

An aerial photograph of a river delta, likely the Merrimu River, showing a complex network of channels and floodplains. The image is color-coded, with green and yellow representing different land types or vegetation, and blue/purple representing water or wetlands. A semi-transparent dark grey rectangular box is overlaid on the right side of the image, containing the title and date.

Merrimu PSP

Final geomorphology and
vegetation assessment

November 2019

alluvium

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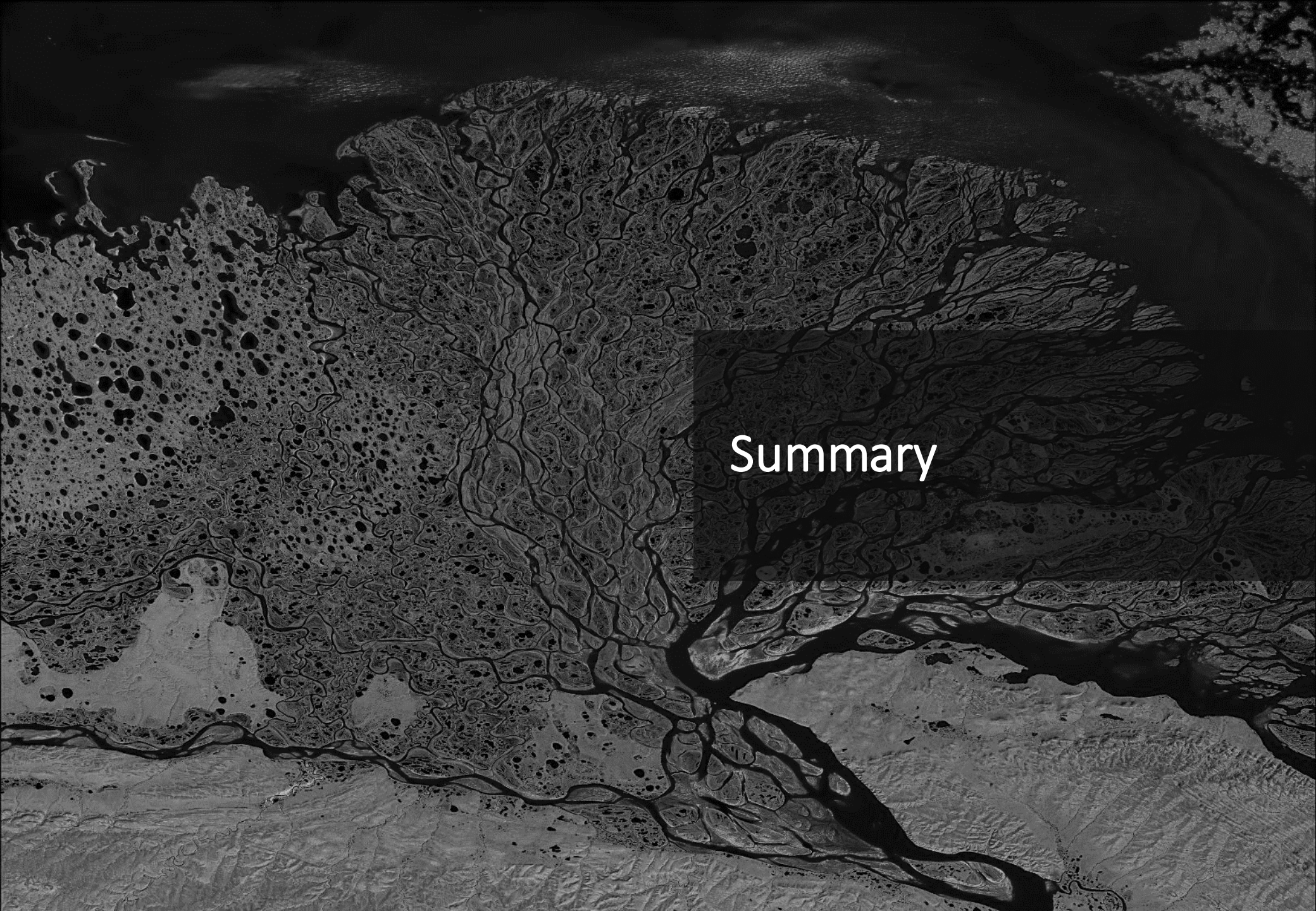
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An aerial photograph of a river delta, showing a complex network of distributaries branching out from a main river channel. The terrain is characterized by a dense, intricate pattern of light-colored, winding lines against a darker background, representing the river's course and the surrounding land. A semi-transparent rectangular box is overlaid on the right side of the image, containing the word "Summary" in white text.

Summary

Investigation summary

Many factors are important in determining a waterways sensitivity to change. These factors may include the magnitude of the change in hydrologic conditions, slope of the waterway and underlying geology.

Across the study area a number of characteristics increase the susceptibility of waterways to change. The majority of waterways investigated for this project have very steep bed slopes, in excess of the 1 in 200 stable grade recommended in the Melbourne Waters Constructed Waterways Design Manual. Independently of additional factors, particularly hydrology, slope alone is not sufficient to quantify sensitivity to change. While sensitivity to change cannot be quantified based on slope alone, the steep bed slope observed does indicate that there may be increased sensitivity to change when hydrology is also accounted for.

Underlying geology across the study area plays an important role in a waterways sensitivity to change. Soils of the study area comprise of sodosols. Werribee Formation sodosols are highly dispersive and particularly prone to erosion.

The majority of waterways across the study site flow over material derived from the Werribee Formation making them extremely sensitive to change. While not

matching the scale of erosion processes occurring on soils from the Werribee Formation parent material, sodic soils derived from other parent materials are also highly erosive.

Geomorphic sensitivity to change is a key driver of biological sensitivity to change. Vegetation sensitivity to change was most pronounced in sites with high and very high geomorphic sensitivity to change.

This study identified six vegetation communities consistent with NatureKit benchmarks for Ecological Vegetation Class (EVC) mapping. All six EVCs have a conservation status of either vulnerable or endangered.

In addition six species of conservation significance were observed. Their sensitivity to change was in part associated with their proximity to waterways. For example significant species that occupied niches on escarpments beyond direct riparian influence were less vulnerable to change. Species that occupied niches on or adjacent to waterways may be more susceptible to decline due to geomorphologic sensitivity. Invasive plants and animals contributed further to the sensitivity of significant species to change.

There is a strong correlation between geomorphic sensitivity and vegetation sensitivity. In general terms vegetation on all minor tributaries of steep gradient are highly sensitive to change. Vegetation on the Werribee River is of low sensitivity to change. Vegetation on the main branch on the Pyrites creek is of moderate sensitivity to change in the upper portion and to low sensitivity to change in the lower portion.

This assessment applies to riparian areas only. It must not be extrapolated to areas beyond the riparian zone. Additional values and sensitivity are likely beyond the riparian area which must be assessed in further detail. Vegetation in public reserves was of better quality and included areas of moderate and high quality vegetation.

The highly sensitive nature of soils to erosion within the study area means that any increase in flow will trigger further erosion. Because soils in the study area are acutely sensitivity to hydrological change a comprehensive framework to address the risk of these highly erosive soils will need to be agreed to and developed. A framework for the assessment of risk will provide a pathway for decisions to be made about future waterway management and development within the study area.



Investigation summary

Key findings

- Most waterways have very steep bed slopes.
- Most waterways are actively eroding under current conditions.
- All waterways are sensitive to hydrological change – increased flows will increase the rate and magnitude of erosion.
- Slope alone is not sufficient to quantify sensitivity to change.
- Increased sensitivity to change can be quantified when hydrology is accounted for.
- Sodosols of the Werribee Formation in particular are highly dispersive.
- Geomorphic sensitivity to change is a key driver of biological sensitivity to change.
- Six vegetation communities (EVCs) identified; all are vulnerable or endangered..
- Six species of conservation significance were observed.
- There is a strong correlation between geomorphic sensitivity and vegetation sensitivity.
- Vegetation adjacent to developed land was of low or very low quality.
- Vegetation in public reserves is of moderate and high quality.
- All waterways flowing from areas currently designated as developable within the Merrimu PSP will flow over highly erodible soils. Almost all assessed waterways are eroding. Any increases in flow will further exacerbate erosion. A comprehensive framework to assess risk is required to address the high erodibility of this site.



Summary of findings: geomorphic sensitivity

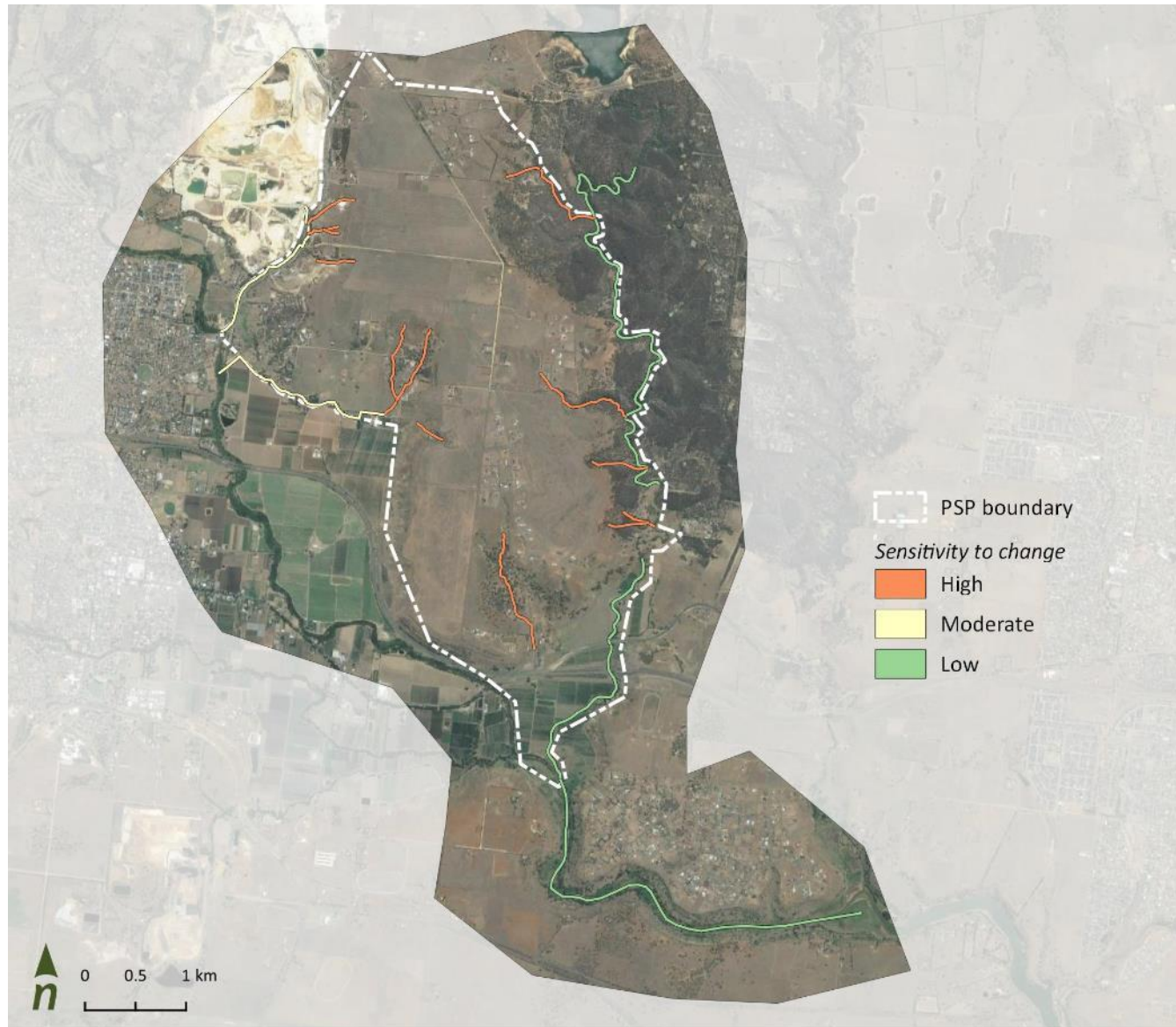


Figure 1. Geomorphic sensitivity to change

Summary of findings: vegetation sensitivity

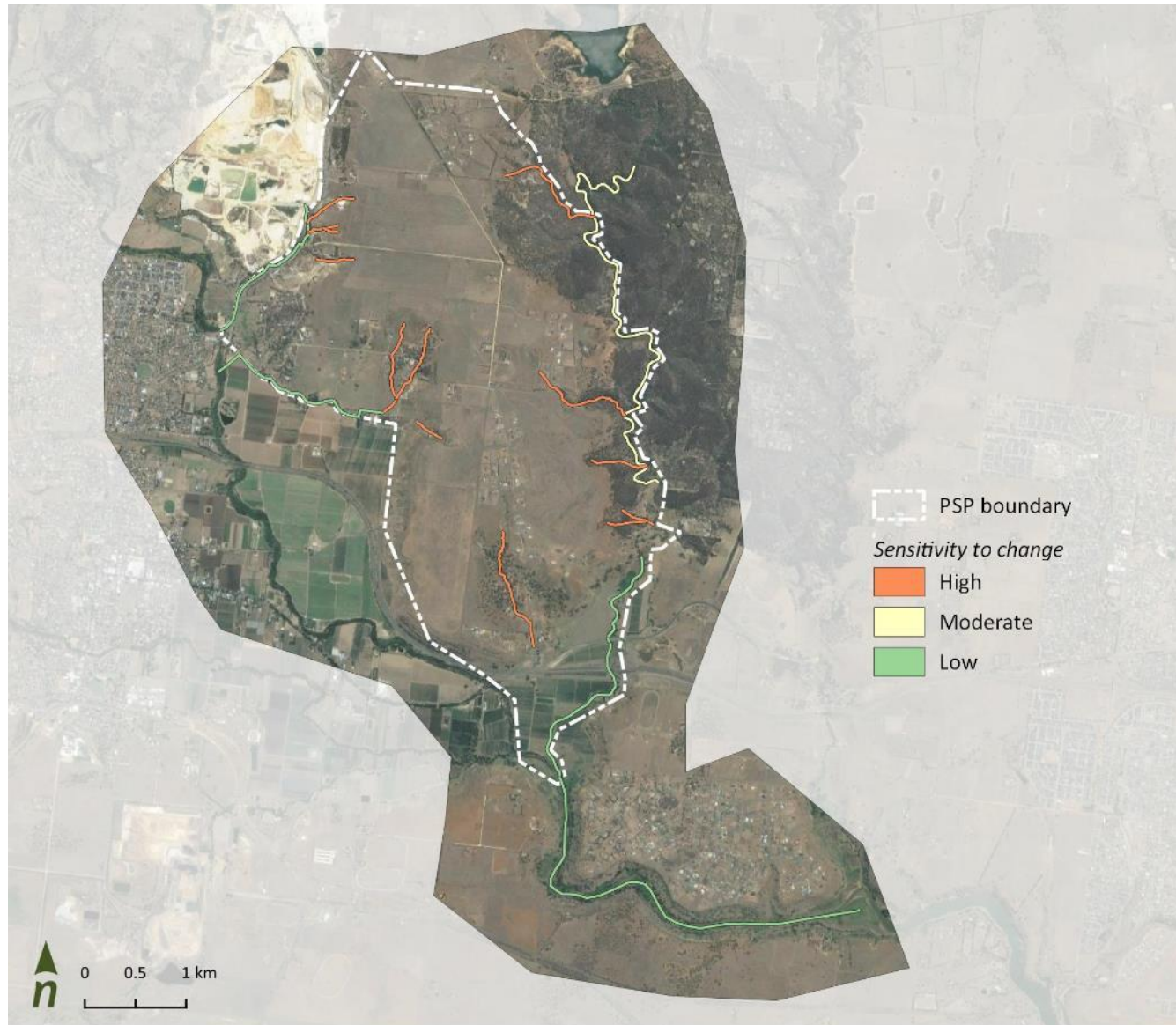
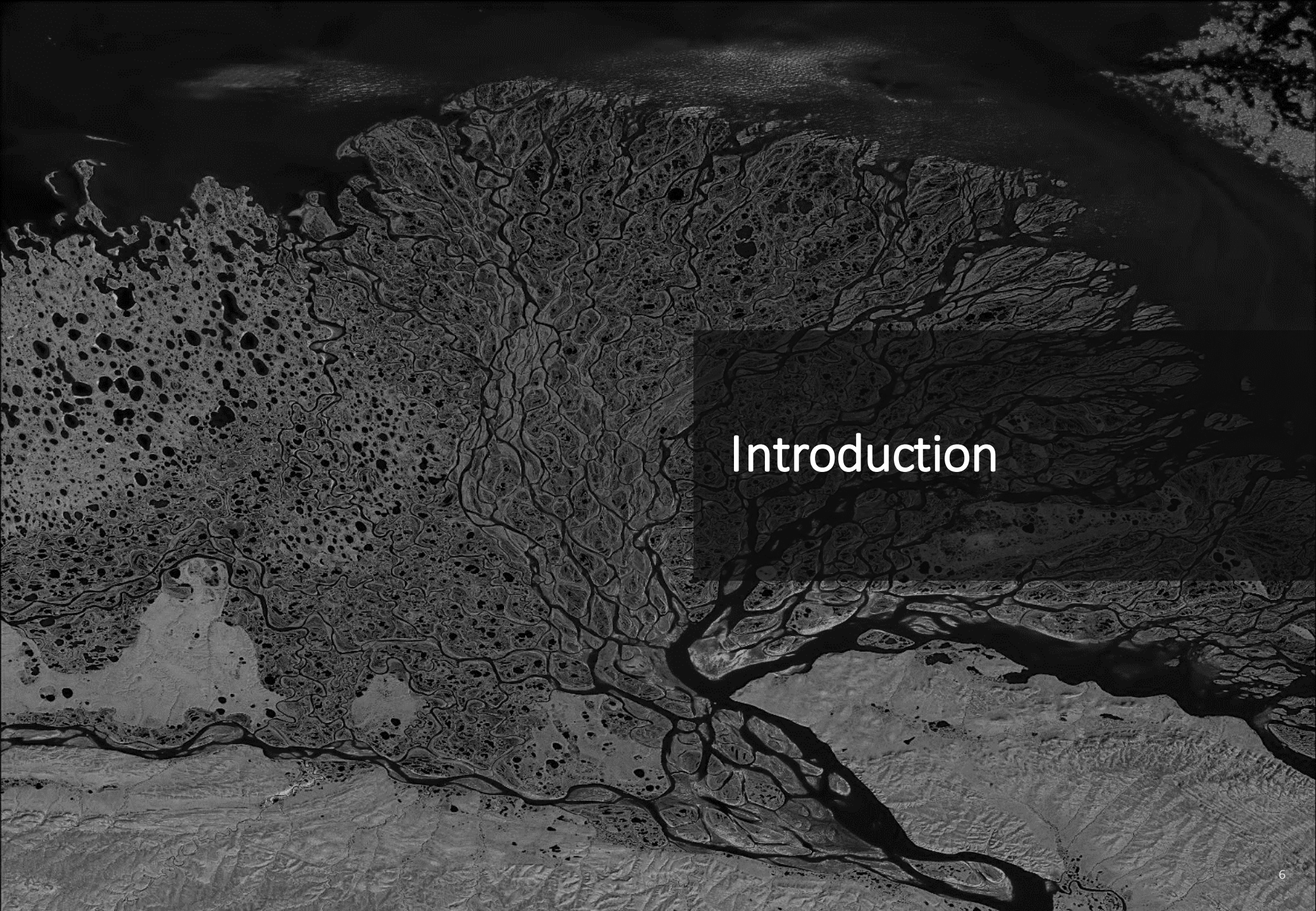


Figure 2. Vegetation sensitivity to change

An aerial photograph of a river delta, showing a complex network of distributaries branching out from a main river into a body of water. The land is characterized by a dense, intricate pattern of channels and ridges, creating a textured appearance. A semi-transparent dark 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 Merrimu area. The DSS is a plan for the drainage, waterway and water quality treatment works required to provide the most effective and environmentally sound stormwater management to protect river health from changes in stormwater runoff from the proposed urban development.

As a part of the DSS development, Melbourne Water engaged Alluvium to assess the riparian vegetation and geomorphic values that may be impacted by urban development, which will inform the site's Precinct Structure Plan (PSP), DSS and ensure these existing values are protected or enhanced.

The Merrimu PSP has an area of nearly 970 ha and is located approximately 50 km north-west of Melbourne (Figure 1). The development poses significant challenges to the safe management of stormwater.

The study area contains distinctly different landscapes: a high basalt plateau, steep escarpments draining to receiving waterways, and areas of floodplain in lower areas.

The objectives of this project are to:

- Identify waterway values including geomorphic form, condition and trajectory and flora and fauna extent, condition and significance.
- Recommend reaches of high value for priority protection
- Identify the sensitivity of waterways to post-development hydrological change
- Recommend if waterways in their current form can be maintained or if management interventions are required
- Recommend further studies where required.

The methods, results and recommendations are described in detail in this report.

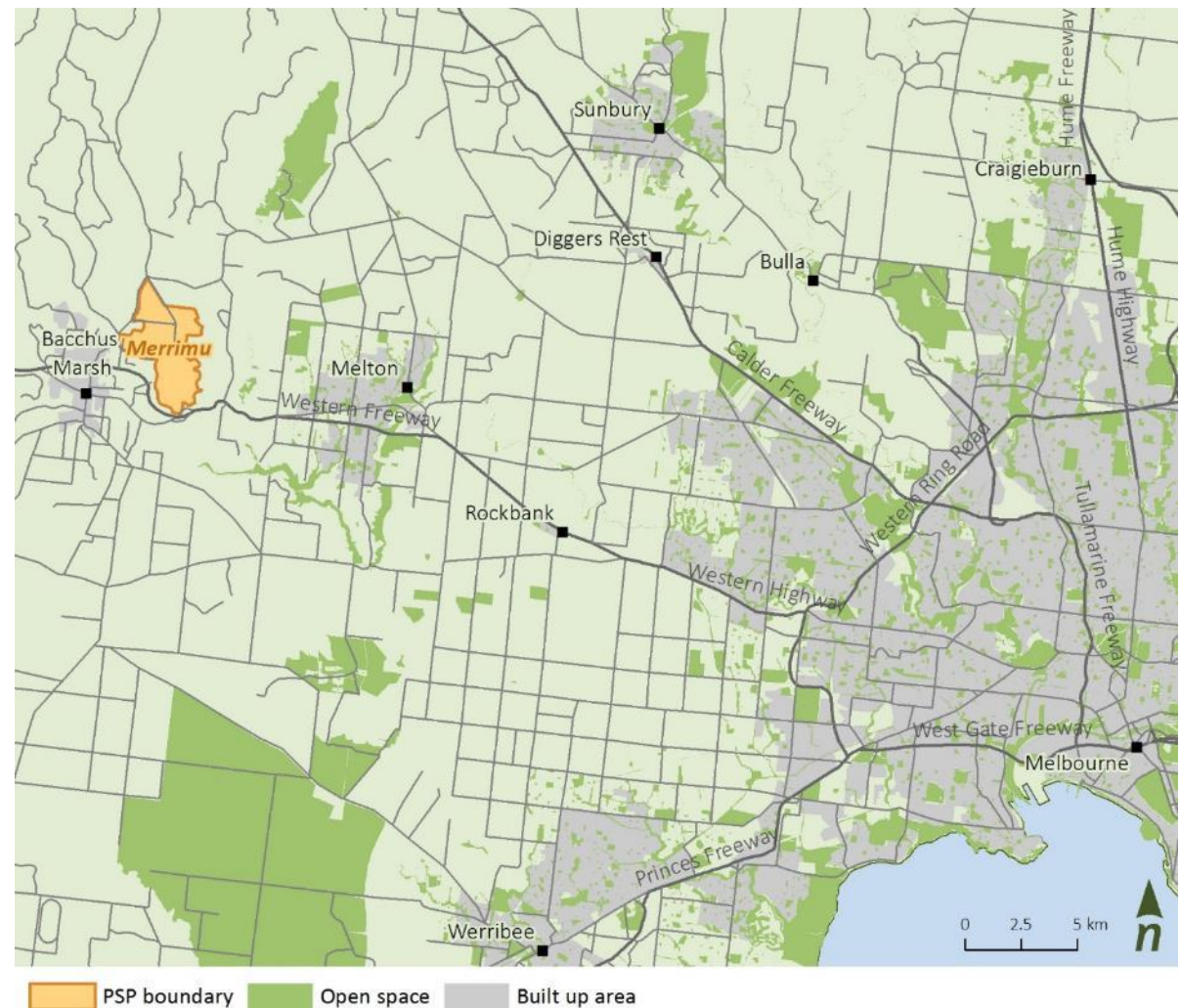
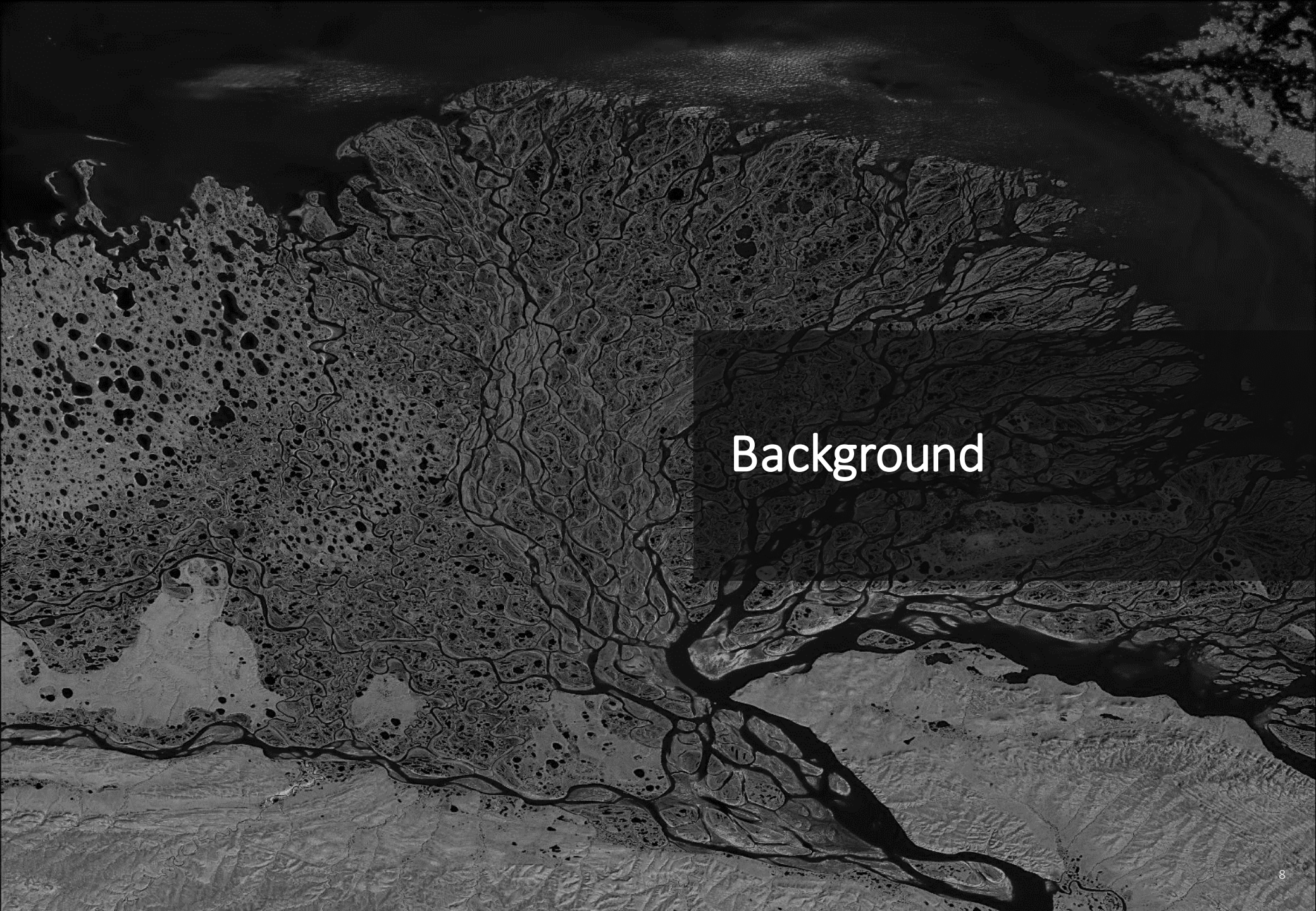


Figure 3. Map showing location of study area

An aerial photograph of a river delta, showing a complex network of channels and distributaries. The land is a mix of light and dark tones, indicating different soil types or vegetation. A semi-transparent dark rectangular box is overlaid on the right side of the image, containing the word "Background" in white text.

Background

Geology

The Merrimu PSP area lies largely on the dissected terrain between the Rowsley and Djerriwarrh Faults. The PSP area is largely dominated by four geologic units.

Newer Volcanic Group

The Miocene-Pleistocene basalt flows of the Newer Volcanic Group are found on the higher elevations of the escarpment. This unit forms an undulating plain with a vertical scarp and is prone to rocks as a result of erosion of underlying material (Earth Tech 2006). This group is very resistant to erosion.

Werribee Formation

The Werribee formation comprises Eocene sedimentary alluvium with sandy and silty sediments that is pyritic in some parts. The material of the Werribee Formation is generally found on the lower slopes of the escarpment and is poorly cemented and highly erodible (Earth Tech 2006).

Castlemaine Group

The Castlemaine Group is composed of Ordovician sedimentary sandstones, siltstones and shale. It is found predominately on the lowest slopes of the escarpment, particularly along Pyrites Creek.

Bacchus Marsh Group

The Bacchus Marsh Group comprises Permian sedimentary sandstone, mudstone and conglomerate. It is found in the north-eastern part of the PSP area and is less resistant to erosion than the sediments of the Castlemaine Group.

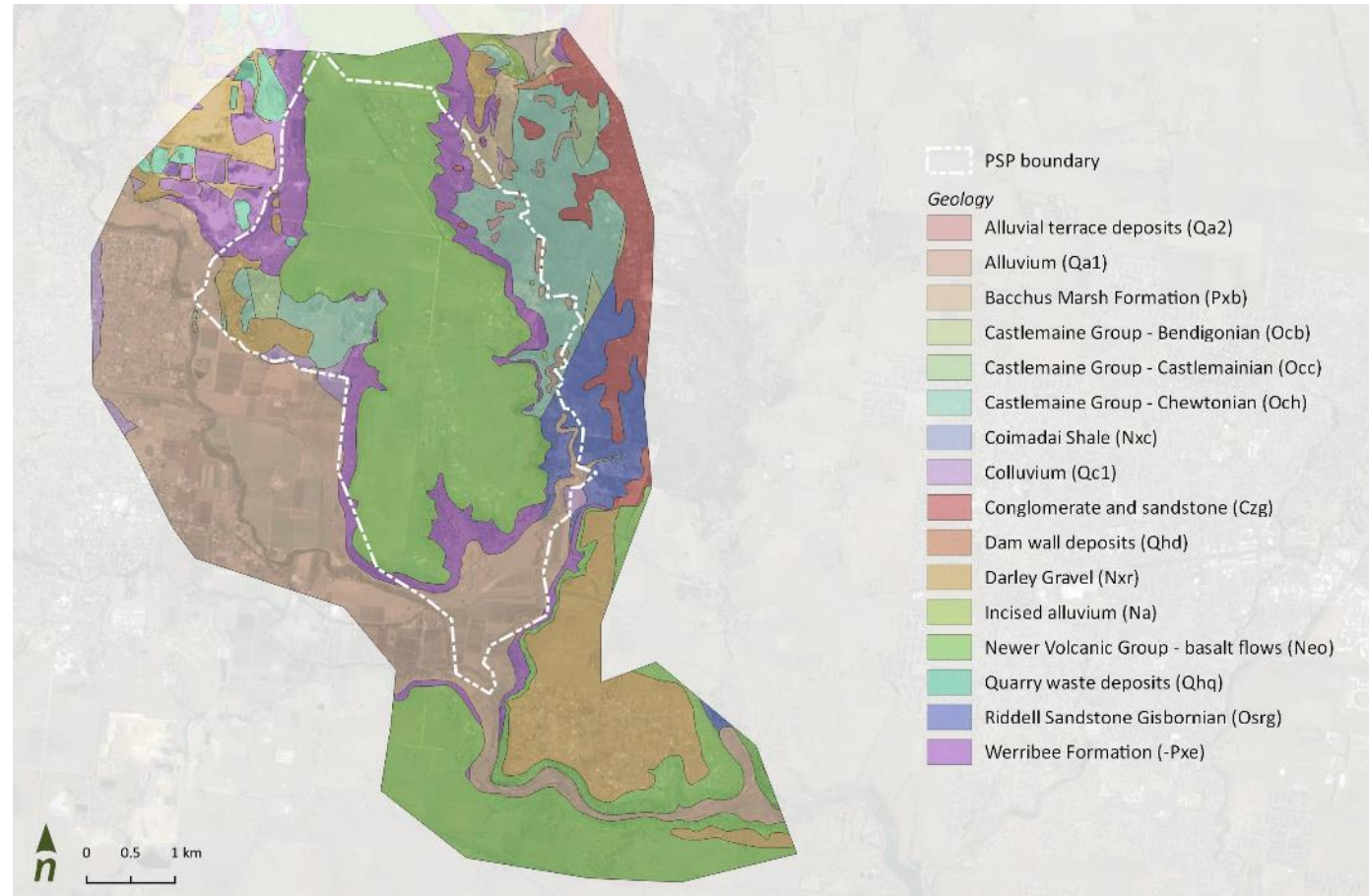


Figure 4. Geology of the study area.

Soils



Figure 5. Soil profile typical of soils associated with the Werribee Formation.

Across the PSP area, soils have been classified according to the Australian Soil Classification as Sodosols. Sodosols are soils that have a strong texture contrast between the A and B horizons with the upper 0.2 m of the B2 horizon being sodic. Piping or tunnel erosion is very often associated with dispersive sodic soils (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).

Earth Tech (2006) also described the soils of the PSP area according to the parent geology as follows.

Soils of the Newer Volcanics

Soils of the Newer Volcanics are a fine textured, dark reddish-brown with little differentiation in soil horizons. The texture of these soils, and their position on the plains makes them resistant to erosion while their structure and fertility allow for good vegetation cover (Earth Tech 2006).

Soils of the Werribee Formation

Soils of the Werribee Formation have a well developed horizon differentiation and are a light coloured, sandy texture. These soils are highly dispersive due to their high sodium content. Erosivity is further enhanced by low fertility and the development of a hard surface layer which limits vegetation development. These soils are among the most erodible in Victoria (Earth Tech 2006).



Figure 6. The bleached horizon of soils associated with the Werribee Formation is fine textured and fragile. Soil structure crumbles easily in the hand.

Geomorphological management units

The project study area sits within three distinct geomorphological management units.

2.1.2 Hills, valley slopes and plains of the Western Uplands, Dissected Uplands

This geomorphological unit occupies a lower topography than the escarpments and mountains of the Dissected Uplands. It is characterised by undulating hills and broad valleys. Chromosols that tend towards Sodosols in lower topographic positions are common.

2.1.6 Eruption points and volcanic plains of the Western Uplands, Dissected Uplands

This geomorphological unit is comprised of recently formed volcanic landscapes. Basalt lava flows have filled many valleys resulting in undulating topography and scattered stony rises are common. Veristosols are common as well as Sodosols that have a conspicuous bleached horizon.

6.1.3 Plains with poorly developed drainage of the Western Plains, Volcanic Plains

This geomorphological unit is formed by the lava flows of the Newer Volcanics and is characterised by poor drainage and shallow regolith development. Sodosols and Dermosols are often associated with this geomorphological unit.

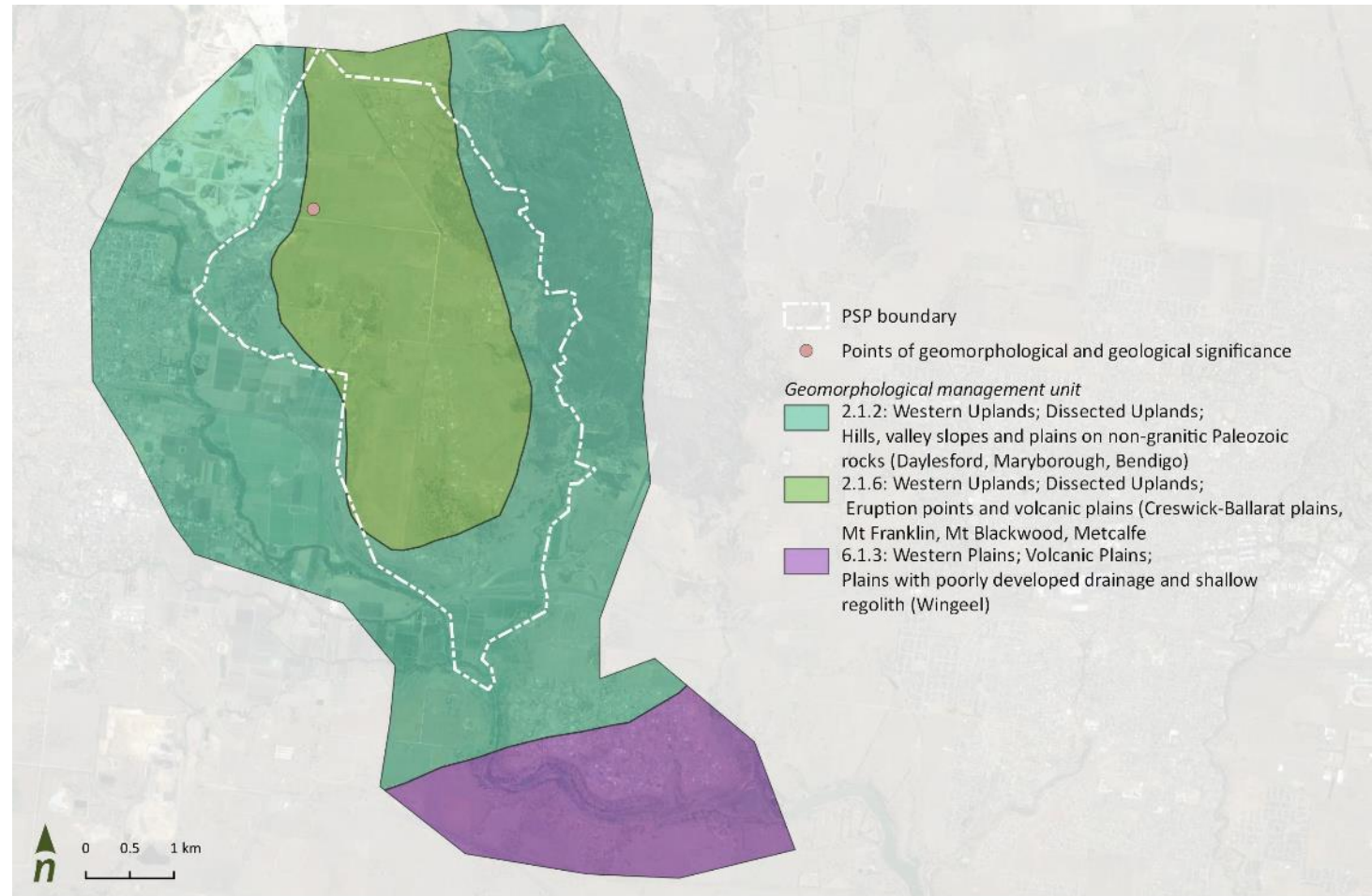


Figure 7. Geomorphological management units of the study area.

RiverStyles

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

Many of the main waterways within this studied were previously categorised according to RiverStyle by EarthTech (2006). Field observations and the desktop assessment are largely in agreement with earlier categorisations.

Where RiverStyle was not previously mapped, we have categorised streams based on our observations in the field and based on our desktop assessment.

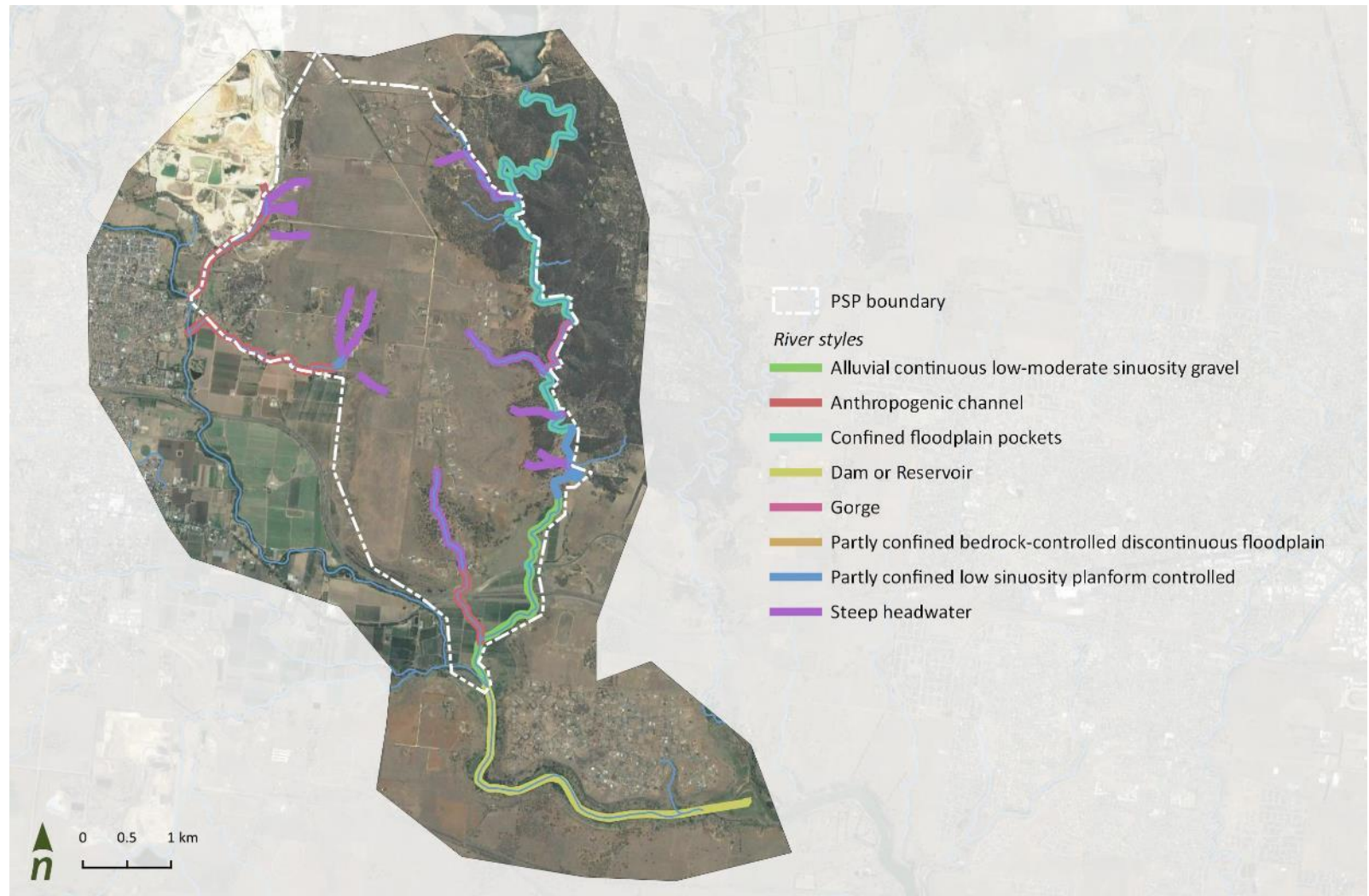
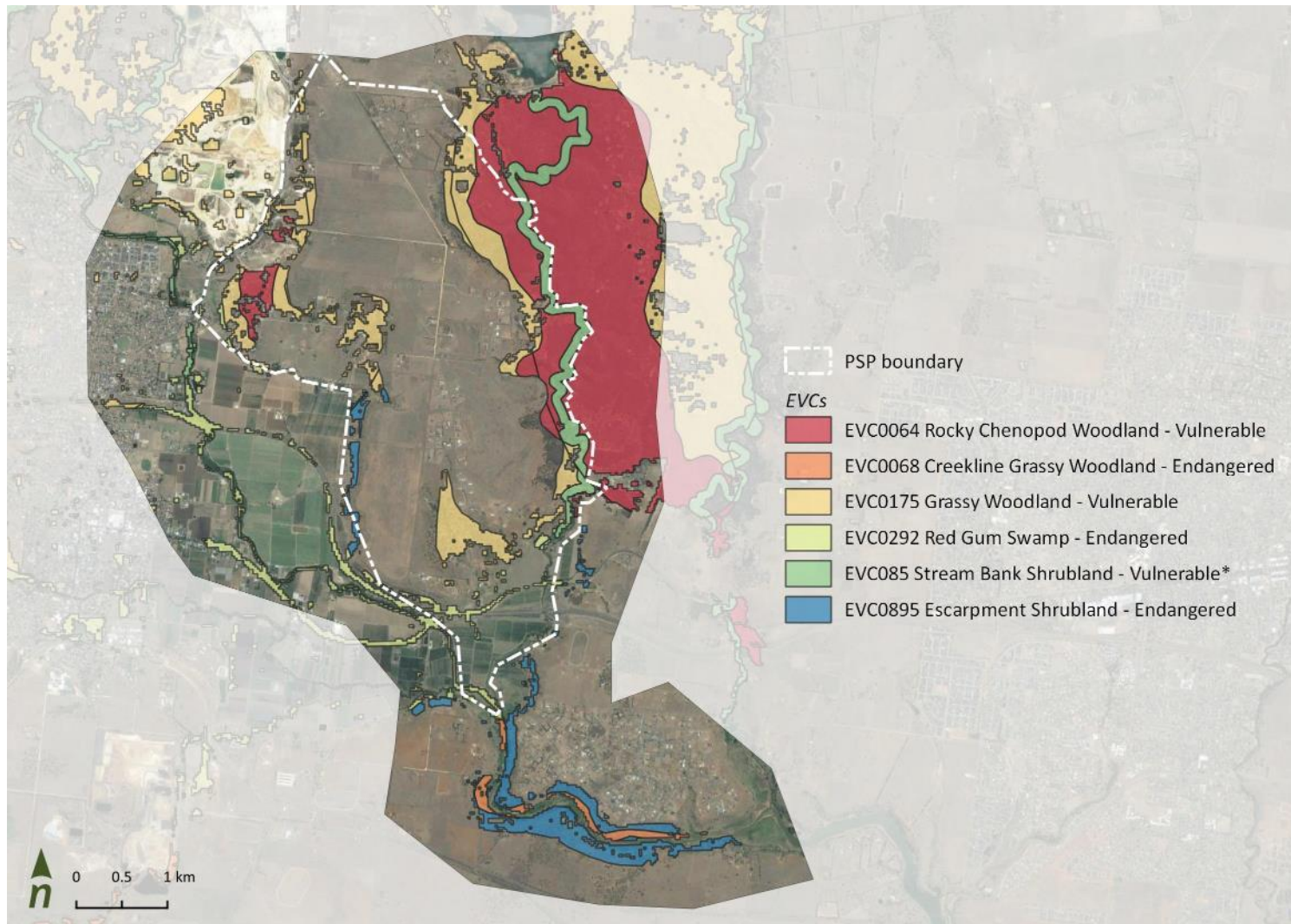


Figure 8. RiverStyles of the study area.

EVC benchmark mapping along waterways

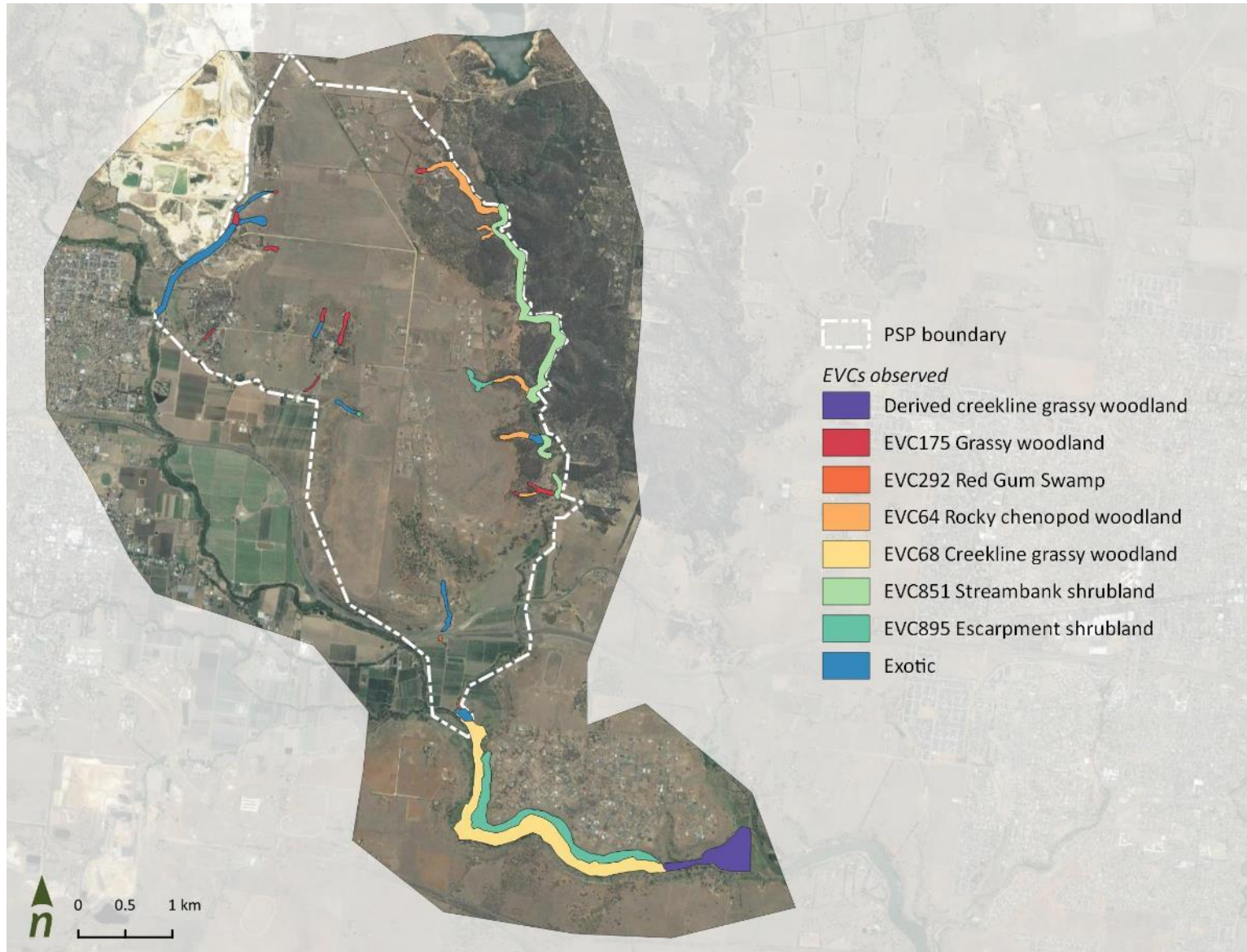


Six EVCs are identified along waterways across two bioregions within the study area.

The boundary of the Central Victorian Uplands (CVU) and Victorian Volcanic Plains (VVP) Bioregions dissects the study area. Benchmark character species differ for EVCs that are in both bioregions.

Figure9. EVC benchmark mapping along waterways

EVCs observed



All six EVCs were confirmed along waterways. An additional exotic category was mapped as was a derived creekline grassy woodland vegetation type.

This vegetation type was substantial different in structure and composition to the EVC benchmark for the community.

Figure 10. EVCs observed along waterways

EVC quality - observed

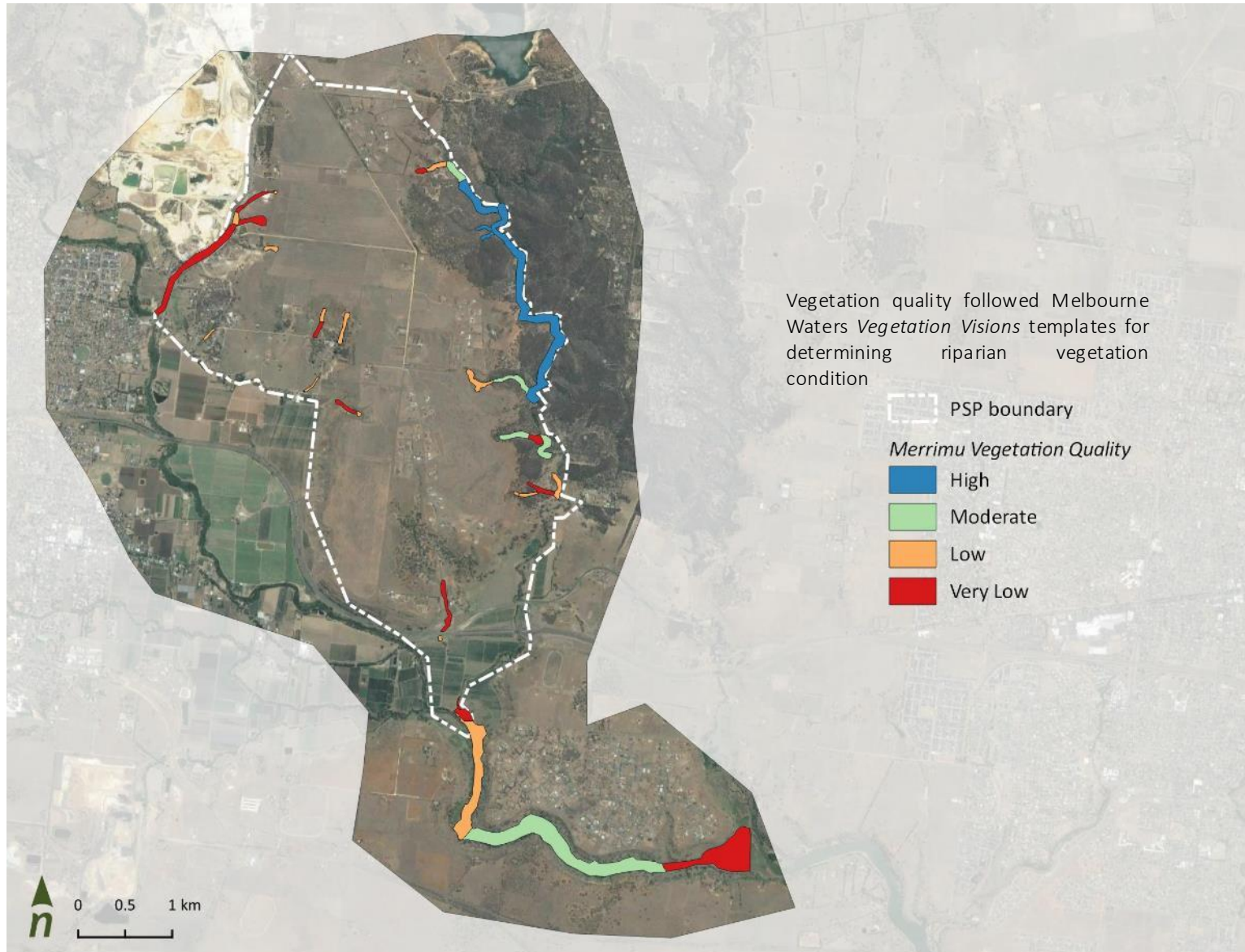
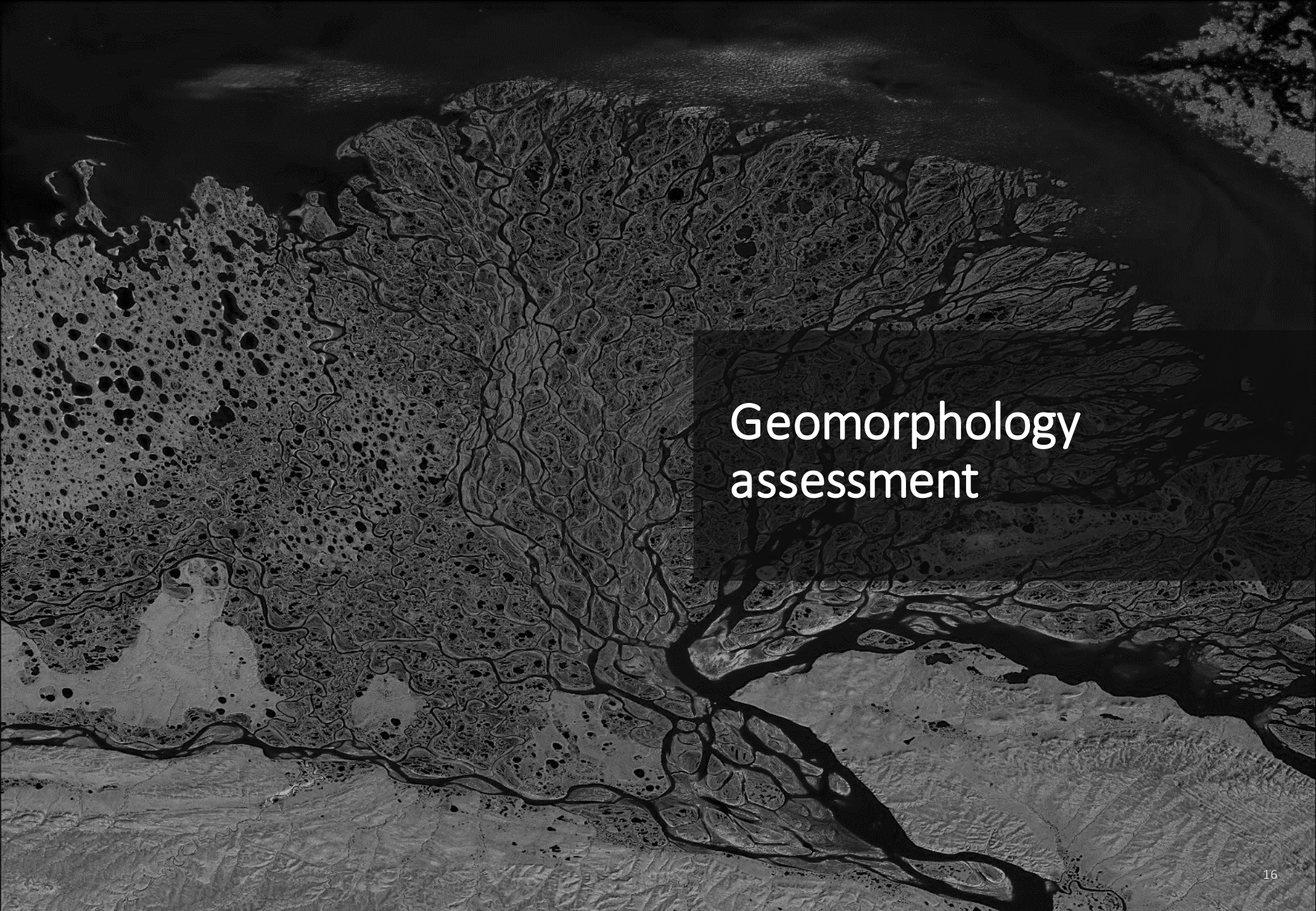


Figure 11. Vegetation quality observed on waterways

An aerial photograph of a river delta, showing a complex network of distributaries branching out from a main river channel. The terrain is characterized by a dense pattern of small, dark, circular features, likely depressions or oxbow lakes, and a lighter, more textured area representing the riverbed and surrounding land. A semi-transparent dark rectangle is overlaid on the right side of the image, containing the text "Geomorphology assessment" in white.

Geomorphology assessment

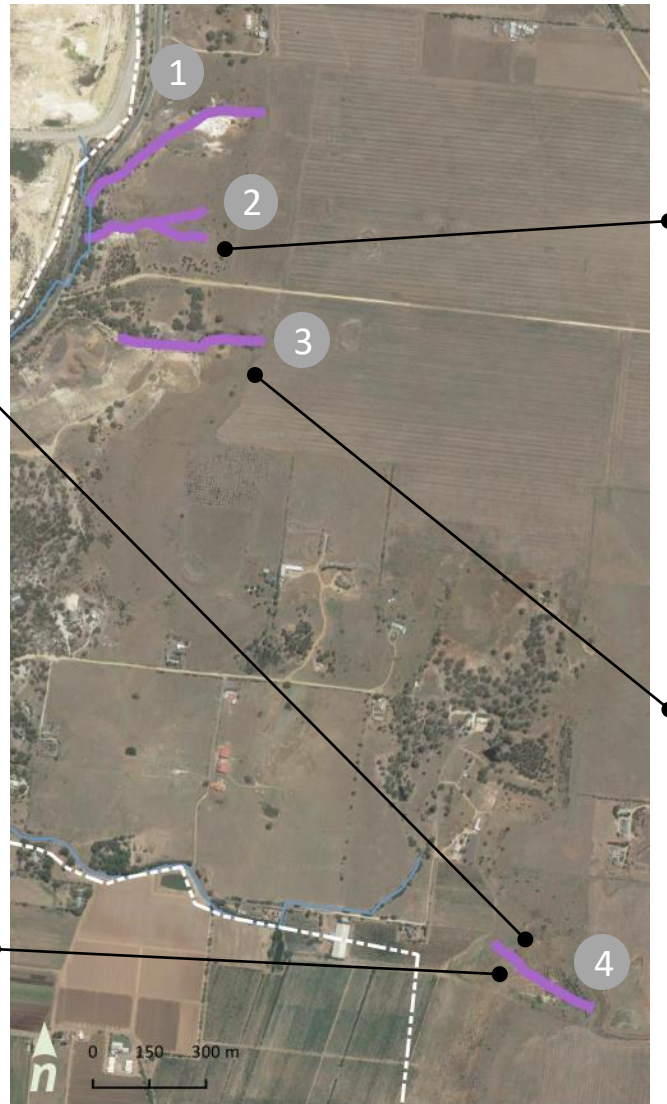
Steep headwater streams on the Werribee Formation

The steep headwater streams on the Werribee Formation are found on the Western side of the escarpment and flow into tributaries of the Lerderderg River. Four steep headwater streams on the Werribee Formation were assessed and a summary of each is provided on the following pages.

Steep waterway draining the western escarpment via a terraced and vegetated slope. A dam is located at the uppermost extent of the waterway, likely to control the flow of water off the escarpment.



Tunnel erosion is a common feature at sites on the Werribee Formation.



Steep headwaters have steep bed and bank slopes draining off the escarpment. Waterways with good vegetation cover are in better condition than those with poorer vegetation cover where erosion is extensive.



Steep headwater on the Werribee Formation #1

This waterway is a headwater stream that has been subject to significant erosion. The lower section of the waterway is deeply incised and in its upper extent, there is significant gully development. Tunnel erosion is evident in many places and is made possible by the dispersive soil found across the site.

Parameter	Steep headwater
Channel	Single, continuous channel.
Bank/valley sides	Channel mostly confined by valley margins except for middle reach where extensive erosion has occurred, possibly initiated by former excavation. Typical bank height up to 8 m in the upper reach. Typical bank height in mid-lower reaches is 3 – 6 m.
Bed	Waterway has three distinct longitudinal slope reaches. Typical slope in the upper reach is 0.25 m/m. Typical slope in the middle reach is 0.032 m/m. Typical slope in the lower reach is 0.067 m/m. Bed substrate comprises silts, sands and gravel. Active incision is evident throughout.
Planform	Straight channel. Active widening evident. Through the middle reach, channel is poorly defined as a result of extensive erosion.
Geology	Werribee Formation – sedimentary (sand, silt, clay, gravel).
Land use	Current land use is uncertain but adjoining property is used for agriculture. Possible excavation of the site sometime in the past. Likely given the proximity to the current quarry.
Soil type	Red Sodosol – sodic B2 horizon with a strong texture contrast between A horizon and B horizon. Highly dispersive sodosol associated with the Werribee Formation.
Sediment load	Ephemeral stream. No streamflow at the time of field inspection.
Riparian vegetation	Limited riparian vegetation present. Site is largely cleared and exotic. Some scattered trees and shrubs, particularly in the lower reach.
In stream vegetation	Limited instream vegetation.
Habitat value	Limited habitat values.



Steep headwater on the Werribee Formation #2

This waterway is a headwater stream that shows evidence of active erosion processes. The upper reach is steep as it flows from the top of the escarpment, however the slope of the bed and bank becomes gentler downstream. Like the nearby site, erosion processes are active with dispersive soil playing a large part in these processes.

Parameter	Steep headwater
Channel	Single, continuous channel.
Bank/valley sides	Channel confined by valley margins. Typical bank height of 2 -3 m.
Bed	Typical longitudinal slope of 0.1 m/m. Bed substrate comprises silts, sands and gravel. Active incision is evident throughout.
Planform	Straight channel. Active widening evident. Through the middle reach, channel is poorly defined.
Geology	Werribee Formation – sedimentary (sand, silt, clay, gravel).
Land use	Current land use is uncertain but adjoining property is used for agriculture.
Soil type	Red Sodosol – sodic B2 horizon with a strong texture contrast between A horizon and B horizon. Highly dispersive sodosol associated with the Werribee Formation. Possible that fill has been placed on the site, some areas have a substrate that is inconsistent with that at other locations across the site and includes elements such as glass.
Sediment load	Ephemeral stream. No streamflow at the time of field inspection.
Riparian vegetation	Limited riparian vegetation present. Site is largely cleared and vegetation comprises exotic grasses.
In stream vegetation	Limited instream vegetation.
Habitat value	Limited habitat values.



Steep headwater on the Werribee Formation #3

This waterway is a well vegetated headwater stream. The upper reach is very steep and rocky as it flows from the top of the escarpment, however the slope of the bed and bank becomes gentler downstream. Erosion processes appear to be relatively limited at this site.

Parameter	Steep headwater
Channel	Single, continuous channel.
Bank/valley sides	Channel confined by very steep valley margins. Valley margins are comprised of silts. Large boulders are present in some places. Typical height from channel to top of valley is 10 – 16 m.
Bed	Waterway has two distinct longitudinal slope reaches. Typical slope in the upper reach is 0.25 m/m. Typical slope in the lower reach is 0.089 m/m. Bed substrate comprises silts, sands and gravel.
Planform	Straight channel.
Geology	Werribee Formation – sedimentary (sand, silt, clay, gravel).
Land use	Current land use is uncertain but adjoining property is used for agriculture. Possible excavation of the site sometime in the past. Lower extent of the waterway was unassessed and sits on land belonging to the nearby quarry.
Soil type	Red Sodosol – sodic B2 horizon with a strong texture contrast between A horizon and B horizon. Highly dispersive sodosol associated with the Werribee Formation.
Sediment load	Ephemeral stream. No streamflow at the time of field inspection.
Riparian vegetation	Limited riparian vegetation present. Some scattered trees and shrubs throughout, both native and exotic.
In stream vegetation	Limited instream vegetation.
Habitat value	Limited habitat values.



Steep headwater on the Werribee Formation #4

This waterway is a steep headwater stream that flows off the escarpment over a terraced slope. At the upstream extent of the waterway there is dam that was likely to have been constructed to control the flow of water off the slope. Both the dam and the terracing at this site may be an indication of past attempts at stabilising the site. Tunnel erosion is evident at the site and the soil characteristics mirror those at other sites on the Werribee Formation.

Parameter	Steep headwater
Channel	Single, continuous channel.
Bank/valley sides	Channel confined by steep, terraced valley margins.
Bed	Waterway has two distinct longitudinal slope reaches. Typical slope in the upper reach of 0.22 m/m. Typical slope of 0.07 m/m in the lower reach. Bed substrate comprises silts, sands and gravel with scattered cobbles and boulders.
Planform	Straight channel confined by valley margins.
Geology	Werribee Formation- sedimentary (sand, silt, clay, gravel).
Land use	Current land use is uncertain but adjoining property is used for agriculture.
Soil type	Red Sodosol – sodic B2 horizon with a strong texture contrast between A horizon and B horizon. Highly dispersive sodosol associated with the Werribee Formation.
Sediment load	Ephemeral stream. No streamflow at the time of field inspection.
Riparian vegetation	Limited riparian vegetation, predominately exotic.
In stream vegetation	Limited instream vegetation, predominately exotic.
Habitat value	Limited habitat values.

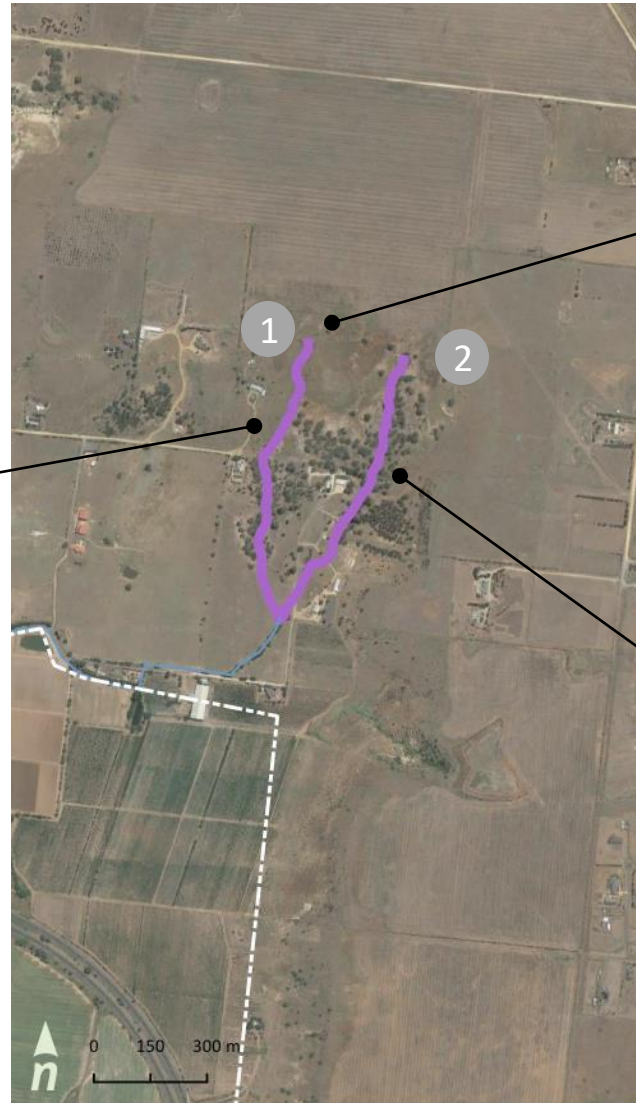


Steep headwater streams on the Castlemaine Group

The steep headwater streams on the Castlemaine Group are found on the Southern face of the escarpment and appear to flow to drainage channels along Lederderg Park Road. Two steep headwater streams on the Castlemaine Group were assessed and a summary of each is provided on the following pages.



This steep headwater on the Castlemaine Group is well vegetated by woody weeds and grasses. Valley sides are very steep, however large boulders are present throughout the reach. These well vegetated, rocky slopes display minor evidence of erosion.



The upper reaches of these waterways are cleared and display more evidence of instability than the lower, better vegetated reaches.

This steep headwater stream is well vegetated with tress and woody weeds. Erosion processes are limited here with frequent occurrences exposed bedrock throughout the reach.



Steep headwater on the Castlemaine Group #1

This waterway is a steep headwater stream that flows off the escarpment in a southerly direction. At the upstream extent of the waterway there is dam that controls the flow of water into the waterway. The waterway is fully confined between steep valley sides. Large boulders are common along the upstream reach of the waterway. Like other sites, there is evidence of tunnel erosion processes at the site. Although still sodic in nature, the soils appear less fragile than those found on the Werribee Formation.

Parameter	Steep headwater
Channel	Single, continuous channel.
Bank/valley sides	Channel confined by steep valley margins. Valley margins are composed on sand/silt with frequent boulders, particularly along the upstream reach.
Bed	Waterway has two distinct longitudinal slope reaches. Typical slope in the upper reach is 0.24 m/m. Typical slope in the lower reach is 0.058 m/m. Bed material comprises sands and silts.
Planform	Low sinuosity channel confined by the valley margins.
Geology	Largely Castlemaine Group – sedimentary (sandstone, mudstone, shale). Upper 50 m within Werribee Formation – sedimentary (sand, silt, clay, gravel).
Land use	Current land use is uncertain but likely used for agriculture in the past.
Soil type	Red Sodosol – sodic 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	Limited riparian vegetation, predominately exotic. Some scattered eucalypts.
In stream vegetation	Limited instream vegetation, predominately exotic.
Habitat value	Limited habitat values.



Steep headwater on the Castlemaine Group #2

This waterway is a steep headwater stream that flows off the escarpment in a southerly direction. At the upstream extent of the waterway there is dam that controls the flow of water into the waterway. The waterway is fully confined between steep valley sides. Unlike the neighbouring waterway, it is relatively well vegetated. Large boulders are common throughout as is exposed bedrock. There is limited evidence of erosion at this location.

Parameter	Steep headwater
Channel	Single, continuous channel.
Bank/valley sides	Channel confined by steep valley margins. Valley margins are composed on sand/silt with frequent boulders, particularly along the upstream reach.
Bed	Typical longitudinal slope of 0.069 m/m. Bed material comprises sands and silts with large boulders and frequent occurrences of exposed bedrock.
Planform	Low sinuosity channel confined by the valley margins.
Geology	Castlemaine Group – sedimentary (sandstone, mudstone, shale).
Land use	Current land use is uncertain but likely used for agriculture in the past.
Soil type	Red Sodosol – sodic 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	Moderate riparian vegetation. Lacking understory but canopy of predominately eucalypt species.
In stream vegetation	Limited instream vegetation.
Habitat value	Minor habitat values associated with exposed bedrock, large boulders and riparian vegetation.



Partly confined low sinuosity stream on colluvium

This partly confined low sinuosity channel sits on colluvium and flows in a southerly direction off the escarpment. Only one partly confined low sinuosity channel on colluvium was assessed and a summary is provided on the following page.



The waterway is partly confined by the steep slope of the escarpment. The waterway is heavily vegetated with trees throughout the channel, however the adjoining landscape is cleared agricultural land.



Upstream of the partly confined reach, the waterway is a steep headwater channel as it flows off the escarpment.

Downstream of the partly confined reach, the waterway transitions to an anthropogenic channel

Partly confined low sinuosity on colluvium #1

This waterway is a partly confined, low sinuosity channel flowing in a southerly direction to join drainage along Lerderderg Park Rd. Upstream of this reach, the waterway is a steep headwater channel. The channel sits in a cleared setting and vegetation along the reach is exotic, mostly willow. The bed grade is relatively gentle through this reach and there is little evidence of erosion.

Parameter	Partly confined low sinuosity
Channel	Single, continuous channel.
Bank/valley sides	Channel confined by valley margin along the right hand bank but relatively unconfined along the left hand bank. Typical bank is 1-2 m. Bank substrate comprises well grassed silt.
Bed	Typical longitudinal slope of 0.024 m/m. Substrate is sand silt and is well vegetated with grasses and some willows.
Planform	Low sinuosity channel partly confined by the valley margins.
Geology	Colluvium.
Land use	Current land use is uncertain but likely used for agriculture in the past.
Soil type	Red Sodosol – sodic 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	Limited riparian vegetation. Occasional Peppercorn and Eucalypts, exotic grasses.
In stream vegetation	No aquatic or semi aquatic species. Well vegetated with terrestrial exotic grasses and tress.
Habitat value	Limited habitat value.



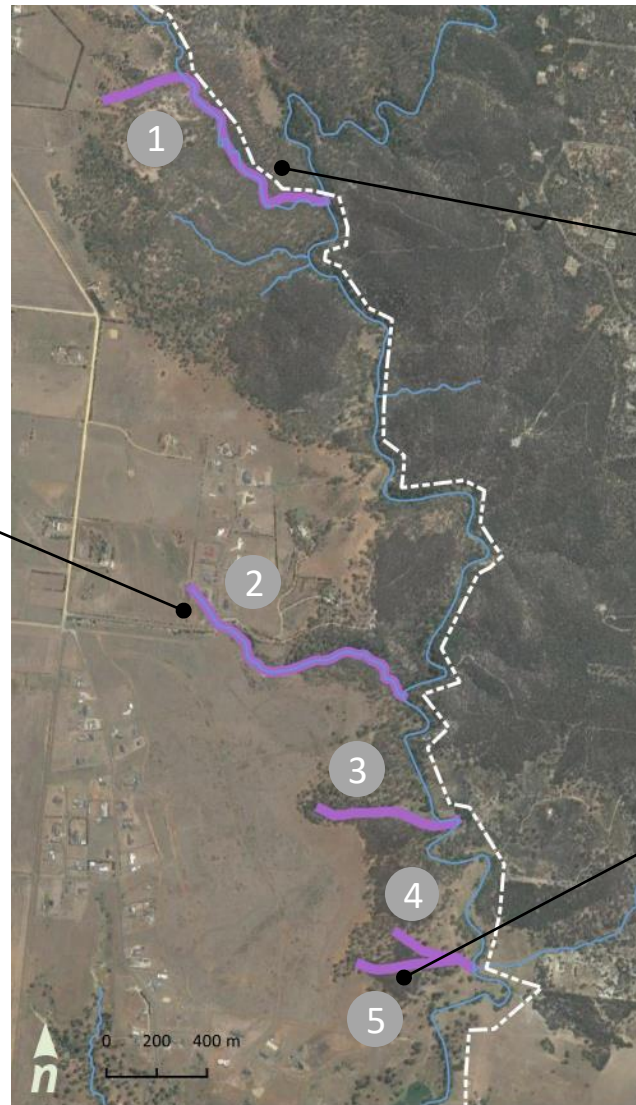
Steep headwater streams on mixed sedimentary geology

The steep headwater streams on the Castlemaine Group are found on the eastern face of the escarpment and flow into Pyrites Creek. Five steep headwater streams on the mixed sedimentary geology were assessed and a summary of each is provided on the following pages.



The upper reaches of the steep headwater streams on the eastern escarpment are somewhat cleared compared with the lower reaches of these waterways.

The streams are very steep as the flow off the escarpment. They are confined by steep valley sides and large boulders are frequently found throughout these waterways.



Exposed bedrock is a common feature within the steep headwater streams on the eastern side of the escarpment.

These waterways are generally well vegetated, being within the Long Forest Nature Conservation Reserve, however there are some areas that appear to be disturbed and erosion is a common feature in these locations.



Steep headwater on mixed sedimentary geology #1

This waterway is a reasonably well vegetated steep headwater that flows off the eastern side of the escarpment. The channel is confined by steep valley margins which steepen towards the confluence with Pyrites Creek. Exposed bedrock and large boulders are frequent occurrences along the waterway. Incision and gully development are evident along the waterway, particularly through the mid reaches.

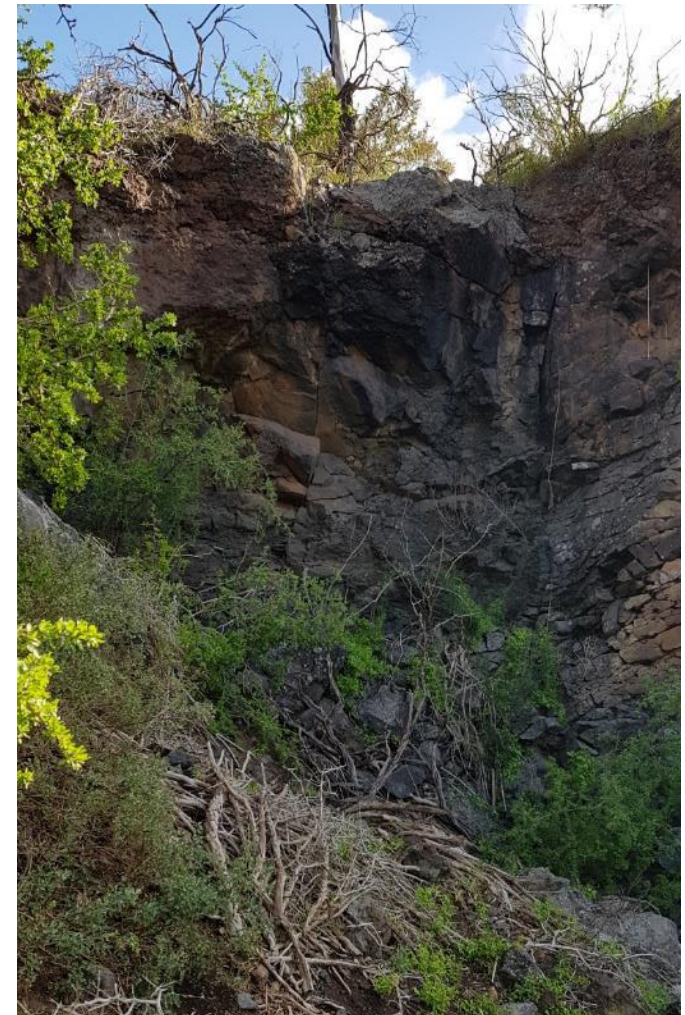
Parameter	Steep headwater
Channel	Single, continuous channel.
Bank/valley sides	Channel confined by valley margins. Steepening of bank slopes downstream towards the confluence with Pyrites Creek.
Bed	Typical longitudinal slope of 0.076 m/m in the upstream reach and 0.018 m/m in the downstream reach. Well vegetated in the upstream extent. Bed substrate is silt/sand with frequent boulders and exposed bedrock.
Planform	Low sinuosity channel confined by the valley margins.
Geology	Upper reach = Werribee Formation – sedimentary (sand, silt, clay, gravel). Mid reach = Bacchus Marsh Formation – sedimentary (mudstones, sandstone). Lower reach = Castlemaine Group – sedimentary (sandstone, mudstone, shale).
Land use	Nature conservation reserve.
Soil type	Brown Sodosol – sodic 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	Well vegetated riparian zone. Trees and understory largely native.
In stream vegetation	Some instream vegetation (grasses), particularly through the upper reach.
Habitat value	Moderate quality instream habitats associated with instream grasses, large woody debris, boulders and exposed bedrock.



Steep headwater on mixed sedimentary geology #2

This waterway is steep headwater that flows off the eastern side of the escarpment. The upper reach has limited vegetation, however the lower reaches are well vegetated. The channel is confined by steep valley margins and exposed bedrock and large boulders are frequent occurrences along the waterway. There are a number of bedrock knickpoints along the length of the waterway.

Parameter	Steep headwater
Channel	Single, continuous channel.
Bank/valley sides	Channel confined by steep valley margins. Exposed bedrock and large boulders are common throughout the reach. Bank material composed of silts.
Bed	Typical longitudinal slope of 0.068 m/m. Well vegetated throughout. Bed substrate is silt/sand with frequent boulders and exposed bedrock.
Planform	Low sinuosity channel confined by the valley margins.
Geology	Upper reach = Werribee Formation – sedimentary (sand, silt, clay, gravel). Mid reach = Castlemaine Group – sedimentary (sandstone, mudstone, shale). Lower reach = Alluvium (gravel, sand, silt).
Land use	Nature conservation reserve.
Soil type	Brown Sodosol – sodic 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	Well vegetated riparian zone. Trees and understory largely native.
In stream vegetation	Some instream vegetation (grasses), particularly through the upper reach.
Habitat value	Moderate quality instream habitats associated with instream grasses, large woody debris, boulders and exposed bedrock.



Steep headwater on mixed sedimentary geology #3

This waterway is steep headwater that flows off the eastern side of the escarpment. The upper reach is well vegetated and confined by very steep valley margins. Valley sides become gentler and less well vegetated in a downstream direction. Exposed bedrock is frequently found throughout the reach.

Parameter	Steep headwater
Channel	Single, continuous channel.
Bank/valley sides	Channel confined by steep valley margins. Exposed bedrock and large boulders are common throughout the reach. Bank material composed of silts.
Bed	Typical longitudinal slope of 0.12 m/m. Well vegetated, particularly in the upstream reach. Bed substrate is silt/sand with frequent boulders and exposed bedrock.
Planform	Low sinuosity channel confined by the valley margins.
Geology	Upper reach = Castlemaine Group – sedimentary (sandstone, mudstone, shale). Mid reach = Riddell Sandstone – sedimentary (sandstone, shale). Lower reach = Alluvium (gravel, sand, silt).
Land use	Nature conservation reserve.
Soil type	Brown Sodosol – sodic 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	Well vegetated riparian zone. Trees and understory largely native.
In stream vegetation	Some instream vegetation (grasses), particularly through the upper reach.
Habitat value	Moderate quality instream habitats associated with instream grasses, large woody debris, boulders and exposed bedrock.



Steep headwater on mixed sedimentary geology #4

This waterway is steep headwater that flows off the eastern side of the escarpment. The waterway less well vegetated than neighbouring stream with areas that appear to have been formerly cleared. The waterway is highly disturbed with incision up to 6 m in some places. In places where incision processes have reached underlying bedrock, widening processes appear to be occurring with evidence of bank collapse and undercutting. Tunnel erosion processes are evident at this location.

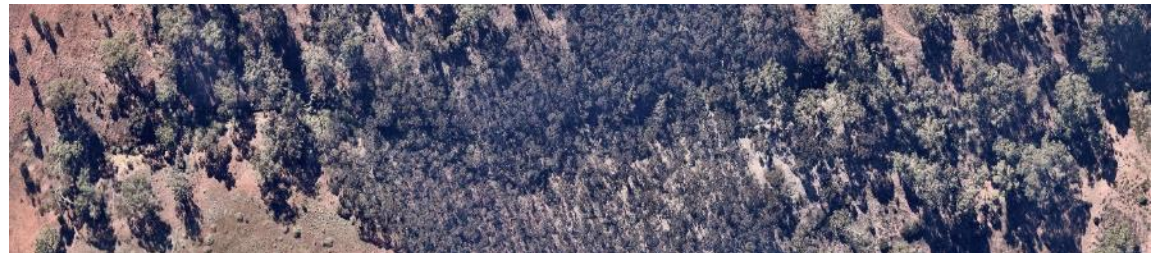
Parameter	Steep headwater
Channel	Single, continuous channel.
Bank/valley sides	Channel is deeply incised, up to 6 m in some locations. Where significant incision has occurred bank are vertical. In areas where less incision has occurred the waterway is confined within the valley margin.
Bed	Typical longitudinal slope of 0.114 m/m. Bed substrate is composed of sand, silt and gravels
Planform	Low sinuosity channel confined by the valley margins.
Geology	Largely Riddell Sandstone – sedimentary (sandstone, shale). At the confluence with Pyrites, alluvium (gravel, sand, silt).
Land use	Nature conservation reserve.
Soil type	Brown Sodosol – sodic 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	Limited riparian vegetation in some places. Lacking understory in others.
In stream vegetation	Limited instream vegetation.
Habitat value	Limited habitat quality



Steep headwater on mixed sedimentary geology #5

This waterway is steep headwater that flows off the eastern side of the escarpment. The upper reach of the waterway is poorly vegetated, however the mid-lower reaches are well vegetated, largely with natives. The waterway is confined within steep valley sides where are steepest through the mid reaches. Exposed bedrock is common along the reach and there is a high load of leaf litter and large wood through the well vegetated zones. Erosion processes in this waterway appear limited to the most upstream extent.

Parameter	Steep headwater
Channel	Single, continuous channel.
Bank/valley sides	Channel confined by steep valley margins. Exposed bedrock and large boulders are common throughout the reach. Bank material composed of silts.
Bed	Typical longitudinal slope of 0.12 m/m in the upstream reach and 0.099 m/m in the downstream reach. Well vegetated in the mid reaches. Bed substrate is silt/sand with frequent boulders and exposed bedrock.
Planform	Low sinuosity channel confined by the valley margins.
Geology	Largely Riddell Sandstone – sedimentary (sandstone, shale). At the confluence with Pyrites, alluvium (gravel, sand, silt).
Land use	Nature conservation reserve.
Soil type	Brown Sodosol – sodic 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	Well vegetated riparian zone in the mid-lower reaches. Trees and understory largely native.
In stream vegetation	Some instream vegetation through the middle reach. Large load of leaf litter and large wood.
Habitat value	Moderate quality instream habitats associated with instream grasses, large woody debris, boulders and exposed bedrock.

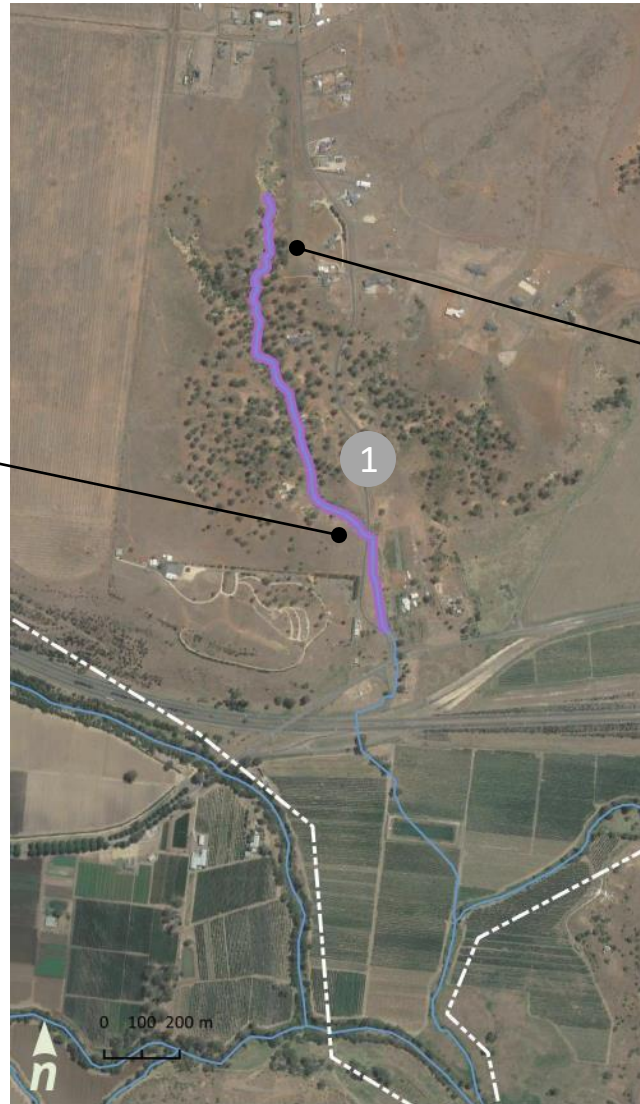


Steep headwater on mixed geology

This steep headwater sits on mixed geology and flows in a southerly direction off the escarpment. Only steep headwater on mixed geology was assessed and a summary is provided on the following page.



The downstream reach of the waterway is still largely confined by steep valley sides. This reach sits on the more fragile soils of the Werribee Formation and like other sites within the study area significant erosion is evident. Eroded waterway banks display that classic bleached horizon that soils of the Werribee Formation are known for.



The upper reach of the waterway is very steep as it flows off the escarpment. It is confined by very steep valley sides. At its most upstream extent, the waterway sits on the resistant basalt of the Newer Volcanics. Large basalt boulders are evident in this part of the waterway.

Steep headwater on mixed geology #1

This waterway is steep headwater that flows off the southern side of the escarpment. Access to this waterway was limited during the field investigations so observations are based on those that could be made from adjoining public roads. The waterway is confined by steep valley sides that become gentler at the downstream extent. The upper extent of the waterway is characterised by large basalt boulders while the downstream extent shows evidence of erosion processes that have been identified elsewhere on the Werribee Formation.

Parameter	Steep headwater
Channel	Single, continuous channel.
Bank/valley sides	Channel confined by steep valley margins. Large basalt boulders are common in the upper reach of the waterway.
Bed	Typical longitudinal slope of 0.062 m/m in the upstream reach and 0.025 m/m in the downstream reach.
Planform	Low sinuosity channel confined by the valley margins.
Geology	Upper reach = Newer Volcanics – basalt. Lower reach = Werribee Formation – sedimentary (sand, silt, clay, gravel).
Land use	Current land use is uncertain but likely used for agriculture in the past.
Soil type	Red Sodosol – sodic 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	Well vegetated riparian zone in many places. Mostly native from observation points viewing mid reaches. Limited riparian vegetation at the most upstream extent, exotic vegetation at the most downstream extent.
In stream vegetation	Some instream vegetation observed from the road. Mostly grasses but some shrubs, most likely exotic.
Habitat value	Limited instream habitat.

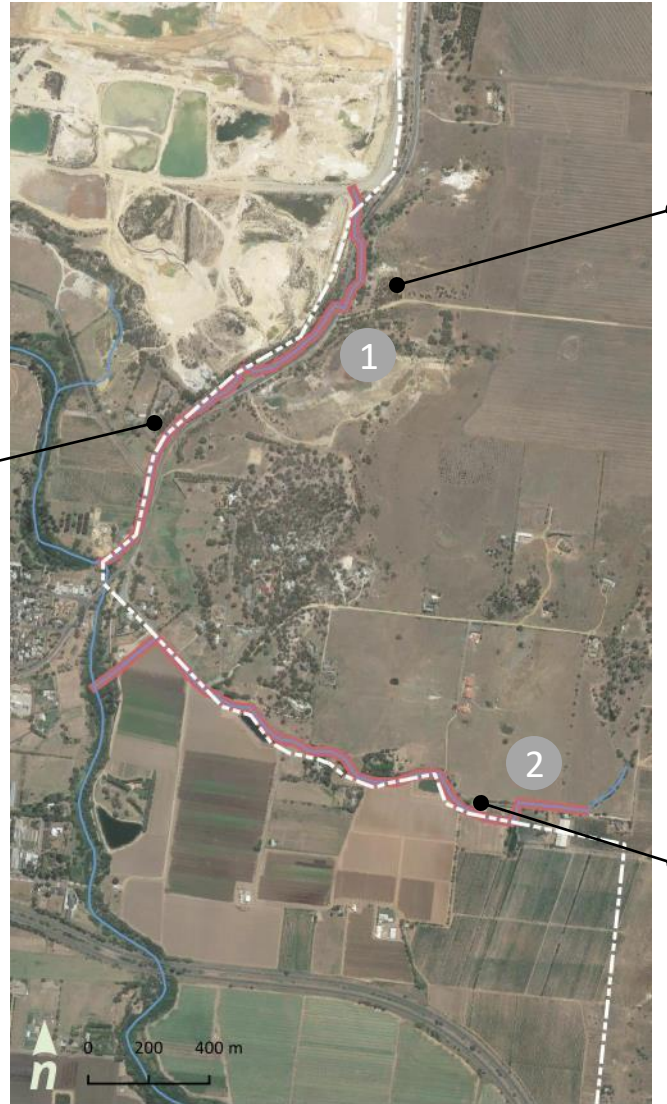


Anthropogenic channels on mixed sedimentary geology

The anthropogenic channels on mixed sedimentary geology are found along the eastern base of the escarpment. Two anthropogenic channels on the mixed sedimentary geology were assessed and a summary of each is provided on the following pages.



Several old grade control structures are present within the channel running alongside Bacchus Marsh – Gisborne Rd. At various locations along the waterway, the channel passes beneath the road via concrete pipes and culverts.



Anthropogenic channels within the study area are a combination of roadside drains and water delivery channels. In some places, drainage lines become indistinct and difficult to follow.



Anthropogenic channel on mixed sedimentary geology #1

This waterway is an anthropogenic channel that runs alongside Bacchus Marsh-Gisborne Rd. The channel flows alongside the road and crosses it several times through a number of pipes and culverts. There are a number of structures within the channel which appear to be old grade control structures. There is also evidence of erosion in some locations.

Parameter	Anthropogenic channel
Channel	Single, continuous channel.
Bank/valley sides	Anthropogenic shaped channel. Well defined channel banks in most places, especially where incision has occurred. Poorly defined in other areas. Bank material silt/sand.
Bed	Bed material is silt/sand. In some places waterway passes beneath roads in concrete pipes or culverts. Along the length of the waterway there are a series of structures which appear to be old grade control structures.
Planform	Low sinuosity channel largely confined between the quarry boundary and Bacchus Marsh-Gisborne Rd.
Geology	Upper reach = Werribee Formation – sedimentary (sand, silt, clay, gravel). Lower reach = Alluvium (gravel, sand, silt).
Land use	Road reserve.
Soil type	Red Sodosol – sodic B2 horizon with a strong texture contrast between A horizon and B horizon. Highly dispersive sodosol associated with the Werribee Formation.
Sediment load	Ephemeral stream. No streamflow at the time of field inspection.
Riparian vegetation	Well vegetated riparian zone although vegetation is composed of largely exotic overstory species.
In stream vegetation	Some instream vegetation, largely exotic.
Habitat value	Limited habitat value.



Anthropogenic channel on mixed sedimentary geology #2

This waterway is an anthropogenic channel that runs alongside Lerderderg Park Rd. Despite being mapped as a natural waterway, the field visited revealed that the waterway is actually an active irrigation channel. It appears as though the channel is used to deliver water to market gardens on the floodplain flats. Drainage patterns in this area require further investigation.

Parameter	Anthropogenic channel
Channel	Single, continuous channel.
Bank/valley sides	Anthropogenic shaped channel.
Bed	Concrete lined irrigation channel.
Planform	Straight, concrete lined irrigation channel.
Geology	Upper reach = Werribee Formation – sedimentary (sand, silt, clay, gravel). Lower reach = Alluvium (gravel, sand, silt).
Land use	Adjoining land used for market gardens.
Soil type	Red Sodosol – sodic B2 horizon with a strong texture contrast between A horizon and B horizon. Highly dispersive sodosol associated with the Werribee Formation.
Sediment load	N/A
Riparian vegetation	N/A
In stream vegetation	N/A
Habitat value	N/A



Werribee River

One reach of the Werribee River, between the confluence of Pyrites Creek and the Melton Reservoir was assessed. The reach has previously been classified as a dam or reservoir according to the RiverStyles framework and does appear to have been influenced by backwater effects from Melton Reservoir. A summary is provided on the following page.



Throughout the reach, former high water marks are evident on trees and rocks. Areas of bank 'notching', common in weirs and reservoirs where water is held at consistent levels, was also evident in some places.



Werribee River

This waterway has previously been categorised as a dam or reservoir. Field observations indicated that this reach of the Werribee River is indeed impacted by backwater effects from Melton Reservoir. Without the effect of the reservoir the reach could best be described as partly confined with floodplain pockets. This reach of the waterway is confined within steep valley sides, although narrow floodplain pockets have developed along either side of the waterway.

Parameter	Dam or reservoir
Channel	Single, continuous channel.
Bank/valley sides	Channel is largely confined by the valley margins, although there is some floodplain development within these valley sides. Waterway bank are generally less than 1 m and gently sloping. Bank material comprises silt/mud.
Bed	Typical longitudinal slope of 0.0009 m/m. Riparian zone generally well vegetated with grasses, trees and shrubs. Bed substrate is silt/clay.
Planform	Moderate sinuosity channel confined by the valley margins.
Geology	Alluvium (gravel, sand, silt).
Land use	Water storage.
Soil type	Red and Brown Sodosols - sodic B2 horizon with a strong texture contrast between A horizon and B horizon. Black Vertosol - black cracking clay with 35% clay content.
Sediment load	Water was very turbid at time of inspection indicating a high suspended sediment load.
Riparian vegetation	Moderately well vegetated riparian zone with trees, grasses, shrubs and reeds.
In stream vegetation	Moderate instream vegetation. Mostly grasses and reeds.
Habitat value	Moderate quality instream habitats associated with instream grasses, reeds and pools.

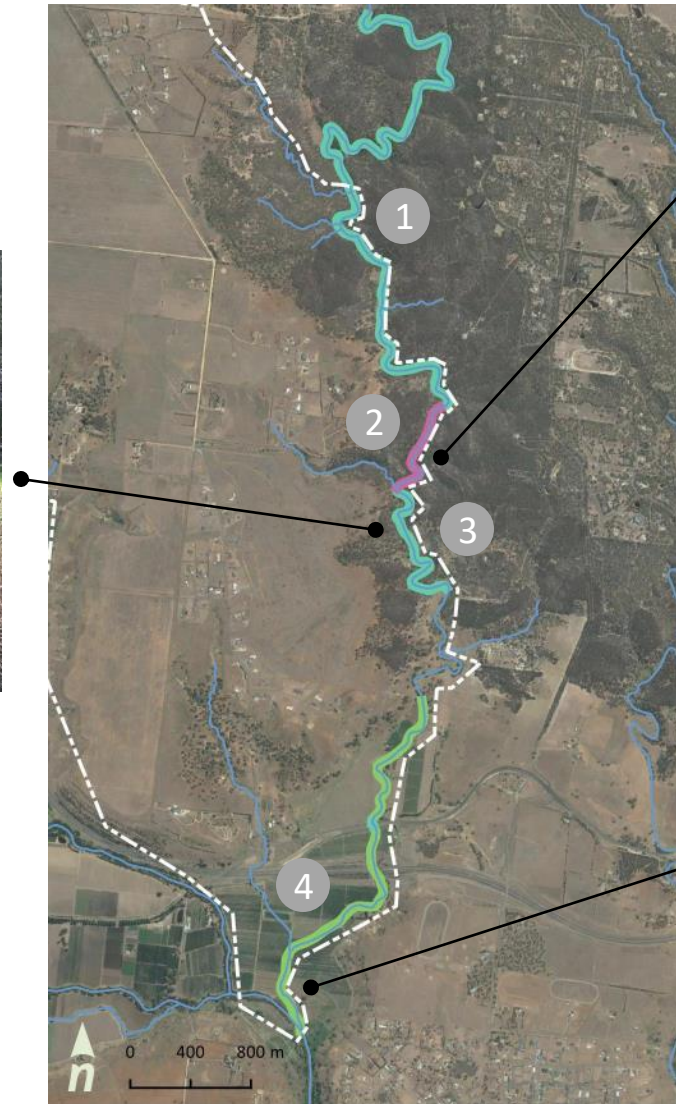


Pyrites Creek

Four reaches of Pyrites Creek were assessed. The reaches were previously been classified as either a gorge, a confined channel with floodplain pockets or an alluvial continuous low-moderate sinuosity gravel channel according to the RiverStyles framework. A summary of each is provided on the following pages.



Much of Pyrites Creek is classified as a confined channel with floodplain pockets according to the RiverStyles framework. In these reaches the channel is largely confined by the valley margins, however floodplain pockets are common where the channel becomes only partly confined.



In some reaches, Pyrites Creek has been classified as a gorge according to the RiverStyles framework. Very steep, rock valley sides are characteristic of this reach.

At its confluence with the Werribee River, Pyrites Creek has been classified as an alluvial, continuous, low-moderate sinuosity gravel channel. In this reach that waterway is unconfined and both bed and bank grade are gently sloping.



Pyrites Creek reach 1

Reach 1 of Pyrites Creek is a partly confined waterway with floodplain pockets. This reach lies within the Long Forest Nature Conservation Reserve and is very well vegetated. Valley sides are steep, however, channel banks are gently sloping. Occasional pockets of narrow floodplain have developed in places along this reach. There is very little evidence of channel erosion in this reach of Pyrites Creek.

Parameter	Partly confined floodplain pockets
Channel	Single, continuous channel.
Bank/valley sides	Channel is largely confined by the valley margins, although there is some floodplain development within these valley sides. Waterway banks are generally less than 0.5 m and gently sloping. Bank material comprises silt/mud.
Bed	Typical longitudinal slope of 0.006 m/m. Bed substrate is silt/clay.
Planform	Moderate sinuosity channel confined by the valley margins.
Geology	Largely Castlemaine Group – sedimentary (sandstone, mudstone, shale). Alluvium (gravel, sand, silt).
Land use	Nature Conservation Reserve.
Soil type	Brown Sodosol – sodic B2 horizon with a strong texture contrast between A horizon and B horizon
Sediment load	Low suspended sediment load. Water was clear at the time of inspection, mostly likely owing to the fact that the reach is directly downstream of Merrimu Reservoir.
Riparian vegetation	Well vegetated riparian zone, dominated by native species.
In stream vegetation	Excellent instream vegetation, dominated by native reeds and grasses.
Habitat value	Excellent quality habitat associated with well vegetated riparian zone, excellent instream vegetation, large woody debris, pools and riffles.



Pyrites Creek reach 2

Reach 2 of Pyrites Creek is categorised as a gorge. This reach lies within the Long Forest Nature Conservation Reserve and is very well vegetated. Valley sides are very steep and comprised of exposed bedrock. Channel bed comprises sand/silt and large boulders are very common throughout the reach. There is limited evidence of erosion along this reach of Pyrites Creek.

Parameter	Gorge
Channel	Single, continuous channel.
Bank/valley sides	Channel is confined within the steep bedrock margins of the valley. Valley sides are largely composed of bedrock. Channel banks are gently sloping.
Bed	Typical longitudinal slope of 0.004 m/m. Bed substrate is silt/clay with frequent large boulders.
Planform	Low sinuosity channel confined by the valley margins.
Geology	Largely Castlemaine Group – sedimentary (sandstone, mudstone, shale). Alluvium (gravel, sand, silt).
Land use	Nature Conservation Reserve.
Soil type	Brown Sodosol – sodic B2 horizon with a strong texture contrast between A horizon and B horizon
Sediment load	Low suspended sediment load. Water was clear at the time of inspection, mostly likely owing to the fact that the reach is directly downstream of Merrimu Reservoir.
Riparian vegetation	Well vegetated riparian zone, dominated by native species.
In stream vegetation	Excellent instream vegetation, dominated by native reeds and grasses.
Habitat value	Excellent quality habitat associated with well vegetated riparian zone, excellent instream vegetation, large woody debris, exposed bedrock, large bedrock and pools and riffles.



Pyrites Creek reach 3

Reach 3 of Pyrites Creek is a partly confined waterway with floodplain pockets. This reach lies within the Long Forest Nature Conservation Reserve and is moderately well vegetated. Valley sides are steep, however, channel banks are gently sloping. Occasional pockets of floodplain have developed in places along this reach that are more extensive than along reach 1. There is some evidence of channel erosion in this reach of Pyrites Creek.

Parameter	Partly confined floodplain pockets
Channel	Single, continuous channel.
Bank/valley sides	Channel is largely confined by the valley margins, although there is some floodplain development within these valley sides. Waterway banks are generally less than 0.5 m and gently sloping. Bank material comprises silt/mud.
Bed	Typical longitudinal slope of 0.009 m/m. Bed substrate is silt/clay.
Planform	Moderate sinuosity channel confined by the valley margins.
Geology	Largely Castlemaine Group— sedimentary (sandstone, mudstone, shale). Alluvium (gravel, sand, silt). Riddell Sandstone – sedimentary (sandstone, shale).
Land use	Nature Conservation Reserve.
Soil type	Brown Sodosol – sodic B2 horizon with a strong texture contrast between A horizon and B horizon
Sediment load	Low suspended sediment load. Water was clear at the time of inspection, mostly likely owing to the fact that the reach is directly downstream of Merrimu Reservoir.
Riparian vegetation	Moderately vegetated riparian zone, dominated by native species.
In stream vegetation	Excellent instream vegetation, dominated by native reeds and grasses.
Habitat value	Excellent quality habitat associated with well vegetated riparian zone, excellent instream vegetation, large woody debris, pools and riffles.

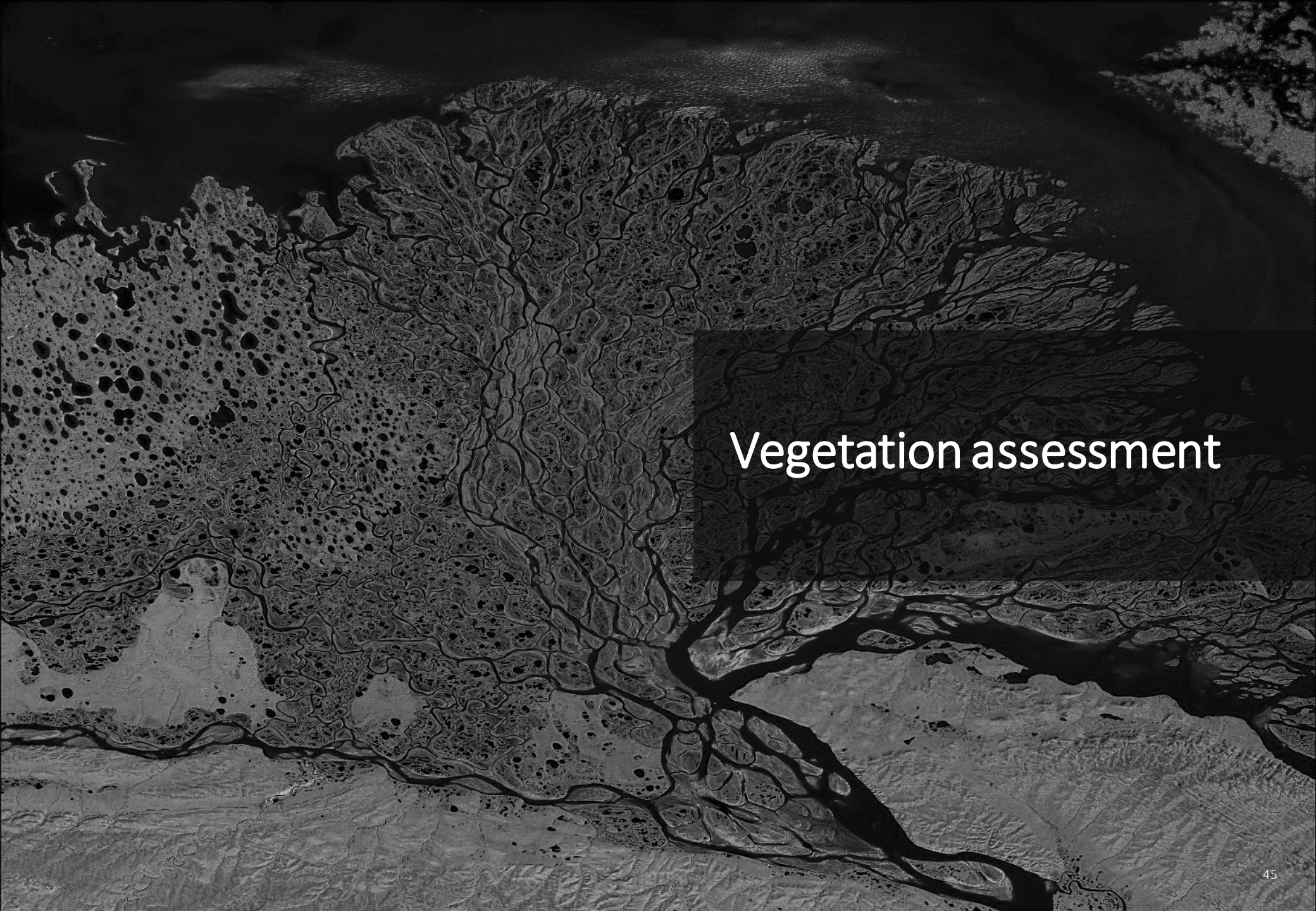


Pyrites Creek reach 4

Reach 4 of Pyrites Creek is an alluvial continuous low-moderate sinuosity gravel bed channel. This reach sits outside the Long Forest Nature Conservation Reserve on the floodplain flats where it joins the Werribee River. The channel is unconfined with gently sloping banks and a relatively flat bed grade. The riparian zone along this reach has been cleared although there are extensive reed beds along the reach, particularly at the confluence with the Werribee River.

Parameter	Alluvial continuous low-moderate sinuosity gravel
Channel	Single, continuous channel.
Bank/valley sides	Channel is unconfined and located on the floodplain flats. Waterway banks are generally less than 1 m and gently sloping. Bank material comprises silt/mud.
Bed	Typical longitudinal slope of 0.004 m/m. Bed substrate is silt/sand/gravel.
Planform	Unconfined, low sinuosity channel.
Geology	Alluvium (gravel, sand, silt).
Land use	Current land use is uncertain but likely used for agriculture in the past.
Soil type	Red Sodosol – sodic B2 horizon with a strong texture contrast between A horizon and B horizon.
Sediment load	Water was turbid at time of inspection indicating a moderate - high suspended sediment load.
Riparian vegetation	Cleared riparian zone. Dominated by exotic grasses.
In stream vegetation	Some instream vegetation. Largely native reeds.
Habitat value	Limited instream habitat associated with reeds.



An aerial photograph of a river delta, showing a complex network of channels and distributaries. The land is characterized by a dense, intricate pattern of small, dark, irregular shapes, likely representing vegetation or soil texture. A large, semi-transparent rectangular box is overlaid on the right side of the image, containing the text "Vegetation assessment".

Vegetation assessment

Vegetation assessment; Methodology

Desktop assessment

Prior to field work Alluvium conducted a desktop review of the study area. The Victorian Biodiversity Atlas (VBA) and NaturePrint were used as the primary data source. The review was conducted to highlight significant species and overall flora diversity. This desk top review provided an historical insight to build a picture of how the flora may have changed over time particularly in response to exotic species diversity and impact.

Included in this review was an overview of Melbourne Waters Healthy Waterways Strategy (HWS) and MWs current assessment of vegetation condition.

Given the sites diverse geology and the significance of remnant vegetation on the Victorian Volcanic Plain bioregion it was highly likely that a number of significant species would be identified.

Limitations.

This assessment applies to riparian areas only and can not be applied to areas beyond those assessed. Grassland and Grassy woodland values on the Merrimu plateau must be subject to further assessment. A number of areas were not accessed due to access issues and may have additional grassland, grassy woodland and escarpment values that were not assessed.

Mapping and data templates

This study drew upon MWs *Inventory of values and threats* methodology. This methodology was developed to build a consistent approach to vegetation assessment on waterways. The standard application of this method assigns plots of approximately 100m length along a waterway for assessment. However in this survey the size of assessment areas was extended. The following features were identified as points to demarcate survey reaches

- Changes in parent soil material,
- Differences in vegetation condition
- Confluences with tributaries
- Assets such as bridges culverts or boundary fences. as to reflect the character of a waterway.

Exotic species of management concern (i.e. those species which are a high threat to waterway function and riparian biodiversity) were recorded. Also noted was the presence of species which were of low management priority ie those that had little biodiversity or waterway function impact. Population attributes including location, extent of infestation and threat to native vegetation were recorded based upon Melbourne Water's template for assessing values and threats.

Melbourne Water Vegetation Visions templates

Alluvium assessed vegetation quality using Melbourne Waters Vegetation Visions templates. This method categorises vegetation into 5 categories. 1 Very low. Riparian vegetation is highly modified, predominantly comprising exotics

- 2 Low. Riparian vegetation is highly modified, fragmented and meets social and amenity requirements
- 3 Medium. Riparian vegetation consists of fragmented relevant EVC vegetation
- 4 High. Riparian vegetation is relatively intact with structural elements present with high connectivity
- 5 Very high. Riparian vegetation is intact with all structural components present and very high connectivity

No vegetation of very high condition was observed, category's 1-4 were relatively evenly represented

In addition to mapping vegetation quality Alluvium also reviewed the presence of natural wetlands as these features are a priority listed in the Healthy Waterways Strategy. A wetland feature identified on the Werribee River not currently mapped by Melbourne Water may warrant further investigation although it is possible its formation is due to the back-up of water from Merrimu Reservoir in its bank full state.

Ecological Vegetation Classes; Benchmark mapped from Nature Kit

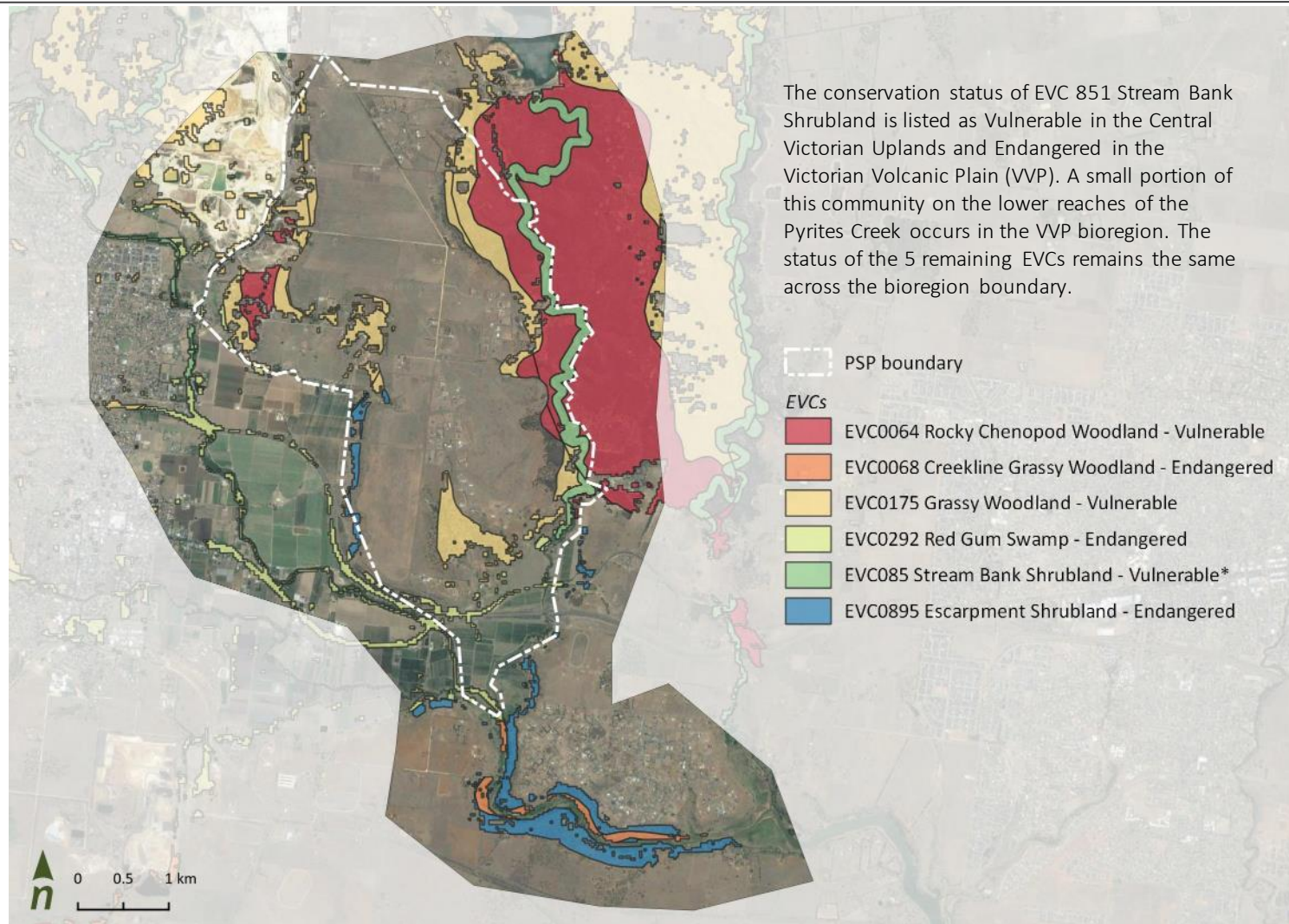


Figure 12. Ecological Vegetation Classes; Benchmark mapped from Nature Kit

Ecological Vegetation Classes; Observed

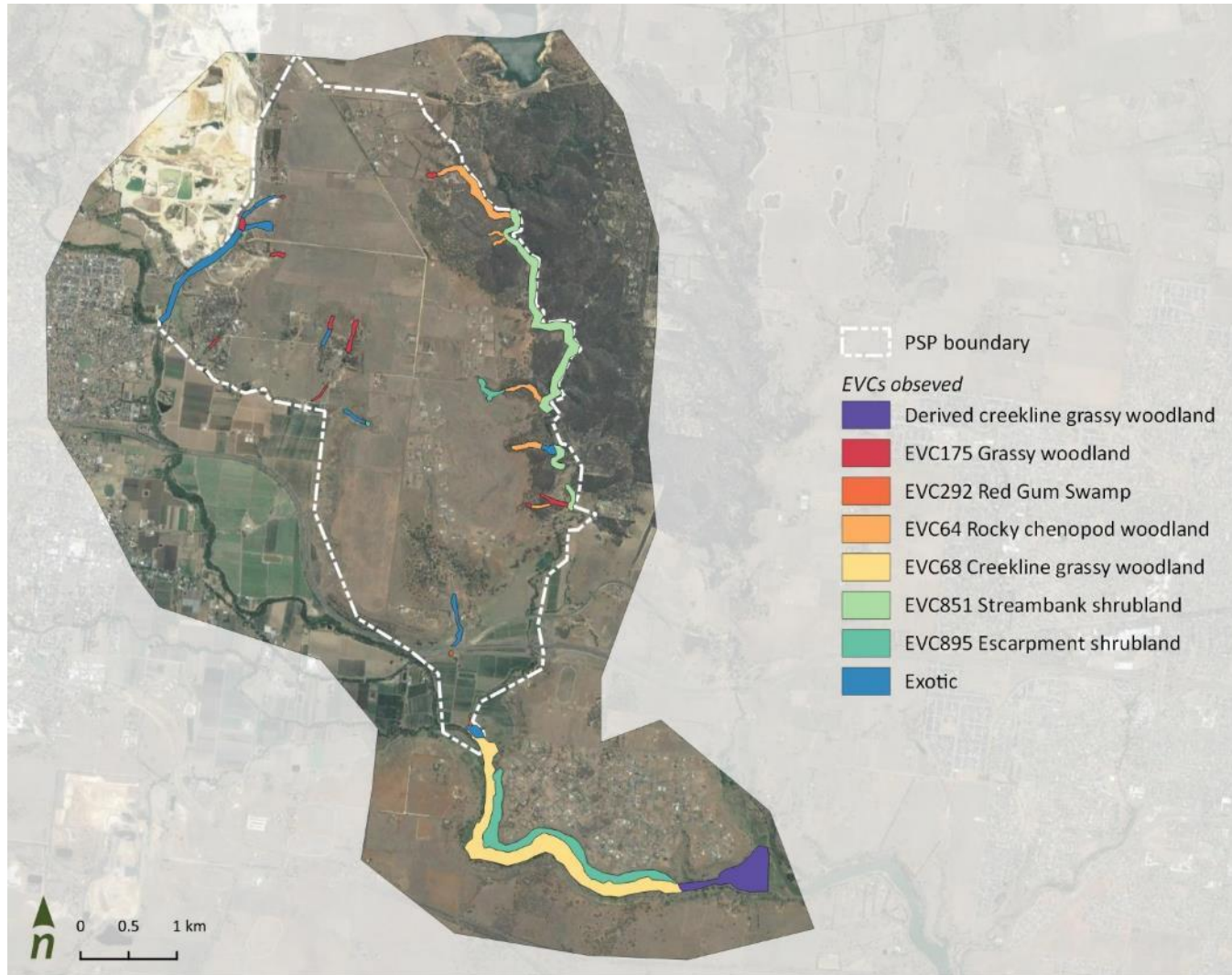


Figure 13. Ecological Vegetation Classes; Observed

All six Ecological Vegetation Classes identified via desktop assessment were observed in the field.

Of the six, EVC 64 Rocky Chenopod Woodland, EVC 68 Creekline Grassy Woodland, EVC 851 Stream Bank Shrubland and EVC 895 Escarpment Shrubland were most abundant. EVC 175 Grassy Woodland and EVC 292 Red Gum Swamp were highly restricted.

In addition the lower reaches of the Werribee River which are subject to regular inundation was highly modified. The tree layer expected in Creekline Grassy Woodland was absent due to excessive and prolonged flooding. The area where this community previously occurred is now highly modified and dominated by species tolerant of regular disturbance and inundation. This novel community was mapped as Derived creekline grassy woodland.

Vegetation comprising of entirely non-native species was mapped as exotic. This mapping unit was extensive, especially in areas subject to historic disturbance as occurs in the western portion of the study area. Anthropogenic channels along Lerderderg Park Rd were

Ecological Vegetation Classes; Quality

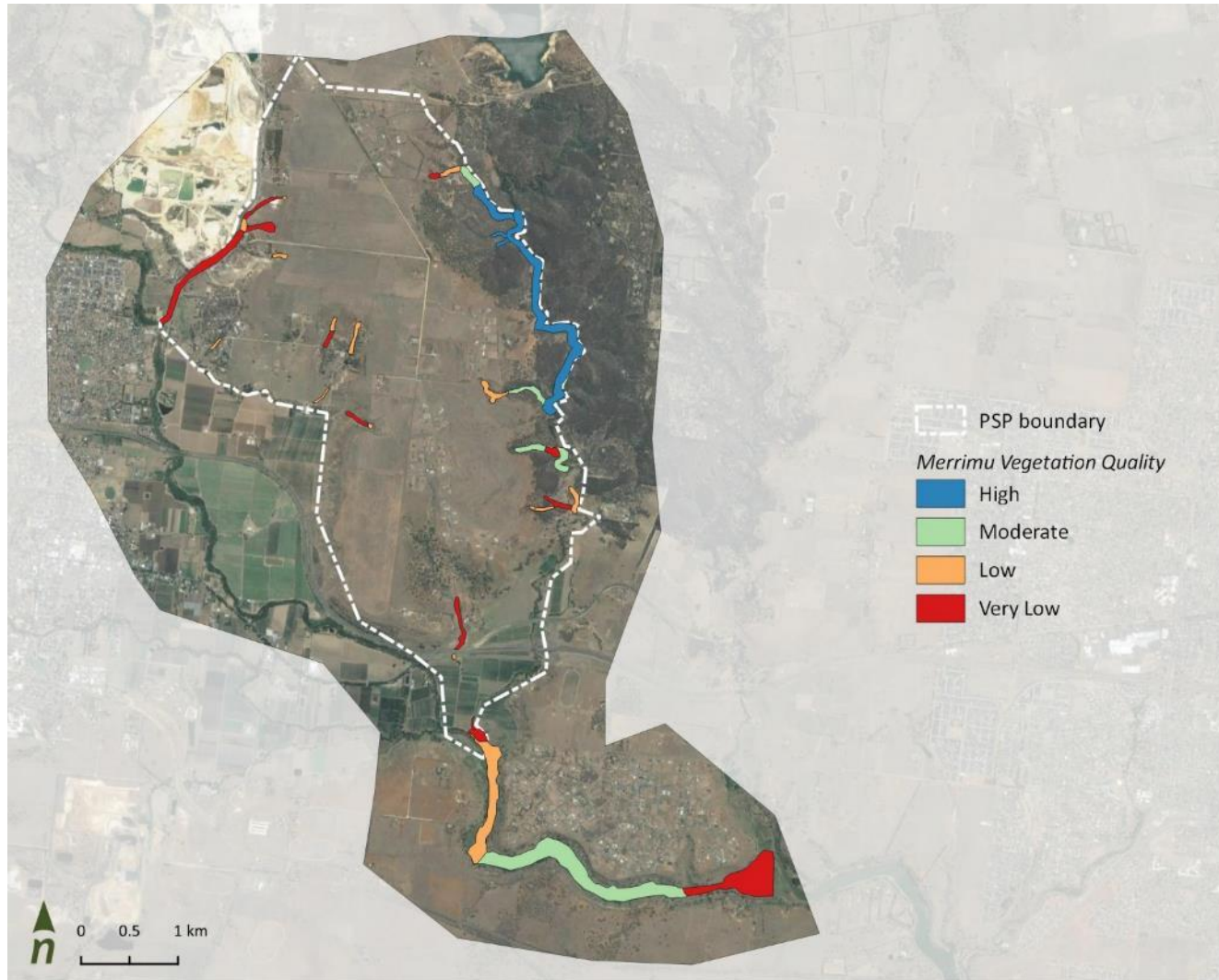


Figure 14. Ecological Vegetation Classes; Quality observed

All vegetation mapped was classified using Melbourne Water Vegetation Visions template for allocating vegetation quality.

The 5 categories determined by Melbourne Water are;

- 1 Very low. Riparian vegetation is highly modified, predominantly comprising exotics
- 2 Low. Riparian vegetation is highly modified, fragmented and meets social and amenity requirements
- 3 Moderate. Riparian vegetation consists of fragmented relevant EVC vegetation
- 4 High. Riparian vegetation is relatively intact with structural elements present with high connectivity
- 5 Very high. Riparian vegetation is intact with all structural components present and very high connectivity

No areas of very high quality were identified during this assessment. It should be noted that areas comprising almost entirely of exotic vegetation were mapped as very low as were some areas where the abundance of indigenous vegetation was extremely low but was sufficient to determine community. For example a dominant tree characteristic of the EVC and identified in the benchmark or ground flora component was observed, albeit at low frequency.

Rocky Chenopod Woodland EVC 64

Status Vulnerable

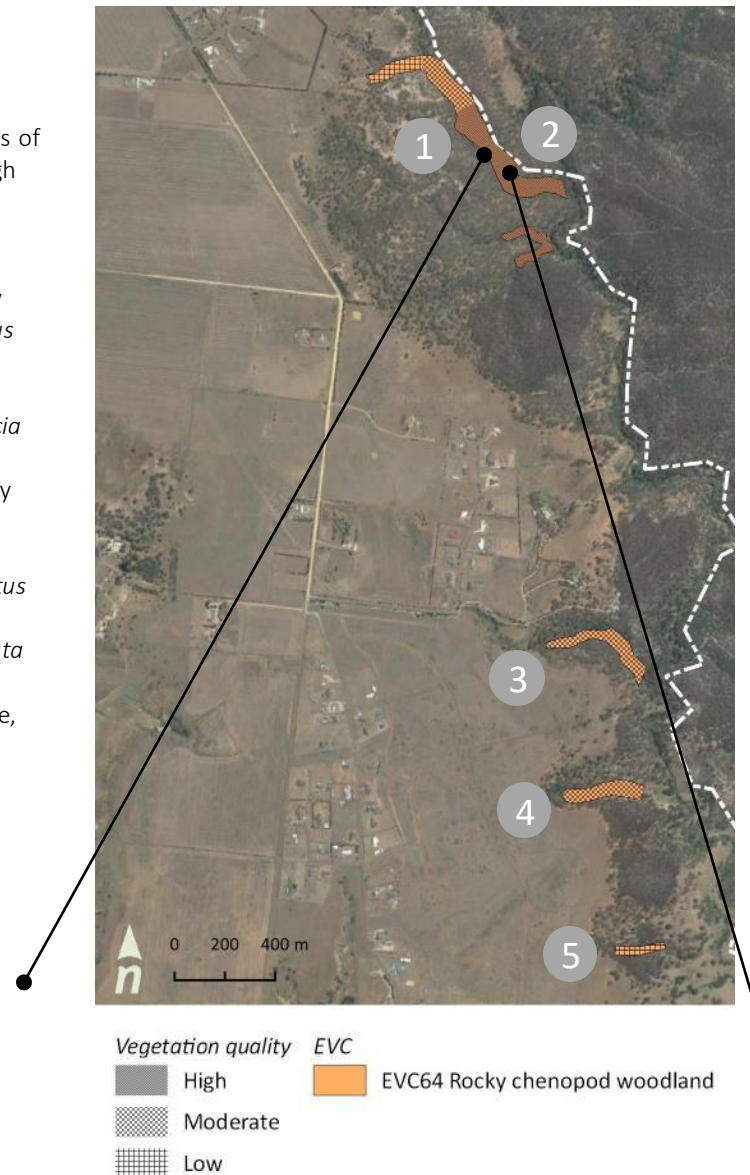
Description low open woodland to 8 m tall with an understorey dominated by chenopod (saltbush) species. Occurs on ridge-tops and steep upper slopes of hills with skeletal duplex soils that tend to have a high salt content and are fairly porous or impervious to water.

Typical character species from EVC benchmark

Overstorey Grey Box *Eucalyptus microcarpa*, Yellow Gum *Eucalyptus leucoxylon*, or Bull Mallee *Eucalyptus behriana* **Mid-storey** *Melaleuca lanceolata* ssp. *lanceolata* Moonah, *Rhagodia parabolica* Fragrant Saltbush, *Acacia acinacea* s.l. Gold-dust Wattle, *Acacia pycnantha* Golden Wattle, *Cassinia longifolia* Shiny Cassinia, *Enchylaena tomentosa* var. *tomentosa* Ruby Saltbush. **Ground-storey** *Einadia hastata* Saloop, *Einadia nutans* ssp. *nutans* Nodding Saltbush, *Dichondra repens* Kidney-weed, *Carpobrotus modestus* Inland Pigface, *Crassula sieberiana* Sieber Crassula, *Calandrinia calypttrata* Pink Purslane, *Dianella revoluta* s.l. Black-anther Flax-lily, *Austrodanthonia setacea* Bristly Wallaby-grass, *Amyema miquelii* Box Mistletoe, *Clematis microphylla* Small-leaved Clematis

Typical Geology Mixed sedimentary

Typical river style Steep headwater



High quality examples observed at site 1 and 2.

Relatively species rich. Herbaceous species, eg *Dichondra repens* Kidney Weed, *Austrostipa breviglumis* Cane Spear-grass (listed as a rare species) and *Pleurosorus rutifolius* Blanket Fern observed. Character species include; *Eucalyptus microcarpa* (Grey Box), *Acacia acinacea* s.l. (Gold-dust Wattle), *Cassinia* sp. aff. *arcuata* (Midlands-Drooping Cassinia), *Rhagodia parabolica* (Fragrant Saltbush) *Carpobrotus modestus* (Inland Pigface), *Einadia hastata* (Saloop), *Einadia nutans* (Nodding Saltbush), *Enchylaena tomentosa* var. *tomentosa* (Ruby Saltbush) and *Rytidosperma racemosum* var. *racemosum* (Slender Wallaby-grass). Note; a vegetation assessment was conducted for Site 2 but not a geomorphology assessment. Its form is consistent with site 1. The assessment for site 1 established the river style as steep headwater.

Observed cover abundance. Overstorey 6-25%

Mid-storey 6-25% Ground-storey 6-25%

Threats

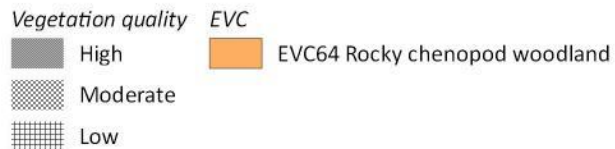
- Grazing, particularly by rabbits
- Exotic flora, woody weed invasion observed, most notably in low and moderate examples
- Erosion via slumping of margins



Rocky Chenopod Woodland EVC 64

Moderate quality examples observed at sites 3 and 4. A reduced species rich flora was observed with robust character species remaining. Eg *Eucalyptus microcarpa* (Grey Box), *Acacia acinacea* s.l. (Gold-dust Wattle), *Rhagodia parabolica* (Fragrant Saltbush), *Melaleuca lanceolata* (Moonah), *Carpobrotus modestus* (Inland Pigface), *Einadia hastata* (Saloop), *Einadia nutans* (Nodding Saltbush), *Enchylaena tomentosa* var. *tomentosa* (Ruby Saltbush) and *Rytidosperma racemosum* var. *racemosum* (Slender Wallaby-grass).

Observed cover abundance. Overstorey 6-25%
Mid-storey 6-25% Ground-storey 1-5%



Low quality examples observed at site 5. A reduced species rich flora was observed with robust character species remaining. Exotic species such as *Nassella trichotoma* Serrated Tussock and

Remnant vegetation was reduced substantially with robust species such as *Eucalyptus microcarpa* (Grey Box), *Rhagodia parabolica* (Fragrant Saltbush), *Carpobrotus modestus* (Inland Pigface), *Einadia nutans* (Nodding Saltbush), *Enchylaena tomentosa* var. *tomentosa* (Ruby Saltbush)



Creekline Grassy Woodland EVC 68

Status Endangered

Description Woodland to 15 m. Eucalypt-dominated. Occasional scattered shrubs over a mostly grassy/sedgy to herbaceous ground-layer. On low-gradient ephemeral to intermittent drainage lines, typically on fertile colluvial/alluvial soils, on a wide range of geological substrates. Can include a range of graminoid and herbaceous species tolerant of waterlogged soils, presumed to have sometimes resembled a linear wetland or system of interconnected small ponds.

Typical character species from EVC benchmark

Overstorey River Red Gum *Eucalyptus camaldulensis*

Mid-storey *Acacia melanoxylon* Blackwood, *Acacia retinodes* Wirilda, *Melicystus dentata* s.l. Tree Violet, *Rubus parvifolius* Small-leaf Bramble.

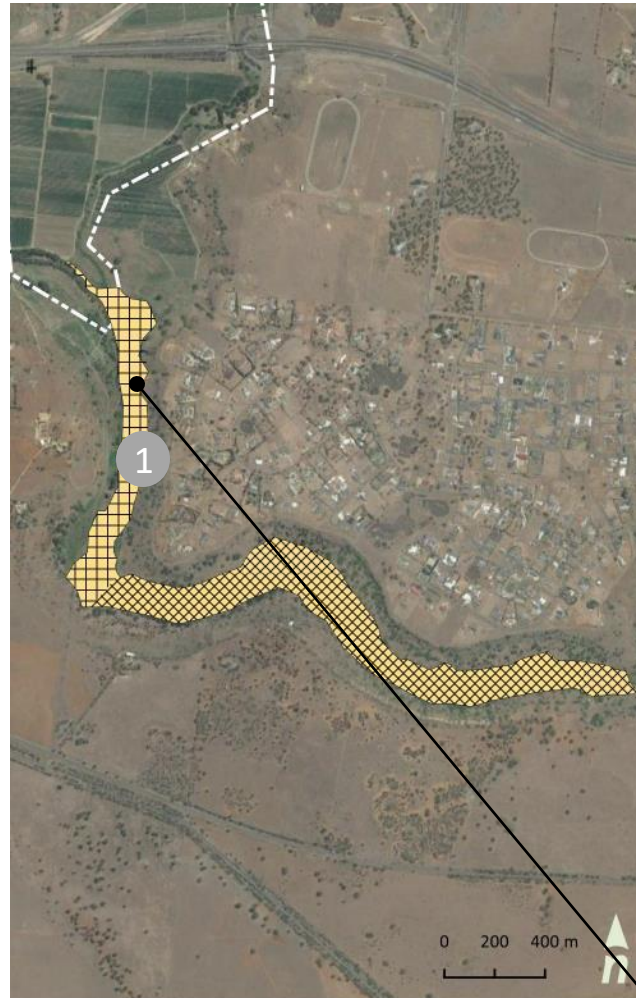
Ground-storey *Enchylaena tomentosa* var. *tomentosa* Ruby Saltbush, *Oxalis perennans* Grassland Wood-sorrel, *Azolla filiculoides* Pacific Azolla, *Lemna disperma* Common Duckweed, *Austrostipa bigeniculata* Knead Spear-grass, *Poa labillardierei* Common Tussock-grass, *Phragmites australis* Common Reed, *Austrodanthonia racemosa* var. *racemosa* Stiped Wallaby-grass, *Austrodanthonia caespitosa*, Common Wallaby-grass *Microlaena stipoides* var. *stipoides*, Weeping Grass *Glycine clandestina* Twining Glycine

Typical Geology Alluvium (gravel, sand, silt).

Typical river style Alluvial continuous low-moderate sinuosity gravel (upper portion only), Dam or reservoir for the majority of the site assessed

Threats

- Grazing, particularly by rabbits
- Exotic flora invasion throughout and occupation of exposed flats when Melton Reservoir is low.
- Erosion and smothering



Low quality examples observed at northern end of the Werribee River site 1.

Species poor and dominated by exotic species with a scattered occurrence of indigenous species. River Red Gum *Eucalyptus camaldulensis* on the margins of the river and Werribee Blue-box *Eucalyptus baueriana* subsp. *thalassina* on colluvial margins. *Rhagodia parabolica* Fragrant Saltbush occurred as an understorey.

Observed cover abundance. Overstorey 1-5% Mid-storey 6-25% Ground-storey 1-5%

Exotic species dominated much of the ground-flora and mid-storey vegetation through this portion of the study site. *Juncus acutus* Spiny Rush, *Galenia pubescens* var. *pubescens* Galenia, *Lycium ferocissimum* Boxthorn and *Schinus molle* Peppercorn were in high abundance throughout.



Creekline Grassy Woodland EVC 68

Low quality example of a floodplain wetland observed at northern end of the Werribee River site 1.

Species poor and dominated by exotic flora with a scattered occurrence of indigenous species.

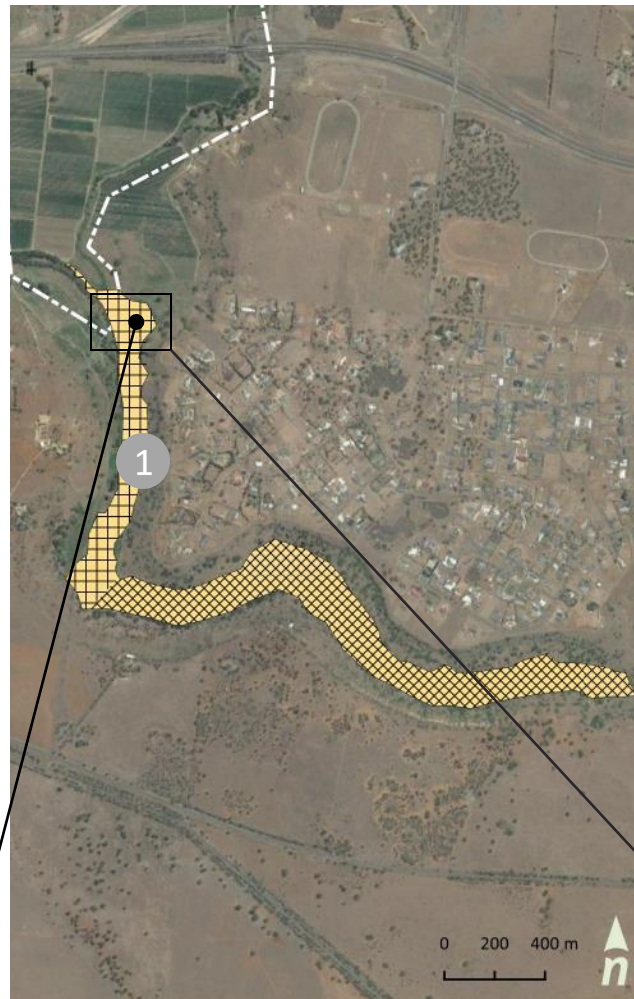
Overstorey; River Red Gum *Eucalyptus camaldulensis* has either been planted or has regenerated on the margins of this depression.

Midstorey; No midstorey was observed although species such as *Melicystus dentata* s.l. Tree Violet would be likely to establish given the changed nature of floodplain function, that is the site is less likely to engage due to drainage and changed hydrology.

Groundstorey; Scattered *Bolboschoenus caldwellii* Marsh Club-rush and occasional *Carex appressa* Common Sedge, *Phragmites australis* Common Reed was most abundant.

Observed cover abundance. Overstorey less than 1%
Mid-storey 0% Ground-storey 6-25%

Exotic species dominated the ground-flora of this depression. *Cynodon dactylon* Couch, *Cenchrus clandestinus* Kikuyu, *Dipsacus* sp Teasel and *Juncus acutus* subsp. *acutus* Spiny Rush



Vegetation quality	EVC
Low	EVC68 Creekline grassy woodland
Moderate	

This partially intact wetland represents one of the few accessible wetland features within the study area not on private land.

Melbourne Waters Healthy Waterway Strategy specifically identifies regional targets for wetlands. High value RAMSAR wetlands are the focus of wetland management efforts in the HWS. Most objectives in the HWS relate to these 'key' wetland sites. This site is in poor condition and not considered a 'key' wetland however a broad HWS objective relevant to this site is;

Ensure that wetland vegetation communities are adequately protected from urban and rural threats through appropriate interpretation and guidance on wetland vegetation and community types in the application of the native vegetation planning controls for wetland vegetation

The development of this wetland feature may be a result of water back up from Merrimu Reservoir. The protection of this wetland may warrant consideration in future management decisions.



Creekline Grassy Woodland EVC 68

Moderate quality examples observed at site 2 and 3

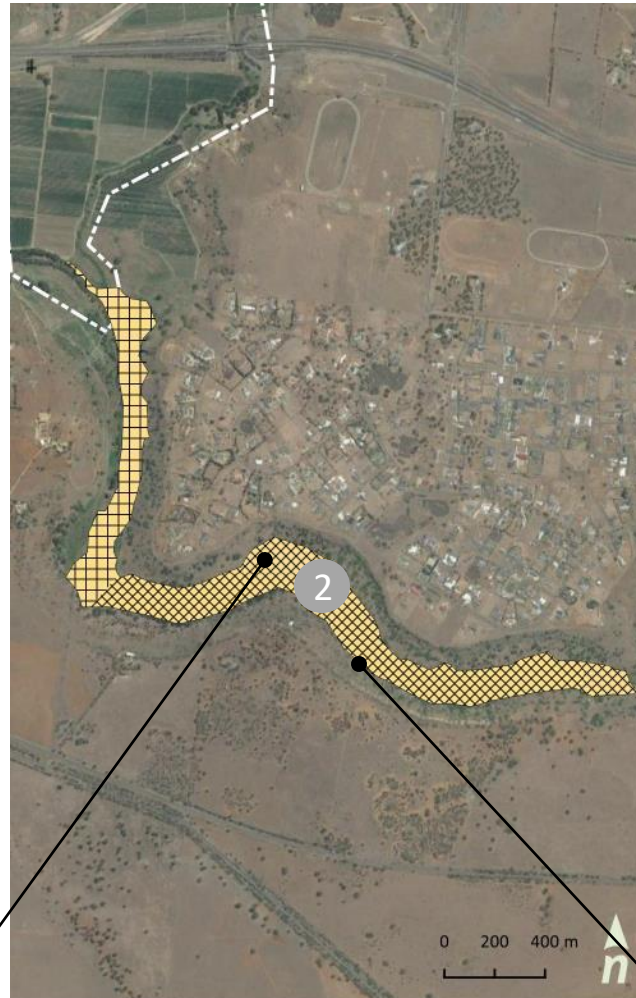
Species poor at the margins of the Werribee river where vegetation is dominated by exotic species or where robust native species able to tolerate inundation and drying are able to persist. Indigenous flora diversity increase upslope of the edge influence by the operation of Melton Reservoir.

Observed cover abundance. Overstorey 6-25% Mid-storey 6-25% Ground-storey 6-25%

Typical Geology Alluvium (gravel, sand, silt).

Typical river style Dam/reservoir influenced across entire site assessed

Overstorey River Red Gum *Eucalyptus camaldulensis* on river margins often with *Phragmites australis* Common Reed. Werribee Blue-box *Eucalyptus baueriana* subsp. *thalassina* on colluvial margins. **Midstorey** *Rhagodia parabolica* Fragrant Saltbush occurred as an understorey.



Vegetation quality	EVC
Low	EVC68 Creekline grassy woodland
Moderate	

Scattered *Acacia melanoxylon* Blackwood, *Melicystus dentata* s.l. Tree Violet, *Rubus parvifolius* Small-leaf Bramble observed.

Ground-storey Commonly observed species, *Enchylaena tomentosa* var. *tomentosa* Ruby Saltbush, *Oxalis perennans* Grassland Wood-sorrel, *Austrostipa bigeniculata* Knead Spear-grass, *Poa labillardierei* Common Tussock-grass, *Phragmites australis* Common Reed, *Austrodanthonia racemosa* var. *racemosa* Stiped Wallaby-grass, *Austrodanthonia caespitosa*, Common Wallaby-grass *Microlaena stipoides* var. *stipoides*, Weeping Grass. edge. Less frequently observed species included; *Acaena novae-zelandiae* Bidgee-widgee, *Atriplex semibaccata* Berry Saltbush, *Clematis microphylla* s.l. Small-leaved Clematis, *Einadia nutans* Nodding Saltbush, *Themeda triandra* Kangaroo Grass, *Wahlenbergia* spp. Bluebell. *Carex appressa* Common Sedge, *Crassula helmsii* Swamp Crassul, *Ficinia nodosa* Knobby Club-sedge at water's edge.



Derived Creekline Grassy Woodland

Status NA

This vegetation community is derived from EVC 68 Creekline Grassy Woodland which is listed as endangered. Observed vegetation no longer contains the range of structural or species elements that would enable it to be categorised as EVC 68.

Prolonged flooding caused by the construction of the Melton Reservoir has resulted in the death of all mature trees. Recruiting trees within this zone are also prevented from establishing due to hydrological fluctuation. Mid storey vegetation has been similarly effected. No mid-storey vegetation remains.

A substantially reduced ground storey diversity remains and has been largely replaced by a range of exotic and indigenous species that are tolerant of prolonged flooding or are able to respond rapidly to receding water levels.



Vegetation quality EVC
 Very Low
 Derived creekline grassy woodland



The original herbaceous and graminoid/tussock vegetation structure and composition has been greatly reduced. It now comprises of a much simplified flora. Indigenous species comprise of *Juncus pallidus* Pale Rush, *Juncus sp* Juncus, *Schoenoplectus tabernaemontani* River Club Rush, *Persicaria decipiens* Slender knotweed, *Persicaria lapathifolia* Pale knotweed and *Persicaria prostrata* Creeping Knotweed.

Typical exotic species dominating the zone.

Brassica sp. Brassica, *Conium maculatum* Hemlock, *Cynara cardunculus subsp. flavesces* Artichoke Thistle, *Cirsium vulgare* Spear Thistle, *Cyperus eragrostis*, *Erigeron sumatrensis* Tall Fleabane, *Plantago lanceolata* Ribwort, *Rumex crispus* Curled Dock

Typical Geology Alluvium (gravel, sand, silt).

Typical river style Dam or reservoir

Opportunities

- Limited by operational needs of Melton Reservoir
- Habitat development provided by hollow trees



Grassy Woodland EVC 175

Status Vulnerable

Description 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. The shrub component is usually sparse. It occurs on sites with moderate fertility on gentle slopes or undulating hills on a range of geologies.

Typical character species from EVC benchmark

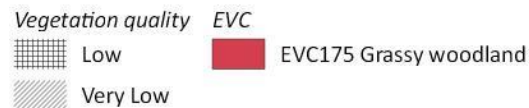
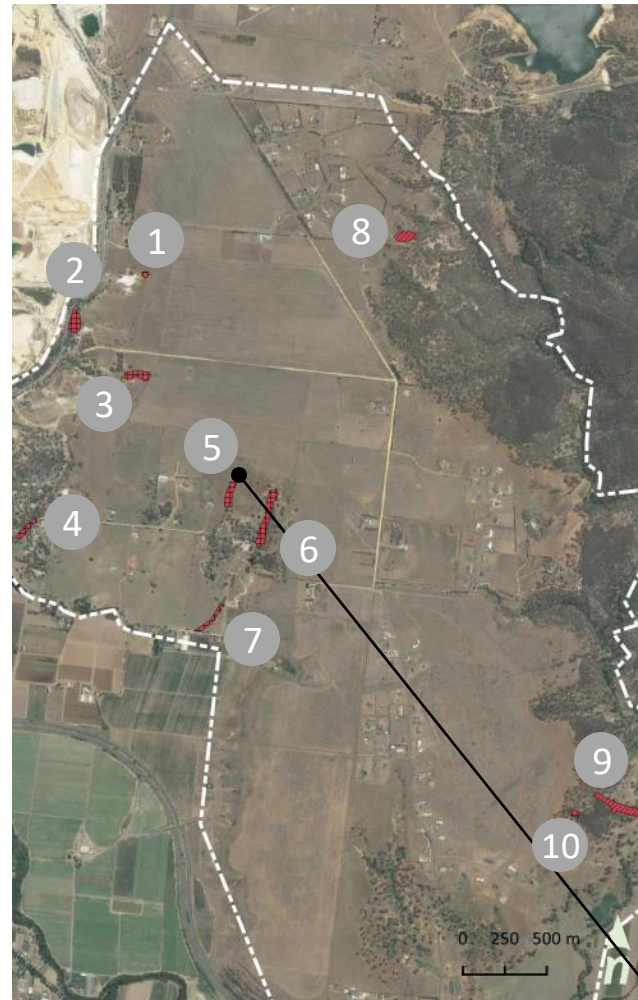
Overstorey *Eucalyptus ovata* Swamp Gum, *Eucalyptus radiata* s.l. Narrow-leaf Peppermint, *Eucalyptus viminalis* Manna Gum, *Allocasuarina verticillata* Drooping Sheoak, *Acacia implexa* Lightwood, *Acacia mearnsii* Black Wattle **Mid-storey** *Bursaria spinosa* Sweet Bursaria, *Cassinia arcuate* Drooping Cassinia, *Acacia pycnantha* Golden Wattle, *Melicystus dentata* s.l. Tree Violet **Ground-storey** *Pimelea humilis* Common Rice-flower, *Atriplex semibaccata* Berry Saltbush, *Acaena echinata* Sheep's Burr, *Einadia nutans* ssp. *Nutans* Nodding Saltbush, *Gonocarpus tetragynus* Common Raspwort, *Crassula sieberiana* Sieber Crassula, *Dichondra repens* Kidney-weed, *Lomandra filiformis* Wattle Mat-rush, *Austrostipa scabra* Rough Spear-grass, *Austroanthonia caespitosa* Common Wallaby-grass, *Dianella revoluta* s.l. Black-anther Flax-lily, *Microlaena stipoides* var. *stipoides* Weeping Grass, *Clematis microphylla* Small-leaved Clematis

Typical Geology Newer Volcanics, Werribee Formation

Typical river style Steep headwater

Threats

- Grazing, particularly by rabbits
- Exotic flora invasion
- Erosion via the development of head cuts originating in Werribee formation material



This community typically occurs in small isolated patches. These isolated patches are subject to degradation from grazing and weed invasion. These patches also occur on a geology type which is highly sensitive to erosion once subsoil is exposed.. These small patches will continue to decline due to external biological pressures and the collapse of the substrate on which they occur. Any change in hydrology will further exacerbate their decline.

Low quality examples observed at sites 4-7 and 10

Species observed *Acacia implexa* Lightwood, **Mid-storey** *Bursaria spinosa* Sweet Bursaria, *Rhagodia parabolica* Fragrant Saltbush, *Eremophila desertii* Turkey-bush *Eremophila* **Ground-storey**, *Atriplex semibaccata* Berry Saltbush, *Acaena echinata* Sheep's Burr, *Einadia nutans* ssp. *Nutans* Nodding Saltbush, *Dichondra repens* Kidney-weed, *Lomandra filiformis* Wattle Mat-rush, *Austrostipa scabra* Rough Spear-grass, *Austroanthonia caespitosa* Common Wallaby-grass,, *Microlaena stipoides* var. *stipoides* Weeping Grass, *Clematis microphylla* Small-leaved Clematis, *Themeda triandra* Kangaroo Grass.

Observed cover abundance. Overstorey 6-25%
Mid-storey 1-5% Ground-storey 6-25%



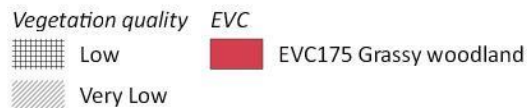
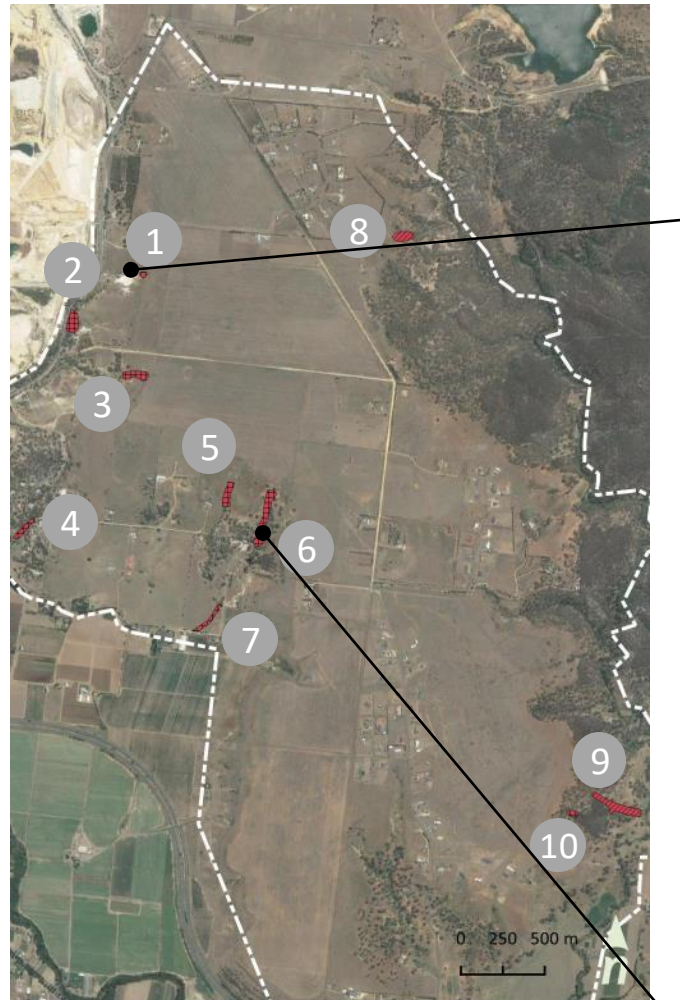
Grassy Woodland EVC 175

Low quality examples observed at sites 1, 2 and 3

Species observed *Eucalyptus leucoxylon* Yellow Gum, *Eucalyptus microcarpa* Grey Box, *Eucalyptus melliodora* Yellow Box, *Acacia implexa* Lightwood, **Mid-storey** *Bursaria spinosa* Sweet Bursaria, *Rhagodia parabolica* Fragrant Saltbush, *Eremophila desertii* Turkey-bush **Ground-storey**, *Atriplex semibaccata* Berry Saltbush, *Acaena echinata* Sheep's Burr, *Einadia nutans ssp. Nutans* Nodding Saltbush, *Dichondra repens* Kidney-weed, *Lomandra filiformis* Wattle Mat-rush, *Austrostipa scabra* Rough Spear-grass, *Austrodanthonia caespitosa* Common Wallaby-grass,, *Microlaena stipoides var. stipoides* Weeping Grass, *Clematis microphylla* Small-leaved Clematis, *Themeda triandra* Kangaroo Grass

Observed cover abundance. Overstorey 6-25% Mid-storey 1-5% Ground-storey 1-5%

Abundance and biomass of exotic species. *Nassella trichotoma* Serrated Tussock, *Lycium ferocissimum* Boxthorn are becoming increasingly dominant across these sites. Numerous ground storey and sub shrub species are scattered across sites including *Dipsacus sp.* Teasel, *Marrubium vulgare* Horehound, *Oxalis pes-caprae* Soursob and *Physalis hederifolia* Ivy leaf ground cherry.



Sites 1, 2 & 3; low quality vegetation. Similar structural and species composition; particularly vulnerable to the instability of the substrate on which they occur. Overstorey typically comprises a range of Eucalypt species and a sparse mid storey of *Bursaria spinosa* Sweet Bursaria, *Eremophila desertii* Turkey-bush and *Rhagodia parabolica* Fragrant Saltbush. Ground-storey is limited to robust graminoids such as *Austrostipa scabra* Rough Spear-grass, *Austrodanthonia caespitosa* Common Wallaby-grass,, *Microlaena stipoides var. stipoides* Weeping Grass. *Nassella trichotoma* Serrated Tussock makes up the majority of ground-storey biomass



Grassy Woodland EVC 175

Very low quality examples observed at sites 8 & 9. These sites had minimal native species diversity and a high abundance and diversity of exotic flora. At both sites structural diversity was low with a tree layer and sparse native shrub species observed. Ground-storey native diversity was minimal or absent.

Species observed

Over-storey *Eucalyptus microcarpa* Grey Box, *Eucalyptus melliodora* Yellow Box,

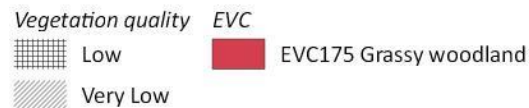
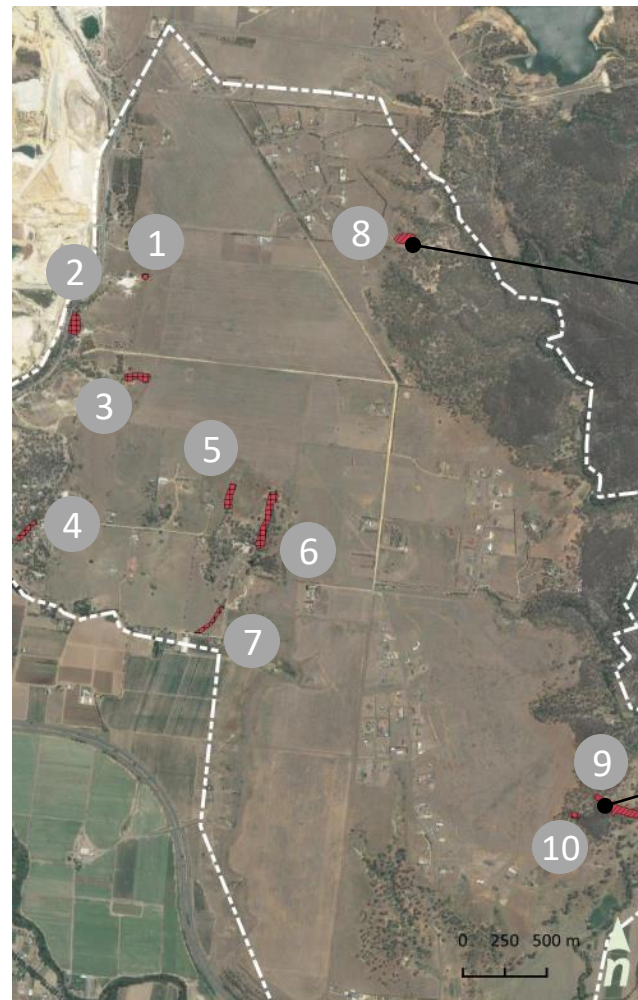
Mid-storey *Bursaria spinosa* Sweet Bursaria, *Cassinia arcuate* Common Cassinia, *Eremophila desertii* Turkey-bush and *Rhagodia parabolica* Fragrant Saltbush.

Ground-storey, *Einadia nutans ssp. nutans* Nodding Saltbush, *Microlaena stipoides var. stipoides* Weeping Grass, *Clematis microphylla* Small-leaved Clematis, *Themeda triandra* Kangaroo Grass

Observed cover abundance. Overstorey 1-5% Mid-storey 1-5% Ground-storey 1-5%

Abundance and biomass of exotic species. *Nassella trichotoma* Serrated Tussock, *Lycium ferocissimum* Boxthorn and *Phalaris aquatica* Toowoomba Canary-grass are becoming increasingly dominant across these sites.

Additional examples of EVC 175 are likely to occur on the southern escarpments of the study zone. They could not be accessed during this investigation but should be assessed as part of a more detailed review of values on the Merrimu plateau.



Site 8&9 exemplify the impact of isolation. These patches are subject to degradation from grazing, weed invasion and are highly sensitive to erosion. Note the dominance of exotic grasses (above) and presence of exotic woody weeds (below).

These small patches will continue to decline or at best remain in very poor condition without intervention. Any change in hydrology will further exacerbate their decline particularly at site 9 (below) where extensive erosion is clearly evident and continues to expand laterally.



Red Gum Swamp EVC 292

Status Endangered

Description Open woodland to 15 m tall. Occurs on alluvial plains in the seasonally wet depressions of shallow drainage lines or prior stream meanders, typically associated with heavy paludal soils, sometimes with gilgai development. The annual rainfall across its distribution is generally below 700 mm, and the period of inundation may range from 2 to 6 months. River Red Gum woodland with sedgy or grassy-herbaceous ground-layer, comprising various balances of true aquatics and species tolerant of intermittent to seasonal inundation.

Typical character species from EVC benchmark

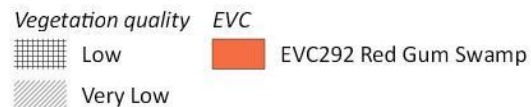
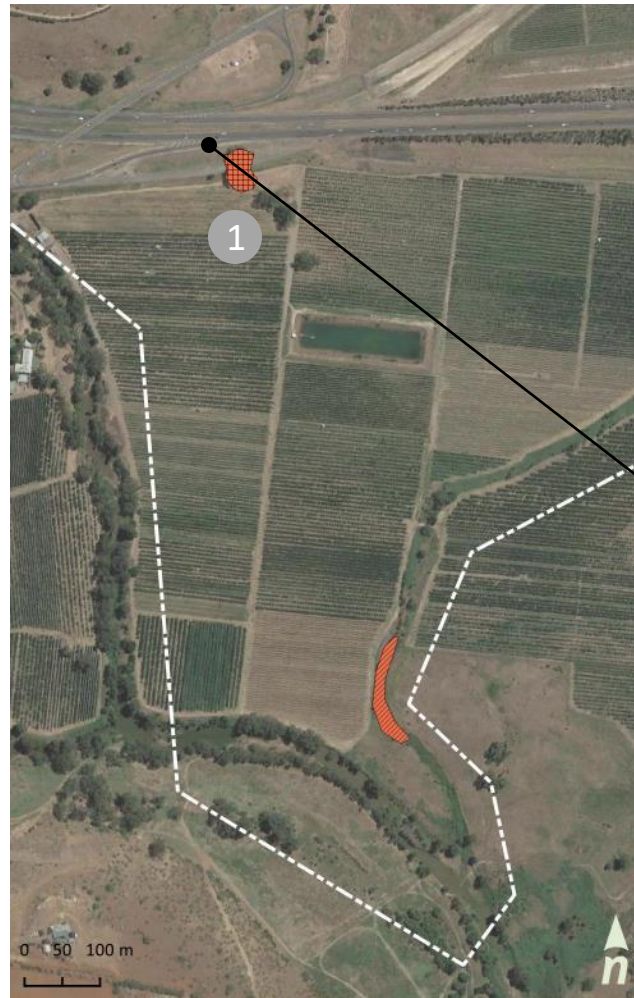
Overstorey *Eucalyptus camaldulensis* River Red-gum

Mid -storey typically sparse or absent with occasional occurrence in dry years of species from adjoining communities which do not persist.

Groundstorey *Villarsia reniformis* Running Marsh-flower, *Eryngium ovium* Blue Devil, *Potamogeton tricarinatus* s.l. Floating Pondweed, *Lythrum hyssopifolia* Small Loosestrife, *Drosera peltata* ssp. *Peltate* Pale Sundew, *Haloragis aspera* Rough Raspwort, *Lobelia pratioides* Poison Lobelia, *Solenogyne dominii* Smooth Solenogyne, *Amphibromus nervosus* Common Swamp Wallaby-grass, *Carex tereticaulis* Hollow Sedge, *Juncus holoschoenus* Joint-leaf Rush, *Lachnagrostis filiformis* Common Blown-grass, *Schoenus tesquorum* Soft Bog-sedge, *Isolepis fluitans* Floating Club-sedge, *Eleocharis acuta* Common Spike-sedge

Typical Geology Alluvial

Typical river style Anthropogenic channel



Observed cover abundance. Overstorey 6-25%
Mid-storey; absent, Ground-storey 1-5%

Threats

- Vegetation removal for agriculture and infrastructure development
- Exotic flora invasion
- Further drainage of swampy areas

This vegetation type is not sensitive to an increase in duration or extent of flow. Increased wetness would benefit this community.



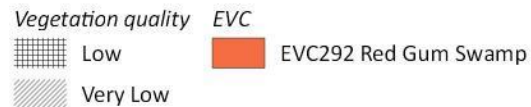
Sites 1; low quality vegetation. Overstorey is reduced to a small patch of *Eucalyptus camaldulensis* River Red-gum. Groundstorey vegetation is reduced to *Phragmites australis* Common Reed and *Persicaria decipiens* Slender Knotweed. True aquatics and species tolerant of intermittent to seasonal inundation are absent.

Red Gum Swamp EVC 292

Site 2 within the study area comprises of a small patch of revegetated Red Gum Swamp. This revegetation appears to be in response to the removal of willows from within the channel of the lower Pyrites creek before its confluence with the Werribee River. Over time this patch may score more highly as the revegetation matures. Greater structural complexity and a reduced cover of exotic species will improve the score based on Melbourne Waters Vegetation Visions categorisation of vegetation.

Very low quality example

Observed cover abundance. Overstorey 1-5% Mid-storey 1-5% Ground-storey <1 %



Sites 2 very low quality; Species observed.

Overstorey is reduced to recently planted *Eucalyptus camaldulensis* River Red-gum. Ground-storey vegetation is reduced to *Carex appressa* Common Sedge, *Persicaria decipiens* Slender Knotweed and *Phragmites australis* Common Reed. True aquatics are absent.

Exotic species dominating this portion of the study are include *Cenchrus clandestinus* Kikuyu, *Cirsium vulgare* Spear Thistle, *Conium maculatum* Hemlock, *Cyperus eragrostis* Drain Sedge, *Foeniculum vulgare* Fennel and *Juncus acutus subsp. acutus* Spiny Rush

Streambank Shrubland EVC 851

Status Vulnerable

Description

Tall shrubland to 8 m tall above a ground layer of sedges and herbs. A sparse eucalypt overstorey to 15 m tall may sometimes be present. Occurs along rivers and major streams where the watercourse consists of either rocky banks, a flat rocky stream bed or broad gravel banks which are often dry but are also regularly flooded by fast flowing waters.

Typical character species from EVC benchmark

Over-storey

Eucalyptus spp. *Acacia mearnsii* Black Wattle *Acacia melanoxylon* Blackwood

Mid-storey

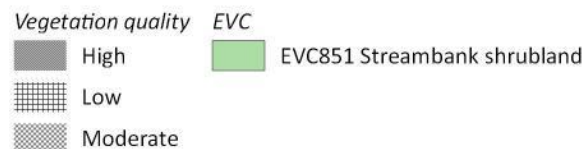
Cassinia aculeata Common Cassinia *Dodonaea viscosa* ssp. *cuneata* Wedge-leaf Hop-bush *Acacia verticillata* Prickly Moses

Groundstorey

Chrysocephalum semipapposum Clustered Everlasting *Wahlenbergia stricta* Tall Bluebell *Geranium potentilloides* Cinquefoil Cranesbill *Acaena novae-zealandiae* Bidgee-widgee *Dichondra repens* Kidney-weed *Oxalis exilis* Shady Wood-sorrel *Lomandra longifolia* Spiny-headed Mat-rush *Juncus gregiflorus* Green Rush *Carex appressa* Tall Sedge *Poa labillardierei* Common Tussock-grass *Lepidosperma laterale* Variable Sword-sedge *Isolepis inundata* Swamp Club-sedge *Microlaena stipoides* var. *stipoides* Weeping Grass *Cheilanthes austrotenuifolia* Green Rock-fern *Adiantum aethiopicum* Common Maidenhair *Clematis microphylla* Small-leaved Clematis

Typical Geology Mixed sedimentary

Typical river style Confined floodplain pockets



Threats

- Grazing, particularly by rabbits also cattle
- Exotic flora invasion observed, most notably in low and moderate examples
- Erosion via slumping of margins

High quality examples; Site 1 extending downstream for approximately 2.5km

Structure is largely intact and healthy. Moisture dependant species such as *Callistemon sieberii* River Bottlebrush and semi aquatic species are robust and actively growing. Their condition is supported by the abundant moisture provided by the Merrimu Reservoir flows.

Observed cover abundance.

Overstorey	2 (6-25)	Mid storey	3 (26-50)
Ground storey	2 (6-25)		

Streambank Shrubland EVC 851

High quality vegetation was identified in site 1.

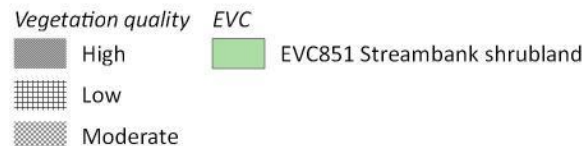
Species observed in this reach include;

Overstorey; *Eucalyptus baueriana* subsp. *thalassina* (Werribee Blue-box), *Eucalyptus viminalis* (Manna Gum)

Midstorey *Bursaria spinosa* Sweet Bursaria *Callistemon sieberii* River Bottlebrush, *Leptospermum lanigerum* Woolly Tea-tree and *Melicystus dentata* s.l. Tree Violet

Groundflora *Carex appressa* (Common Sedge), *Crassula helmsii* (Swamp Crassula) *Dichondra repens* Kidney-weed, *Poa labillardierei* (Common Tussock-grass), *Lomandra longifolia* (Spiny-headed Mat-rush) *Phragmites australis* (Common Reed) *Triglochin procerum* s.l. (Water Ribbons) *Microlaena stipoides* var. *stipoides* (Weeping Grass) *Ficinia nodosa* (Knobby Club-sedge)

Exotic flora. Few exotic species of management concern observed. *Galenia pubescens* Galenia and *Oxalis pes-caprae* Soursob, *Asparagus asparagoides* Asparagus Fern, *Cirsium vulgare* Spear Thistle, *Schinus molle* Peppercorn, *Lycium ferocissimum* Boxthorn, *Nassella trichotoma* Serrated Tussock, *Marrubium vulgare* Horehound occurred at low abundance or as an isolated individual. Native vegetation dominated.



The upstream extent of this vegetation type was well vegetated with *Eucalyptus baueriana* subsp. *thalassina* (Werribee Blue-box) as the dominant overstorey. Instream vegetation was dominated by *Typha domingensis* Narrow-leaf Cumbungi (see above).

The down stream extent was well vegetated with *Eucalyptus viminalis* (Manna Gum) as the dominant overstorey. Instream vegetation was dominated by *Carex appressa* Tall Sedge, *Carex fascicularis* Tassel Sedge, shrubs such as *Callistemon sieberii* River Bottlebrush were thriving (see a below).



Streambank Shrubland EVC 851

Medium quality vegetation site 2.

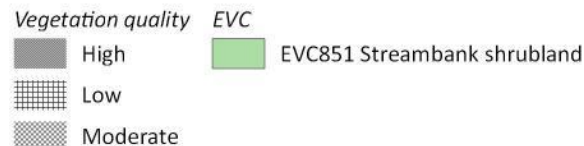
Structure is intact. Moisture dependant and semi aquatic species are robust and actively growing.

Overstorey; *Eucalyptus baueriana* subsp. *thalassina* Werribee Blue-box, *Eucalyptus microcarpa* Grey Box

Mid-storey; *Callistemon sieberi* River Bottlebrush *Melaleuca lanceolata* Moonah, *Rhagodia parabolica* Fragrant Saltbush. **Ground-flora;** *Austrostipa* spp. Spear Grass, *Carex appressa* Tall Sedge, *Carex fascicularis* Tassel Sedge, *Clematis microphylla* s.l. Small-leaved Clematis, *Crassula helmsii* Swamp Crassula, *Crassula sieberiana* s.l. Sieber Crassula, *Dichondra repens* Kidney-weed, *Einadia hastata* Saloop, *Enchylaena tomentosa* var. *tomentosa* Ruby Saltbush, *Microlaena stipoides* var. *stipoides* Weeping Grass, *Nicotiana suaveolens* Austral Tobacco, *Pleurosorus rutifolius* s.l. Blanket Fern, *Poa labillardierei* Common Tussock-grass, *Triglochin* sp Water Ribbons, and *Typha domingensis* Narrow-leaf Cumbungi

Observed cover abundance. Overstorey 6-25% Mid-storey 6-25% Ground-storey 6-25%

Exotic flora. A similar composition of exotic species was observed and are more frequent than in upstream reaches.



Low quality vegetation site 2.

Structure partially intact. Moisture availability decreases further downstream. The diversity and vigour of semi aquatic species decreases accordingly.

Overstorey; *Eucalyptus baueriana* subsp. *thalassina* Werribee Blue-box, *Eucalyptus microcarpa* Grey Box

Mid-storey; *Callistemon sieberi* River Bottlebrush *Melaleuca lanceolata* Moonah, *Rhagodia parabolica* Fragrant Saltbush. **Ground-flora;** *Austrostipa* spp. Spear

Grass, *Carex appressa* Tall Sedge, *Clematis microphylla* s.l. Small-leaved Clematis, *Dichondra repens* Kidney-weed, *Einadia hastata* Saloop, *Enchylaena tomentosa* var. *tomentosa* Ruby Saltbush, *Microlaena stipoides* var. *stipoides* Weeping Grass, *Poa labillardierei* Common Tussock-grass, and *Typha domingensis* Narrow-leaf Cumbungi

Observed cover abundance. Overstorey 6-25% Mid-storey 6-25% Ground-storey 6-25%

Exotic flora. A similar composition of exotic species was observed with the additional of *Schinus molle* Peppercorn, *Conyza* sp Fleabane, *Cynodon dactylon* Couch, *Cyperus eragrostis* Drain Sedge, *Ehrharta erecta* var. *erecta* Panic Veldt grass, *Juncus acutus* subsp. *acutus* Spiny Rush and *Phytolacca octandra* Inkweed. Exotic species were more frequent than upstream.



Escarpment Shrubland EVC 895

Status Endangered

Description Occurs on rocky escarpments in steep valleys or gorges, associated with limestone or basalt. Sites have moderate to high fertility, are well-drained but subject to regular summer drought due to shallow soils. Eucalypt woodland to 15 m tall or non-eucalypt shrubland to 8 m tall, with occasional eucalypts; lichen-covered rock outcrops are common.

Typical character species from EVC benchmark

Overstorey *Acacia implexa* Lightwood, *Allocasuarina verticillata* Drooping Sheoak, *Acacia mearnsii* Black Wattle, *Bursaria spinosa* Sweet Bursaria, *Eucalyptus viminalis* ssp. *viminalis* Manna Gum **Mid-storey** *Rhagodia parabolica* Fragrant Saltbush, *Hymenanthera dentata* s.l. Tree Violet **Ground-storey** *Enchylaena tomentosa* var. *tomentosa* Ruby Saltbush, *Wahlenbergia communis* s.l. Tufted Bluebell, *Oxalis perennans* Grassland Wood-sorrel, *Maireana enchylaenoides* Wingless Bluebush, *Einadia nutans* ssp. *nutans* Nodding Saltbush, *Chamaesyce drummondii* Flat Spurge, *Dichondra repens* Kidney-weed, *Austrostipa bigeniculata* Kneed Spear-grass, *Austrodanthonia racemosa* var. *racemosa* Stiped Wallaby-grass, *Austrodanthonia setacea* Bristly Wallaby-grass, *Panicum effusum* Hairy Panic, *Cheilanthes distans* Bristly Cloak-fern, *Clematis microphylla* Small-leaved Clematis, *Convolvulus erubescens* spp. agg. Pink Bindweed

Typical Geology Newer volcanic basalt flow

Typical river style Steep headwater or NA

Threats

- Grazing, particularly by rabbits
- Exotic flora, woody weed invasion and abundant exotic ground-storey observed
- Erosion due to unstable substrate below basalt cap
- Illegal clearance and spoil deposition



Vegetation quality EVC
 Low  EVC895 Escarpment shrubland



Low quality examples observed at site 1.

Observed species

Overstorey *Acacia implexa* Lightwood, *Allocasuarina verticillata* Drooping Sheoak, *Allocasuarina luehmanna* Buloke, *Acacia mearnsii* Black Wattle, *Bursaria spinosa* Sweet Bursaria,

Midstorey *Rhagodia parabolica* Fragrant Saltbush, *Hymenanthera dentata* s.l. Tree Violet

Groundstorey *Enchylaena tomentosa* var. *tomentosa* Ruby Saltbush, *Maireana enchylaenoides* Wingless Bluebush, *Einadia nutans* ssp. *nutans* Nodding Saltbush, *Austrostipa bigeniculata* Kneed Spear-grass, *Austrodanthonia racemosa* var. *racemosa* Bristly Wallaby-grass, *Clematis microphylla* Small-leaved Clematis

Sparse indigenous plant cover and the great dominance of exotics resulted in a classification of low quality even though this community sometimes had higher diversity than communities listed as moderate quality. Escarpment vegetation was structurally poor

Observed cover abundance. Overstorey <1% Mid-storey 1-5% Ground-storey 1-5%

Escarpment Shrubland EVC 895

Exotic flora dominates all three sites. Species of high abundance included

Over-storey *Schinus molle* Peppercorn

Mid-storey *Lycium ferocissimum* Boxthorn, *Opuntia stricta* Common Prickly-pear

Ground-storey *Asparagus asparagoides* Asparagus Fern, *Cirsium vulgare* Spear Thistle, *Cynara cardunculus subsp. flavescent* Artichoke Thistle, *Ehrharta erecta* var. *erecta* Panic Veldt-grass, *Foeniculum vulgare* Fennel, *Galenia pubescens* Galenia, *Marrubium vulgare* Horehound *Nassella trichotoma* Serrated Tussock, *Oxalis pes-caprae* Soursob, *Paspalum dilatatum* Paspalum

Low quality examples observed at site 2.

Observed species

Overstorey *Acacia implexa* Lightwood,, *Bursaria spinosa* Sweet Bursaria, *Eucalyptus melliodora* Yellow Box

Midstorey *Rhagodia parabolica* Fragrant Saltbush, *Melicystus dentata* s.l. Tree Violet

Groundstorey *Enchylaena tomentosa* var. *tomentosa* Ruby Saltbush, *Wahlenbergia communis* s.l. Tufted Bluebell, *Oxalis perennans* Grassland Wood-sorrel, *Maireana enchylaenoides* Wingless Bluebush, *Einadia nutans* ssp. *nutans* Nodding Saltbush, *Dichondra repens* Kidney-weed, *Austrostipa bigeniculata* Kneed Spear-grass, *Austrodanthonia racemosa* var. *racemosa* Bristly Wallaby-grass,, *Clematis microphylla* Small-leaved Clematis

Sparse indigenous plant cover and the great dominance of exotics resulted in a classification of low quality even though this community sometimes had higher diversity than communities listed as moderate quality. Escarpment vegetation was structurally poor

Observed cover abundance. Overstorey <1% Mid-storey 1-5% Ground-storey 1-5%



Vegetation quality EVC
 Low  EVC895 Escarpment shrubland



Low quality vegetation at site 2. Observed species;

Overstorey *Acacia implexa* Lightwood, *Bursaria spinosa* Sweet Bursaria, *Eucalyptus melliodora* Yellow Box

Midstorey *Rhagodia parabolica* Fragrant Saltbush, *Melicystus dentata* s.l. Tree Violet

Groundstorey *Enchylaena tomentosa* var. *tomentosa* Ruby Saltbush, *Wahlenbergia communis* s.l. Tufted Bluebell, *Oxalis perennans* Grassland Wood-sorrel, *Maireana enchylaenoides* Wingless Bluebush, *Einadia nutans* ssp. *nutans* Nodding Saltbush, *Dichondra repens* Kidney-weed, *Austrostipa bigeniculata* Kneed Spear-grass, *Austrodanthonia racemosa* var. *racemosa* Bristly Wallaby-grass, *Clematis microphylla* Small-leaf Clematis

Exotic vegetation

Status NA

Description. Exotic vegetation is variable across the study site in both composition and structure. In the north west of the study area overstorey comprised exotic trees, planted native species and occasional examples of mature indigenous tree species. It appears that attempts have been made to stabilise soil with a range of species including native shrubs and exotic grasses. Exotic grasses and annual broadleaf species currently dominate and are representative of the broad range of naturalised exotic species in Victoria.

Typical Geology Mixed sedimentary

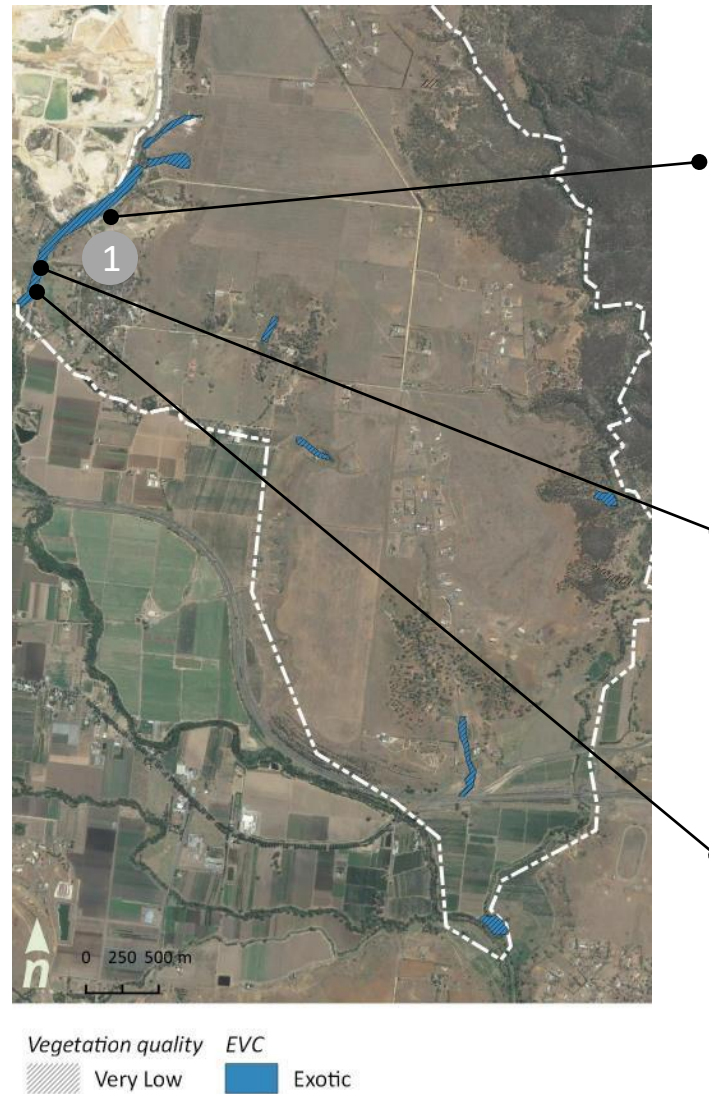
Typical river style Anthropogenic channel

Frequently encountered species site 1

Asparagus asparagoides Asparagus fern, *Brassica sp.* Brassica, *Cynara cardunculus subsp. flavescentis* Artichoke Thistle, *Ehrharta erecta var. erecta* Panic Veldt-grass, *Galenia pubescens var. pubescens* Galenia, *Juncus acutus subsp. acutus* Spiny Rush, *Marrubium vulgare* Horehound, *Nassella neesiana* Chilean Needle Grass, *Nassella trichotoma* Serrated Tussock, *Oxalis pes-caprae* Soursob

In addition to the diverse range of exotic species this reach also contains areas planted with non-indigenous native species including Eucalypts and Acacias. Isolated patches of high density, high biomass robust exotic species such as *Arundo donax* Giant Reed were observed (image 3). This section has a number of grade control structures (Image 2) to reduce erosion and potentially minimise the effects of sedimentation from the adjoining quarry

Observed cover abundance. Overstorey 6-25% Mid-storey 6-25% Ground-storey 50-75%



Exotic vegetation

Status NA

Description. Exotic vegetation is highly variable across the study site in both composition and structure. Some locations have a near continuous cover of mid and ground-storey species with an intermittent overstorey comprising exotic trees, planted native species and occasional examples of mature indigenous tree species. Where soils are shallow or absent and where grazing pressure is intense (particularly by rabbits) tree and shrub growth is reduced. Exotic grasses and annual broadleaf species may dominate.

Frequently encountered species site 2, 3 and 4

Arctotheca calendula Capeweed, *Asparagus asparagoides* Asparagus Fern, *Bromus catharticus* Prairie Grass, *Cenchrus clandestinus* Kikuyu, *Cirsium vulgare* Spear Thistle, *Conyza sp* Fleabane, *Cynara cardunculus subsp. flavescentis* Artichoke Thistle, *Cynodon dactylon* Couch, *Galenia pubescens var. pubescens* Galenia, *Lycium ferocissimum* Boxthorn, *Nassella neesiana* Chilean Needle Grass, *Nassella trichotoma* Serrated Tussock, *Opuntia stricta* Common Prickly-pear, *Oxalis pes-capre* Soursob, *Physalis hederifolia* Physalis, *Plantago lanceolata* Ribwort, *Rubus fruticosus spp. agg.* Blackberry, *Schinus molle* Peppercorn, *Solanum linnaeanum* Apple of Sodom

The diversity of exotic ground-flora species at these three sites was particularly high. Exotic species occupied vacant niches in response to soil disturbance and rabbit grazing. *Lycium ferocissimum* Boxthorn was observed at all three sites, providing habitat for some native species as well as harbouring rabbit and foxes.



Vegetation quality EVC
 Very Low Exotic

Frequently encountered species site 5 and 6

Asparagus asparagoides Asparagus Fern, *Ehrharta erecta var. erecta* Panic Veldt-grass, *Galenia pubescens var. pubescens* Galenia, *Juncus acutus subsp. acutus* Spiny Rush, *Lycium ferocissimum* Boxthorn, *Marrubium vulgare* Horehound, *Nassella neesiana* Chilean Needle Grass, *Nassella trichotoma* Serrated Tussock, *Opuntia stricta* Common Prickly-pear, *Oxalis pes-capre* Soursob, *Phalaris aquatica* Toowoomba Canary-grass, *Schinus molle* Peppercorn.

Ground-flora exotics dominated these sites with minimal occurrence of Boxthorn and Peppercorn being the exception.



Seasonal Herbaceous Wetlands (SHW)

Status critically endangered under the Australian Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act).

Description

Seasonal herbaceous wetlands are freshwater systems which are usually inundated by winter and spring rainfall events. These wetlands then dry out completely and may be dry for many consecutive years in drought and low rainfall periods. Seasonal herbaceous wetlands have an open structure dominated by herbs (grasses, sedges and forbs) that are adapted to seasonally wet or waterlogged conditions. Woody cover in the form of trees and shrubs is largely absent or may occasionally be a sparse component of these systems.

Assessment methodology

SHW were not observed during field assessments. This vegetation type was not identified by Melbourne Water as a specific item for investigation. However a desk top assessment was conducted which indicated areas where SHW may occur. The desktop assessment identified that the most likely habitat for SHW occurred on private land. This assessment was constrained to riparian areas largely on public land and was unable to access private land. Modelled imagery has differentiated artificial and natural waterbodies. Future investigations into the presence of SHW in the study area should investigate areas mapped as natural wetlands as a first priority. A sample of artificial wetlands could be conducted to field test the accuracy of the modelled data for the presence of SHW.

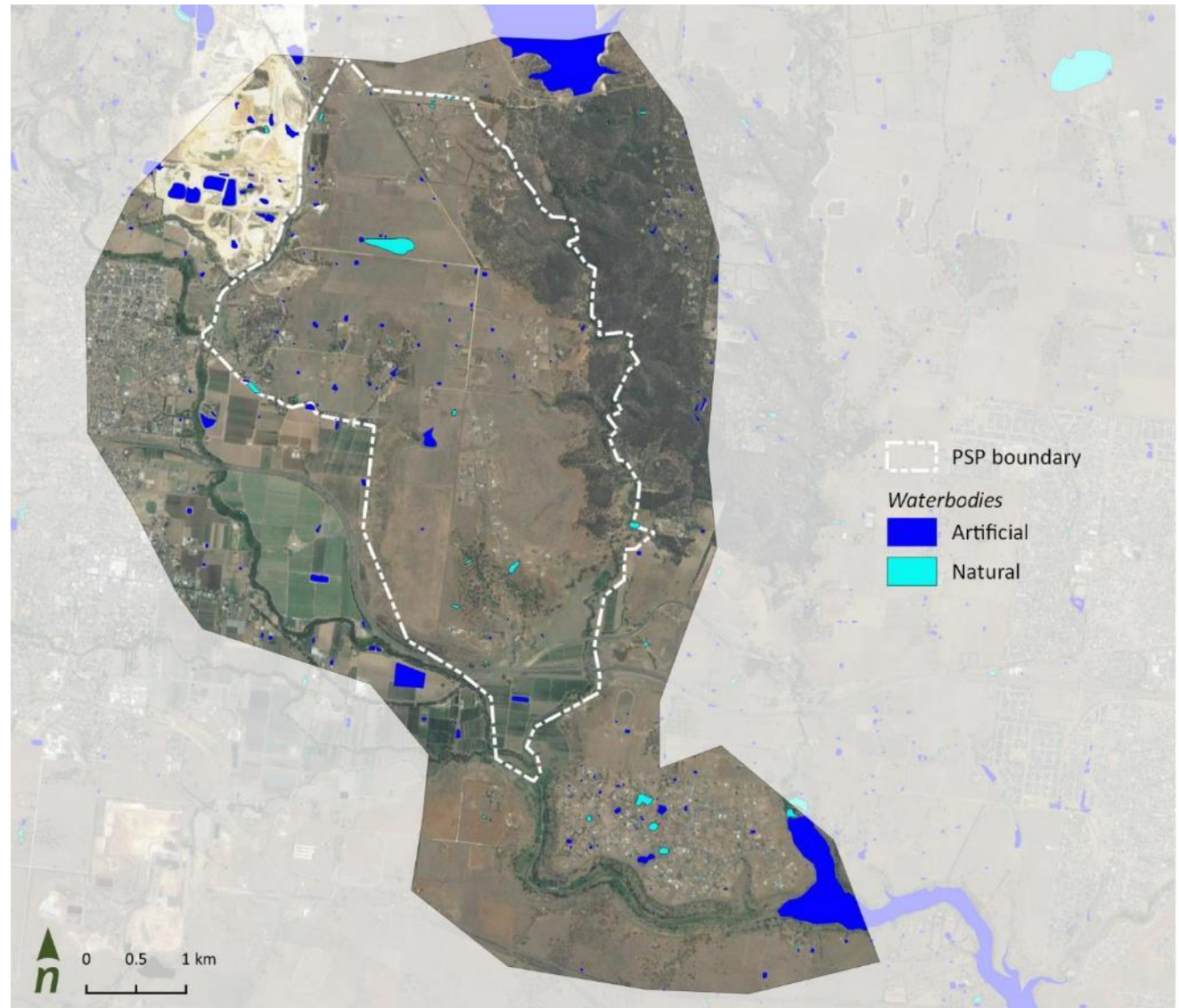


Figure 14. Natural and artificial wetlands throughout the study area

Seasonal Herbaceous Wetlands (SHW)

Status critically endangered under the Australian Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act).

Expression of characteristics during survey time

The relatively dry conditions during the survey period and preceding months meant that the likelihood of SHW developing during this survey event was low. Future survey events focusing on the locations identified in the desktop assessment may detect SHW if conditions are wet enough.

Threats likely to affect the persistence of SHW in the survey area.

The survey location is intensively managed for cropping and has low density rural subdivision within it. These features may result in the degradation of SHW that might occur within the study area.

Threatening process observed and potential impacts

- Cropping
- Cultivation, herbicide and fertilisers
- Grazing via biomass removal, pugging, potential introduction of exotic species and eutrophication
- Changed hydrology due to drainage for semi-rural subdivisions
- Exotic flora from agriculture and urban areas
- Sedimentation and nutrient changes due to increased rural subdivision.

Recommendation

Future investigations to conduct on-ground surveys in areas of private land where modelling suggests the potential for SHW expression in wet years.

DWELP has developed a methodology for determining the presence and describing features of SHW ecology.

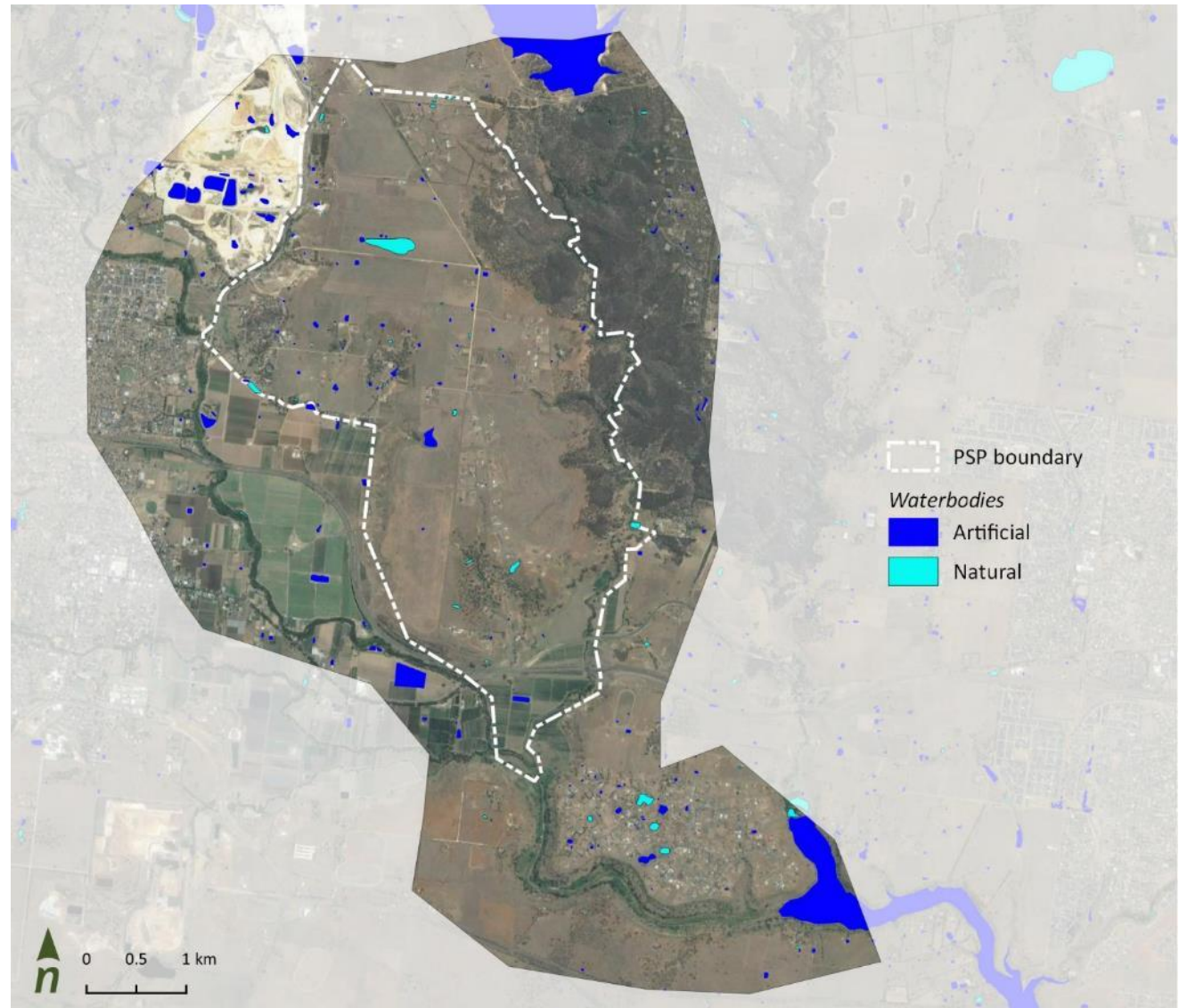


Figure 15. Natural and artificial wetlands throughout the study area

Seasonal Herbaceous Wetlands (SHW)

Key Factors for determining SHW (Pappas et al. 2016)

Landscape context

- Flat plains grading into slopes, below 500 m elevation
- Associated soils are generally fertile, poorly draining clays derived from a range of geologies
- Typically occur in rainfall zones with a winter seasonal rainfall pattern (wet winter/low summer rainfall), extending into a uniform seasonal rainfall pattern at the edge of its range
- Mean annual rainfall is usually 400 to 800 mm per year but can be lower at the northern edge of its range
- Occur on isolated drainage lines or depressions

Hydrology

- Water regime is seasonal: wetlands are typically inundated during winter-spring and subsequently dry out by late summer (in drought periods however, they may be dry for many years)
- Rainfall is the main water source (these wetlands are not dependent on overbank flooding from riverine systems)

Water properties

- Salinity of the water is fresh to slightly brackish (mostly in the range 0 to 1000 mg/L but can be up to 3000 mg/L), typically exhibiting a progressive increase in salinity as wetlands dry)

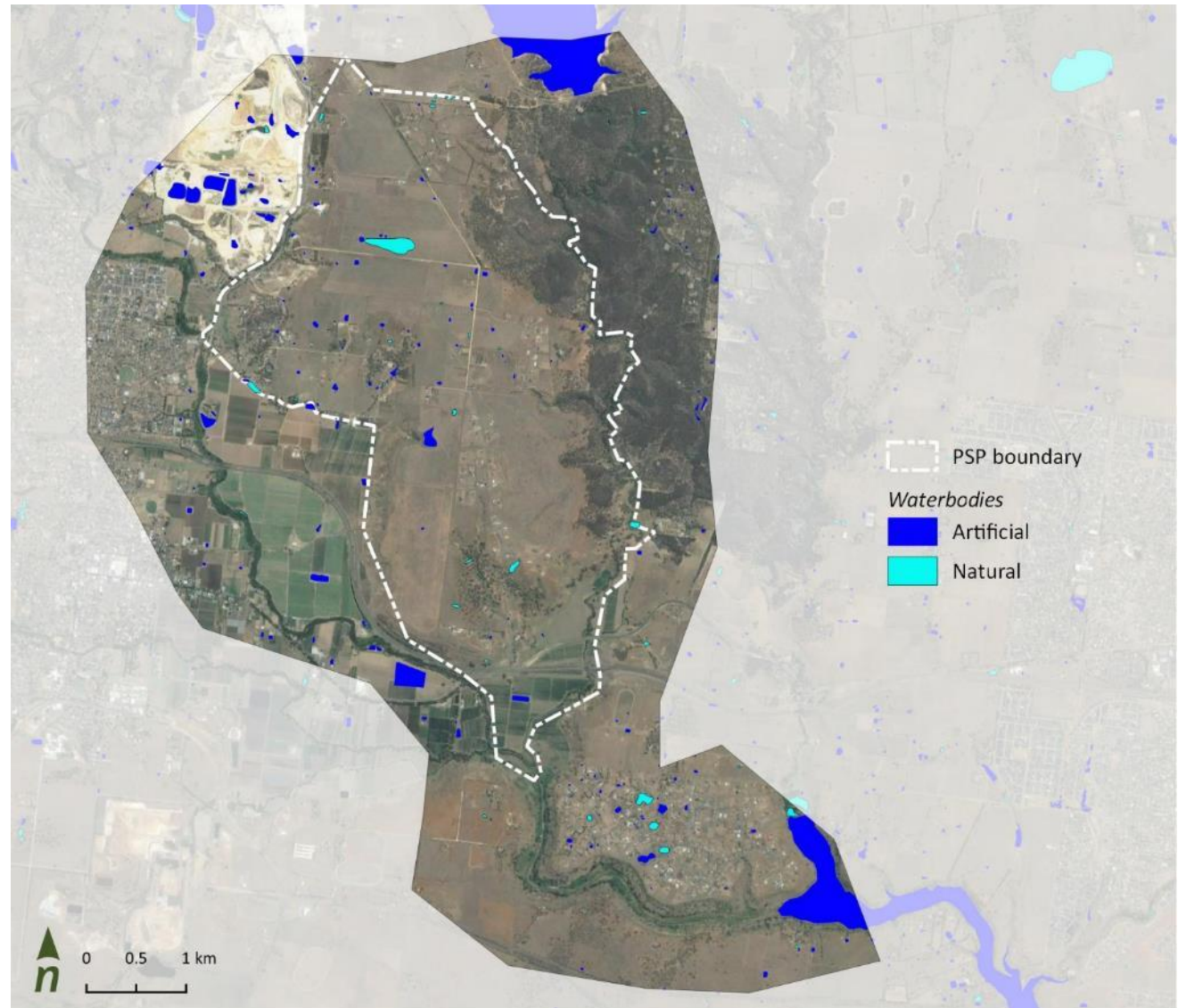


Figure 16. Natural and artificial wetlands throughout the study area

Seasonal Herbaceous Wetlands

Key Factors continues

Biota

- Trees and shrubs are sparse to absent. When present, they mostly occur as fringing or scattered individuals and their cover accounts for no more than 10% across the wetland
- Vegetative cover is dominated by a ground layer of native wetland graminoids (grasses and sedges) and/or native wetland forbs
- Graminoids that are present often include one or more of the following taxa: *Amphibromus spp.*, *Carex tereticaulis*, *Deyeuxia spp.*, *Glyceria spp.*, *Lachnagrostis spp.*, *Poa labillardieri*, and *Rytidosperma duttonianum* (other graminoid taxa may also occur, though are not necessarily common)
- At least one native wetland forb species must be present (preferably more) after the ecological community is inundated
- The suite of forbs that may occur within the ecological community's range is variable and potentially large
- Freshwater algae often are present when the wetland is wet or has been recently wet
- Characteristic fauna that may be associated with the ecological community include invertebrate groups that are temporary water specialists
- The types of fauna present can be highly variable and is dependent on the inundation history, current conditions and other factors

Condition

- 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.

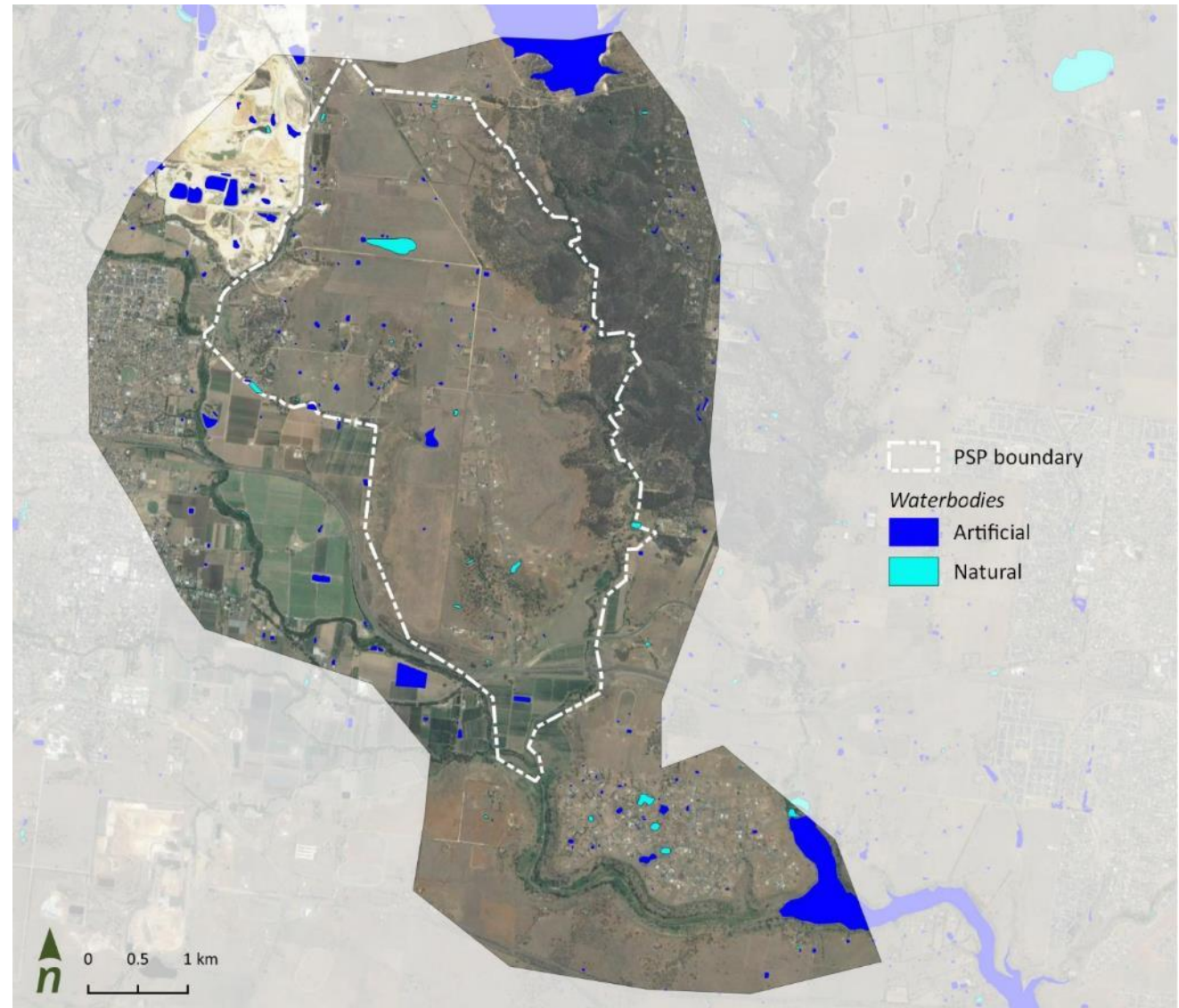


Figure 17. Natural and artificial wetlands throughout the study area

Significant species. Status, distribution and threats.

Six significant species were located on waterways or in escarpment vegetation adjacent to riparian areas.



Species	<i>Acacia rostriformis</i> Bacchus Marsh Wattle
Status	Vulnerable
Distribution	Locally abundant throughout the study area as an understorey to Grey Box
Community	Generally occurs within Rocky Chenopod Woodland EVC 64
Threats	Herbivores, woody weeds and interrupted recruitment regime

(Image b; VICFLORA online)



Species	<i>Amyema linophylla subsp. orientalis</i>	Buloke Mistletoe
Status	Vulnerable	
Distribution	Highly restricted in the study area with only a single individual located on a large Buloke in escarpment above the Werribee River	
Community	Confined to Escarpment Shrubland EVC 895	
Threats	Absence of or insufficient recruitment of host species due to herbivores especially rabbits	

(Image a and b; VICFLORA online)

Significant species and their conservation status



Species	<i>Austrostipa breviglumis</i> Cane Spear-grass
Status	Rare
Distribution	Scattered within the Pyrites Creek catchment of the study area in small patches of 10s to 100s of individuals
Community	Observed within Rocky Chenopod Woodland EVC 64 within the streamside zone, where vegetation condition is high.
Threats	Herbivores, exotic groundflora, interrupted recruitment regime and changes to streamside geomorphology due to increased erosive power.



Species	<i>Eucalyptus baueriana subsp. thalassina</i> Werribee Blue-box
Status	Endangered
Distribution	Locally common through the study area along the Pyrites creek both along and above the riparian interface. Common along the Werribee River between escarpment shrubland vegetation but above the niche where Red Gum is the dominant riparian species.
Community	Stream Bank Shrubland EVC 851 on the Pyrites Creek and Creekline Grassy Woodland EVC 68 on the Werribee River.
Threats	Herbivores and interrupted recruitment regime due to browsing or inappropriate fire regime and changes to streamside geomorphology due to increased erosive power.

Significant species and their conservation status

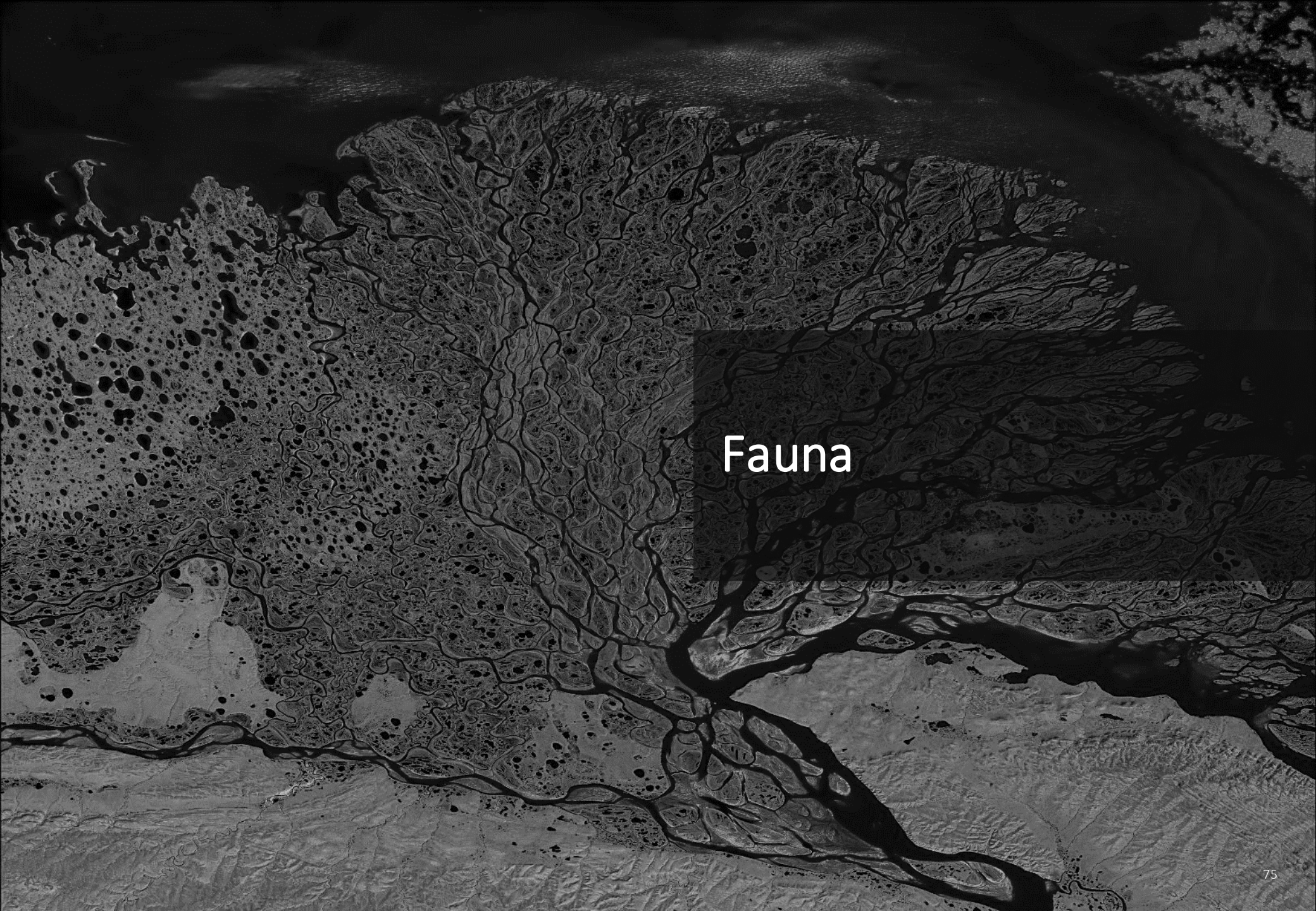


Species	<i>Nicotiana suaveolens</i>	Austral Tobacco
Status	Rare	
Distribution	Scattered on exposed rocky escarpments and slopes	
Community	EVC 64 Rocky Chenopod Woodland, EVC 175 Plains Grassy Woodland, EVC 895 Escarpment Shrubland	
Threats	Herbivores, weed competition (particularly exotic ground-flora) and interrupted recruitment due to browsing or inappropriate fire regime	

Austral Tobacco (Image; VICFLORA online)



Species	<i>Rhagodia parabolica</i>	Fragrant Saltbush
Status	Rare	
Distribution	The Victorian range of this species is limited however it is common throughout the study area. It occurs in sites that are degraded as well as sites of higher ecological value. Its capacity to persist in a range of conditions may be due to its high tolerance to drought and possibly its ability to withstand or resist browsing pressure. It must be stressed that while this species occurs in low quality vegetation this occurrence does not impinge on its conservation significance. Quality takes into account the range of factors contributing to an assessment of vegetation on a waterway but does not diminish significance.	
Community	EVC 64 Rocky Chenopod Woodland, EVC 895 Escarpment Shrubland and Stream Bank Shrubland EVC 851	
Threats	Non-permitted clearance/smothering by fill, trampling/grazing, competition with woody weeds and exotic ground-flora reducing recruitment	

An aerial photograph of a river delta, showing a complex network of channels and distributaries. The land is characterized by a dense pattern of small, dark, circular features, likely depressions or ponds. A semi-transparent rectangular box is overlaid on the right side of the image, containing the word "Fauna" in white text.

Fauna

Significant fauna species and their conservation status

Assessment

A desk top assessment for significant fauna records was conducted for the study area. Records from the Victorian Biodiversity Atlas (VBA) were reviewed and collated. VBA records were assessed to identify when the most recent records of significant species were made.

A search of additional local information was undertaken via Nature Share. This data source identified nearby populations of significant species and provided further detail of their recent presence locally. Nature Share records for the study area were cross checked with VBA records.

Victorian and national status was noted for all significant species. This assessment identified 12 species of significance recorded with in the study area. 11 species are birds with one moth species, the Golden Sun Moth listed. The Golden Sun Moth is listed as critically endangered via the EPBC Act. This species does not rely on riparian habitat. It has been recorded on the grassy plains on the Merrimu Plateau.

Of the 11 bird species, nine may be associated with habitat identified on waterways but are not exclusively dependant upon riparian habitat. Two species, Black Falcon and White-throated Needletail are free ranging transient aerial predators not associated with riparian habitat.

Limitations

A specific assessment or on ground search for significant fauna was not conducted as part of this evaluation. Anecdotal observation were recorded. Of these Scarlet Honeyeater and Peregrine Falcon were of local interest.

Figure 17 Scarlet Honeyeater observed on the flats of the Pyrites Creek

(Source; WikiCommons <https://www.flickr.com/photos/gregbm/5449916547/>)

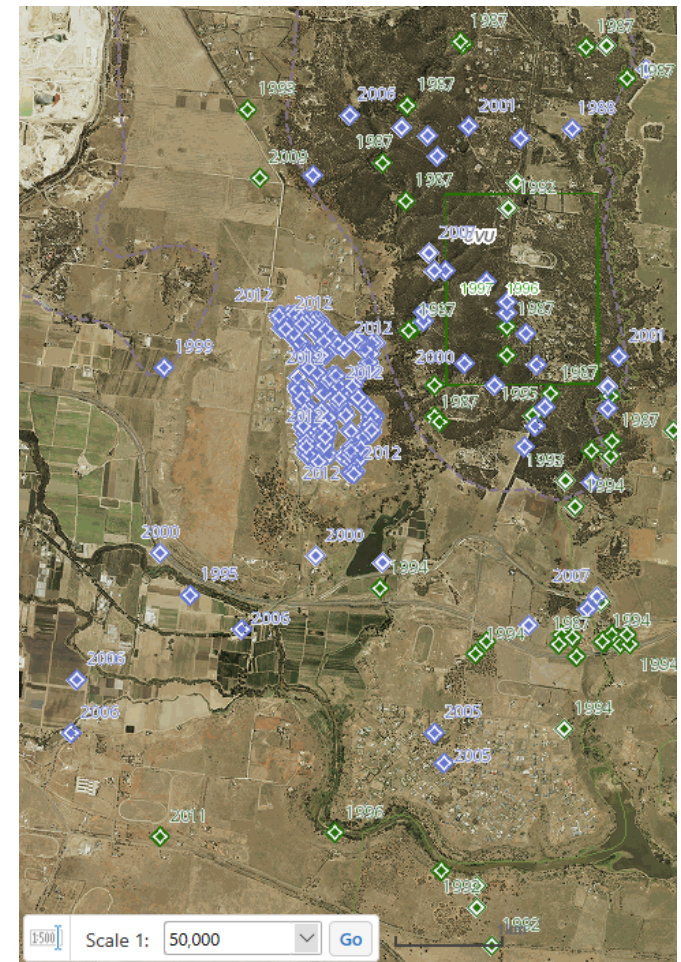


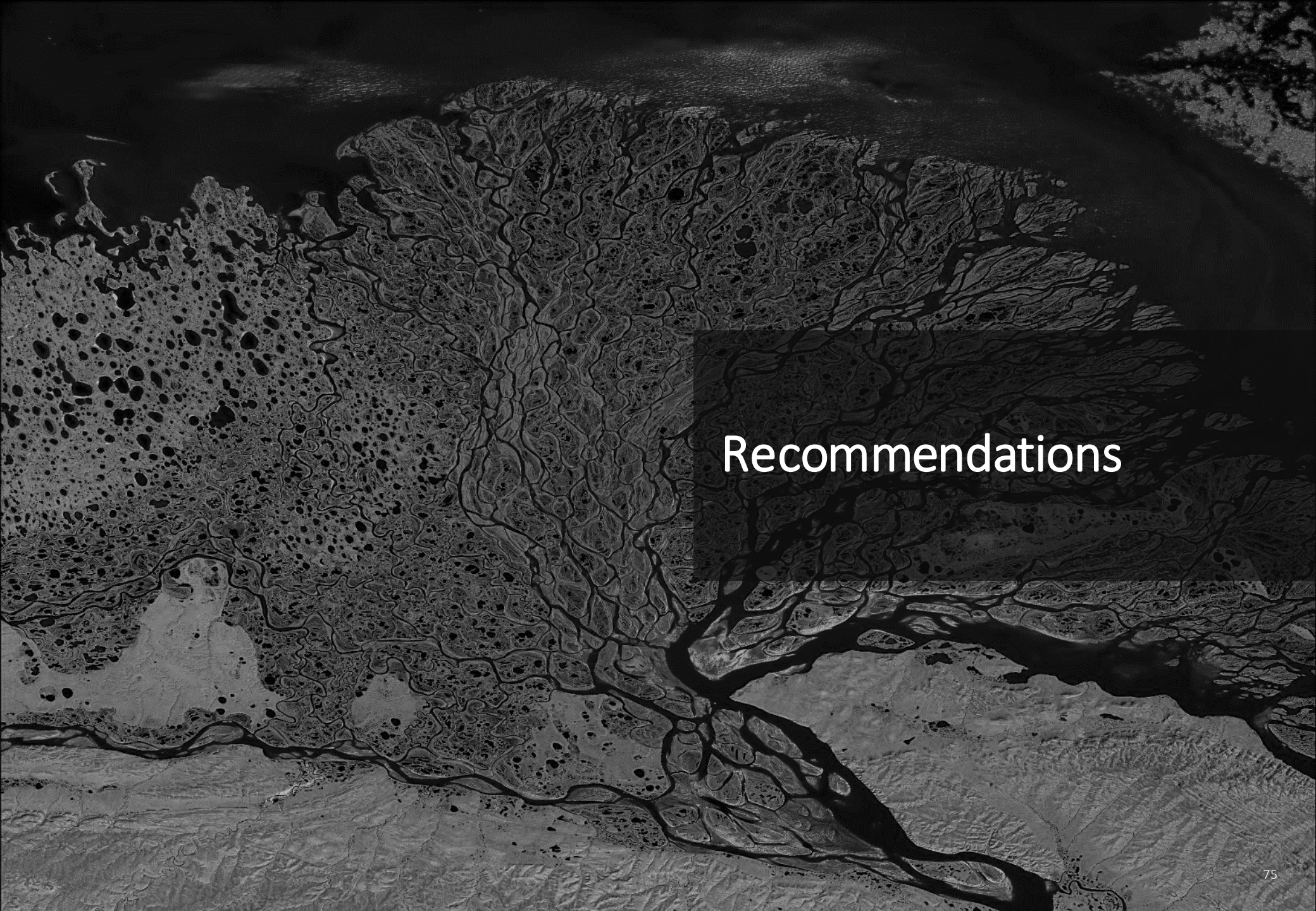
Figure 18. Fauna species records from Nature Print

Significant fauna species and their conservation status

Scientific name	Common Name	FFG Description	Victorian advisory list	EPBC status
<i>Ninox connivens connivens</i>	Barking Owl	Listed	Endangered	
<i>Falco subniger</i>	Black Falcon		Vulnerable	
<i>Chrysococcyx osculans</i>	Black-eared Cuckoo		Near threatened	
<i>Climacteris picumnus victoriae</i>	Brown Treecreeper (south-eastern ssp.)		Near threatened	
<i>Calamanthus pyrrhopygius</i>	Chestnut-rumped Heathwren	Listed	Vulnerable	
<i>Oreica gutturalis gutturalis</i>	Crested Bellbird	Listed	Near threatened	
<i>Stagonopleura guttata</i>	Diamond Firetail	Listed	Near threatened	
<i>Synemon plana</i>	Golden Sun Moth	Listed	Critically endangered	Critically Endangered
<i>Melanodryas cucullata cucullata</i>	Hooded Robin	Listed	Near threatened	
<i>Nycticorax caledonicus hillii</i>	Nankeen Night Heron		Near threatened	
<i>Chthonicola sagittatus</i>	Speckled Warbler	Listed	Vulnerable	
<i>Hirundapus caudacutus</i>	White-throated Needletail		Vulnerable	

Significant fauna; habitat suitability within riparian areas

Common Name	Comment	Common Name	Comment	Common Name	Comment
Barking Owl	Potential to use habitat on waterways and riparian areas as part of home range. Recorded in 1994 within the study area (VBA) and in the Long Forest between 1984 and 2002 (Hewish et al 2006). Habitat is suitable along riparian areas for this species with large trees potentially providing nesting sites.	Chestnut-rumped Heathwren	Potentially resident or transient through the study area and may occasionally utilise riparian habitat within the assessment area. This species tends to utilise dense shrublands, shrubby woodlands and heathlands often in coastal locations. Possibly vulnerable to predation at nesting due to extensive edge effect of surrounds. Observed nearby in Brisbane Ranges	Golden Sun Moth	Detected within the study area on Merrimu Plateau. Not observed in riparian areas, although timing was not appropriate for the detection of this species which has a short emergence period. Suitable habitat may occur on the flats of the Pyrites Creek although this species is largely observed more frequently on plains and grassy woodland locations. An appropriately timed survey on riparian flats for this species may be conducted as part of additional surveys on the Merrimu plateau.
Black Falcon	Transient, recorded at Western Treatment Plan, Werribee. May utilise part of the study area during foraging but not a species that is specific to or dependant on riparian areas.	Crested Bellbird	Generally an arid species with potential to utilise habitat within the study area which is the periphery of its typical range.	Hooded Robin	Potentially resident or transient through the study area and may utilise densely vegetated riparian habitat within the assessment area. Often further inland, recorded in woodland to the north east of the study area.
Black-eared Cuckoo	This species may utilise woodlands and adjacent habitat with sufficient cover. Generally a summer visitor and more common in Northern Victoria. May be resident in Long Forest in some seasons, this species tends to utilise woodland habitat, it is not riparian dependant.	Diamond Firetail	Potentially resident or transient through the study area and may utilise riparian habitat within the assessment area. Often observed in woodland habitat. Populations observed at Eyensbury and Brisbane Ranges. Populations are widespread but in low numbers.	Speckled Warbler	Likely resident through the study area with consistent observations made in the past. May utilise riparian habitat within the assessment area. Nearest other population Brisbane Ranges.
Brown Treecreeper (south-eastern ssp.)	Potentially resident and/or transient through the study area and may utilise riparian habitat within the assessment area. Brown Treecreeper have been observed in modified open creek-line habitat in Long Forest. Nearest other population at Eyensbury and previously in the Brisbane Ranges.	Nankeen Night Heron	Potentially resident or transient through the study area and may utilise vegetated riparian habitat along Werribee River and permanently wet areas at Melton Reservoir. Not observed on the Pyrites creek during this investigation but habitat may be suitable.	White-throated Needletail	A transient species foraging for insects in large fast moving flocks often associated with summer storm fronts. Not a riparian dependant species.

An aerial photograph of a river delta, showing a complex network of channels and distributaries. A semi-transparent rectangular box is overlaid on the right side of the image, containing the word "Recommendations" in white text.

Recommendations

Key findings

The assessment of the environmental values of the Merrimu PSP area has identified a number of significant values and landscape and water management challenges. The landscape is unstable, actively eroding in many locations, and is highly sensitive to changes in the flow regime of the tributary waterways draining the plateau which comprise much of the study area.

The central findings from the assessments are summarised on this page, with commentary and recommendations on the following pages.

1. Most waterways have very steep bed slopes
2. Most waterways are actively eroding under current conditions.
3. All waterways are sensitive to hydrological change – increased flows will increase the rate and magnitude of erosion.
4. Slope alone is not sufficient to quantify sensitivity to change.
5. Increased sensitivity to change can be quantified by inclusion of slope, vegetation, soil type and hydrology.
6. Sodosols of the Werribee Formation in particular are highly dispersive
7. Geomorphic sensitivity to change is a key driver of biological sensitivity to change
8. Six vegetation communities (EVCs) identified all are vulnerable or endangered.
9. Six species of conservation significance were observed.
10. Extensive buffers and setbacks to protect public land reservations are highly desirable to minimise future impacts
11. Additional vegetation assessments are required on the Merrimu plateau to document values beyond the scope of this riparian focused investigation.
12. Additions to the Long Forest Nature Conservation Reserve should be a considered as an option to protect environmental and biodiversity values.
13. There is a strong correlation between geomorphic sensitivity and vegetation sensitivity.
14. Vegetation adjacent to developed land was of low or very low quality.
15. Vegetation in public reserves is of moderate and high quality.
16. **All waterways flowing from the developable areas of the Merrimu PSP will flow over soils of high erodibility. Each of these waterways visited are already experiencing erosion and increases in flow associated with urbanisation will exacerbate this erosion**



Developing management interventions

At the outset of the project we planned to use the *tributary filtering* approach we developed with Melbourne Water and applied in the environmental assessment and drainage planning work we undertook for the Sunbury PSPs. The tributary filtering approach was an integral component of the holistic approach to drainage design in the steep, escarpment-dominated landscapes of Jacksons and Emu Creeks. Essentially, the tributary filtering approach identified the appropriate type of engineering and geomorphic analyses needed to provide for increased post-urbanisation flows down the steep tributaries without triggering or accelerating erosion.

Given the similar landscapes in the Merrimu study area we anticipated applying the tributary filtering approach to guide the management recommendations for the Merrimu PSP environmental study. However, the detailed field assessment described in this report clearly illustrate that the landscapes in Merrimu are fundamentally different to the Sunbury.

In particular the dispersive nature of the soils, rapidly and actively eroding tributaries, and observed, extreme, sensitivity to any increase in flow mean the tributary filtering approach is not appropriate.

As described previously, any increase in flow to sensitive waterways is likely to increase the scale and rate of erosion, so management recommendations need to focus on:

- Minimising change to hydrology that results in any increase in flow rates or concentration of stormwater discharge.
- Increasing the resistance—where feasible—of waterways that will experience an increase in flow (if this is unavoidable).

The landscape sensitivity of the Merrimu PSP area limits the scope of waterway management options, as discussed on the following page.



Possible management interventions

The scope of this study was to assess and describe vegetation as well as geomorphologic processes and identify locations of geomorphic sensitivity to changes in hydrology. The objective was to generate a baseline to provide an indication of the likely geomorphic response to hydrological change. The interaction between geomorphic processes and response of vegetation to potential geomorphic change was considered. From this assessment the following options are proposed

1. Do not develop the plateau. This may be a challenging option given the process that has been undertaken to date. However the sensitivity of the landscape means that this option should be considered. Even without development there will be an ongoing decline in natural waterway values due to the combination of pressures on biological value and geomorphology.
2. Development proceeds but with significantly higher requirements on engineering and water management standards than are currently applied to development such as;
 - a. All additional runoff is retained on site and reused, infiltrated or evaporated and/or;
 - b. All additional runoff bypasses the tributary waterways and is disposed off site either;
 - i. below the escarpment in the more robust downstream reaches of Pyrites Creek and/or
 - ii. Via temporary storages and pumped to other storages such as Merrimu Reservoir

All options would require a comprehensive risk assessment and cost benefit analysis that considers current risks and identifies future management and maintenance costs.

We have developed these options in light our investigation. In the development and consideration of these options it should be noted that:

- There are likely to be other options that we have not considered. Given the sensitivity of the landscape identified in this preliminary study a comprehensive evidence base is required to support future decisions and options. A detailed geotechnical engineering assessment of the extent of highly sensitive geological types, their distribution, composition and susceptibility is needed to support future evaluations.
- Additional options may be advanced by Melbourne Water leading workshops with other agencies to develop other novel solutions.
- The feasibility of the options has not been tested. A significant amount of work will be required (outside the scope of this study) to ascertain if any or all of the options are feasible. Detailed commentary on the risks associated with these options is required.
- Consideration was given to the potential for a large and wide rock-lined channel or channels constructed on Flanagan's waterway. Initial feedback was that this option is unlikely to be supported by Melbourne Water.



Recommendations

Recommendation 1: Development does not proceed on the plateau without the prior identification of a clear pathway for the management of risks associated with development and associated changes to the hydrologic regime. This pathway could be informed by;

- i. A risk assessment within an agreed risk management framework.
- ii. Further detailed assessments including the development of integrated surface water and groundwater models for the current and for any proposed future development scenarios.
- iii. Further exploration and development of options consistent with the risk framework and detailed assessments

The unique sensitivity of this site to changes in hydrology have been highlighted in this investigation. The development of a comprehensive risk management framework, to assess potential management intervention, was not requested as part of this investigation. However a framework has been identified as a tool that would enable further assessment of options.

A risk management framework could consider waterway characteristics and/or processes that increase the likelihood of erosion events. The framework may consider but not be limited to factors such as landform, sensitivity, failure modes and event scenarios.

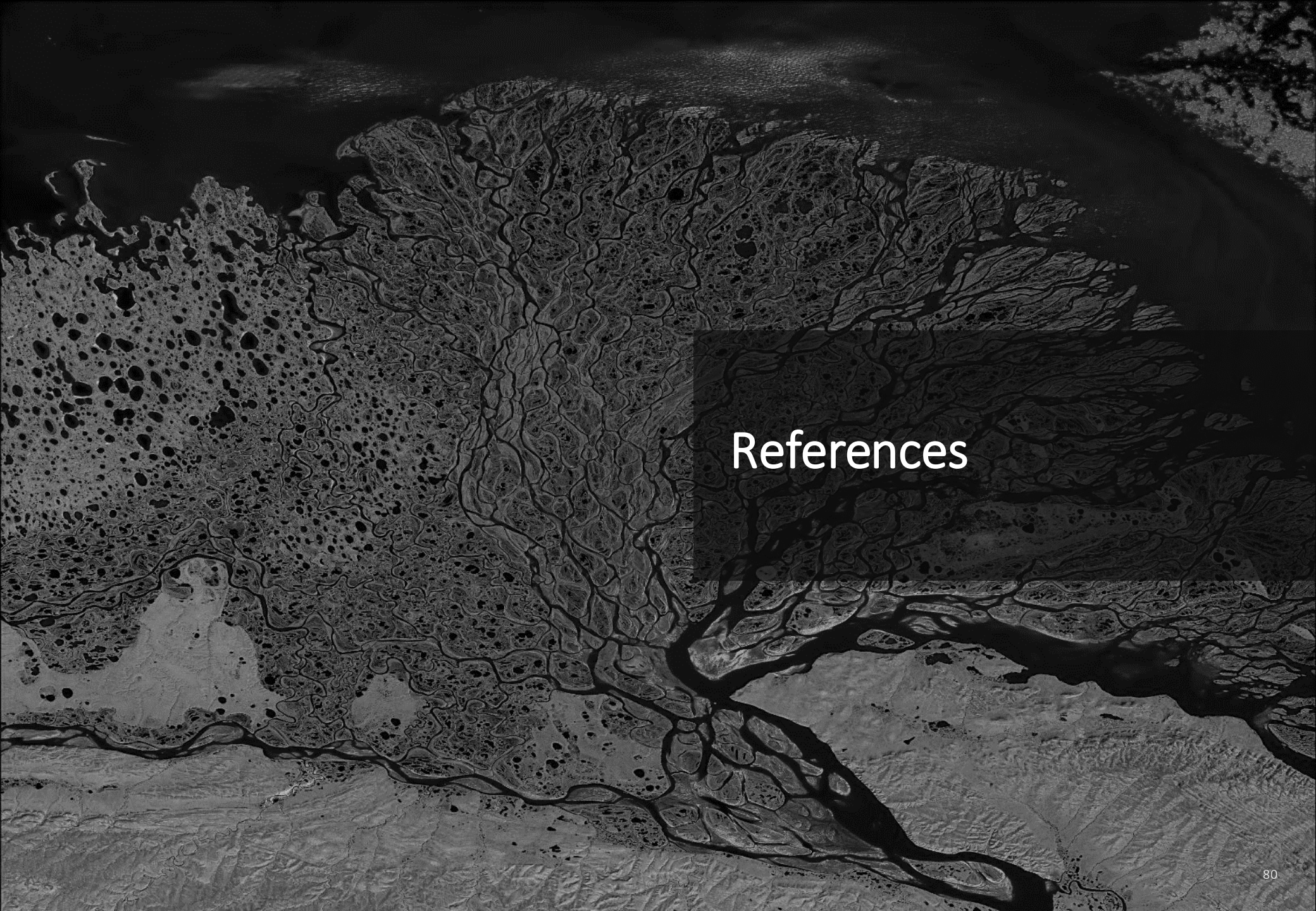
Recommendation 2: Conduct further evaluation of novel approaches and options

Further evaluation of novel approaches and options, potentially in workshops situations, to be developed in consideration of risk assessment approach as proposed above.

Recommendation 3: Conduct additional ecological assessment for values that may be influenced by options in response to recommendations 1 and 2.

Further ecological assessment should focus particularly on SHWs on private land in an appropriate season when SHW flora is expressed. This critically endangered community requires further consideration and needs to be included in any risk management scenario that addresses natural values, geomorphic sensitivity and socio-economic impacts.



An aerial photograph of a river delta, showing a complex network of distributaries branching out from a main river into a body of water. The land is characterized by a dense, intricate pattern of small, dark, circular features, possibly ponds or depressions. A semi-transparent rectangular box is overlaid on the right side of the image, containing the word "References" in white text.

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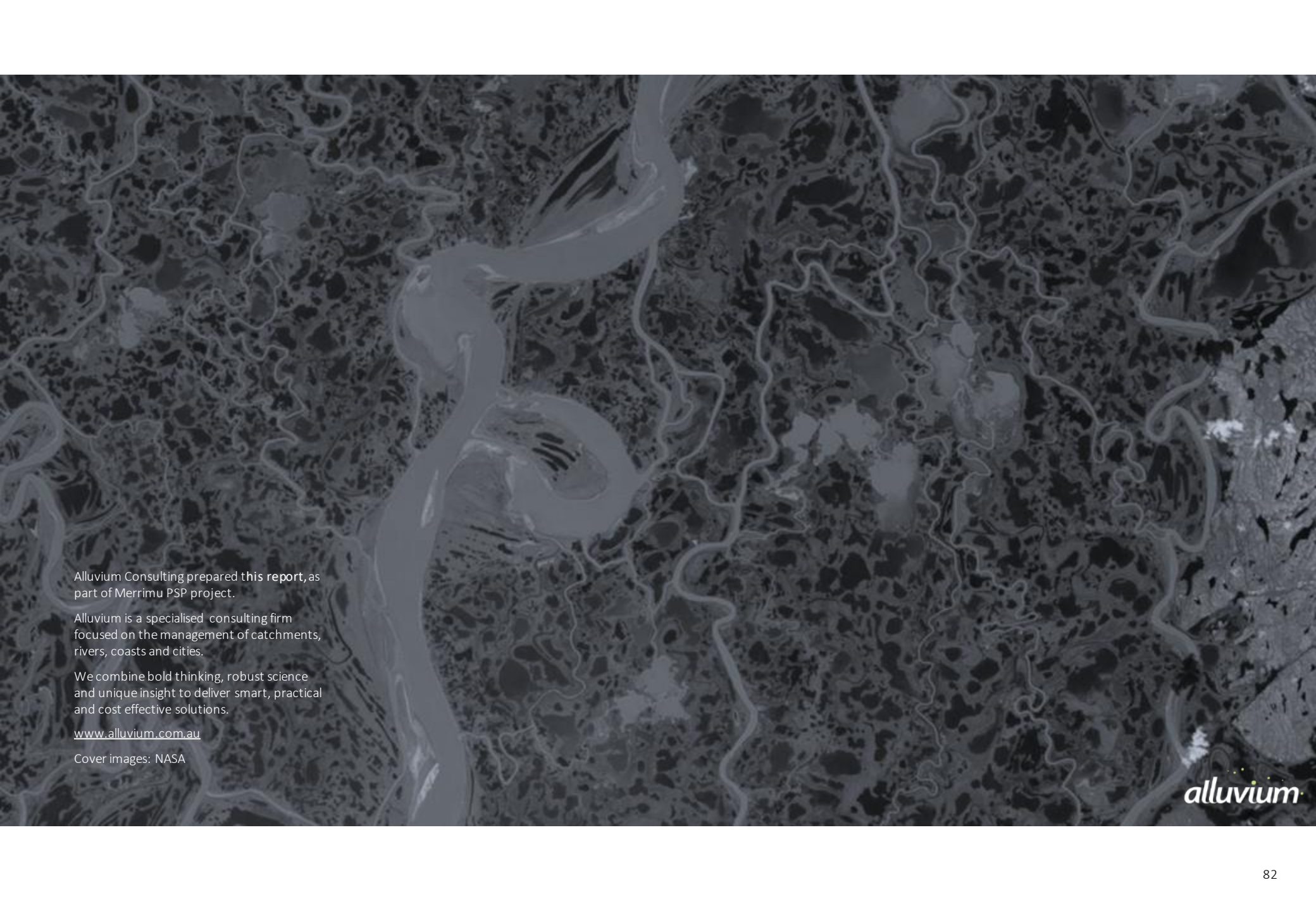
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Alluvium Consulting prepared **this report**, as part of Merrimu PSP project.

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