC 68)
- 7 Modified Watercourse with River Red Gum values (EVC 55)

- 8 Retarding basin channels (EVC 999)
- 9 Retarding basin channel - Higher veg quality channel (EVC 654)
- 10 Kalkallo Creek South (EVC 654)

Other

- Areas not surveyed due to access constraints
- PSP Boundary
- Dams
- Wetland

Figure 31. Wetlands from the Wetland current layer and waterway reaches assessed.

Reach 1 *Modified* Creekline Grassy Woodland EVC 88

BCS Status: Endangered.

Description

Reach 1 sits on the eastern border between the Victorian Volcanic Plains Bioregion and the Central Victorian Upland Bioregion. It is comprised of a deep eroded gully with patches of highly modified Creekline Grassy Woodland (EVC 88) vegetation on either side of the gully. Native ground story accounts for <5% of vegetation both within the gully and on 20m either side of the gully. The ground layer was sparse in the westernmost (top) half of the reach with mostly bare ground and leaf litter, transitioning to increasing weed dominated ground layer in the eastern (bottom) half. There was evidence of recruitment with some established juvenile trees and shrubs. The creek bed was dry during the site visit.

Flora present at the site

Overstorey

Sugar gum (*Eucalyptus cladocalyx*), Radiata Pine (*Pinus radiata*).

Midstorey

Gorse (*Ulex europaeus*), Prunus (*Prunus* sp.), and non-local Honey Myrtle (*Melaleuca* sp.) and Wattle (*Acacia* sp.).

Groundstorey

Toowoomba Canary-grass (*Phalaris aquatica*), Tall Fescue (*Festuca arundinacea*) and Paspalum (*Paspalum dilatatum*).

DELWP Modelled pre 1750 EVC

Plains Grassy Woodland EVC 55.



Figure 32. Reach 1 Ecology.



Melbourne Water Riparian Vegetation Visions Quality Assessment: 3

Threats

- Further erosion due to increased flows
- Erosion due to slumping of margins
- Increased exotic flora invasion (particularly exotic trees and shrubs)



Reach 2 Unknown/ unclassified EVC 999

Status: Unknown.

Description

Heavily grazed exotic pasture with shallow depressions in the pasture indicating flow paths. >95% introduced species cover.

Flora present at the site

Groundstorey

Dominant pasture species included grasses such as Toowoomba Canary-grass, Cocksfoot, and Brown-top Bent with occasional scattered native Rush (*Juncus* sp.).

DELWP Modelled pre 1750 EVC

Grassy Woodland EVC #175.

Melbourne Water Riparian Vegetation Visions Quality Assessment: 1.

Threats

- Cattle grazing (currently).
- Increased biomass cover (and therefore fire risk) once grazing is reduced/ removed.

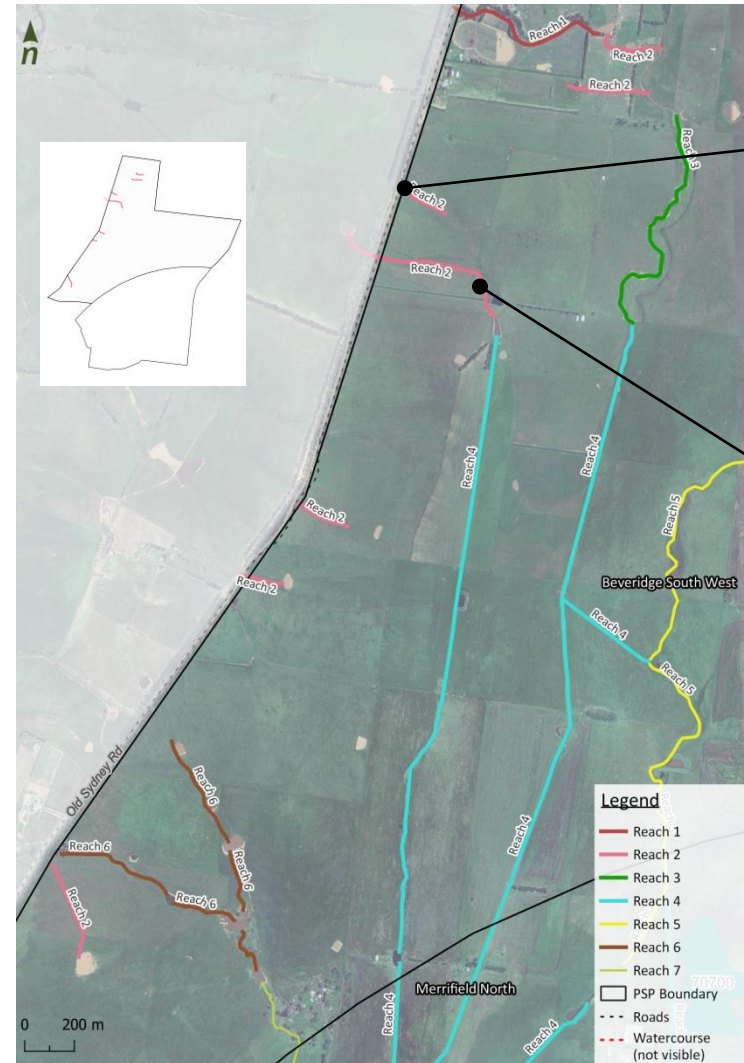


Figure 33. Reach 2 Ecology.



Flow path taken from Old Sydney Road facing into the fenced paddock.



Waterway/ drainage channel with pipe.

Reach 3 *Modified* Creekline Tussock Grassland EVC 654

BCS Status: Endangered.

Description

A meandering, non-channelised incised section of Kalkallo Creek with a rocky substrate and instream vegetation dominated by introduced Spiny rush **Juncus acutus*. Individual/ very small patches of native/ remnant species (Wallaby grass and Blue Devil) were found within 20m of the creek edges however introduced species made up >95% of instream and riparian vegetation across the reach.

Flora present

Groundstory

Sharp Club-sedge (*Schoenoplectus pungens*), Blue Devil (*Eryngium ovinum*), Wallaby Grass (*Rytidosperma* sp.), Spiny Rush (**Juncus acutus*), Cocksfoot, Paspalum (**Paspalum dilatatum*), Chilean Needle-grass (**Nassella neesiana*), Buck's-horn plantain (**Plantago coronopus*), Tall Fescue (**Festuca arundinacea*).

DELWP Modelled pre 1750 EVC

Plains Grassland EVC 132.

Melbourne Water Riparian Vegetation Visions Quality Assessment: 2.

Threats

- Grazing Cattle.
- Exotic flora invasion (biomass will increase when cattle are removed).
- Erosion with increasing run off.

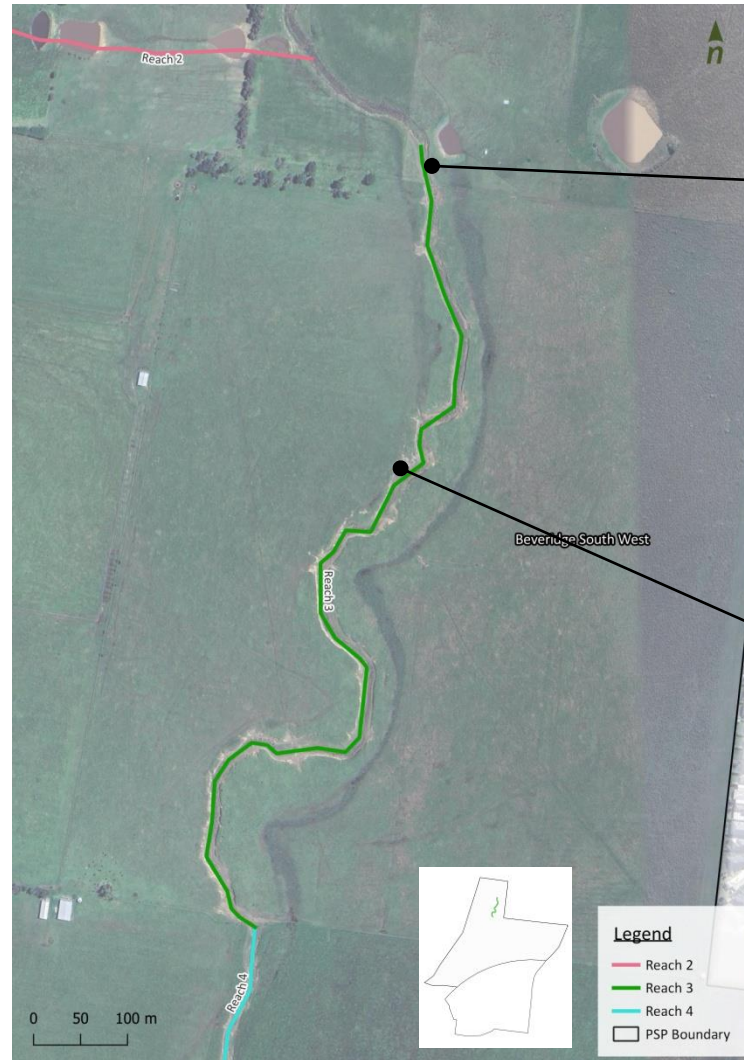


Figure 34. Reach 3 Ecology.



Image north facing.



Blue Devil *Eryngium ovinum*
approximately 15m from waterway

Reach 4 Unknown/ unclassified EVC 999 (highly modified drainage line vegetation)

BCS Status: Unknown.

Description

A series of artificially straightened/ excavated channels with a width of between 1m-5m wide. Vegetation is typically very weedy, with evidence of grazing adjacent to/within the creek. Soil was regularly disturbed by grazing cows limiting the ability for regeneration in highly trafficked areas.

Instream vegetation various across one / a mix of the following categories:

- Patches of bare ground with no/ minimum instream vegetation.
- Patches dominated by Spiny Rush (**Juncus acutus*) with occasional patches of native perennial rush *Juncus amabilis*.
- A mix of Water Couch and around 20% cover of the native Common Spike-sedge (*Eleocharis acuta*).
- A mix of Spiny Rush and Bulrush (*Typha* sp.)

There is a large crop of Canola between the easternmost channels. The crop had been harvested however stalks indicated the crop had been patchy due to seasonally wet conditions, with a high cover of Toad Rush (*Juncus bufonius*) and a component of Little Club-Sedge (*Isolepis marginata*) on cracking clay soils.

It appears that prior to construction of these modifications, Kalkallo Creek and Mandalay Creek would have been poorly defined through the larger part of the PSPs, entering a broad area of seasonally swampy basin prone to shallow inundation following larger rainfall events, before coalescing into the defined stream channel towards the south-western corner of the Merrifield North PSP.

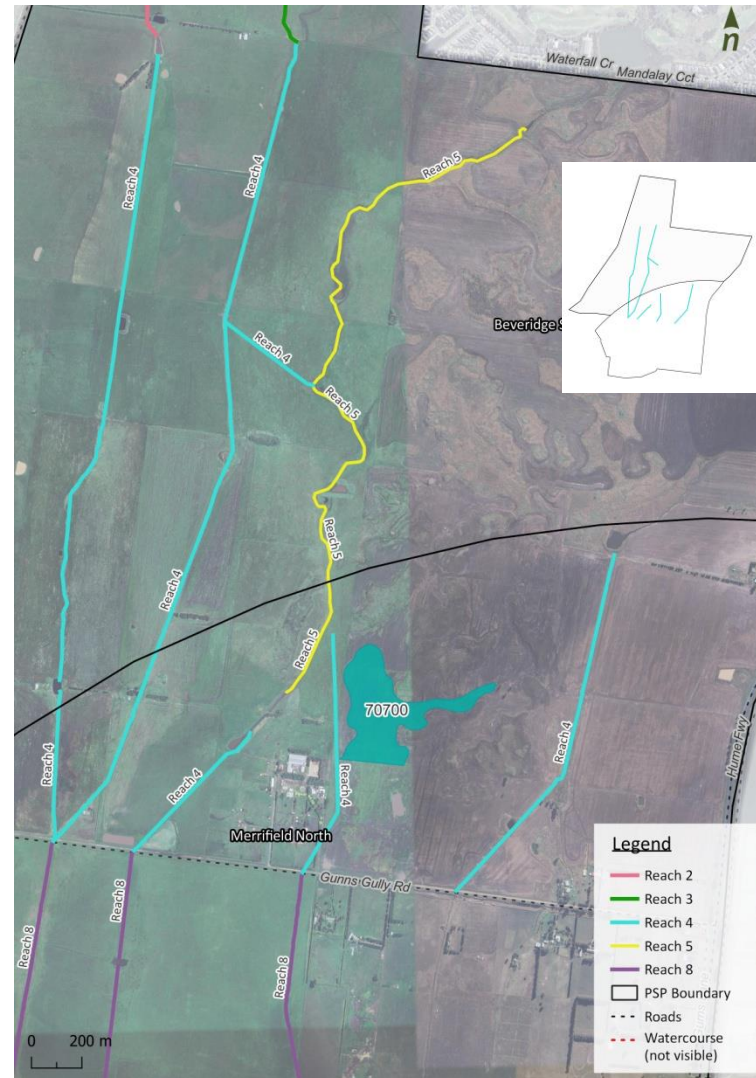


Figure 35. Reach 4 Ecology.

Flora present at the site (within and 20m of drain)

Groundstory

Spiny Rush (**Juncus acutus*), Toowoomba Canary-grass (**Phalaris aquatica*), Cocksfoot (**Dactylis glomerata*) and Curly Dock (**Rumex crispus*). Native species include scattered patches of Kangaroo Grass (*Themeda triandra*) and incidental individuals including Blue Devil (*Eryngium ovinum*), Brown-back Wallaby-grass (*Rytidosperma duttonianum*) and Common Woodruff (*Asperula conferta*).

Melbourne Water Riparian Vegetation Visions Quality Assessment : varied from 1 to 2 across the reach.

DELWP Modelled pre 1750 EVC (west to east)

Plains Grassland EVC 132/ Plains Grassy Wetland 125.

Threats

- Grazing cattle.
- Soil disturbance.
- Increased biomass cover (and therefore fire risk) once grazing is reduced/ removed.

Reach 4 cont. Unknown/ unclassified EVC 999 (highly modified drainage vegetation)



Fenced off 'native' planting (~0.3 ha), predominately non-indigenous trees and shrubs likely planted 1970's or 80's.



Riparian vegetation is dominated by exotic Tall wheatgrass. Patch of Tall Wheat-grass *Lophopyrum ponticum* (syn. *Thinopyrum ponticum*) population found around dam - FFG Act 1988 listed as a potentially threatening process.

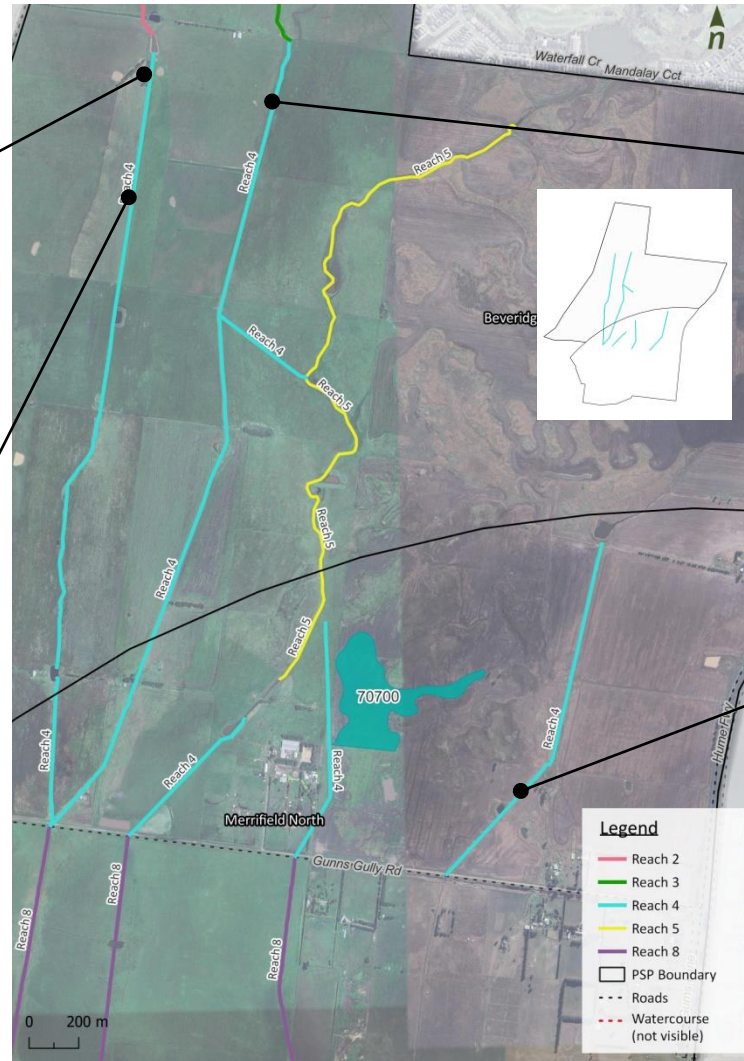
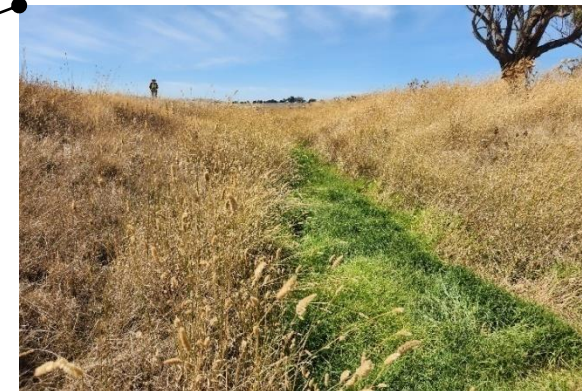


Figure 36. Reach 4 Ecology. Cont.



South facing image with scattered VVP Plains Grassland species around 20m on the western flank of the creek may expand beyond the area surveyed. A full assessment of the extent and quality of VVP Grasslands is recommended.



Reach 5 Modified Grey Clay Drainage-line Aggregate EVC 124

BCS Status: Endangered.

Description

The reach represents a primarily non-channelised portion of Mandalay Creek. Moving South to North, the creek bed changes from a 400m stretch of channelised shallow creek bed to patches of tessellated columnar rocks, to a shallow weed dominated natural depression with a grey clay bed, to a heavily pugged grey clay creek bed in northern 600m of the reach.

The channelised southern 200m of the reach is dominated by Common Spike-sedge (*Eleocharis acuta*), with Bulrush *Typha* sp. and Common Water-ribbons (*Cycnogeton procerum* – a native aquatic herb) also present. Introduced species ranged from c. 30 – 70% cover within the channel formation, with an overall average c. 40% cover and native species a little over 50% cover.

Spiny Rush (**Juncus acutus*) reaches over 70% cover of instream and riparian vegetation in patches across the central 2/3 of the reach and around dams. These dense patches of Spiny Rush impede access to the creek bed at several points. None of the FFG Act threatened Curly Sedge (*Carex tasmanica*) was identified during the field survey. The area in red outlines the region where >50 plants were identified in 2012 by Alluvium. **A detailed targeted survey is needed to determine presence/ absence of Curly Sedge individuals.**

Patches across the reach are clearly subject to natural saline seepage from groundwater, with halophytic species present instream and on the sloping sides of the channel. Halophytic species include: Australian Salt-grass (*Distichlis distichophylla*), Marsh Club-sedge (*Bolboschoenus caldwellii*), Shiny Bog-sedge (*Schoenus nitens*) and Sharp Club-sedge (*Schoenoplectus pungens*).

The northern 600m of the reach has roughly 50% cover of native instream species oscillating from a mix of Marsh Club-sedge (*Bolboschoenus caldwellii*) and Common Spike-sedge (*Eleocharis acuta*) to patches of Narrow- leaf Cumbungi (*Typha domingensis*) and Common Reed (*Phragmites australis*). The remaining 50% of vegetated area is dominated by Toowoomba Canary-grass (**Phalaris aquatica*). Common Eastern Froglet (*Crinia signifera*) calls were heard in the northern section of the reach.

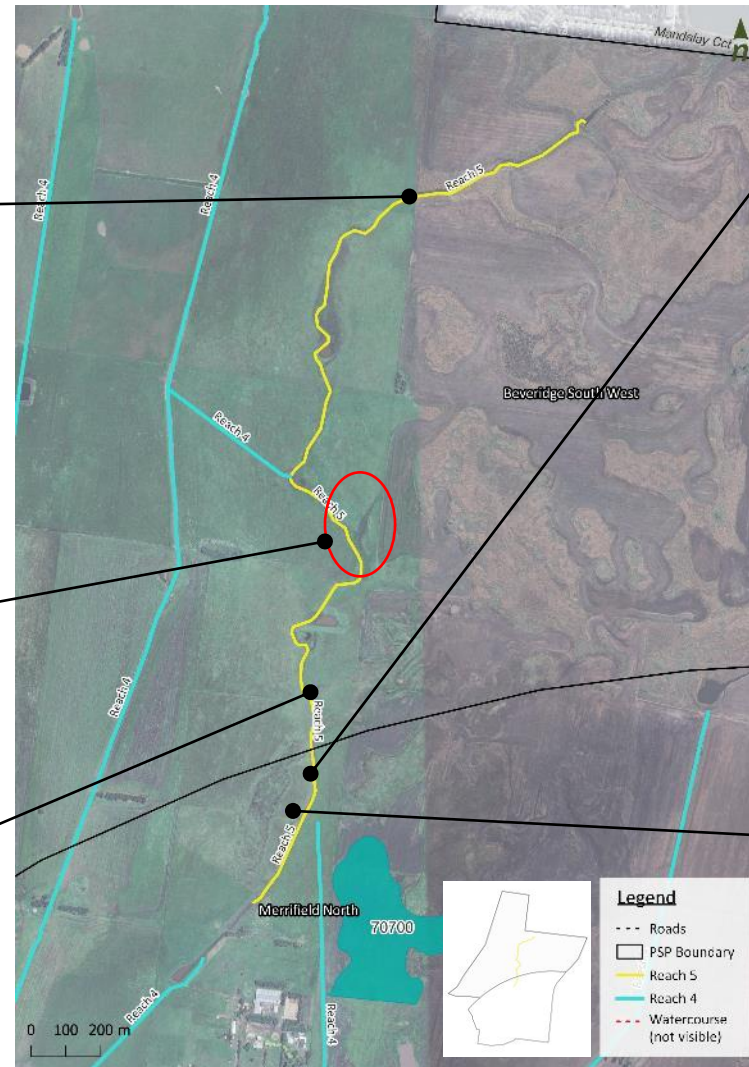


Figure 37. Reach 5 Ecology.



Columnar rocks comprising stream bed

DEECA Modelled pre 1750 EVC (north to south)

Plains Grassland EVC 132/ Plains Grassy Wetland 125.

Melbourne Water Riparian Vegetation Visions Quality Assessment: 2.

Threats:

- Increased run-off may reduce salinity impacting the small patches of saline dependent native species including Shiny Bog-rush (*Schoenus nitens*) with Australian Salt-grass (*Distichlis distichophylla*).
- Increased flows may cover or silt up gaps in columnar rocks which act as habitat for skink species.



Facing south along channelised stream course.

Reach 6 *Modified* Creekline Grassy Woodland EVC 68

BCS Status: NA

Description

Reach 6 is comprised of highly modified drainage vegetation and a fenced planted gully. The planted/ mixed revegetated fenced gully patch showed evidence of prior erosion. The planted species mix includes Sugar Gum (**Eucalyptus cladocalyx*), Lightwood (*Acacia implexa*) and Sheoak (*Casuarina* sp. s.l.). Introduced species including Drain Sedge (**Cyperus eragrostis*), Ox-tongue (**Helminthotheca echioides*), Toowoomba Canary-grass (**Phalaris aquatica*) dominate the groundstorey. Above the bank there was a patch of native grassy groundstorey dominated by Wallaby Grass (*Rytidosperma* sp.) (NOTE: native grasses and the bryophytes likely to be the only truly indigenous component of this vegetation). Abundant rabbit scat observed in revegetated areas.

The drainage lines are heavily grazed and dominated by exotic pasture species including Toowoomba Canary-grass, Cocksfoot, Brown-top Bent, Ribwort and Dock (**Rumex* sp.). A small number of scattered native species present included Plains Rush (*Juncus semisolidus*) along dam edges and Brown-back Wallaby-grass (*Rytidosperma duttonianum*), Toad Rush (*Juncus bufonius*) and Small Loosestrife (*Lythrum hyssopifolia*) in drainage lines. Scattered trees near dams are exotic (Cypress, Willow) or presumably planted non-remnant Eucalypt sp. with the exception of one observed Tree Violet (*Melicytus dentatus*).

DELWP Modelled pre 1750 EVC
Plains Grassy Woodland EVC 55.

Melbourne Water Riparian Vegetation Visions Quality
Assessment: 1 to 2.

Threats

- Grazing by rabbits and cattle.

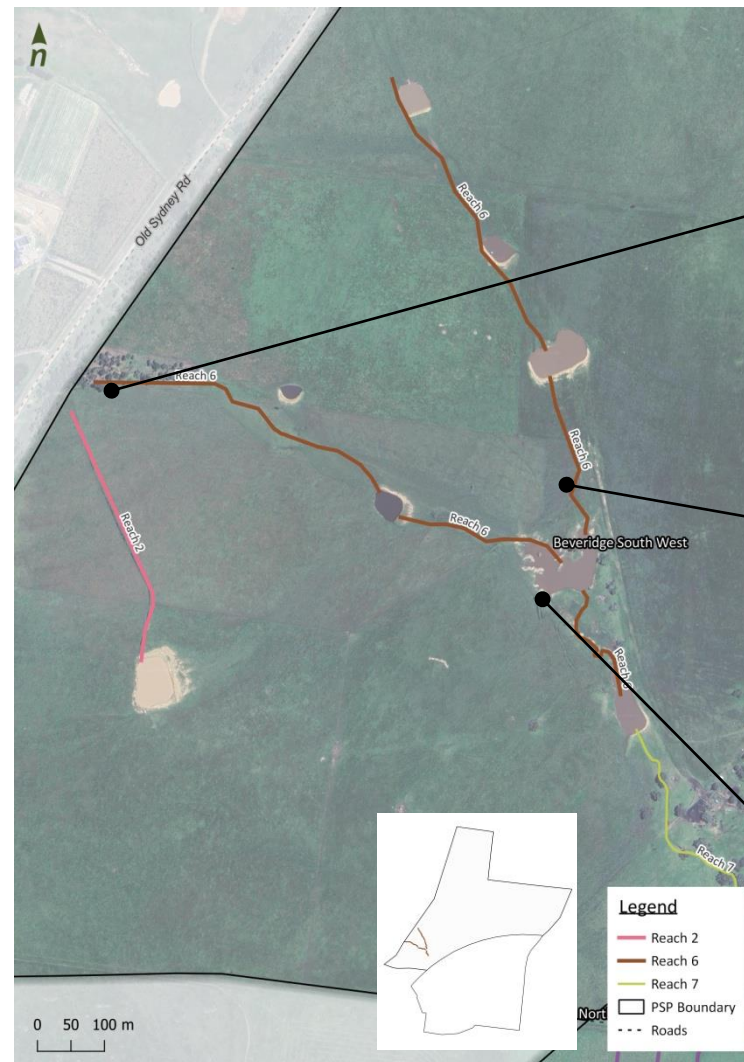


Photo looking south, indistinct drainage line



Photo looking NNE across dam

Figure 38. Reach 6 Ecology.

Reach 7 Modified Plains Grassy Woodland EVC 55



BCS Status: Endangered.

Description

Old growth River Red-gum (*Eucalyptus camaldulensis*) with a heavily grazed ground layer comprising mostly exotic pasture species and diffuse drainage lines. The centre of the River Red-Gum patch is occupied by farm sheds and parking. Unlikely to meet the criteria of the EPBC listed community “Grassy Eucalypt Woodland of the Victorian Volcanic Plain” due to the ground layer (future survey when ground layer not dried off recommended to confirm this). This equates to modified Plains Grassy Woodland (potentially with a prior component of gilgai micro wetlands) – the trees in the remnant stand are still of high value even if the ground layer is primarily exotic. It is possible some limited wet site flora may be still present in the seed bank in the wetter areas.

DELWP Modelled pre 1750 EVC

Plains Grassy Woodland EVC 55.

Melbourne Water Riparian Vegetation Visions Quality

Assessment: 1 to 2.

Threats

- Direct removal.
- Inadequate buffer between development.
- Grazing by rabbits and cattle.



Figure 39. Reach 7 Ecology.



Photo facing south towards Gunns Gully Rd. This part of Reach 7 is characterised by indistinct drainage lines without River Red-gums. Vegetation in and around this part of the reach is heavily grazed, exotic dominated pasture, with minor elements of a native *Juncus* sp.

Reach 8 Unknown/ unclassified EVC 999 (highly modified drainage vegetation)



BCS Status: unknown.

Description

Reach 8 is comprised of a series of interconnected channelised drains. There are two primary types of drain in Reach 8:

Flora Drainage type A = Shallow (mostly <30cm deep) drains running north to south starting at Gunns Gully Road. These drains vary in width from c. <0.5 to 3m wide.

Flora Drainage type B = East/west running excised to shallow drains with an average greater depth (max 2m deep) and a width from 1-3m wide.

All vegetation in Reach 8 is groundstorey vegetation. Species composition differs slightly across each drainage line however it can be broadly summarised based on the two drain types above with areas of exception (i.e., higher quality SHW patches) highlighted on the following page.

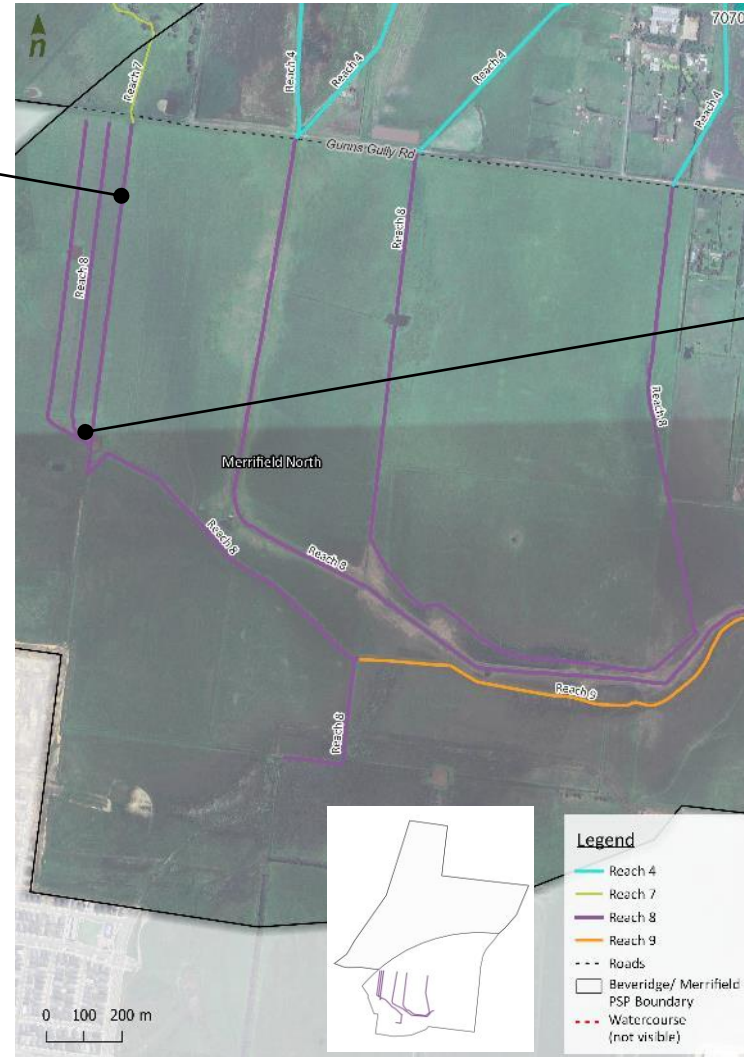


Figure 40. Reach 8 Ecology.

Flora Drainage type a:

A very low cover of native species in the eastern / central 3 drains. Instream vegetation in weedier sections is dominated (80-90%) by introduced species. Water Couch (**Paspalum distichum*) is the dominant species with small scattered patches of Spiny Rush (**Juncus acutus*) and Drain Flat-sedge (**Cyperus eragrostis*). The outer edges are dominated by Toowoomba Canary-grass (**Phalaris aquatica*) with interspersed patches of Chilean Needle-grass (**Nassella neesiana*) in the western half of the reach and Curly Dock (**Rumex crispus*) as a minor associate.

The three parallel drains in the west showed a greater cover (max c. 80%) of native species including Common Spike-sedge (*Eleocharis acuta*), Gold Rush (*Juncus flavidus*), Joint-leaf Rush (*Juncus holoschoenus*), Grey Willow-herb (*Epilobium billardioreanum* subsp. *cinereum*), Common Swamp Wallaby-grass (*Amphibromus nervosus*), Common Blown-grass (*Lachnagrostis filiformis*), Small Spike-sedge (*Eleocharis pusilla*), Brown-back Wallaby-grass (*Rytidosperma duttonianum*), and incidental Plains Rush (*Juncus semisolidus*). The vegetation along the drains supporting the higher cover of native species meets the criteria for Seasonal Herbaceous Wetland. **A full assessment of the extent and quality of the SHW patch is recommended (late spring is the ideal time for surveying).**

Flora Drainage type b:

Instream vegetation is dominated by parallel bands of Water Couch (**Paspalum distichum*) and Common Spike-sedge (*Eleocharis acuta*). Vegetation above the escarpment banks is dominated by Toowoomba Canary-grass (**Phalaris aquatica*) and Chilean Needle-grass (**Nassella neesiana*) with some Cocksfoot (**Dactylis glomerata*) and the occasional Artichoke Thistle (**Cynara cardunculus*). Common Spike-sedge (*Eleocharis acuta*) is the dominant in-channel native vegetation reaching a maximum cover of c. 70%.

DEECA Modelled pre 1750 EVC

Plains Grassy Wetland 125.

Melbourne Water Riparian Vegetation Visions Quality Assessment: 1 to 2.

Reach 9 *Remnant* Creekline Tussock Grassland EVC 654

BCS Status: Endangered.

Description

Reach 9 is comprised of a high-quality band of Creekline Tussock Grassland adjacent to channelised drainage-lines of Kalkallo Creek. The eastern part of the reach likely represents the original waterway channel. Patches of Seasonal Herbaceous Wetland species were scattered along the small watercourse. The cover of instream vegetation was comprised of c. 40% native groundstorey species and riparian vegetation 20m either side of the waterway was comprised of c. 70% native species.

Flora Present

Common Tussock-grass (*Poa labillardierei*) and Common Spike-sedge (*Eleocharis acuta*) are the two dominant species, with scattered Basket Sedge / Poong'ort (*Carex tereticaulis*), Common Swamp Wallaby-grass (*Amphibromus nervosus*), Hollow Rush (*Juncus amabilis*), Grey Willow-herb (*Epilobium billardiereanum* subsp. *cinereum*), Water Plantain (*Alisma plantago-aquatica*), Slender Knotweed (*Persicaria decipiens*), Common Woodruff (*Asperula conferta*), Varied Raspwort (*Haloragis heterophylla*) and Tufted Bluebell (*Wahlenbergia capillaris*). The cover of introduced species comprise c. 30% of instream vegetation and c.25% of riparian vegetation. Dominant introduced species include Paspalum, Drain Flat-sedge, Curled Dock, Toowoomba Canary-grass, Flatweed (**Hypochaeris radicata*), Artichoke thistle (**Cynara cardunculus*), Rough Sow-thistle (**Sonchus asper*) and Ribwort.

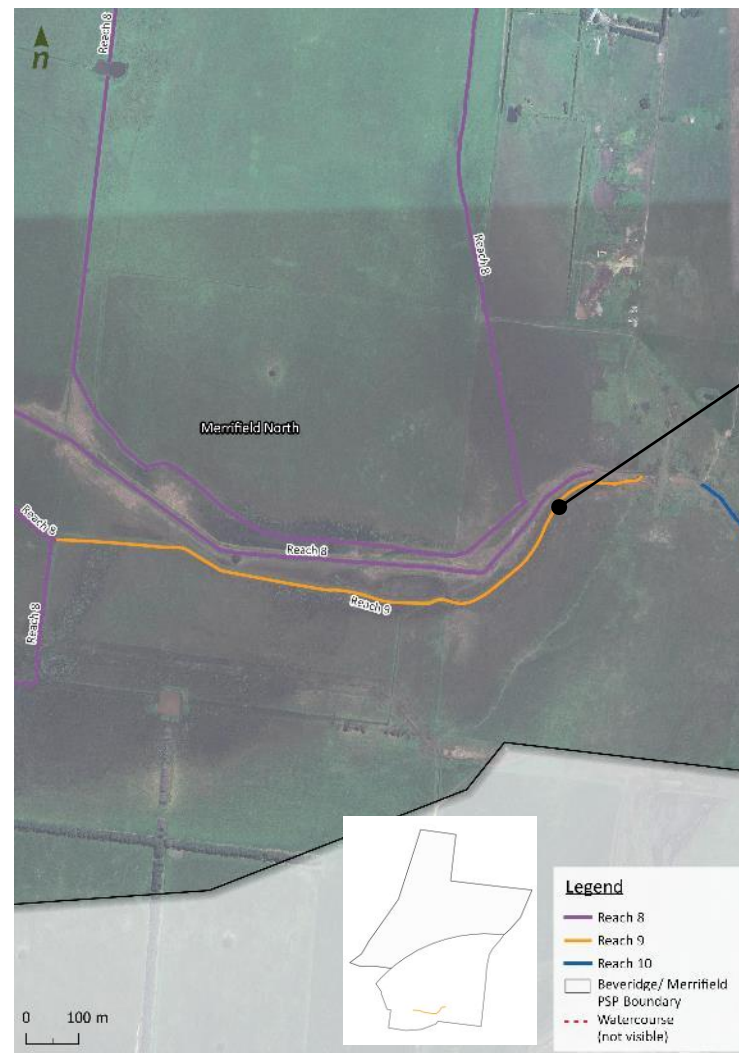


Figure 41.. Reach 9 Ecology.



DEECA Modelled pre 1750 EVC
Plains Grassy Wetland 125.

Melbourne Water Riparian Vegetation Visions Quality Assessment: 3
to 4.

NOTE: This was the most intact creekline vegetation community observed across the whole two PSP's. A full assessment of the extent and quality of the SHW patch is recommended.

Reach 10 Creekline Tussock Grassland EVC 654 (modified)



Band of Poong'ort (*Carex tereticaulis*) sedgeland on west side of creek.

BCS Status: Endangered.

Description The southernmost point of Kalkallo Creek in the PSP. The vegetation comprises of a narrow band of disturbed Creekline Tussock Grassland and fringing riparian species, changing into a rocky channel with minimum standing water then moving back into a more modified patch of Creekline Tussock Grassland at the PSP's south-eastern edge. A small tributary runs adjacent to the creekline for c. 250m within the south of the PSP. The tributary is dominated by a 1-3m wide band of Basket Sedge/ Poong'ort (*Carex tereticaulis*), a culturally important plant for the Koori peoples. This section is included in the Conservation Area 23.

Species List: Pale Rush (*Juncus pallidus*), Couch, Sharp Club-sedge, Water Couch, Lesser Joyweed (*Alternanthera denticulata*), Curled Dock, Clustered Dock, Buck's-horn Plantain (**Plantago coronopus*), Ribwort , Common Spike-sedge, Ox-tongue (**Helminthotheca echioides*), Blue Sow-thistle (**Sonchus asper* subsp. *glaucescens*), Hollow Rush (*Juncus amabilis*), Naked Crane's-bill (*Geranium* sp. 5), Spiny Rush and Sheep Sorrell (**Acetosella vulgaris*).

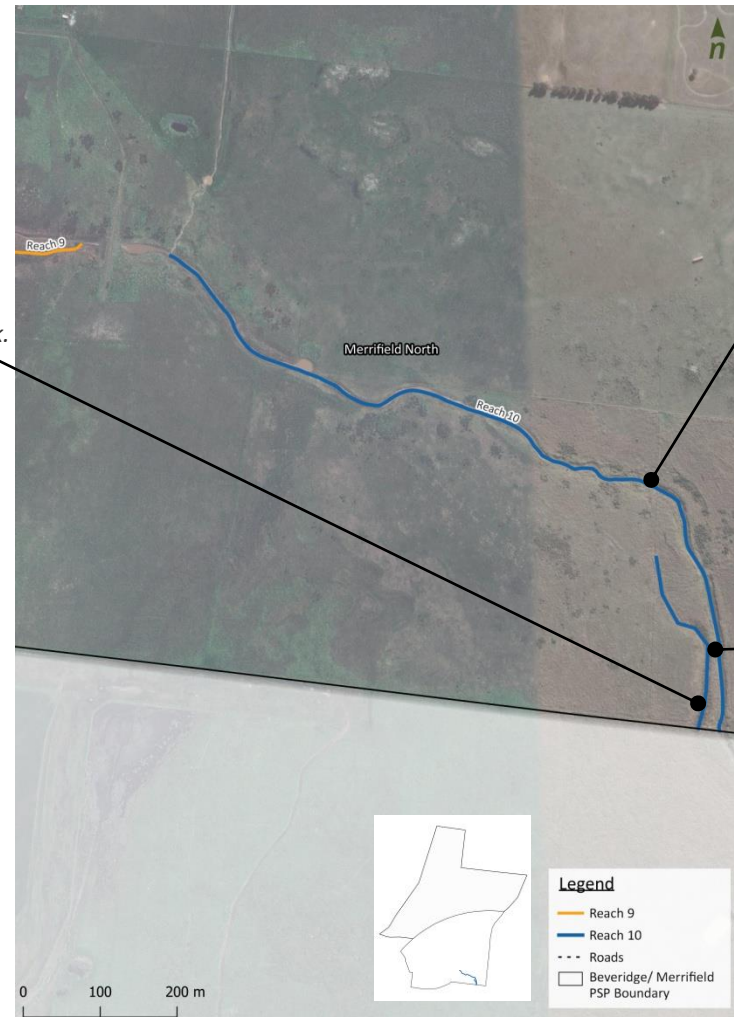


Figure 42. Reach 9 Ecology.



Kalkallo Creek, looking upstream, from start of rocky section, near south-east corner of site.



Image due north.

DELWP Modelled pre 1750 EVC
Riparian Scrub EVC 191.

Threats: Increased stormwater poses a potential threat to instream vegetation if not treated effectively.

Melbourne Water Riparian Vegetation Visions Quality Assessment: 2 to 3.

Wetland 70700 - Unknown/ unclassified EVC 999

The mapped wetland 70700 sits in the south of the Beveridge South PSP. It has been highly modified and cropped with Canola and is no longer functional as a wetland. While the Canola crop has performed poorly on heavy waterlogged soils during the extremely wet spring, there is no indication of any more than very shallow inundation having occurred in the wetland.

Index of Wetland condition scores

The overall IWC Wetland Condition score for Wetland #70700 is 3 out of 10 indicating that the mapped wetland condition is Poor. The score for the biota component is assessed as 'Very poor', due to its total conversion to cropping and lack of representative obligate wetland flora. In the event of a more successful Canola crop and consequently a higher cover of introduced species, the score for the biota component would have been reduced, resulting in the reduction of the assessment of overall condition to 'Very Poor'.

Native species in remnant grasslands on a low elevated stony knoll include Kangaroo Grass (*Themeda triandra*), Sheep's Burr (*Acaena agnipila*), Blue Devil (*Eryngium ovium*) and Tough Scurf-pea (*Cullen tenax* - two plants noted at and near 0317368 / 5847361). – See Figure 47 for stony knoll extent.



Image description: *Cullen tenax* (narrow green leaflets in the centre of the image) within remnant patch of *Themeda triandra* grassland/ Stony knoll shrubland. This taxon is listed as Endangered on the FFG Act 1988 Threatened List.

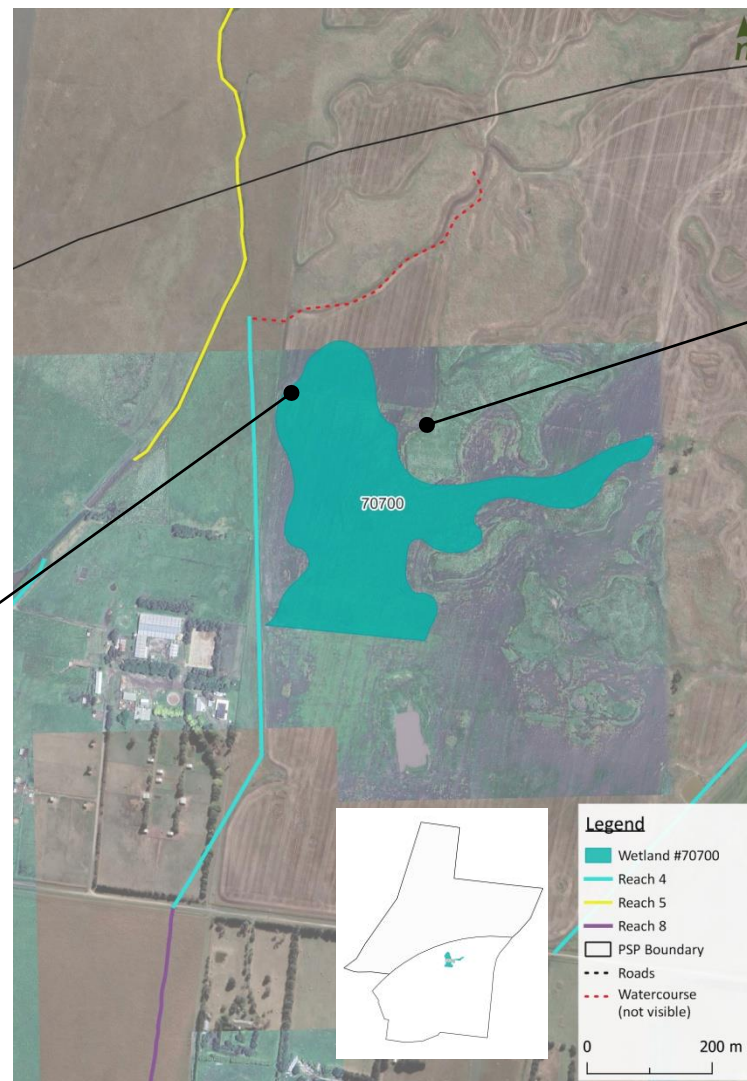


Figure 43. DELWP mapped wetland #70700

Very patchy Canola stems – overall c. 20% of crop successful, with Toad Rush (*Juncus bufonius*) c. 30% cover with associated native species including Little Club-sedge (*Isolepis marginata*) and Small Loosestrife (*Lythrum hyssopifolia*). Introduced non-crop species c. 1% cover overall, including **Lolium rigidum*, **Bromus hordeaceus*, **Vulpia bromoides* and localised **Phalaris aquatica* patch. Crop mostly unsuccessful due to wet conditions, but prior wetland only holding very shallow depth of water accumulation (presumably due to effectiveness of drainage system). Site with cracking black soil.



Reference photo, looking across mapped wetland 70700



Mapped wetland 70700: *Juncus bufonius* in the foreground, with residual stems of Canola in band towards upper right-hand side of image.

Wetland 70753 – Brackish Wetland Aggregate EVC 656

The DELWP mapped wetland (mapped as wetland #70753) comprises an excavated dam structure surrounded by spoil mounds. Extensive sections of low-lying area to the immediate west of the mapped wetland were inundated and are estimated to comprise part of the original extent of this wetland (as outlined in Figure 18). Approximately 50% of the total mapped area in figure 18 is comprised of unvegetated open water with the remaining 50% comprised of native and non-native vegetation.

Index of Wetland condition scores

The overall IWC Wetland Condition score for Wetland #70753 is 3 out of 10 indicating that the mapped wetland condition is Poor. The score for the biota component is assessed as 'Very Poor', due to its low cover and diversity of native obligate wetland flora, and high cover of weeds as a consequence of disturbance.

Vegetation composition within 70753 mapped wetland

95% cover comprised of introduced species. Spoil mounds were dominated by a mix of Toowoomba Canary-grass (**Phalaris aquatica*) and artichoke thistle (**Cynara cardunculus*). Dominant introduced species outside of spoil mounds include: Toowoomba Canary-grass (**Phalaris aquatica*), Spiny Rush (*Juncus acutus*), Water buttons (**Cotula coronopifolia*), Fat Hen (**Chenopodium album*), Mediterranean Barley-grass (**Hordeum hystris*), Borrer's Saltmarsh-grass (**Puccinellia fasciculata*), Hogweed (**Polygonum aviculare*), Buck's-horn plantain (**Plantago coronopus*), Strawberry Clover (**Trifolium fragiferum*) and Aster-weed (**Symphyotrichum subulatum*).

Native species making up the other 5% include: Narrow-leaf Cumbungi (*Typha domingensis*) on the fringes of the dam, scattered Annual Fire-weed (*Senecio glomeratus*) on the adjacent wet flat and a couple of patches of the FFG ACT 1988 listed Brackish Plains Buttercup (*Ranunculus diminutus*). Although the patches of *Ranunculus diminutus* only made up around 1-2% of the total vegetated area, where they were present, they were the dominant species.



Brackish Plains Buttercup (*Ranunculus diminutus*) patch.

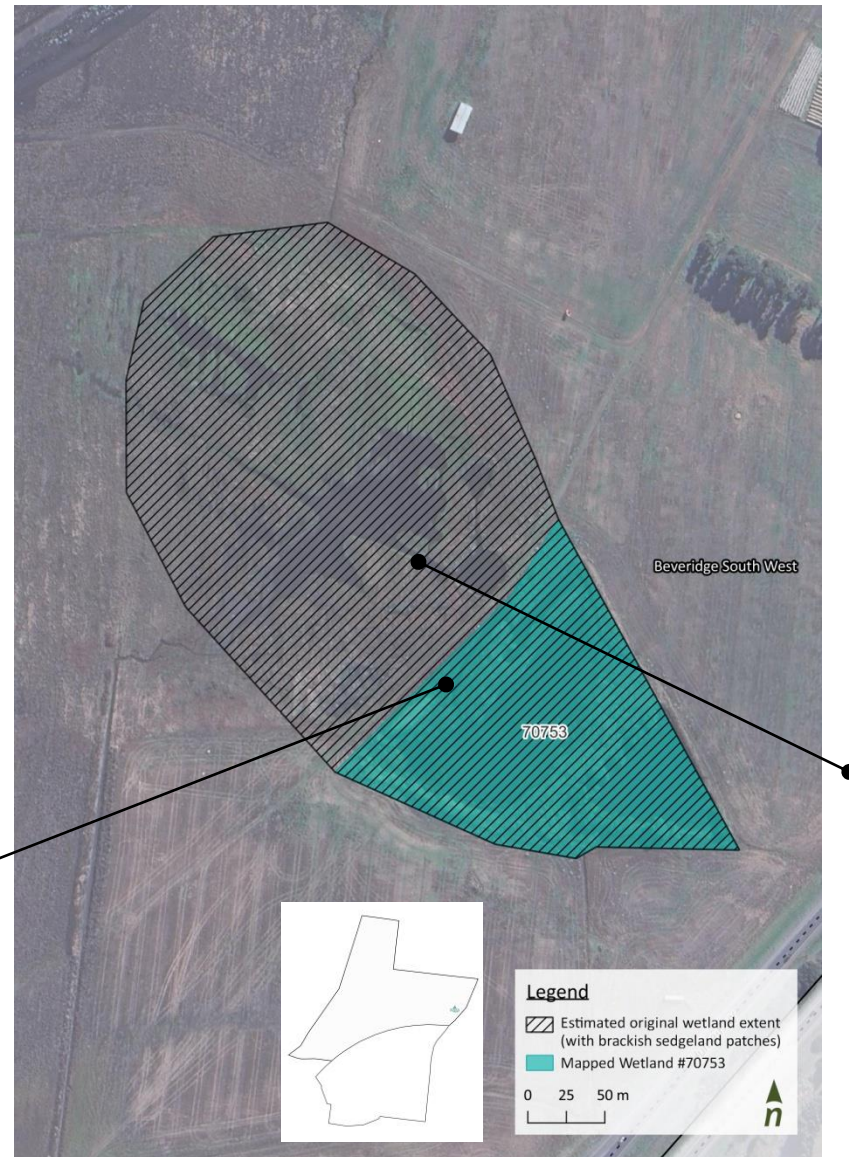


Figure 44.. DELWP mapped wetland #70753

Vegetation composition of the additional estimated original wetland extent (excluding the mapped wetland area 70753).

The main native wetland species present in the vegetated parts of the low-lying area include:

- C. 10% cover of Toad Rush (*^Juncus bufonius*).
- Combined c. 5% cover of Salt Club-Sedge (*Bolboschoenus caldwellii*) and Sharp Club-Sedge (*Schoenoplectus pungens*).
- <1% cover of Common Spike-sedge *Eleocharis acuta*,
- Scattered plants (<1%) of River Club-sedge (*Schoenoplectus tabernaemontani*)

The native species present across the extent of this wetland are indicative of a brackish groundwater influence and are consequently considered representative of the **Brackish Wetland Aggregate EVC 656**.

The most abundant species was introduced Water Buttons (**Cotula coronopifolia*) locally providing c. 80% cover. Other species observed include Small Loosestrife (*^Lythrum hyssopifolia*), Wimmera Rye-Grass (**Lolium rigidum*), Annual Beard-grass (**Polypogon monspeliensis*) and Fat hen (**Chenopodium album*). The inundation prone area was surrounded by land cropped for wheat.



Inundation prone area adjacent to the area mapped as wetland 70753.

Seasonal Herbaceous Wetland/ Plains Grassy Wetland EVC 125 patches within Reach 8

Low lying patch with remnant flora including Seasonal Herbaceous Wetland (SHW) component

Wetter area c. 20% native overall, to c. 40% in patches (Native component of cover primarily *Poa labillardierei*).

Low lying patch with remnant flora, including marginal SHW and grassland species. Introduced species Toowoomba Canary-grass (**Phalaris aquatica*) and Brown-top bent (**Agrostis capillaris*) dominate at 60-80% cover however native species cover fluctuates from 20-40% (native component of cover primarily *Poa labillardierei*). Other native species present in SHW patches include Brown-back Wallaby-grass (*Rytidosperma duttonianum*), Prickfoot (*Eryngium vesiculosum*) -- e.g. at 0315605 / 5846004 and 0315626 / 5846003; Common Spike-sedge (*Eleocharis acuta*), Small Spike-sedge (*Eleocharis pusilla*), Common Blown-grass (*Lachnagrostis filiformis*), Gold Rush (*Juncus flavidus*), Joint-leaf Rush (*Juncus holoschoenus*) and Common Bog-sedge (*Schoenus apogon*). Surrounding the SHW wetland patches are drier patches with scattered Blue Devil (*Eryngium ovinum*), Slender Speedwell (*Veronica gracilis*), Sheep's Burr (*Acaena echinata*), Lemon Beauty-heads (*Calocephalus citreus*), Slender Bindweed (*Convolvulus angustissimus* subsp. *omnigracilis*) and Slender Dock (*Rumex browni*).

If retained, a strategic approach could be to burn this area and reassess – it appears to have a high potential for rehabilitation with management from personnel with bushland regeneration skills. A few plants tentatively identified as River Swamp Wallaby-grass (*Amphibromus fluitans*) from vegetative material were noted around the drawn down verges of the adjacent dam. *A. fluitans* is listed as a nationally threatened flora species under the EPBC Act, but not included in the Victorian FFG (Flora and Fauna Guarantee) list of threatened species. **A full assessment of the extent and quality of the potential SHW patch is recommended.**



Figure 45. Potential SHW patches within reach 8

Small c. 3m wide and 70 - 90% cover native species surrounding marker <5% cover introduced species, primarily Water Couch (**Paspalum distichum*) and Toowoomba Canary-grass (**Phalaris aquatica*). Native species include Common Spike-sedge (*Eleocharis acuta*), Small Spike-sedge (*Eleocharis pusilla*), Gold Rush (*Juncus flavidus*), Perennial Blown-grass (*Lachnagrostis perennis* spp. agg.) and incidental plants of Thread Rush (*Juncus filicaulis*), Finger Rush (*Juncus subsecundus*) and Knob Sedge (*Carex inversa*). Fringed by **Phalaris aquatica*, also including **Paspalum distichum* and Annual Beard-grass (**Polypogon monspeliensis*) along drain. **A full assessment of the extent and quality of the SHW patch is recommended.**



Dense sward of Common Spike-sedge (*Eleocharis acuta*) surrounding the dam, fringed by introduced species, with Common Duckweed (*Lemna disperma*) floating on water within dam.

Description of Seasonal Herbaceous Wetlands

Seasonal Herbaceous Wetlands (Freshwater) of the Temperate Lowland Plains

The ecological community Seasonal Herbaceous Wetlands (Freshwater) of the Temperate Lowland Plains (SHW) is listed by the Department of Climate Change, Energy, the Environment and Water (2023b) as 'Critically Endangered' under the Federal EPBC Act 1999. This community can occur as both isolated wetlands and as clusters of small wetlands associated with terrain supporting Gilgai features. Gilgai refers to surface micro-relief formed by the shrinking and swelling of clays during alternate drying and wetting cycles. The surface eventually becomes covered by a pattern of small mounds and depressions that give the soil surface a 'pock-marked' appearance (TSSC, undated).

The characteristic hydrology, geographical position and vegetation structure, which is subject to fluctuation depending on seasonal conditions, is captured in the naming of this ecological community. The inundation of the wetlands is not dependent on connections to riverine systems rather, it is fed by local rainfall. The variability in depth, duration and frequency of the inundation of the wetlands can make them difficult to identify depending on the prevailing weather conditions. Flora and fauna associated with these wetlands is highly adapted to this seasonal variation and its expression may vary depending on the phase that the wetland is in.

The seasonal pattern of rainfall across distribution of Seasonal Herbaceous Wetlands is classified as Winter (wet winter/low summer rainfall). They form on isolated drainage lines and depressions that are filled by local rainfall rather than being connected to riverine systems. The salinity of the water is fresh to slightly brackish with salinity levels increasing as the wetlands dry out (<https://www.legislation.gov.au/Details/F2012L00686>).

These wetlands are complex due to their drying and wetting stages related to seasonal inundation. Native wetland plants and animals can be invisible in dry periods, persisting as desiccated material or propagules in the ground which become evident when inundation occurs and standing water is present. The size, seasonality and condition (often degraded by agriculture) make mapping Seasonal Herbaceous Wetlands difficult. They are often dominated by a ground layer of native wetland graminoids and/or native wetland forbs and invertebrate groups that can survive in seasonal watering conditions (<https://www.legislation.gov.au/Details/F2012L00686>).

“To meet EPBC Act condition criteria 50% or more of the total cover of plants in the ground layer of the wetland during a ‘typical’ wet phase must be dominated by native species characteristic of the ecological community” (ARI, 2016).



Seasonal herbaceous wetland in the Riverina (Diane Crowther) (Source: Arthur Rylah Institute, 2016)

Conservation areas 23 and 34 (Around Reach #10)

BCS Conservation Area 23 is identified as a Golden Sun Moth Reserve. The vegetation is primarily Heavier-soils Plains Grassland EVC 132_61 characterised by heavy black cracking clay soil, with some patches of lighter red soil also noted within the site.

BCS Conservation Area 34C has been identified as a Growling Grass Frog reserve. The vegetation community is a mix of modified Creekline Tussock Grassland EVC 654 and Clay Drainage-line Aggregate EVC 124.



Poa labillardierei Plains Grassland, looking eastward

Patch of Heavier Soils Plains Grassland EVC 132_61 dominated by Common Tussock-grass (*Poa labillardierei*), unusually with Lemon Beauty-heads (*Calocephalus citreus*) as a co-dominant. The patch has some species indicative of wetter sites but does not meet the criteria to comprise SHW. The combination of dominant species is unusual as *C. citreus* is generally associated with drier soils, whereas the closely related Milky Beauty-heads (*Calocephalus lacteus*), not found on site, is associated with gilgai grasslands and creekline tussock grasslands EVC 654.

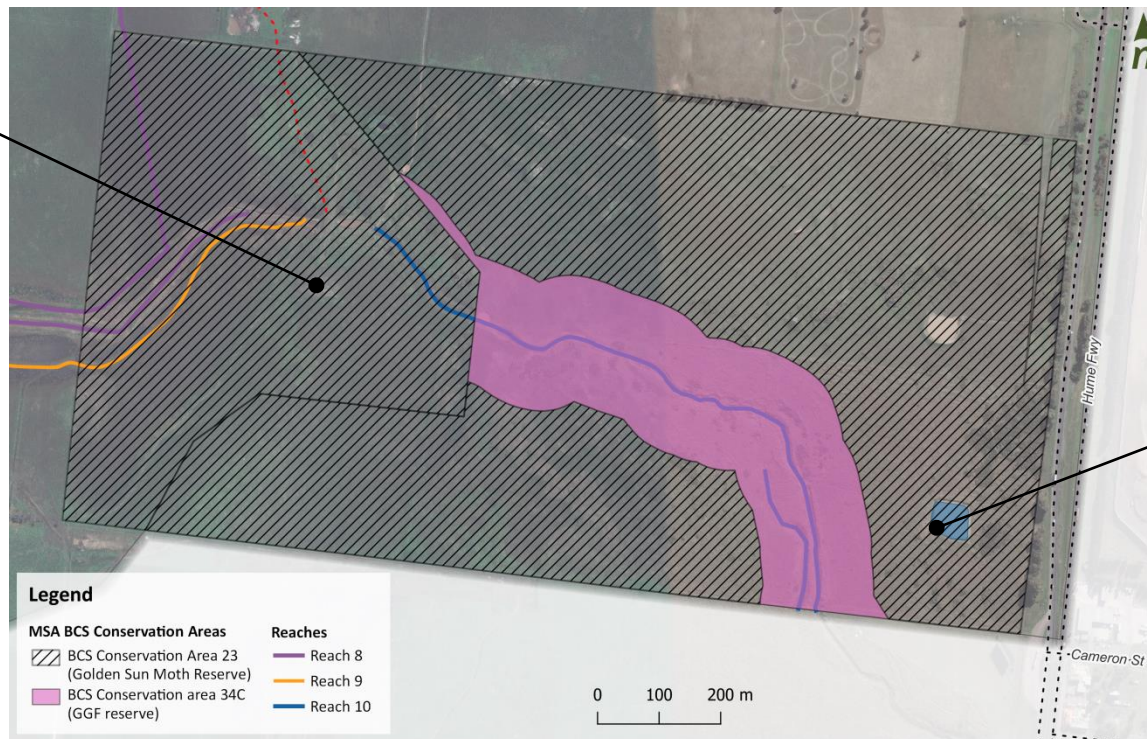


Figure 46. Conservation areas 23 and 34 within the Merrifield North PSP



Patch of Heavier Soils Plains Grassland EVC 132_61 with a distinct species mix compared to the remnant patch in the west of the conservation reserve.

Species noted were a mix of exotic and native species including: Brown-top Bent (**Agrostis capillaris*), Toowoomba Canary-grass (**Phalaris aquatica*), Gorse (**Ulex europaeus*), Kangaroo Grass (*Themeda triandra*), Common Tussock-grass (*Poa labillardierei* var. *labillardierei*), Slender Bindweed (*Convolvulus angustissimus* subsp. *omnigracilis*), Lemon Beauty-heads (*Calocephalus citreus*) and Sweet Briar (**Rosa rubiginosa*).

Heavier Soils Plains Grassland EVC 132_61 is characterised by heavy black cracking clay soil, with some patches of lighter red soils also noted as present across conservation reserve 23.

Conservation Areas 23 and 34

Potential impacts of development values within the conservation reserves

Groundwater changes

An increase in development surrounding the conservation areas will result in a decrease in area for natural ground water recharge impacting ground water stores. The grassland vegetation within conservation area 23 predominantly receives its moisture from rainwater. Changes in ground water stores are therefore unlikely to significantly impact grassland vegetation.

Flow changes

Development of the PSP will result in an increase in freshwater stormwater runoff into the waterways on site. An increase in storm water will to some extent override the brackish ground water seeps across the PSP. The impacts within the conservation area are unlikely to significantly increase, as the brackish flora appears locally restricted to Sharp Club-sedge within the channel. As the channel is quite incised, overflow into the adjacent grassland areas will be highly unlikely outside of extreme storm events.

The 1-3m wide band of culturally significant Basket Sedge/ Poong'ort (*Carex tereticaulis*) (see Reach 10) shouldn't be critically influenced by small increases in fresh water because it is a freshwater dependent species and elevated above base flows. However, it is easily drowned by total immersion underwater so controlled flows will be necessary. If the area becomes saturated year-round, the patch will likely shift into a Juncus/ Typha dominated system as the species will be sensitive to major hydrological change.

Weed Invasion

Increased urbanisation has been shown to increase the threat of weed invasion and nutrient addition on previously grazed patches of remnant Heavier-soils Plains Grassland EVC132_61 resulting in a landscape scale decrease in species richness without effective management (Zeeman 2017). Grassland patches that back directly onto private property are at increased risk due to an increased prevalence in the potential for introduced species into vulnerable grassland patches and potential nutrient enrichment.

Management steps to protect values.

The protection of the area as a conservation area will help to mitigate impacts of surrounding development, however management will be essential to prevent further declines in ecosystem values.

- If storm water quality is effectively treated, then it shouldn't heavily impact the remnant wetland values in conservation areas 23 and 24. All storm water should be diverted to treatment ponds before entering Kalkallo Creek through the conservation reserve. Our recommendation would be treatment ponds in the retarding basin to the west of the conservation area.

- The low creek incision relative to the grassland means that increased flows (due to storm water run off from adjacent development) shouldn't impact the grassland vegetation under average rainfall conditions **unless** extreme rainfall and subsequent flows exceed channel capacity. i.e. the channel is big enough to hold increased flows under average rainfall events.

- Maintenance of the Golden Sun Moth habitat is of concern. The adjacent freeway indicates that burning will be difficult. Slashing or Kangaroo grazing will help but a GSM sensitive burning regime would be the ecological best practice. Our recommendations include:

- a full assessment for the potential for late summer/ autumn ecological burning within the GSM habitat (all burning must be conducted within a safe time buffer outside of the flying season). If ecologically burning is assessed to not be an option, then a biomass reduction plan (slashing or mowing outside of the local flying season for GSM) should be established.
- a long-term Kangaroo population management plan to ensure safe access into and out of the conservation reserve

- A road boundary should be established on the northern edge of Conservation Area 23 to reduce the impacts of houses backing directly onto the conservation area. In areas where houses directly back onto a conservation reserve there is greater risk of weed infestation, particularly in grasslands and unauthorised incursions. A road can also act as a fire break.

- Ensure that flows do not exceed the inundation tolerance of Poong'ort or backfill into the remnant Creekline Tussock Grassland to the west.

Uncertainty in the impacts – areas requiring future investigation.

There is a degree of uncertainty in relation to the potential impacts of climate change on the Golden Sun Moth population within the site. Because the grassland is mostly rainwater fed, fluctuations in rainwater have the potential to impact stands of the grasses which are primary habitat for the moth. No significant stands of *Rytidosperma* spp. were found during the 2023 March surveys which could indicate that habitat quality may be already declining within the site. A seasonally relevant Golden Sun Moth survey is recommended to understand the current population dynamics more accurately. Previous records date back to the development of the MSA BCS areas in 2011/2012.

If storm water is treated and quality is improved before entering Kalkallo Creek, then flow changes because of development would appear unlikely to impact the habitat potential of the Growling Grass Frog within Kalkallo Creek.

Other native vegetation (not confined to reaches)

Modified Stony Knoll Shrubland (EVC 649) patches exist between cropped areas in the northeast of the PSP. The EVC was identified during field observations and the estimated extent was mapped in QGIS using a 2023 Near Map layer. The area surveyed exhibited >99% introduced species cover with a handful of Prickly Wattle (*Acacia paradoxa*) scattered on the knolls and two Manna Gums (*Eucalyptus viminalis*) and three planted Sugar Gums (**Eucalyptus cladocalyx*) nearby. The only other native species identified was one example of Sheep's Burr (*Acaena echinata*). There are likely other ground layer species across the rocky knolls; however due to the heavy grazing and history of ploughing in the adjacent paddocks it is unlikely that species rich patches of Stony Knoll Shrubland are still extant within the PSP. **A detailed study of vegetation within the Stony Knoll Shrubland patches outlined in the map is recommended.**



Figure 47. Other vegetation patches not confined to reaches observed during Jan 2023 field surveys.



Manna Gum (*Eucalyptus viminalis*).



Stony Knoll Shrubland with Prickly Wattle (*Acacia paradoxa*) in the background.

Key remnant vegetation observed across the two PSPs

Southern Conservation Area:

Two distinct Heavier Soils Plains Grassland EVC 132_61 patches (within Conservation Area 23).

Poong'ort (*Carex tereticaulis*) sedgeland adjacent to Kalkallo Creek channel (within Conservation Area 34).

Southern Retarding Basin:

Localised patch of Plains Grassy Wetland EVC 125.

Drain system supporting Plains Grassy Wetland EVC 125 flora.

High quality Creekline Tussock Grassland EVC 654 (Reach 9).

Northern section:

Localised Plains Grassland EVC 132 patches between cropped area including FFG Act 1988 listed endangered *Cullen tenax*.

Mandalay Creek channel with Grey Clay Drainage-line Aggregate EVC 124 and EPBC 1999 listed *Carex tasmanica*.

Western:

Stand of mature *Eucalyptus camaldulensis* trees (modified Plains Grassy Woodland) with a *Rytidosperma* species understory.

Areas recommended for detailed assessment

1. *Modified* Stony Knoll Shrubland (EVC 649) patches between cropped areas in the northeast of the PSP.
2. Potential remnant Curly Sedge within reach 5.
3. Seasonal herbaceous wetland extent within reach 8.
4. Creekline Tussock Grassland EVC 654 within reach 9.

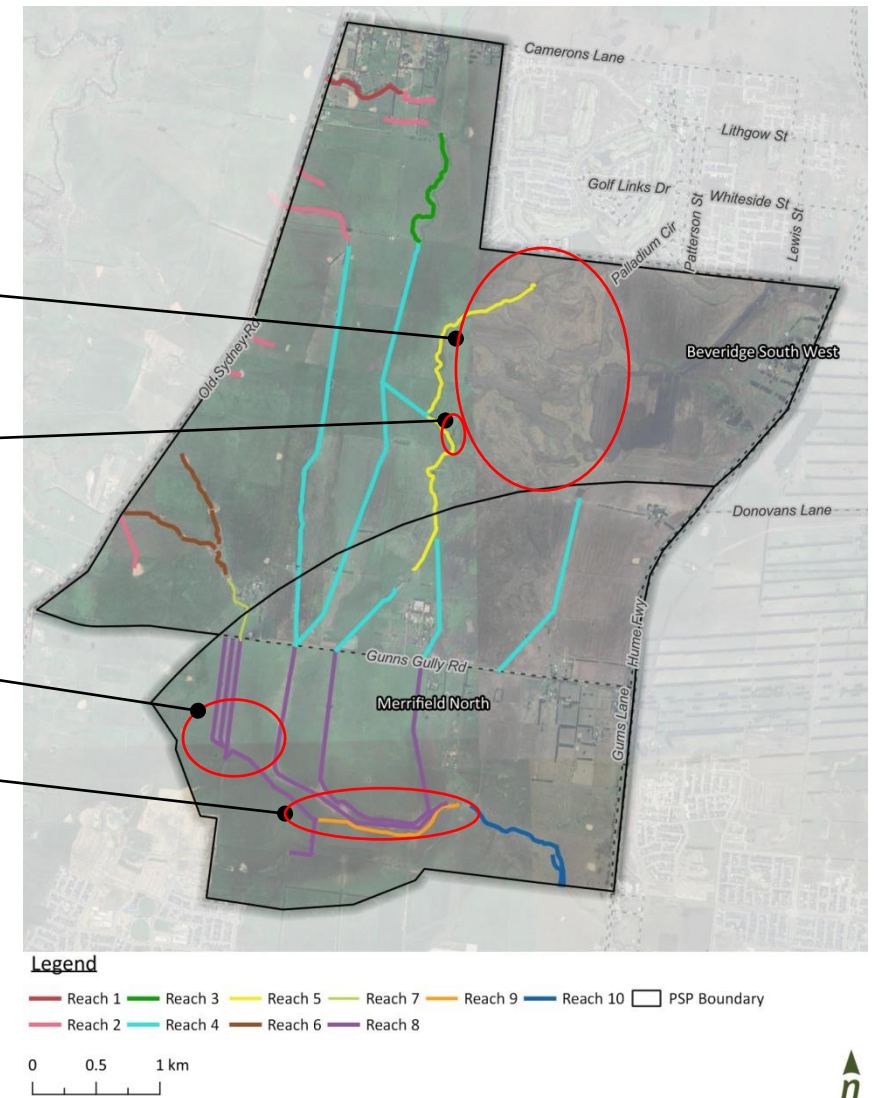


Figure 48. Areas recommended for more detailed assessment.

EVCs (observed or projected) and their Bioregional Conservation Status

EVCs are recorded or projected from the subject land, including based on pre-1750 EVC modelling. Bioregional Conservation Status (BCS) in brackets follows EVC name: 'e' denotes endangered in the Victorian Volcanic Plain bioregion.

- **EVC 68: Creekline Grassy Woodland (e):** Presumed prior occurrence along gully on the western side of the subject land, and potentially also near the north-western margins.
- **EVC 654: Creekline Tussock Grassland (e):** Extensive remnant noted in the southern conservation area as a band along a minor drainage line to the south of the channelised Kalkallo Creek.
- **EVC 124: Grey Clay Drainage-line Aggregate (e: Frood and Papas, 2016):** Recorded from the upper section of Mandalay Creek by Alluvium (2012).
- **EVC 132_61: Heavier Soils Plains Grassland (e):** Localised remnant patches, mainly in the southern conservation area.
- **EVC 125: Plains Grassy Wetland (e):** Access not available to patch recorded in the southern conservation area, otherwise very small remnants and representative flora persisting along shallow drains in the southern retarding basin and modelled along the south east of Reaches 4 and 5.
- **EVC 767: Plains Grassy Wetland/Brackish Herbland Complex (e: Frood and Papas, 2016):** Interpreted from along Mandalay Creek by Alluvium (2012), based on the occurrence of *Rytidosperma* spp. with introduced herbs indicative of brackish sites.
- **EVC 55_61: Plains Grassy Woodland (Victorian Volcanic Plain bioregion) (e):** Restricted to remnant trees, notably a stand near the western boundary.
- **EVC 191: Riparian Scrub (e):** Modelled along lower section of Kalkallo Creek, presumed by Alluvium (2012) as having occurred along Kalkallo and Mandalay Creeks. Restricted to modified remnants lacking the shrub component if correctly interpreted as comprising a prior vegetation component.
- **EVC 649: Stony Knoll Shrubland (e):** *Modified* Stony Knoll Shrubland patches between cropped areas in the northeast of the PSP.
- **EVC 175: Grassy Woodland (e):** A variable open eucalypt woodland to 15 m tall or occasionally Sheoak/Acacia woodland to 10 m tall over a diverse ground layer of grasses and herbs. It occurs on sites with moderate fertility on gentle slopes or undulating hills on a range of geologies. No remnants observed.
- **EVC 651: Plains Swampy Woodland (e):** Eucalypt woodland to 15 m tall with ground layer typically dominated by tussock grasses, sedges and herbs. Occurs on poorly drained, seasonally waterlogged heavy soils. Possibly present – no remnants observed.
- **EVC 656: Brackish Wetland aggregate (e: Frood and Papas, 2016):** Observed in vicinity of mapped wetland #70753.
- **EVC 47: Valley Grassy Forest (e):** A eucalypt woodland to open forest to 20m tall. A diverse ground layer of grasses and herbs. It occurs on lower slopes on soils of moderate fertility. No remnants observed.
- **EVC 22: Grassy Dry Forest (e):** Eucalypt woodland to open forest to 15m tall with ground layer dominated by tussock grasses, herbs and small shrubs. Occurs on dry hills and slopes. No remnants observed.

Significant flora observed during field assessment



(Image; VICFLORA online)

Species	<i>Ranunculus diminutus</i> Brackish Plains Buttercup.
Status	Endangered (FFG Act).
Overview	(from Vicflora online) Stoloniferous perennial, mostly 2–5(–c. 10) cm high. Flowers September – Feb.
Distribution	Occurs in Vic, SA, NSW and Tas. Rare in Vic.
Community	Seasonally wet clay soils in brackish habitats.
Threats	Development, hydrological changes; overgrazing and trampling of livestock.



(Image; VICFLORA online)

Species	<i>Cullen tenax</i> Tough Scurf-pea.
Status	Endangered (FFG Act).
Overview	(from Vicflora online) Trailing or ascending perennial herb; stems to c. 50 cm long
Distribution	Occurs in SA, QLD, NSW and ACT. Was widespread in dry heavy soils across Vic but now depleted range.
Community	Grows in heavy soils grassland and grassy woodlands.
Threats	Development in habitat areas, invasion of remnant habitats by exotic grasses and weeds, grazing.



(Image; VICFLORA online)

Species	<i>Amphibromous fluitans</i> River Swamp Wallaby Grass.
Status	Vulnerable (EPBC Act).
Overview	(from Vicflora online) Rhizomatous and stoloniferous aquatic or semi-aquatic perennial grass, to 80 cm tall. Sometimes forming loose turf-like colonies at the edge of receding waters.
Distribution	Occurs in southern NSW, Victoria, South Australia and Tasmania.
Community	Inhabits edges of both natural and man-made water-bodies, including swamps, lagoons, billabongs and dams.
Threats	Development, grazing and trampling by livestock, particularly late in the season as the swamps dry and become accessible; hydrological changes; and invasion of remnant habitats by exotic grasses and weeds.

Groundwater influenced / dependent vegetation

Halophytic (saline-tolerant) species and subsaline EVC's (Grey Clay Drainage EVC 124 and Brackish Wetland Aggregate EVC 656) occur at the site a result of ground water influence, as salinity is derived from the ground water.

A range of halophytic plant species including Shiny Swamp-mat (*Goodenia radicans*), Sharp Club-sedge (*Schoenoplectus pungens*), Shiny Bog-sedge (*Schoenus nitens*) and Streaked Arrow-grass (*Triglochin striata*) occur along sections of the channelised and non-channelised stream courses, indicating the influence of subsaline groundwater near the surface. The abundance of the introduced Spiny Rush (**Juncus acutus*) along some sections of channel is also indicative of a saline influence. It seems likely that where this mineralized groundwater influenced the vegetation, examples of vegetation referable to the EVC Grey Clay Drainage-line Aggregate are likely to have occurred, as for in the vicinity of Curly Sedge Creek to the further south of the Merri Creek catchment. The relevant flora was only observed along sections of the constructed channel, which could be regarded as an adventive example of the EVC, however Grey Clay Drainage-line Aggregate has been recorded from further upstream along Mandalay Creek, including a population of the key indicator species Curly Sedge (*Carex tasmanica*) recorded in 2012 (Alluvium, 2012).

The 2023 field inspection did not find the population of >50 Curly Sedge (*Carex tasmanica*) outlined in the Alluvium's 2012 Kalkallo Creek Waterways Assessment for Melbourne Water due to private property access constraints. A more detailed assessment of the area is needed to confirm the presence or absence of Curly Sedge within the 2012 study area (See Reach 5 for approximate 2012 location). Heavy pugging along the northern section of the streamline resulted in high levels of soil disturbance in which the species is highly unlikely to have survived. If the creek is protected from grazing, then it could be a good location for revegetation due to its proximity to development.

Alluvium (*op. cit.*) also recognised small areas of the EVC Plains Grassy Wetland/Brackish Herbland Complex from the verges of mineralized drainage-lines.

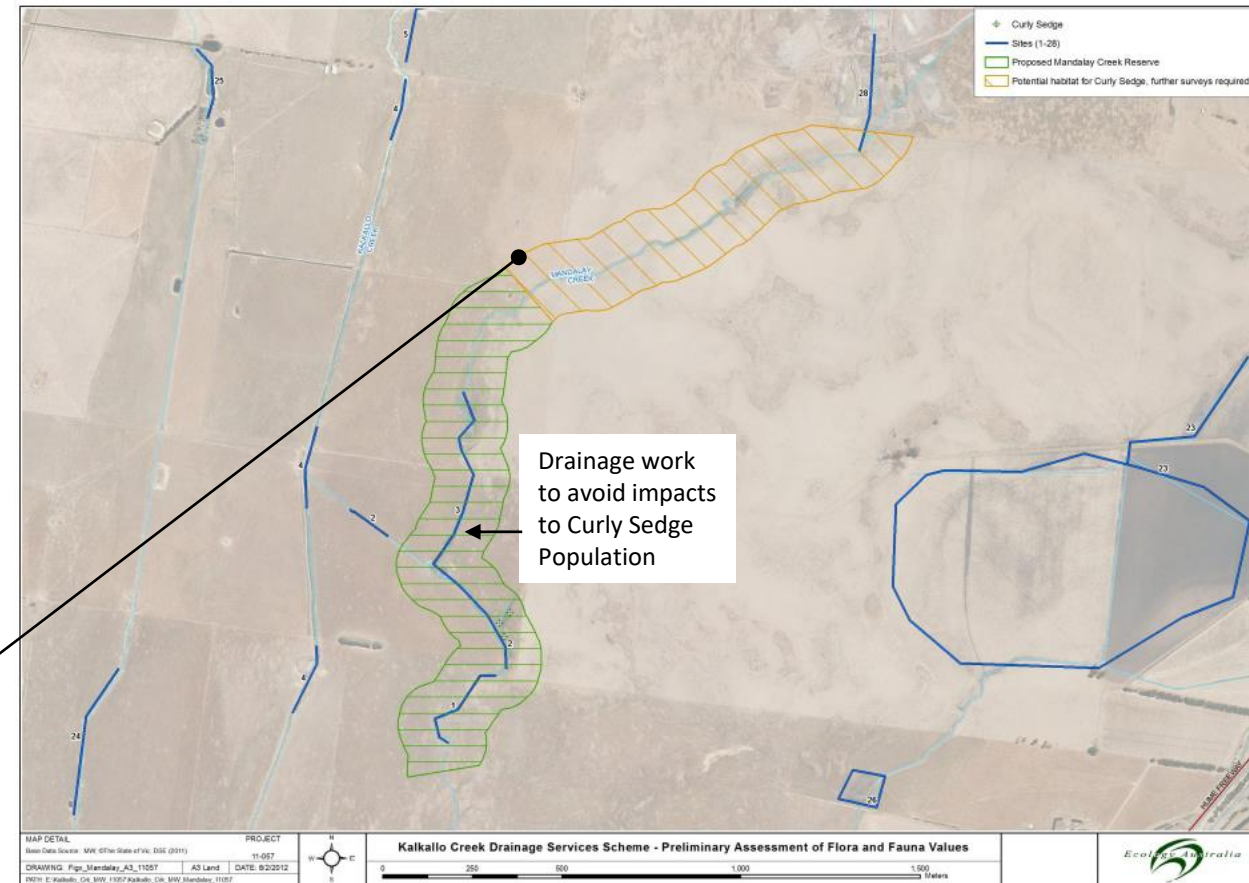
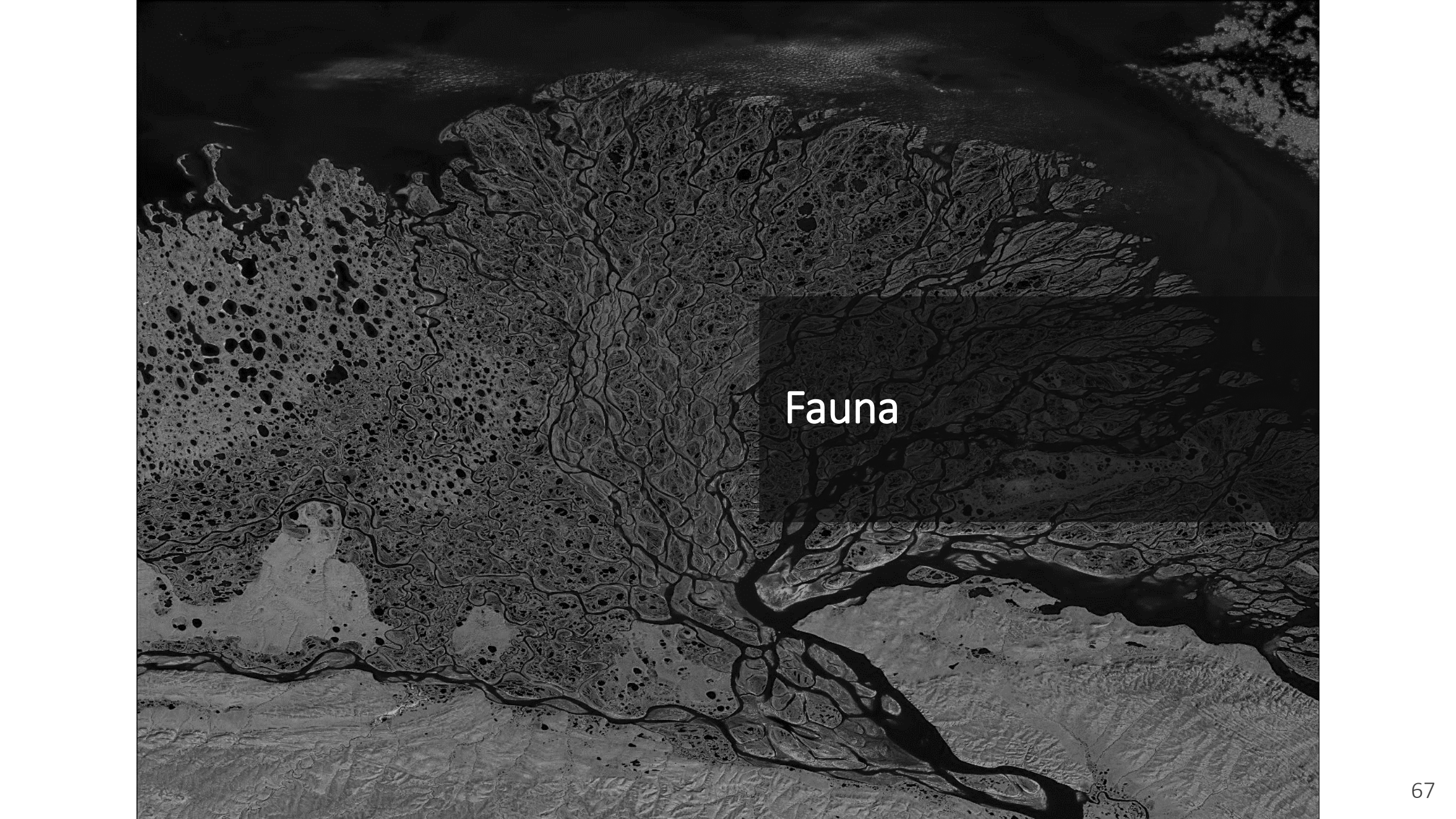


Figure 49. Proposed conservation reserve for the protection of curly sedge population. Map source Alluvium 2012

An aerial photograph of a river delta, showing a complex network of distributaries branching out from a main river channel. The landscape is characterized by a dense pattern of small, dark, circular features, likely depressions or oxbow lakes, interspersed with lighter-toned sedimentary deposits. A semi-transparent rectangular box is overlaid on the right side of the image, highlighting a specific area of the delta. The word "Fauna" is written in white text within this highlighted area.

Fauna

Preliminary desktop fauna assessment

Fauna Desktop Assessment Method

A desktop assessment of significant fauna records was conducted for the study area. Records from the VBA (drawing on a range of sources) and the Matters of National Significance Protected Matters Search Tool were reviewed and collated. Records from the study area and immediate surrounds were examined area to identify relevant records of species that might utilise similar habitat to that which was observed in the study area. Only species that are listed as threatened in Victoria (FFG Act 1988), or nationally under the EPBC Act 1999 were further examined using a Fauna Likelihood of Assessment analysis.

Figure 50 identifies the area that was assessed for fauna records. The results of the VBA search showed no listed threatened species for the Beveridge site and one FFG listed species within the Merrifield site. All records within the Merrifield site were for the Golden Sun Moth (*Synemon plana*) which is listed as vulnerable in both the EPBC Act 1999 and FFG Act 1988. All Golden Sun Moth records are dated to 2008 indicating the last time a species-specific survey occurred.

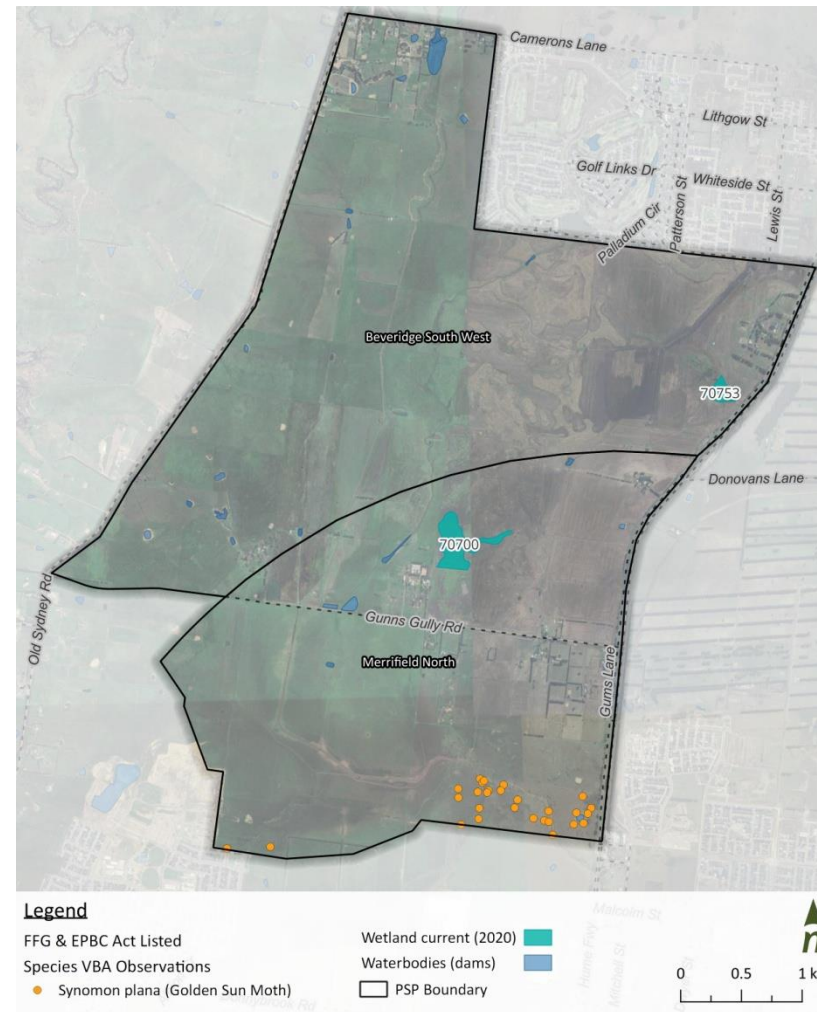


Figure 50. Beveridge – Merrifield map of VBA threatened fauna search (VBA).

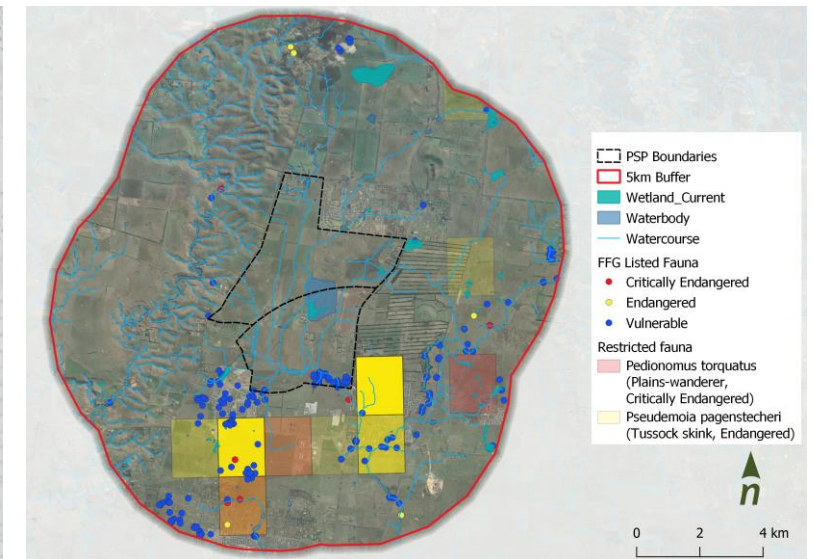


Figure 51. Beveridge and Merrifield FFG listed threatened fauna search within a 5km buffer.

State and federally listed threatened fauna (5km buffer)

Figure 51, 52 and 53 capture the entire study area and an additional 5km buffer area to identify relevant records of species that might utilise similar habitat to that which was observed in the study area. This data source identified nearby populations of significant species and provided further detail of their recent presence locally.

Two species were listed as threatened under the EPBC Act 1999 within the 5km buffer for the site and twenty-four species were listed as threatened under the FFG Act 1988 within the 5km buffer for the site (species lists and status on the following pages).

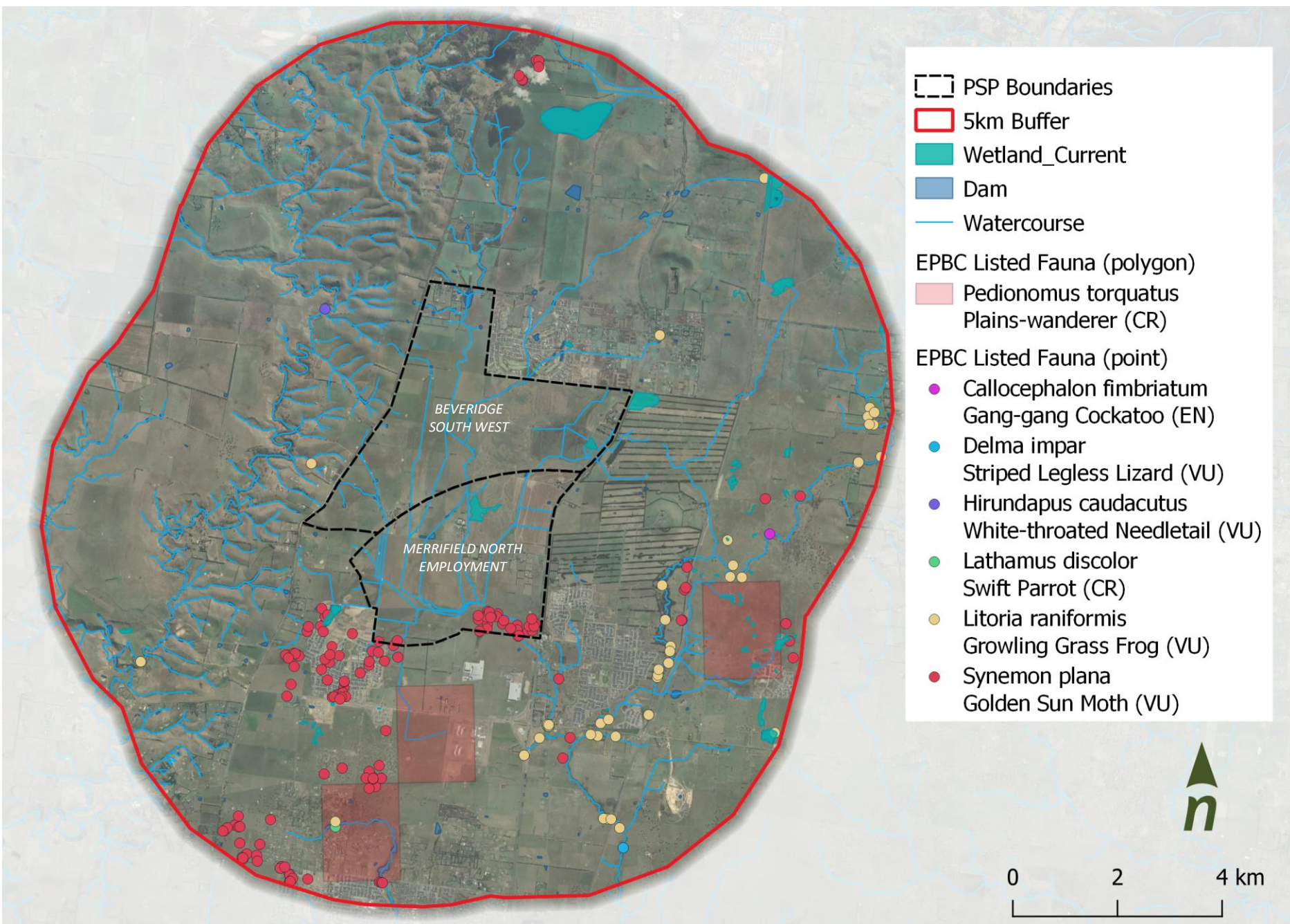


Figure 52. EPBC Listed fauna within a 5km radius of Beveridge South West and Merrifield North PSP.

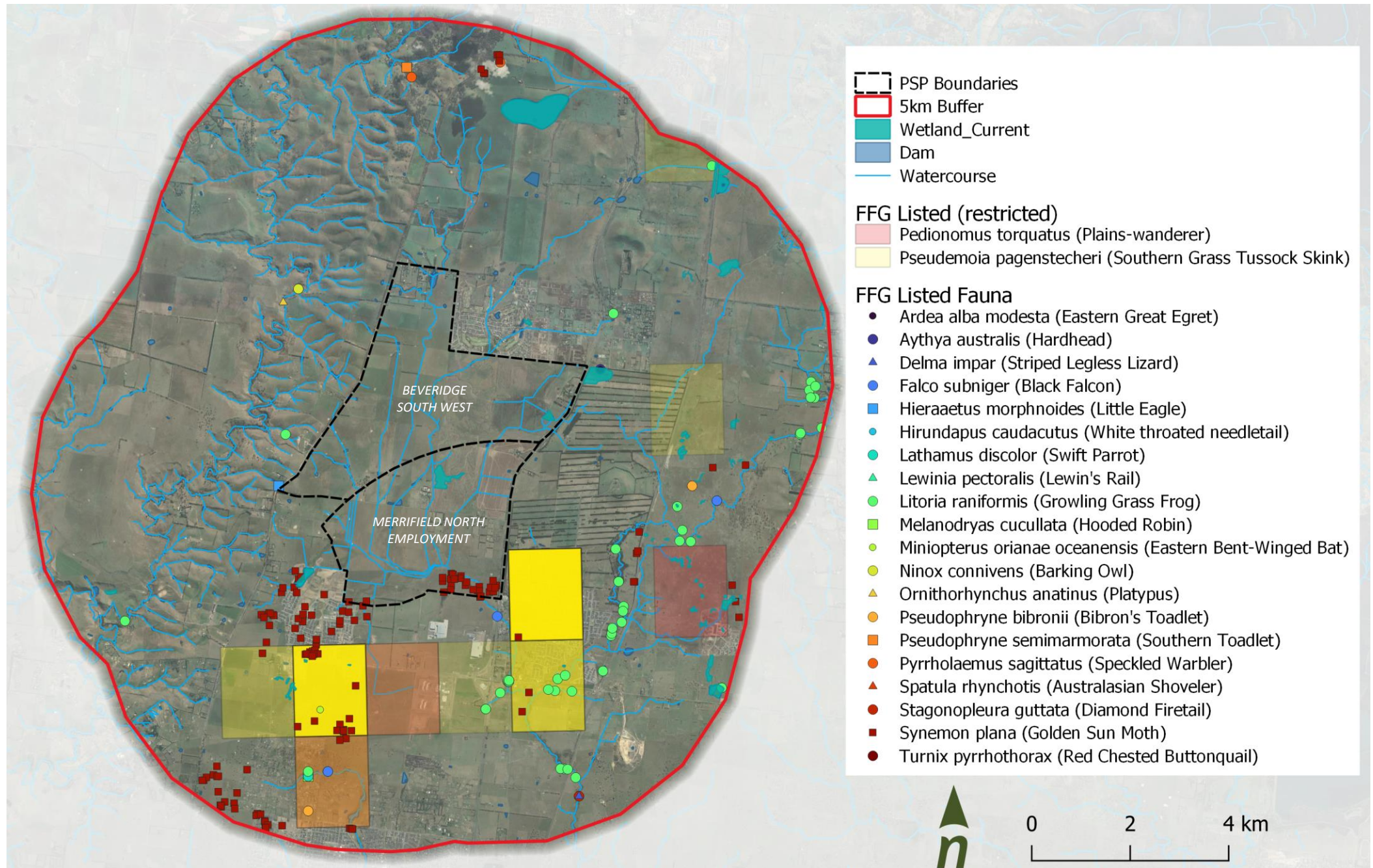


Figure 53. FFG Act Listed fauna within a 5km radius of Beveridge South West and Merrifield North PSP. Note, the intensity of shading of 'restricted' polygons corresponds to the number of observations. Orange polygons represent areas where both the Plains-wanderer and Tussock skink have been observed.

Fauna Likelihood of Assessment analysis.

Fauna Likelihood Assessment Method

All threatened species records available from a Victorian Biodiversity Atlas (VBA) and EPBC protected matters search were recorded within 5km of the PSP area were noted. The state (FFG Act 1988) and federal (EPBC Act 1999) threatened status of each species was recorded and the most recent record date where available was noted based on VBA records. For each species we recorded a qualitative assessment of the habitat requirements in order to ascertain if the quality and quantity of the species habitat was available within the PSP.

Finally, a Likelihood of Occurrence was rated for each species recorded within each habitat patch, comparing the habitat requirements of each species to the habitat present within Merrifield North and Beveridge Southwest PSP. Likelihoods were developed using a structured approach outlined in Table 4.

Habitat: Is the habitat patch within the PSP of appropriate size and quality for the species-specific needs?

Connectivity Score: Is the habitat within the PSP within an accessible range to the closest known population? Closest range and barriers which inhibit access are species specific and therefore a species-specific approach will be used to determine the acceptable range and corridors which would allow for species movement across the landscape. The closest known population will be identified using a combination of data sources including NatureKit and the Atlas of Living Australia.

Species records: Present or absent. If present, has the species been recorded within five years, 5 – 10 years, 10-20 years, 20-70 years ago or >70 years ago.

It should be noted that all faunal species assessed for likelihood appeared in a VBA or EPBC search for the PSP, and therefore this is a relative likelihood of species known to occur either in the bioregion (EPBC Protected Matters Search) or VBA search, which makes them already more likely to occur than species not recorded. Therefore, this likelihood assessment is a relative assessment of species already likely to occur. Also, to be noted is that only threatened species (CEEVNT species) were assessed. The PSP assessed may be important for faunal species outside these categories, and it is likely that many more plants and animals will be added to the threatened lists in coming years, making this assessment a snapshot in time.

Faunal species with records within 5km of the PSP were assessed using the following qualitative rubric:

Table 4 : Rubric for Fauna likelihood assessment

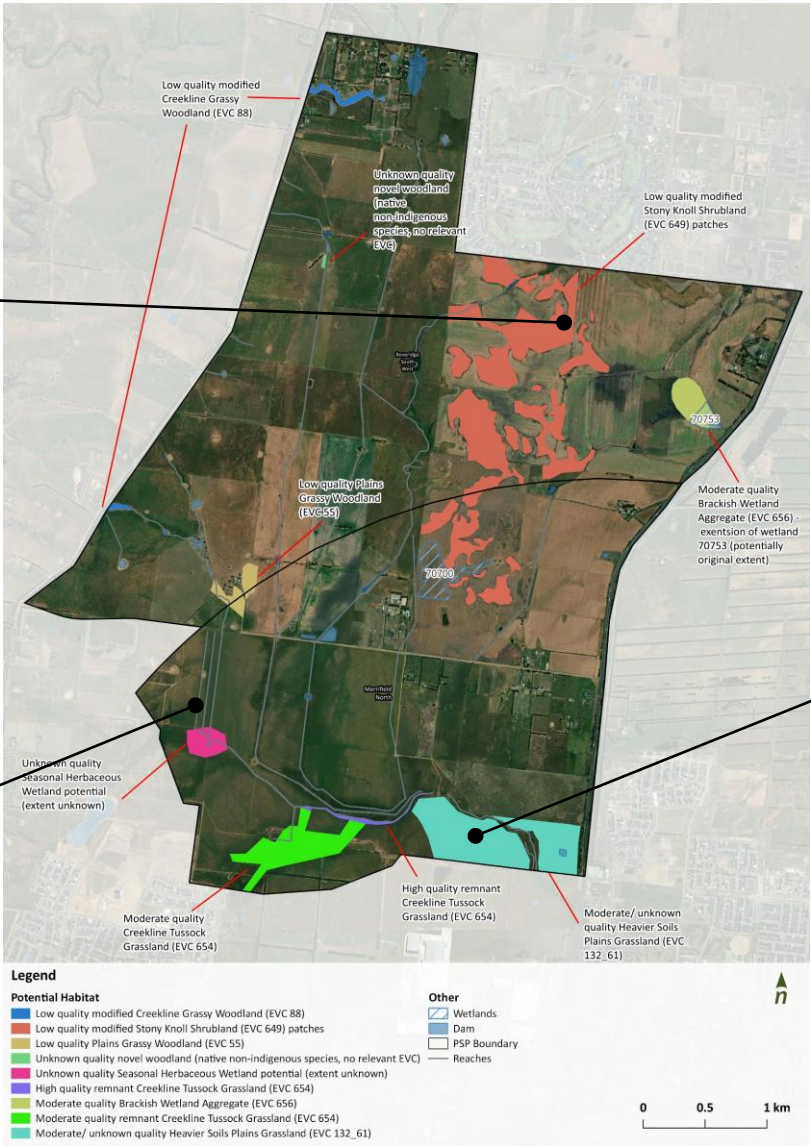
<i>Desktop and Mapping</i>			
	HABITAT The presence of required habitat quality and size (relative to the animal and its ecology).	CONNECTIVITY SCORE WITH CLOSEST KNOWN POPULATION	SPECIES RECORDS VBA Records within 5km of PSP: • Within 5 years • Within 10 years • Within 20 years • >20 years
<i>Likelihood Rating</i>			>70 years or no record
Unlikely	The PSP does not contain the required habitat for the species and may occur in an unsuitable landscape context.	1 – Highly unlikely, too far away or barrier is too great	No record, or >70 years old
Low	The PSP supports some elements of the preferred habitat for the species but is lacking critical habitat features that the species requires. The habitat patch may be located in a landscape context (e.g., highly urbanised, significantly grazed) that is unlikely to support the species.	2 – Possible but significant barriers to movement	Greater 20 – 70 years
Moderate	The PSP has preferred habitat (e.g. contains structural and floristic attributes that the species requires), however is lacking one or more ecological requirement (e.g. suitable landscape context or wetland size).	3 – Feasible	Between 10 – 20 years
High	The PSP contains preferred habitat features for the species, with all flora, structural and hydrologic features being present and ecological requirements such as landscape context and wetland size are suitable.	4- High quality connectivity	Between 5-10 years
Known	NA	NA	Within 5 years (the only criteria required for this likelihood to be allocated)

Potential Habitat Patches



Image: Modified stony knoll Shrubland patch

Remnant Seasonal Herbaceous Wetland species have persisted within some areas of the drainage network—a formal assessment for the extent and quality of the remnant SHW is needed to quantify the remnant area supporting wetland flora.



Mapped potential habitat patches outlined in Figure 23 are a combination of modelled time-stamped vegetation and vegetation assessed during field work. All habitat patches should be viewed as potential habitat many of which a more detailed assessment is recommended. Note this is an estimated only. A detailed fauna assessment is required to determine the actual quantity and quality of available habitat.



Image: Heavier Soils Plains Grassland patch within conservation area 23

Figure 54. Potential habitat patches within the PSP.

Fauna Likelihood Assessment

Species compiled from VBA records and EPBC protected matters search within a 5km buffer of the PSP

Scientific name	Common name	Class	FFG Status	EPBC status	Last record (VBA source)	Key Habitat Requirements	Likelihood Assessment
<i>Litoria raniformis</i>	Growling Grass Frog	Amphibian	Vulnerable	Vulnerable	2018	This species is found mostly amongst emergent vegetation, including <i>Typha</i> sp. (bullrush), <i>Phragmites</i> sp. (reeds) and <i>Eleocharis</i> sp.(sedges), in or at the edges of still or slow-flowing water bodies such as lagoons, swamps, lakes, ponds and farm dams. The Growling Grass Frog can be found floating in warmer waters in temperatures between 18–25°C. Submerged vegetation is important habitat for breeding success as it provides egg-laying sites, calling stages for males, and food and shelter for tadpoles. Grassland provides habitat for foraging, dispersal and shelter, and may also provide overwintering sites for Growling Grass Frogs (DCCEW 2023).	Moderate – The PSP has habitat for the species however there are no previous records of the species within any of the waterways inside the PSP. The closest GGF records on the VBA are: 4 x 2017 records from Deep Creek 600m west of the PSP at the closest point and numerous records dating from 1988 to 2010 from Merri Creek and Kalkallo Creek (1.5 -2.5km east of the PSP at the closest point).
<i>Pseudophryne bibronii</i>	Brown Toadlet	Amphibian	Endangered		2005	The Brown Toadlet utilises a wide variety of habitats, including dry forests, woodland, shrubland, grassland, coastal swamps, heathland, and sub-alpine areas. They live in areas that are likely to be inundated after rain (Robinson 2002). They shelter in damp areas under leaf litter, logs, or other forms of cover (SWIFFT 2023).	Moderate – there is some habitat to support the species but not it's ideal habitat (lacking wet and dry sclerophyll forest with logs). The most recent VBA record was in 2005 along Merri Creek approximately 4km from the PSP.
<i>Pseudophryne semimarmorata</i>	Southern Toadlet	Amphibian	Endangered			The Southern Toadlet is generally found at lower elevations in damp areas usually under leaf litter, logs or rocks. It is recorded from forests, woodlands, heaths and grasslands but not necessarily near permanent water (SWIFFT 2023).	Low – The PSP supports some elements of the preferred habitat however heavy grazing within and around waterways and wetlands have greatly inhibited habitat quality.
<i>Pedionomus torquatus</i>	Plains-wanderer	Bird	Critically Endangered	Critically Endangered	1989	Sparse lowland native grasslands with low-growing herbs especially species in the genus's <i>Austrostipa</i> , <i>Rytidosperma</i> , <i>Helipterum</i> , <i>Helichrysum</i> , <i>Chrysocephalum</i> and <i>Calocephalus</i> , and less than 94% of the vegetation is < 5–8 cm tall, with some larger (10–40 cm high) plants spaced 10–20 cm apart; rarely in cereal stubble and areas that are lightly grazed. Avoids trees, woodland, scrub, dense pasture of introduced plants, and large bare areas of red-brown earths (c. 50% between plants and 10% litter). Patches of habitat tend to be relatively small (50–300 ha). Breeding, feeding and roosting all occur in sparse native grasslands, usually without permanent water (Cornell Lab 2023).	Unlikely - The PSP does not have the required habitat; the nearest known extant population is west of Echuca (150 km north northwest of the PSP).

Fauna Likelihood Assessment cont.

Species compiled from VBA records and EPBC protected matters search within a 5km buffer of the PSP

Scientific name	Common name	Class	FFG Status	EPBC status	Last record (VBA source)	Key Habitat Requirements	Likelihood Assessment
<i>Spatula rhynchotis</i>	Australasian Shoveler	Bird	Vulnerable		2005	Lakes, marshes, swamps and lagoons of shallow, fresh, permanent waters with abundant emergent vegetation, as well as sewage ponds. Outside breeding season, also on temporarily flooded areas and on coast, where uses both brackish and saline waters, including inshore waters and estuaries (Cornell Lab 2023).	High – due to the presence of a permanent wetland (#70753) on site. It is likely that the wetland is visited (if only occasionally) by Australasian Shovelers.
<i>Stagonopleura guttata</i>	Diamond Firetail	Bird	Vulnerable	Vulnerable	1991	Open eucalypt (Eucalyptus) forest and woodland with grassy understory, mallee bush, scrubby grassland, parks and gardens; occurs in more open habitat than that favoured by the other firetails (Cornell Lab 2023).	Low – The PSP has some elements of preferred habitat, and it is feasible that the birds could access the habitat however the most recent record was over 20 years.
<i>Lewinia pectoralis</i>	Lewin's Rail	Bird	Vulnerable		1991	Typically occupies saltwater areas as well as freshwater wetlands and swamps (Victoria Museum 2023). This species prefers permanent, fresh-to-saline wetlands surrounded by dense vegetation. Lewin's rail utilises water sources including swamps, lakes, and wetlands and can be found in artificial wetlands surrounded by dense vegetation.	Low – The PSP has some elements of preferred habitat, and it is feasible that the birds could access the habitat. The most recent VBA record is from 1991 over 4km from the PSP.
<i>Falco subniger</i>	Black Falcon	Bird	Critically Endangered		2019	In Victoria, it is mostly associated with open grassland or in lightly wooded areas, it has also been observed close to urban areas (SWIFFT 2023).	High – The PSP has some preferred habitat; it is feasible that the birds could access the habitat and the recent observation was in 2019.
<i>Aythya australis</i>	Hardhead	Bird	Vulnerable		2018	Hardheads are found in freshwater swamps and wetlands and occasionally in sheltered estuaries. They are rarely seen on land and tend to roost on low branches and stumps near the water. They prefer deep, fresh open water and densely vegetated wetlands for breeding.	Moderate – The PSP supports some elements of the preferred habitat; it is feasible the species could utilise the habitat. The most recent VBA record is from 2018.

Fauna Likelihood Assessment cont.

Species compiled from VBA records and EPBC protected matters search within a 5km buffer of the PSP

Scientific name	Common name	Class	FFG Status	EPBC status	Last record (VBA source)	Key Habitat Requirements	Likelihood Assessment
<i>Hirundapus caudacutus</i>	White-throated Needletail	Bird	Vulnerable	Vulnerable	1995	Although they occur over most types of habitat, they are probably recorded most often above wooded areas, including open forest and rainforest, and may also fly between trees or in clearings, below the canopy, but they are less commonly recorded flying above woodland. They also commonly occur over heathland but less often over treeless areas, such as grassland or swamps (DCCEEW 2023).	Low – The PSP supports some very small elements of their preferred habitat. The most recent VBA record is from 1995.
<i>Ninox connivens</i>	Barking Owl	Bird	Critically Endangered		1989	Inhabits open woodland forest habitats where forests adjoin farmlands, effectively creating an open farmland-woodland mosaic. Use of forest interior habitats is less common; in particular the use of extensive areas of moist forest habitat is uncommon with drier woodlands, particularly box-ironbark woodlands being the most frequented habitat.	Low – The PSP supports no elements of their preferred habitat (closest forested habitat is approximately 7km away), and the last record was >20 years ago however small patches of remnant vegetation may be used as corridors.
<i>Hieraaetus morphnoides</i>	Little Eagle	Bird	Vulnerable			This species occupies open eucalypt forest, woodland or open woodland. Sheoak or Acacia woodlands and riparian woodlands of interior NSW are also used (OEH 2021). They have also been reported from many other habitats but usually not in large areas of wet forest (e.g., Great Divide E of Melbourne), the mallee 'deserts' (Big Desert and Sunset Country-Wyperfeld) or treeless farmland (FFG 2020). Little Eagles utilise Yellow Box-Red Gum grassy woodland which is a component of the EPBC Act-listed ecological community: White Box-Yellow Box-Red Gum Grassy Woodland and Derived Native Grassland (FFG 2020).	Low – The PSP supports no elements of their preferred habitat; the last record is unknown; small patches of remnant vegetation may be used as corridors.
<i>Ardea alba modesta</i>	Eastern Great Egret	Bird	Vulnerable			Wide range of wetland habitats (for example inland and coastal, freshwater and saline, permanent and ephemeral, open and vegetated, large and small, natural and artificial). These include swamps and marshes; margins of rivers and lakes; damp or flooded grasslands, pastures or agricultural lands; reservoirs; sewage treatment ponds; drainage channels; salt pans and salt lakes; salt marshes; estuarine mudflats, tidal streams; mangrove swamps; coastal lagoons; and offshore reefs (DCCEEW 2023)	High – The PSP contains multiple preferred habitat and habitat connectivity is feasible for this species.

Fauna Likelihood Assessment cont.

Species compiled from VBA records and EPBC protected matters search within a 5km buffer of the PSP

Scientific name	Common name	Class	FFG Status	EPBC status	Last record (VBA source)	Key Habitat Requirements	Likelihood Assessment
<i>Biziura lobata</i>	Musk Duck	Bird	Vulnerable			Freshwater marshes, swamps and lakes with extensive bordering reedbeds, also including billabongs, rivers and farm dams. Outside breeding season, juveniles and post-breeding adults disperse to deeper waters including saline bodies, lagoons, sewage ponds, reservoirs, estuaries and along sheltered coasts, occasionally far offshore (BOW 2023).	High – The PSP contains multiple preferred habitat and habitat connectivity is feasible for this species.
<i>Melanodryas cucullata</i>	Hooded Robin	Bird	Vulnerable			Hooded Robin habitat comprises structurally diverse open woodlands containing Eucalyptus, Acacia or Callitris with an understorey of smaller trees, shrubs and grasses. They are not normally found in urban or densely forested areas (SWIFFT 2023).	Low – The PSP does not contain the required habitat for the species. Previous VBA records within the vicinity date back >20years.
<i>Lathamus discolor</i>	Swift Parrot	Bird	Critically Endangered	Critically Endangered		On the mainland they occur in areas where eucalypts are flowering profusely or where there are abundant lerp (from sap-sucking bugs) infestations. Favoured feed trees include winter flowering species such as Swamp Mahogany (Eucalyptus robusta), Spotted Gum (Corymbia maculata), Red Bloodwood (C. gummifera), Forest Red Gum (E. tereticornis), Mugga Ironbark (E. sideroxylon), and White Box (E. albens). Commonly used lerp infested trees include Inland Grey Box (E. microcarpa), Grey Box (E. moluccana), Blackbutt (E. pilularis), and Yellow Box (E. melliodora) (OEH 2022).	Unlikely - The PSP does not contain the required habitat for the species and may occur in an unsuitable landscape context
<i>Pyrholaemus sagittatus</i>	Speckled Warbler	Bird	Endangered			Dry sclerophyll eucalypt (Eucalyptus) forests and woodlands with grassy ground layer and scattered shrubs, mainly on slopes and tablelands, extending to semi-arid plains and floodplains inland, with preference for rocky ridges and gulleys. Sometimes in mallee with cypress pine (Callitris), and in dense acacia (Acacia) shrubland. Ground layer evidently important, with grass, bracken (Pteridium) and sedges and golden wattle (Acacia pycnantha) saplings preferred in some areas.	Unlikely - The PSP does not contain the required habitat for the species and may occur in an unsuitable landscape context
<i>Oxyura australis</i>	Blue-billed Duck	Bird	Vulnerable			The majority of the population is found on artificial wetlands, for example the main site for this species in Victoria is the Melbourne Western Treatment Works at Werribee (SWIFFT 2023). The Blue-billed Duck inhabits fresh to saline, deep permanent open wetlands and deep, densely vegetated lakes (SWIFFT 2023).	Low – The PSP supports some elements of the preferred habitat however heavy grazing within and around waterways and wetlands have greatly inhibited habitat quality.

Fauna Likelihood Assessment cont.

Species compiled from VBA records and EPBC protected matters search within a 5km buffer of the PSP

Scientific name	Common name	Class	FFG Status	EPBC status	Last record (VBA source)	Key Habitat Requirements	Likelihood Assessment
<i>Synemon plana</i>	Golden Sun Moth	Insect	Vulnerable	Vulnerable	2020	The Golden Sun Moth has a symbiotic relationship with <i>Rytidosperma</i> species of grasses and is almost confined to grasslands which are home to these grass species. At least a 40% cover of <i>Rytidosperma</i> species is optimal for Golden Sun Moth. They have a preference for the following <i>Rytidosperma</i> species: <i>Rytidosperma carphoides</i> , <i>Rytidosperma auriculata</i> , <i>Rytidosperma setacea</i> , and <i>Rytidosperma eriantha</i> . The species has been recently recorded to have adapted to utilise the roots of the introduced Chilean needle grass (<i>Nasella neesiana</i>) as a key food source (DEWHA, 2009).	High - Victorian Biodiversity Atlas records recorded 28 individuals in 2008 (the last year a species specific survey occurred). Due to the cryptic nature of the species (they can only be detected over a very short period during their mating season) the current population cannot be confirmed without a follow up survey however the habitat is still intact and there is therefore a high likelihood that the population is still present.
<i>Ornithorhynchus anatinus</i>	Platypus	Mammal	Vulnerable		2021	Platypus are typically found in and near freshwater creeks, slow-moving rivers, lakes joined by rivers, and built water storages such as farm dams.	Unlikely – There is approximately 2km of paddocks and roads in between the closest 2021 record and the PSP.
<i>Miniopterus orianae oceanensis</i>	Eastern Bent-winged Bat	Mammal	Critically Endangered		2020	Habitat preference is associated with the availability of foraging areas and proximity to suitable roosting caves, for example many of the roosting caves are located near coastal cliffs, old mine shafts and rock caves. Foraging areas include forested areas, Volcanic Plains, wetlands and coastal vegetation including beaches (SWIFFT 2023).	Moderate – The PSP has some preferred habitat, however the proximity to roosting habitat is unknown.
<i>Pseudemoia pagenstecheri</i> (Volcanic Plains)	Tussock Skink	Reptile	Endangered		2019	This species occurs in grassland and grassy woodland habitats. Preferred habitat is medium-tall tussock grassland, with exposed rocks for basking.	High - because nearest known population, closest known population is south and easterly adjacent to the site. Species have been recorded within 1km of the site with the most recent record dating to 2019.
<i>Delma impar</i>	Striped Legless Lizard	Reptile	Endangered	Vulnerable	1991	Found only in areas of native grassland and nearby grassy woodland and exotic pasture. animals' shelter beneath loose rocks, grass tussocks and in soil cracks. The species has been found to favour areas of grassland with high levels of structural complexity (Howland et al. 2016). Animals can persist in exotic vegetation types if the habitat structure is suitable (Howland et al. 2016) but is most associated with native temperate grasslands.	Low – The closest most recent VBA was 30 years ago and sits 5km away. The PSP supports some habitat however land management practices have reduced quality and quantity of vegetation. Detailed assessment recommended to determine.

Main habitat types supporting **known** threatened fauna – Golden Sun Moth

Golden Sun Moth

The Golden Sun Moth is a medium sized diurnal (day flying) moth species in the family Castniidae. The species relies on grassland or open grassy woodland with an adequate supply of specific grass species which act as a primary food source for larvae. Historically the roots of wallaby grasses (*Rytidosperma*) species were the dominant food source for larvae, however the species has since adapted to utilise the roots of the introduced Chilean needle grass (*Nasella neesiana*) as a key food source (DEWHA, 2009). Golden Sun Moths are unable to disperse greater than a few hundred meters limiting their opportunity to find suitable new habitat sources. Due primarily to the severe decline in habitat, the species is listed as vulnerable under the EPBC Act 1999 and the FFG Act 1988.

Potential habitat links for Golden Sun Moth (Golden Sun Moth)

Due to their limited dispersal range, focus should be on available grassland patches within 200m of the current records. Time stamped data (Figure 55), outlines modelled and observed grassland within and adjacent to Golden Sun Moth records. If connectivity between grassland patches are maintained and grassland is managed appropriately for Golden Sun Moth, then there is potential for population expansion within the site.

During site visits, we observed large patches of Chilean Needle grass dispersed within Toowoomba Canary-grass (*Phalaris aquatica*) within Melbourne Water owned land in the southwest of Merrifield North. Although modelled as historically Plains Grassy Wetland, due to the extensive drainage system most of the southwestern corner of Merrifield North is now highly modified pasture grass (*Phalaris aquatica* and *Nasella neesiana*). Despite being classified as a Weed of National Significance (WoNS) Chilean needle grass is also a known habitat plant for Golden Sun Moth. This patch of Chilean needle grass to the west of the known population could therefore act as a secondary habitat patch for the Golden Sun Moth population.

The key to maintaining and expanding the population of Golden Sun Moths within the PSP will be appropriate land management techniques and the long-term retention of habitat patches and habitat corridors connecting these patches.

There may be further habitat potential within small grassland patches spread throughout the PSP. Detailed assessment of recommended areas should emphasise the potential for populations of Golden Sun Moth and other threatened species (see fauna likelihood assessment e.g. legless lizards, Tussock Skink).



Female Golden Sun Moth Image source: SWIFFT

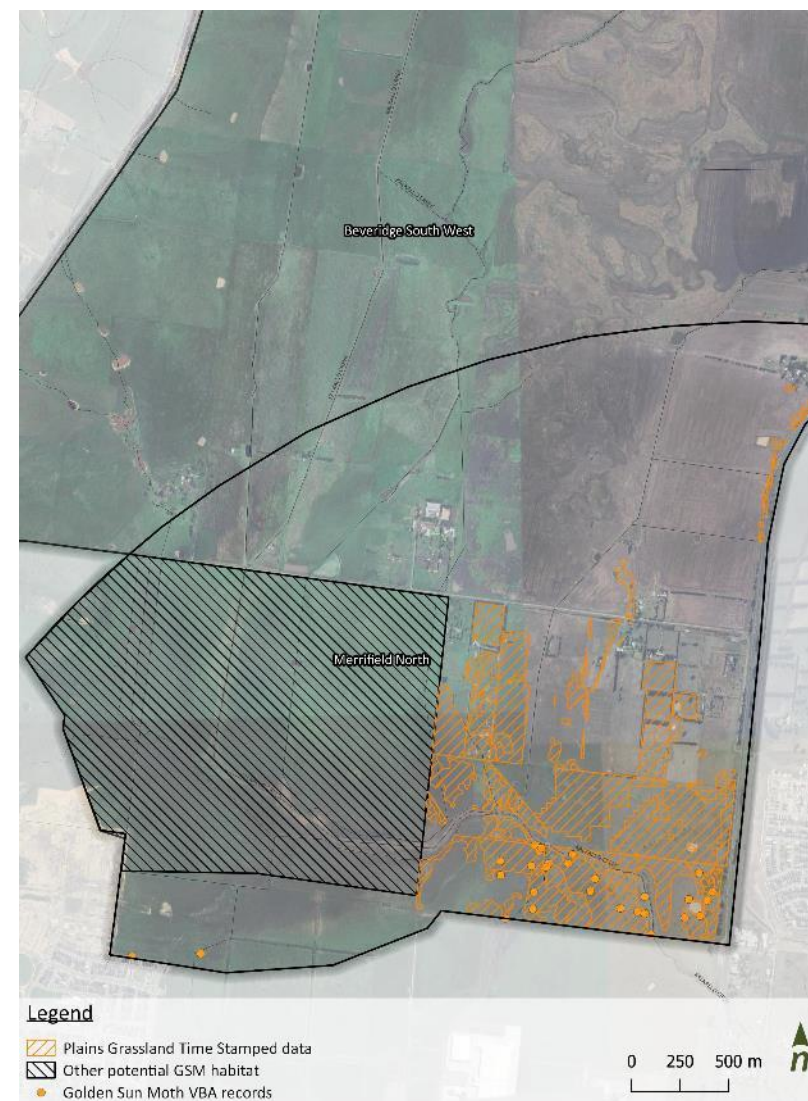


Figure 55. Beveridge and Merrifield VBA listed threatened fauna search within a 5km buffer.

Main habitat types supporting potential fauna – Grasslands and Stony Knoll Shrubland

The sites have several grassy EVCs such as Heavier Soils Plains Grassland(EVC132_61) and Stony Knoll Shrubland that provide specific habitat for many of the species listed as threatened. These include, Tussock Skink (*Pseudemoia pagenstecheri*), Golden Sun Moth (*Synemon plana*), Striped Legless Lizard (*Delma impar*), Diamond Firetail (*Stagonopleura guttata*), Growling Grass Frog (*Litoria raniformis*), Southern Toadlet (*Pseudophryne dendyi*), Black Falcon (*Falco subniger*), and the Plains-wanderer (*Pedionomus torquatus*).

The field investigation showed that most of the grasslands and almost all Stony Knoll Shrubland has been modified or converted into pasture/crops, however several bands and localised patches of remnant vegetation have persisted and are providing habitat values.

The size and quality of these remnant patches make the continued presence of most listed threatened species high unlikely. Golden Sun Moth (*Synemon plana*) is the only threatened species that has been officially recorded within the PSP (inside conservation area 23).



Tussock Skink **Image source: ALA Karen Short**



Striped Legless Lizard **Image source: ALA Scott Baker**



Diamond Firetail **Image source: SWIFFT Julian Robinson**

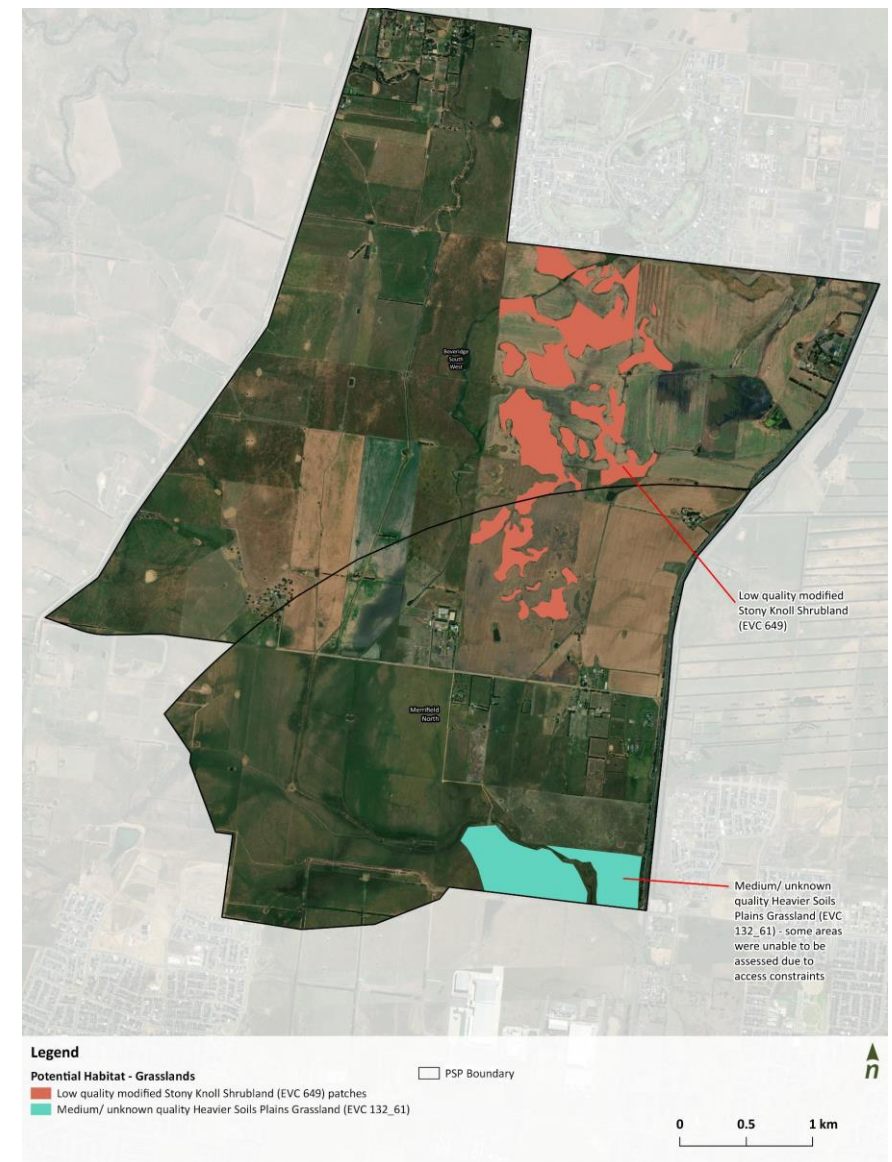


Figure 56. Grassland and stony knoll shrubland habitat.

Main habitat types supporting potential fauna - Woodlands

Restricted evidence of Plains Grassy Woodland occurs towards the western edge of the site with a stand of River Red-gums.

A revegetated gully near this area indicates the probable prior occurrence of a localised patch of Creekline Grassy Woodland.

These areas that are tree dominated could provide potential roosting, nesting, food sources and canopy cover for arboreal species such as Barking Owls (*Ninox connivens*), White-throated Needletail (*Hirundapus caudacutus*) and the Eastern Bent-winged Bat (*Miniopterus schreibersii*).

Flora associated with EVC 191 Riparian Scrub if previously present persists only as highly modified remnants.



Plains grassy woodland Image source: VVPCMN



Eastern Bent-winged Bat Image source: National Parks NSW



White-throated needletail Image source: DCCEEW



Figure 57. Woodland habitat.

Main habitat types supporting potential fauna - Wetlands

Wetlands provide critical habitat for many of the threatened species listed for this site including birds, amphibians and their associated food sources.

The site contains two mapped wetlands. The southern wetland in Merrifield North (#70700) is a large highly modified wetland that has poor habitat values.

Although mapped as smaller, the wetland in the northeast of the site (#70753) includes less modified sections with patches of open water (depth unknown) with an extended shallow brackish inundation prone areas adjacent to the mapped wetland.

Wetland 70753 has potential to provide habitat to species such as the Eastern Great Egret (*Ardea modesta*) who utilise deeper water for feeding on aquatic insects and small fish. The inundation prone area adjacent to the mapped wetland map provide habitat for species such as the Southern Toadlet (*Pseudophryne semimarmorata*).

Patches of wetland vegetation within all waterways within the PSP also provide habitat for fauna and act as corridors between larger wetland patches within the landscape for aquatic species.



Eastern Great Egret. Image source; Norman Chaffer Australian Museum.



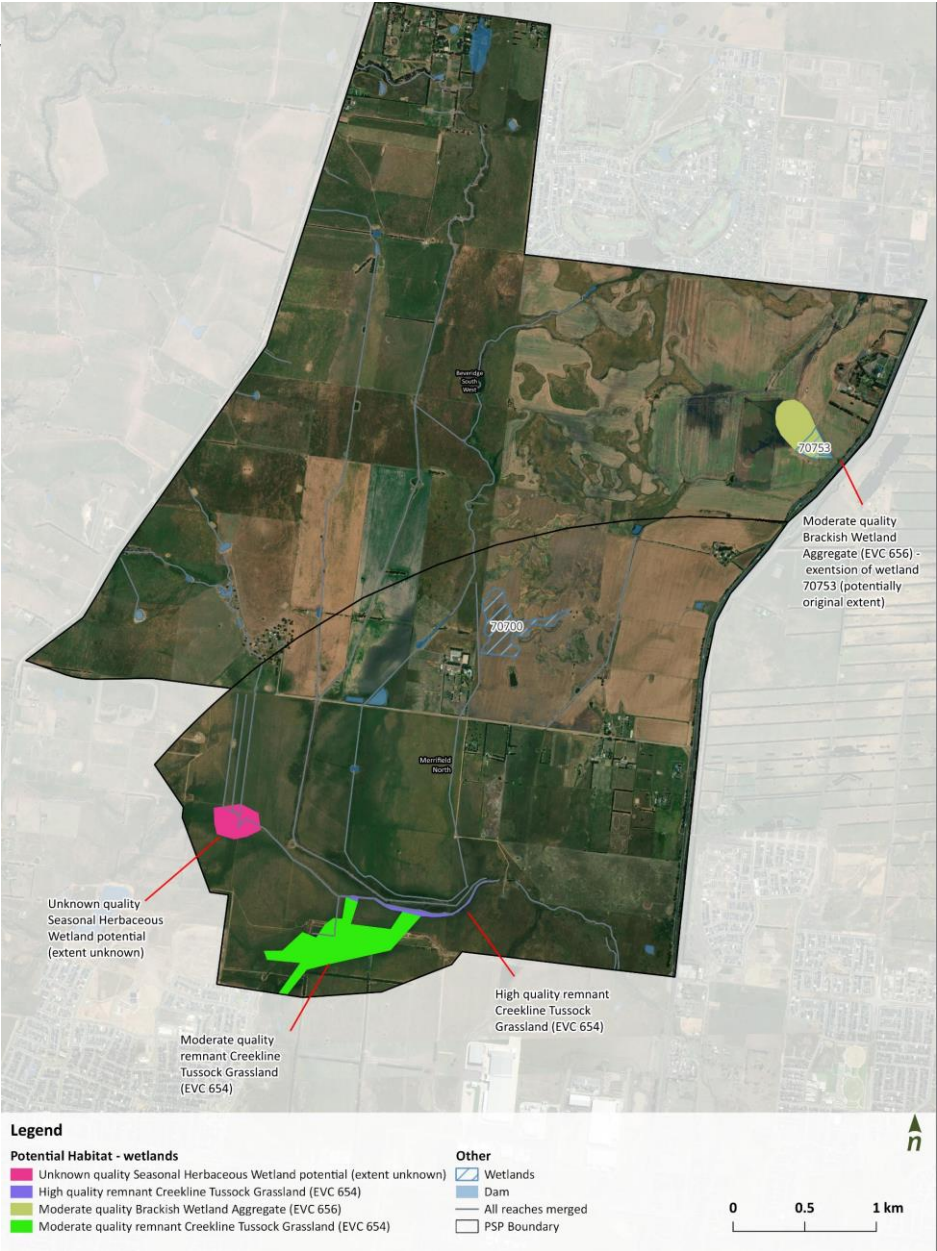
Growling Grass Frog. Image source; Trevor Graham. SWIFFT



Wetland 70753. Image source; Chrissi Charles.



Inundation prone area adjacent to the area mapped as wetland 70753. Image source; Chrissi Charles.



Other Fauna values

Incidental Fauna species

The following fauna species were recorded incidentally during field surveys:

Eastern Grey Kangaroo (*Macropus giganteus*).

Mouse spider (*Missulena sp.*).

Multiple incidental sightings of Red Foxes (*Vulpes vulpes*) were made during field assessments particularly in the drains and channels in Beveridge Southwest.

White Faced Heron (*Egretta novaehollandiae*)



Eastern Grey Kangaroo Source; *deborod iNaturalist*

Habitat values for other non-threatened species of management consideration

In addition to those species identified as being of conservation significance Melbourne Water should also consider the potential role that waterways and wetlands can provide in offering habitat for currently common species. Waterways provide important habitat corridors across the landscape for macropods and monotremes. The Eastern Grey Kangaroo *Macropus giganteus* is generally a common species which has been observed in high abundance particular at the urban peri-urban interface after development, where habitat pressures can result in increased numbers of animals using habitat that has been squeezed by urban/industrial development.

Waterways can offer an important habitat refuge and opportunity to move beyond developed areas for this species. Buffer areas enabling their safe transit through the landscape ought to be considered at the planning phase.

Furthermore, there is an increasing number of species once thought to be common and widespread now qualifying as species of significance. For this reason, future investigation should consider whether any fauna species that are not yet listed may be important in the study area or in the surrounding landscape.

This assessment reviewed ecological values across the Merrifield North and Beveridge Southwest zone with an emphasis on wetland and waterway vegetation. This study identified poor to high quality condition of riparian and instream vegetation at the time of assessment, but with one very low value and one medium value wetland for fauna.

Much of the habitat associated with riparian and wetland values is highly seasonal. Therefore, its potential utilisation by significant fauna should also be viewed in this context. While fauna records may be intermittent there is still high potential for sites to provide habitat for significant fauna in the right season. Wetlands in particular may exhibit great fluctuations in the condition of habitat between any given time period and equally may support significant species even in what may be assessed as poor habitat.

Limitations

A specific assessment or on ground search for significant fauna was not conducted as part of this evaluation. We did not conduct a comprehensive assessment of fauna and their habitat needs. This is an indicative review to highlight known fauna within 5km of the PSP and potential fauna habitat issues across the study area to inform future assessment. Detailed habitat assessment and on-ground assessment of fauna by specialist zoologists is advised combined with planning consideration to maintain and improve habitat connectivity across the landscape.

An aerial photograph of a dry, cracked landscape, possibly a salt flat or a desert. The ground is covered in a complex network of dark, winding cracks that form a honeycomb-like pattern. The overall tone is dark and monochromatic. A semi-transparent rectangular box is overlaid on the right side of the image, containing the word "Recommendations" in white text.

Recommendations

Recommendations – flora, fauna and habitat

In addition to the geomorphology recommendations, we make the following recommendations relating to flora and fauna in the Merrifield and Beveridge Southwest PSPs.

1. Further studies should be completed in the following areas recommended for detailed assessment in Figure 48.

- A detailed study of vegetation within the remnant patches of Stony Knoll Shrubland (EVC 649)/ Plains Grassland (EVC 132) patches outlined in Figure 56 is recommended. – Spring is the ideal study period.
- A full assessment of the extent and quality of the Seasonal Herbaceous Wetland/ Plains Grassy Wetland EVC 125 in the southwest of Reach 8 is recommended. – late spring is the ideal study period.
- Investigation of the persistence of the Curly Sedge (*Carex tasmanica*) population within reach 5. – study could be conducted at any time of the year.
- A detailed assessment of Creekline Tussock Grassland EVC 654 within reach 9. – spring is the ideal study period.

2. Detailed habitat assessment and on-ground assessment of fauna by specialist zoologists is advised combined with planning consideration to maintain and improve habitat connectivity across the landscape.

3. The 1-3m wide band of culturally significant Basket Sedge/ Poong'ort (*Carex tereticaulis*) within the conservation area (see Reach 10) should be maintained. The species favours shallow seasonal inundation however the precise tolerance of altered water regimes is unknown. If the area is inundated permanently the vegetation composition will likely turn into a Phragmites/ Typha dominated system.

4. Reach 9 within Melbourne Water's Retarding Basin should be protected and managed for its high-quality band of Creekline Tussock Grassland (adjacent to channelised drainage-lines of Kalkallo Creek).

5. Both the mapped area for 70753 and the estimated original extent should be protected from development and prioritised for restoration due to its remnant ecological values. The wetland contains patches of Brackish Wetland Aggregate which has a bioregional conservation status of Endangered (Frood & Papas 2016) and contains the FFG listed endangered *Ranunculus diminitus*. The wetland should contain a peripheral buffer to reduce edge effects from surrounding development.

6. Protection of the river red-gum population within Reach 7 through adequate buffer zones to mitigate the impacts of adjacent development. An increase in possum population post development (due to increased habitat within roof cavities and food availability) will increase the predation. Trees may need possum banding to reduce predation.

7. All storm water should be diverted into treatment ponds before entering Kalkallo Creek through the conservation reserve. Our recommendation would be the establishment of water treatment ponds within the retarding basin during PSP development.

8. Targeted surveys to determine an updated status of the golden sun moth population within Conservation area 23 is a recommended alongside a biomass management plan. Ecological burning (outside of the GSM flight time) is the recommended treatment for biomass removal within Volcanic Plains Grasslands however the adjacent freeway indicates that burning however will be difficult. Management of a long-term kangaroo population within the PSP with safe access into and out of the conservation reserve will also play an important role in biomass management. A GSM management plan which addresses the need for biomass removal sensitive to GSM flight times is recommended.

9. BCS conservation areas should follow Melbourne Strategic Assessment guidelines for the buffer design. A road boundary should be established on the northern edge of conservation area 23 to reduce the impacts of houses backing directly onto the conservation area. In areas where houses directly back onto a conservation reserve there is greater risk of weed infestation and incursions from back fences (particularly in grasslands). A road has the dual purpose of acting as a fire break between the reserve and any future property development.

Recommendations – flora, fauna and habitat cont.

In addition to the geomorphology recommendations, we make the following recommendations relating to flora and fauna in the Merrifield and Beveridge Southwest PSPs.

10. Commission an ecological corridor plan that ensures adequate connectivity between all parks and reserves that are managed for conservation/ public open space values within the final PSP's design. All areas with any conservation significance must be connected to a larger habitat patch via a habitat corridor. The width of all corridor patches between reserves/parks must be determined according to the species-specific requirements of remnant species and/or species with a high likelihood of occurrence. This plan could be in conjunction with the areas in need of further assessments outlined under recommendation 1. Corridor access is particularly pertinent for Eastern Grey Kangaroos population management into/ within and out of PSPs. Ideally a corridor for a population of Eastern Grey Kangaroos would include patches of grassland/ grassy woodland with the dual purposes of helping to reduce biomass (and therefore fire risk in grassland vegetation) through kangaroo grazing.

11. Protection of *Ranunculus diminutus* (Brackish Plains Buttercup) within wetland 70753 is dependent on protection of the wetland. The most immediate threat would be herbicide damage either from the adjacent field or during wetland maintenance. Translocation of the species outside of its current confined area into suitable brackish sites both within wetland 70753 and within the PSP will increase the onsite redundancy of the population. Population protection in the longer term will require maintenance crews to be skilled in wetland plant identification and appropriate herbicide application techniques to prevent damage to the species.

Reach sensitivity and geomorphology recommendations

Reach	Reach type	Geomorphic value	Sensitivity to hydrologic alteration	Management recommendation
1	Confined, incised gully with a bed of silt and sand.	Low	High	Halt incision cycle by stabilising bed, establish/maintain riparian vegetation buffer.
2	Unconfined, shallow swales and drainage depressions.	Low	Moderate to low	No intervention recommended, suitable for constructed waterway.
3	Incised, low sinuosity, mixed boulder and fine-grained bed.	Moderate	High	Use tributary/catchment stormwater management to limit future incision, accelerate channel recovery by treating weeds, and investigate possible native instream vegetation that can tolerate drying. Establish riparian buffer.
4	<u>Central and western channels:</u> Central and western channels: Straight, anthropogenic shaped channels with fine grained bed.	Low	High	Central and western: Use tributary/catchment stormwater management to limit future incision, suitable for replacement with constructed waterway.
4	<u>Eastern channels:</u> Straight, anthropogenic shaped channels, bed alternates between fine grained and exposed basalt boulders.	Low	High	Use tributary/catchment stormwater management to limit future incision in sections where basalt not yet exposed. Consider incorporating basalt sections, which emulate locally rare waterways type, into a constructed waterway.
5	Unconfined, continuous, low-sinuosity boulder bed, intermittent fine-grained deposits.	Low-Moderate	Moderate	Central and western: Use tributary/catchment stormwater management to limit future incision. Retain waterway and focus on accelerating recovery by treating weeds, and investigate possible native instream vegetation that can tolerate drying. Establish riparian buffer.

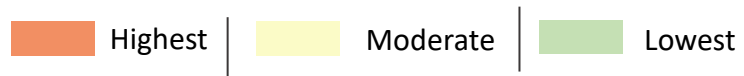
Priority for management

Highest
 Moderate
 Lowest

Reach sensitivity and geomorphology recommendations

Reach	Reach type	Geomorphic value	Sensitivity to hydrologic alteration	Management recommendation
6	<u>Upstream of dam</u> Incised, low sinuosity waterway with fine grained bed.	Low	High	Upstream: Halt incision cycle by stabilising bed, establish/maintain riparian vegetation buffer to protect Old Sydney Road. No intervention recommended in open swale section upstream of dam.
6	<u>Downstream of dam</u> Unconfined, low sinuosity, discontinuous channel.	Low	Moderate	No intervention recommended, suitable for replacement with constructed waterway.
7	Unconfined, low sinuosity, discontinuous channel		Moderate	No intervention recommended, suitable for replacement with constructed waterway – focus on reinstatement/preservation of gum remnant vegetation (see ecology section).
8	Kalkallo retarding basin: Straight, anthropogenic shaped channels with fine grained bed.	Low	Moderate	No intervention recommended.
9	Kalkallo retarding basin: Anthropogenic shaped channels with fine grained bed incl– with ecological values.	Low	Moderate	No intervention recommended, consider managing flow regime to preserve and enhance ecological values.
10	Low sinuosity, partially confined mixed boulder and fine-grained bed with confined floodplain pockets.	Moderate	Low	Use tributary/catchment stormwater management to limit future infilling of pools with fine sediment or undercutting of banks. Not suitable for constructed waterway. Use weed control and native planting to enhance ecological values.

Priority for management



Overall Recommendations and further investigations

We make the following overall recommendations, and identify additional investigations, relating to the future management of the waterways and wetlands in the Merrifield and Beveridge Southwest PSPs:

1. **Sodic soil management.** The presence of sodic, dispersive soils along waterways and most likely the entire PSP area is responsible for the high sensitivity rating applied to alluvial reaches (see [pages 87 & 88](#)). Sodic soils are erosion prone and are highly sensitive to even subtle increases in flow energy or exposure during construction. Fine sediment liberated by the formation of new gullies or expansion of existing sodic waterways will threaten downstream waterways. Standard construction techniques will be insufficient to mitigate this threat and we recommend that a sodic soil management plan that utilises the recommended treatment options outlined in the Regen Soils (2023) report be developed for all works in the PSP areas. Specific management measures include limiting disturbance of sodic topsoil/subsoil, application of soil treatments such as gypsum and stormwater management measures that limit the erosion potential of any retained natural waterways/reaches.
2. **Kalkallo wetland complex.** Investigations completed as part of this project examined the potential Pre-European extents of wetlands within the PSP areas (Alluvium, 2023b). The Pre-European wetland investigation should be used in conjunction with this report and cultural heritage assessments to develop a plan to manage the remaining wetlands within the study area and decide how and where any wetland restoration efforts are best concentrated. The design of the DSS layouts and asset types can be used to assist in this plan which should also consider the role of alternate functions (i.e. non-flood functions) the Kalkallo retarding basin may serve.
3. **A groundwater risk assessment** was unable to be completed for the hydrogeological investigations undertaken as part of this project. Once further detail as to the likely extent of impermeable surface creation and the approximate layout of DSS assets is known this hydrogeological risk assessment should be updated. At the same time, these investigations (and potentially groundwater modelling) could shed further light on the historic extent of Pre-European wetlands, the contribution of groundwater to remaining wetlands within the PSP areas and the interaction between shallow groundwater and the natural (and any future constructed) waterways in the PSP areas.
4. **Spring Street Swamp assessment.** The investigation completed for other parts of this

project (Figure 15 within Merrifield North Employment and Beveridge Southwest PSP Pre-European Wetland Investigation Alluvium 2023b) identified the potential for a wetland within the historic Spring Street Swamp. Due to access constraints, we were unable to access Spring Street Swamp during our 2023 geomorphology or ecology assessments. We recommend a formal ecological assessment of the area historically mapped as Spring Street Swamp.

5. **Cultural heritage assessments.** Further investigation into the cultural heritage values of the Merrifield and Beveridge South West PSP areas is required. These assessments will be especially important to understand the possible extent of wetland prior to European settlement, the cultural values those wetlands provide and the aspirations of traditional owners for this landscape in the future.

Broader waterway connections beyond the boundaries of this PSP

Kalkallo Creek flows through the site exiting in the southeast corner of Merrifield North. After exiting the PSP, it flows under the Hume Freeway and continues in a south easterly direction merging with the Merri Creek approximately 2.25km from the PSP.

The Merri Creek is a major tributary to the Yarra River. Impacts on water quality arising from development in the upper catchment (the PSP Area, including Kalkallo Creek) have the potential to impact water quality in downstream waterways. Increased turbidity due to accelerated erosion of sodic soils in the PSP area is the most obvious example- although the impact of high turbidity will decrease with distance downstream from the PSP area as suspended sediment is diluted by inputs from other tributaries.

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An aerial photograph of a dry, cracked landscape, possibly a salt flat or a desert. The ground is covered in a complex network of dark, winding cracks that form a honeycomb-like pattern. The overall tone is dark and monochromatic. A semi-transparent dark rectangle is overlaid in the center of the image, containing the word "Appendices" in white text.

Appendices

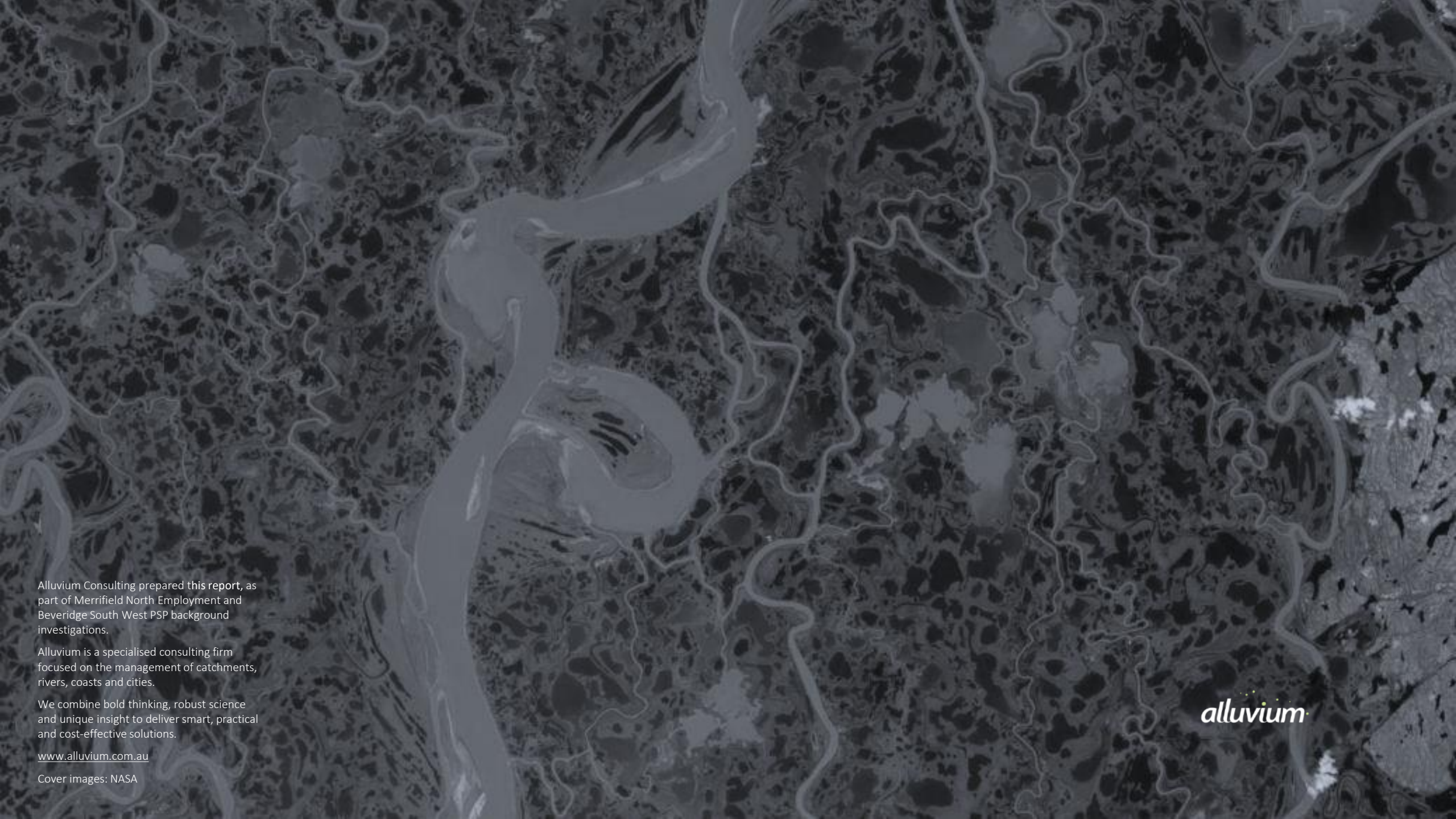
Appendix A: Flora species list (field observations)

Flora Species recorded	Common name	Origin
<i>Acacia paradoxa</i>	Hedge Wattle	Indigenous
<i>Acaena agnipila</i>	Hairy Sheep's Burr	Indigenous
<i>Acaena echinata</i>	Sheep's Burr	Indigenous
<i>Agrostis capillaris</i>	Brown-top Bent	Introduced
<i>Alisma plantago-aquatica</i>	Water Plantain	Indigenous
<i>Amphibromus fluitans</i>	River Swamp Wallaby-grass	Indigenous
<i>Amphibromus nervosus</i>	Common Swamp Wallaby-grass	Indigenous
<i>Asperula conferta</i>	Common Woodruff	Indigenous
<i>Austrostipa bigeniculata</i>	Kneed Spear-grass	Indigenous
<i>Bolboschoenus caldwellii</i>	Salt Club-sedge	Indigenous
<i>Brassica x napus</i>	Canola	Introduced
<i>Bromus hordeaceus</i>	Soft Brome	Introduced
<i>Callitriche stagnalis</i>	Common Water-starwort	Introduced
<i>Calocephalus citreus</i>	Lemon Beauty-heads	Indigenous
<i>Carex inversa</i>	Knob Sedge	Indigenous
<i>Carex tereticaulis</i>	Poong'ort	Indigenous
<i>Chenopodium album</i>	Fat Hen	Introduced
<i>Cirsium vulgare</i>	Spear Thistle	Introduced
<i>Convolvulus angustissimus</i> subsp. <i>omnigracilis</i>	Slender Bindweed	Indigenous
<i>Cotula coronopifolia</i>	Water Buttons	Introduced
<i>Cullen tenax</i>	Tough Scurf-pea	Indigenous
<i>Cycnogeton procerum</i> s.s.	Common Water-ribbons	Indigenous
<i>Cynara cardunculus</i> subsp. <i>flavescens</i>	Artichoke Thistle	Introduced
<i>Cynodon dactylon</i> var. <i>dactylon</i>	Couch	Introduced
<i>Cyperus eragrostis</i>	Drain Flat-sedge	Introduced
<i>Dactylis glomerata</i>	Cocksfoot	Introduced
<i>Distichlis distichophylla</i>	Australian Salt-grass	Indigenous
<i>Eleocharis acuta</i>	Common Spike-sedge	Indigenous
<i>Eleocharis pusilla</i>	Small Spike-sedge	Indigenous
<i>Epilobium billardiereanum</i> subsp. <i>cinereum</i>	Grey Willow-herb	Indigenous
<i>Epilobium hirtigerum</i>	Hairy Willow-herb	Indigenous
<i>Erigeron bonariensis</i>	Flaxleaf Fleabane	Introduced
<i>Eryngium ovinum</i>	Blue Devil	Indigenous
<i>Eryngium vesiculosum</i>	Prickfoot	Indigenous
<i>Festuca arundinacea</i>	Tall Fescue	Introduced
<i>Geranium retrorsum</i> s.l.	Grassland Crane's-bill	Indigenous
<i>Goodenia radicans</i>	Shiny Swamp-mat	Indigenous

Flora Species recorded	Common name	Origin
<i>Helminthotheca echinoides</i>	Ox-tongue	Introduced
<i>Hordeum hystrix</i>	Mediterranean Barley-grass	Introduced
<i>Hypochaeris radicata</i>	Flatweed	Introduced
<i>Isolepis levynsiana</i>	Tiny Flat-sedge	Introduced
<i>Isolepis marginata</i>	Little Club-sedge	Indigenous
<i>Juncus acutus</i> subsp. <i>acutus</i>	Spiny Rush	Introduced
<i>Juncus amabilis</i>	Hollow Rush	Indigenous
<i>Juncus articulatus</i> subsp. <i>articulatus</i>	Jointed Rush	Introduced
<i>Juncus bufonius</i>	Toad Rush	Indigenous
<i>Juncus filicaulis</i>	Thread Rush	Indigenous
<i>Juncus flavidus</i>	Gold Rush	Indigenous
<i>Juncus holoschoenus</i>	Joint-leaf Rush	Indigenous
<i>Juncus pallidus</i>	Pale Rush	Indigenous
<i>Juncus semisolidus</i>	Plains Rush	Indigenous
<i>Juncus subsecundus</i>	Finger Rush	Indigenous
<i>Lachnagrostis filiformis</i> s.s.	Common Blown-grass	Indigenous
<i>Lachnagrostis perennis</i> s.l.	Perennial Blown-grass	Indigenous
<i>Laphangium luteoalbum</i>	Jersey Cudweed	Indigenous
<i>Leontodon saxatilis</i> subsp. <i>saxatilis</i>	Hairy Hawkbit	Introduced
<i>Lolium rigidum</i>	Wimmera Rye-grass	Introduced
<i>Lomandra filiformis</i>	Wattle Mat-rush	Indigenous
<i>Lythrum hyssopifolia</i>	Small Loosestrife	Indigenous
<i>Melicytus dentatus</i> s.s.	Tree Violet	Indigenous
<i>Nassella neesiana</i>	Chilean Needle-grass	Introduced
<i>Oxalis exilis</i>	Shade Wood-sorrel	Indigenous
<i>Paspalum distichum</i>	Water Couch	Introduced
<i>Persicaria decipiens</i>	Slender Knotweed	Indigenous
<i>Phalaris aquatica</i>	Toowoomba Canary-grass	Introduced
<i>Phragmites australis</i>	Common Reed	Indigenous
<i>Plantago coronopus</i>	Buck's-horn Plantain	Introduced
<i>Plantago lanceolata</i>	Ribwort	Introduced
<i>Poa labillardierei</i>	Common Tussock-grass	Indigenous
<i>Polygonum aviculare</i> s.s.	Hogweed	Introduced
<i>Polypogon monspeliensis</i>	Annual Beard-grass	Introduced
<i>Puccinellia fasciculata</i>	Borrer's Saltmarsh-grass	Introduced
<i>Ranunculus diminutus</i>	Brackish Plains Buttercup	Indigenous
<i>Rosa rubiginosa</i>	Sweet Briar	Introduced

Appendix A: Flora species list cont.

Flora Species recorded	Common name	Origin
<i>Rumex brownii</i>	Slender Dock	Indigenous
<i>Rumex conglomeratus</i>	Clustered Dock	Introduced
<i>Rumex crispus</i>	Curled Dock	Introduced
<i>Rytidosperma caespitosum</i>	Common Wallaby-grass	Indigenous
<i>Rytidosperma duttonianum</i>	Brown-back Wallaby-grass	Indigenous
<i>Rytidosperma setaceum</i>	Bristly Wallaby-grass	Indigenous
<i>Schoenoplectus pungens</i>	Sharp Club-sedge	Indigenous
<i>Schoenoplectus tabernaemontani</i>	River Club-sedge	Indigenous
<i>Schoenus apogon</i>	Common Bog-sedge	Indigenous
<i>Schoenus nitens</i>	Shiny Bog-sedge	Indigenous
<i>Senecio glomeratus</i>	Annual Fireweed	Indigenous
<i>Sonchus asper subsp. asper</i>	Rough Sow-thistle	Introduced
<i>Sonchus asper subsp. glaucescens</i>	Blue Sow-thistle	Introduced
<i>Sonchus oleraceus</i>	Common Sow-thistle	Introduced
<i>Symphyotrichum subulatum</i>	Aster-weed	Introduced
<i>Themeda triandra</i>	Kangaroo Grass	Indigenous
<i>Trifolium fragiferum</i> var. <i>fragiferum</i>	Strawberry Clover	Introduced
<i>Triglochin striata</i>	Streaked Arrowgrass	Indigenous
<i>Typha domingensis</i>	Narrow-leaf Cumbungi	Indigenous
<i>Typha</i> sp.	Cumbungi	Indigenous
<i>Typha</i> spp.	Cumbungi	Indigenous
<i>Ulex europaeus</i>	Gorse	Introduced
<i>Veronica gracilis</i>	Slender Speedwell	Indigenous
<i>Vulpia bromoides</i>	Squirrel-tail Fescue	Introduced
<i>Vulpia</i> spp.	Fescue	Introduced
<i>Wahlenbergia capillaris</i>	Tufted Bluebell	Indigenous



Alluvium Consulting prepared this report, as part of Merrifield North Employment and Beveridge South West PSP background investigations.

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