



FINAL REPORT:

Bannockburn Catchment Assessment

May 2020

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Abbreviations

Alluvium	Alluvium Consulting Australia Pty Ltd
AEP	Annual Exceedance Probability
AHD	Australian Height Datum
ARI	Average Recurrence Interval
BPEM	Best Practice Environmental Management (for Urban Stormwater)
CCMA	Corangamite Catchment Management Authority
DELWP	Department of Environment, Land, Water and Planning
ESO	Environmental Significance Overlay
EVC	Ecological Vegetation Classes
GPSC	Golden Plains Shire Council
IWM	Integrated Water Management
LSIO	Land Subject to Inundation Overlay
MUSIC	Model for Urban Stormwater Improvement Conceptualisation
SEPP	State Environmental Protection Policy
VPA	Victorian Planning Authority
VPP	Victorian Planning Provisions

1 Introduction

The Victorian Planning Authority (VPA), along with the Golden Plains Shire Council, is working to investigate the growth areas in Bannockburn. Together they are investigating the opportunity of extending the growth area beyond what was previously identified. The VPA has engaged Alluvium Consulting (Alluvium) to build upon the drainage assessment Alluvium completed for the Bannockburn South West Precinct in 2019, and undertake a catchment assessment for a larger potential Bannockburn Growth Plan Investigation Area.

The purpose of this initial catchment assessment is to assess the area at a larger scale than was previously done and to identify opportunities for stormwater management across the growth area. Further drainage assessments will be required in the future to accurately locate and size drainage assets to ensure stormwater quantity and quality objectives are met. In the first instance this assessment will help guide growth planning for the area. This assessment is not intended to be a comprehensive drainage assessment.

1.1 Location

The growth area investigation area is located 70 km south west of Melbourne's CBD and covers approximately 1027.6ha. The precinct is bounded by Bannockburn-Shelford Road to the north, the railway to the south, Burnside Road to the east and Old Base Road to the west. The growth investigation area consists of privately-owned landholdings for farm use and open paddocks. The Bannockburn South West precinct sits within this investigation area. A small portion of the South West precinct is expected to be zoned for industrial development, whilst the remainder of both this precinct and the greater investigation area is expected for residential development. Bruce's Creek flows south through the area as well as several small tributaries. To the north the area is bounded by existing residential areas. A site context map is provided in Figure 1.

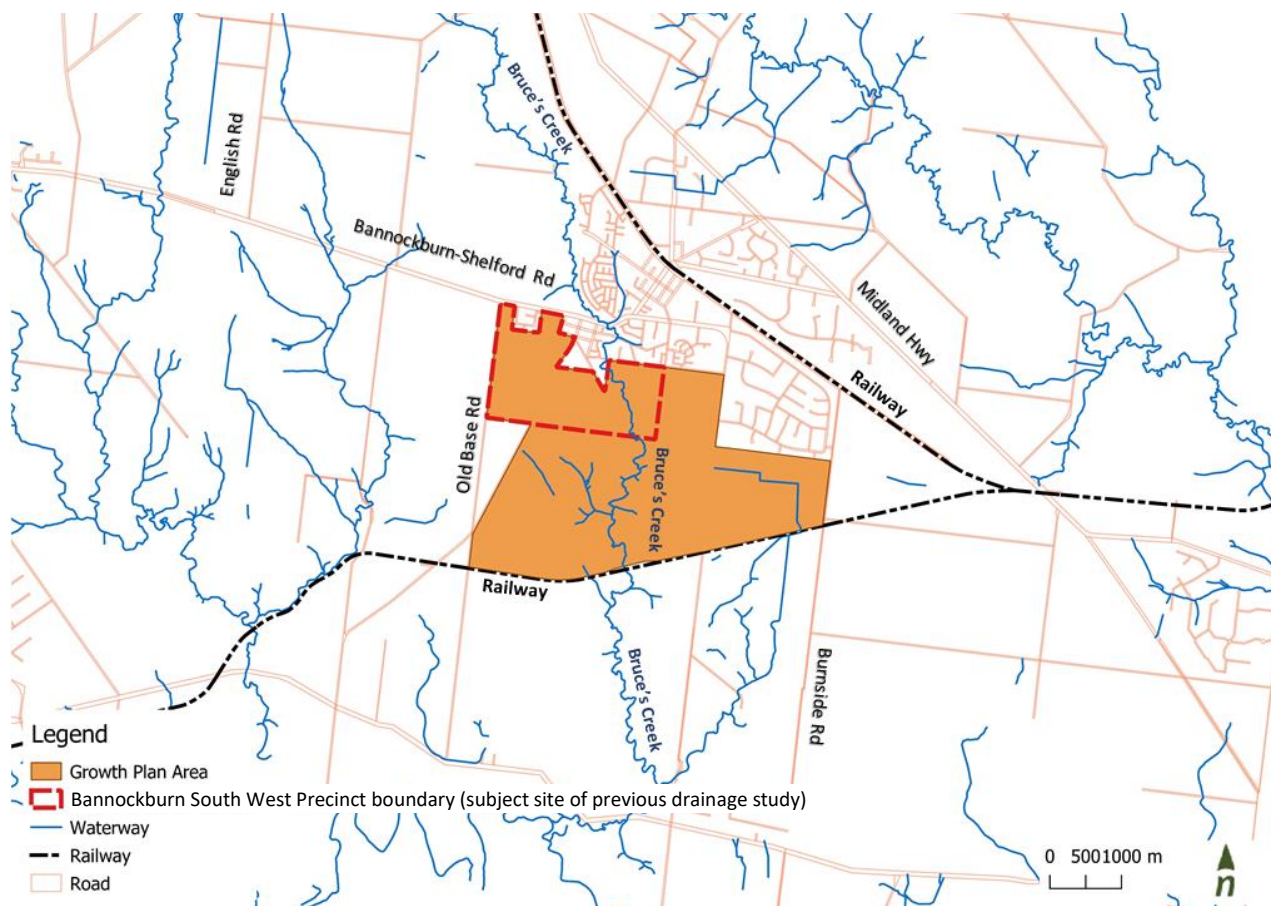


Figure 1. Bannockburn Growth Plan Investigation Area context map

1.2 Project background

The *Bannockburn Urban Design Framework* (2011) was developed for the Shire to provide strategic direction for land use planning in Bannockburn. The framework included the identification of the Bannockburn South West precinct (see Appendix A) within the overall growth area.

The VPA and Shire are investigating whether the growth boundary should extend further south, bounded by the rail line. The extended proposed growth boundary, as well as the investigation area that is the subject of this assessment is shown in Figure 2.

There is no proposed urban layout for this investigation area given the early stages of planning. The investigation area outside of the south west precinct (which has a proposed urban layout) will be assumed to be general residential for the purposes of this investigation.

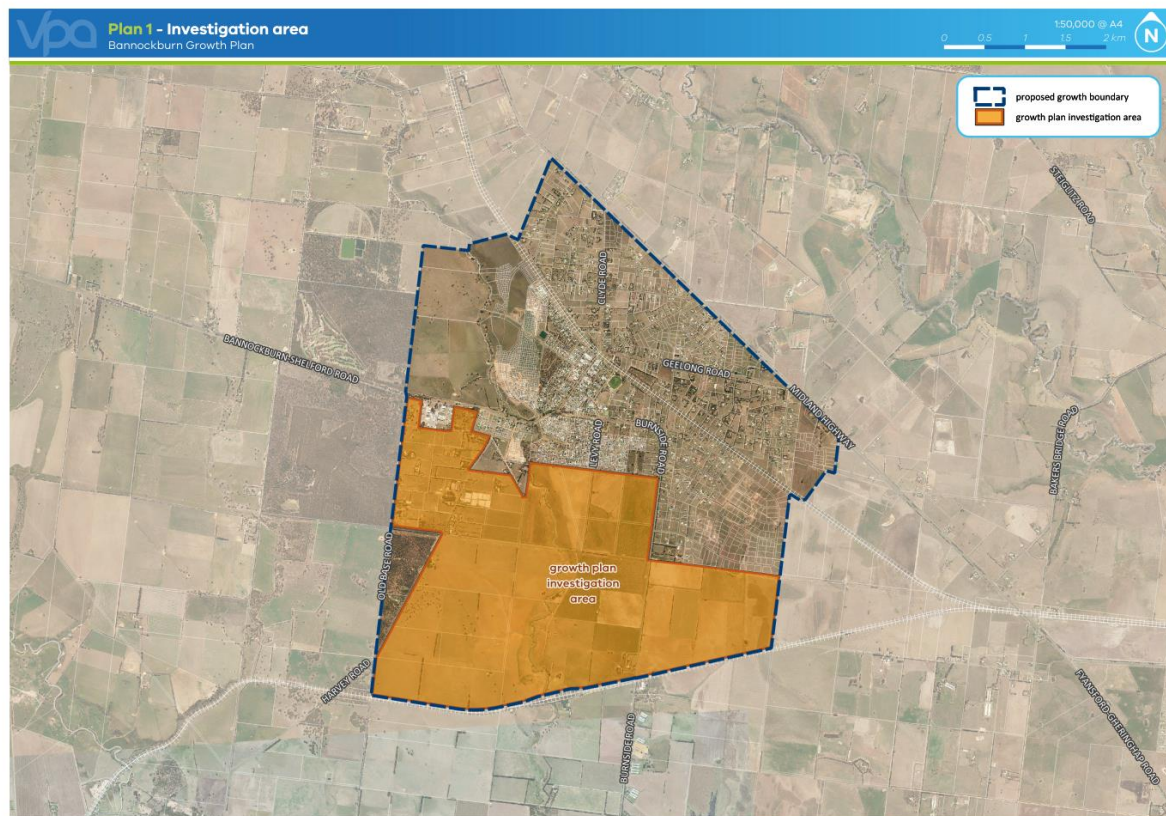


Figure 2. Bannockburn Growth Plan Investigation Area (VPA, 2020)

1.3 Project objectives

The objectives of this assessment are:

- To build upon the work Alluvium completed for the South West Precinct in 2019.
- To provide a high-level understanding of drainage catchments and potential stormwater management treatments within the Growth Plan Investigation Area (Figure 1).
- This Catchment Assessment will inform the identification and staging of precincts for residential and employment growth in the Growth Plan.
- More detailed planning work, including drainage work, will take place in the future at the precinct structure planning stage.

The purpose of the catchment assessment is to assess the area at a larger scale than was previously done and to identify opportunities for stormwater management across the growth area. For example, the area south of

the Bannockburn South West precinct is now identified as a potential growth area, and this may therefore influence the outfall options that were previously identified. The assessment will identify the most likely locations for assets, and an approximate sizing.

The study area will encompass the entire Growth Plan Investigation Area but will acknowledge and respond to any necessary implications associated with drainage catchments upstream and downstream of this area.

This assessment does not include detailed hydrologic or hydraulic modelling, which will be required in a drainage assessment.

1.4 Stakeholders

There are numerous stakeholders to this site. The stakeholders associated directly with surface water management include:

- Victorian Planning Authority (VPA)
- Golden Plains Shire Council
- Barwon Water
- Corangamite Catchment Management Authority (CCMA)
- DELWP Water

Stakeholders have not been directly consulted for this assessment by Alluvium, but inputs from them have been included.

1.5 Strategic context

Any drainage assessment should be guided by a range of strategies and policies at state, regional and local government scales. Key documents have been summarised here and are linked to proposed assets later in the report.

State Government

Water for Victoria – The Victorian State Government’s Water for Victoria (2016), and particularly Chapter 5: Water’s role in resilient and liveable cities and towns, provides guidance on the State government’s desired outcomes for urban water management, which are centred around safe secure and affordable water supplies, effective and affordable wastewater systems, effective stormwater management, healthy and valued landscapes, reflecting community values through place-based planning

DELWP IWM Forums – The IWM Framework for Victoria is designed to help local governments, water corporations, Catchment Management Authorities, Traditional Owners and other organisations work together to ensure the water cycle efficiently contributes to the urban liveability of the region, with communities at the centre of decision making. The Bannockburn South West Precinct is located within the Barwon IWM Forum area. Specifically, the Bannockburn IWM plan is action ‘BR13’ of the Barwon IWM forum.

Barwon Strategic Directions Statement – The Bannockburn IWM plan is identified at one of the 15 priority projects in the Barwon area. The IWM plan aims to consider a wide range of opportunities relating to the water cycle, including stormwater harvesting, Class C recycled water use, stormwater management, WSUD, appropriate growth and enhancing visual amenity of open space and walkability of the towns water assets.

Victorian Planning Provisions: Stormwater management in urban development (clause 53.18) - Recent updates to the VPP in relation to stormwater management include objectives around not only stormwater flow management and pollution reduction, but also applying integrated water management (IWM) principles, amenity and urban cooling. This is in line with the VPA’s sustainable approach, with specific objectives including:

- To encourage stormwater management that maximises the retention and reuse of stormwater.

- To encourage stormwater management that contributes to cooling, local habitat improvements and provision of attractive and enjoyable spaces.

The recent changes extend the BPWM stormwater treatment requirements to all developments beyond residential (i.e. now includes commercial and industrial).

Victorian Planning Provisions: Catchment planning and management (Clause 14.02-15) - requires natural drainage corridors with vegetated buffer zones to be retained along each side of a waterway at least 30 m wide. The CCMA require all development be set outside the 1% Annual Exceedance Probability (AEP) flood extent and / or the 30 m buffer zone – whichever is the greater.

Regional

Barwon Water's Urban Water Strategy 2017 – The Barwon Water urban Water Strategy aims to reuse all treated water from Bannockburn's water reclamation plant either onsite or for irrigation of nearby golf courses, recreate reserves or farmland. Along with surrounding townships, to facilitate greater reuse of recycled water.

Local

Bannockburn Urban Design Framework (2011) – the framework, developed for the Shire, is a key strategic document to guide planning in Bannockburn.

Of relevance to the drainage assessment (excerpts from the report):

- Drainage has been raised as a key concern of the community. Several roads in the town are unsealed and not drained. There is also an ongoing issue to protect Bruce's Creek catchment as much of the drainage outfalls to the Creek.
- The Creek corridor contains remnant vegetation and a diversity of flora and fauna. The Planning Scheme protects this environment via an Environmental Significance Overlay.
- Drainage from residential areas into open space areas and Bruce's Creek to be designed and managed to minimise the volume and speed of run off entering the Creek.
- Framework principles:
 - integrating principles of water sensitive development, and environmentally sustainable design
 - protection of natural systems and significant vegetation

Bruce's Creek Masterplan (Golden plains Shire Council) – The Bruce's Creek Masterplan is centred around establishing the extent of the creek corridor, identifying key connections and linkages from the creek corridor to key features of the Bannockburn township and residential areas. The masterplan identifies that there are areas of remnant vegetation that should be enhanced.

Environment Strategy 2019 – 2027 (Golden Plains Shire Council) – this strategy sets the strategic direction for environmental sustainability in the Shire. The vision is that 'Environmental sustainability underpins life in Golden Plains Shire.'

Of particular relevance to is Theme 3.3 Water Security which sets a vision to 'Protect the ecological health of our waterways and wetlands and facilitates sustainable water use in the GPS community.' The targets that sit under this include:

- Apply appropriate environmental and open space areas in addition to minimum width buffers adjacent to waterways in new development areas.
- Stormwater management meets State environmental protection policy minimum requirements.
- Reduce Council's potable water consumption by 20% by 2027 against a 2018 baseline.

1.6 Background information

For this assessment, the following sources of information have been drawn on:

- Base maps indicating draft development layouts for the South West Precinct (Bannockburn Urban Design Framework)
- VPA provided maps (proposed growth boundary and investigation area, planning overlays, planning zones and constraints map)
- Existing drainage network (Golden Plains Shire Council)
- Aerial imagery (Nearmap)
- Elevation data:
 - 1.0m contour (provided by GPS)
- Watercourses (DELWP)
- Bruce's Creek Masterplan (Golden Plains Shire Council)
- Flood Advice Request – Bannockburn Growth Plan (CCMA, 26 February 2020)

2 Existing conditions

2.1 Current land use

The existing site is within the Farming Zone (Appendix B), which is typically used for agricultural needs. Some title boundaries contain a house, whilst many title boundaries remain as open paddocks (Figure 2). Bruce's Creek flows in a south-westerly direction through the eastern part of the precinct, and eventually outfalls into the Barwon River.

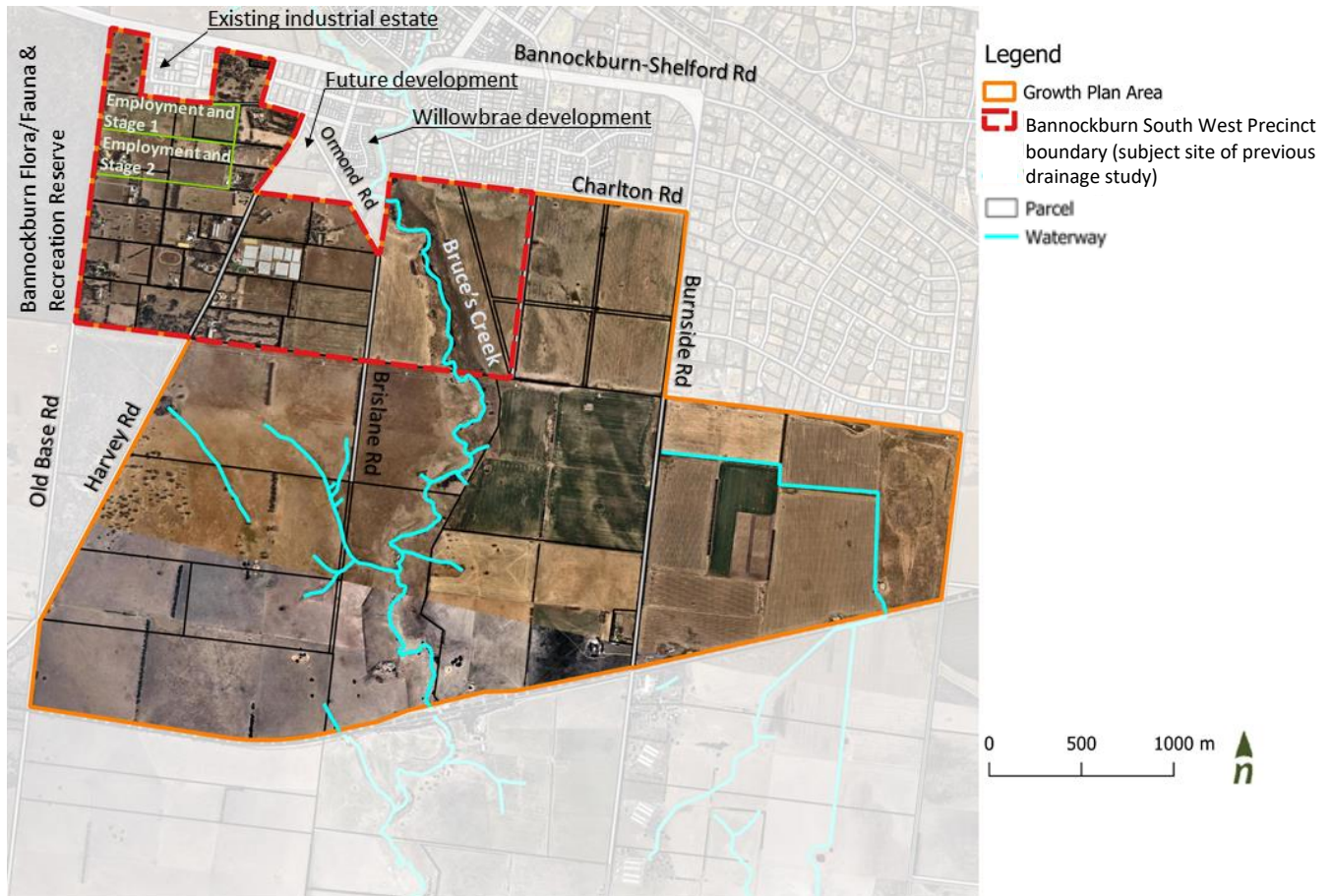


Figure 3. Bannockburn Growth Plan Area

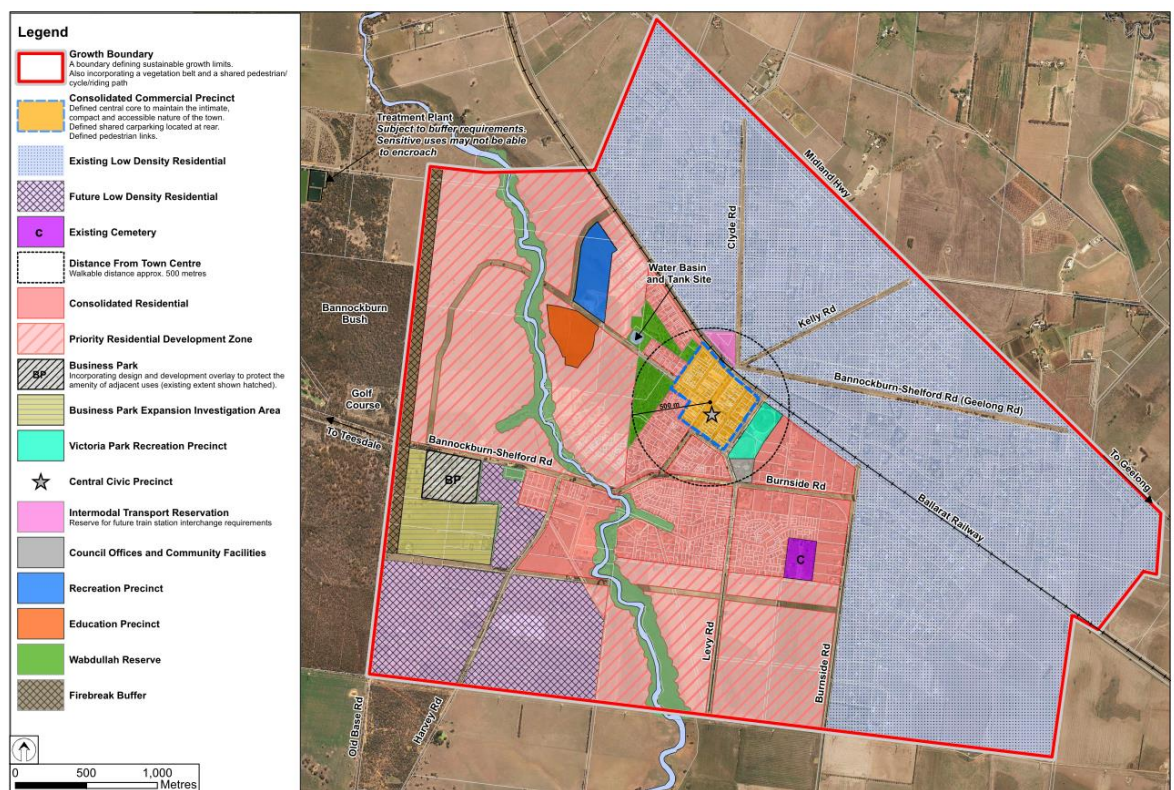
- To the north of the investigation area significant development has occurred in recent years, with the majority being residential development (e.g. the Willowbrae development).
- A small commercial / industrial precinct exists north west of the Bannockburn South West precinct.
- Bannockburn Lagoon is a large pond located to the east of the industrial area. The existing industrial development drains into this lagoon.
- To the west the investigation area is bound by a flora/fauna and recreation reserve.
- West of Old Base Road is Barwon Water land that is used for recycled water irrigation.
- To the south the investigation area is bound by the rail line.
- Environmental Significant Overlays (ESO) and Land Subject to Inundation Overlays (LSIO) exist over Bruce's Creek, and a Bushfire Management Overlay (BMO) covers the western boundary of the precinct (Appendix B).

2.2 Planned future land uses

The site is to be zoned for future residential development and for commercial / industrial use within the Bannockburn South West precinct. The approximate break-downs are as follows:

- 160ha residential
- 40ha industrial (employment land stage 1)
- 40ha employment land (stage 2)

The overall land use breakdown as identified in the Urban Design Framework is shown in Figure 4, and the employment stages are shown in Figure 3 above. The Growth Plan will review the vision established in the Urban Design Framework which may result in changes to the proposed land uses.



Bannockburn Urban Design Framework
Figure 3: Landuse and Activities

Figure 4. Land use and activities for the original growth boundary as identified in the Bannockburn Urban Design Framework (Parsons Brinckerhoff 2011)

Due to the forested parcel to the west, an interface to manage bushfire risk is to be included along the western boundary. This would typically consist of an open grassed section along the extent of the boundary.

For the remainder of the investigation area not covered by this framework, a general residential planned use is assumed (on advice from the VPA). For treatment modelling purposes (i.e. the land use type, areas and associated fraction impervious values adopted), a future general residential density of approximately 500 – 800m² lots will be adopted.

2.3 Topography

Figure 5 shows the topography across the investigation area. Elevation ranges from 63 m AHD along the south eastern boundary of the site near Bruce's Creek, to 107 m AHD at the north western corner of the site. The site generally falls in a south-easterly direction, however there is a small valley falling to the south west corner of the site, and ridge lines along both sides of Bruce's Creek.

The site is generally flat, with grades varying from 0.5-1.5%, however steep escarpments follow Bruce's Creek, with grades varying from 15-35% between the break of slope and the creek bed.

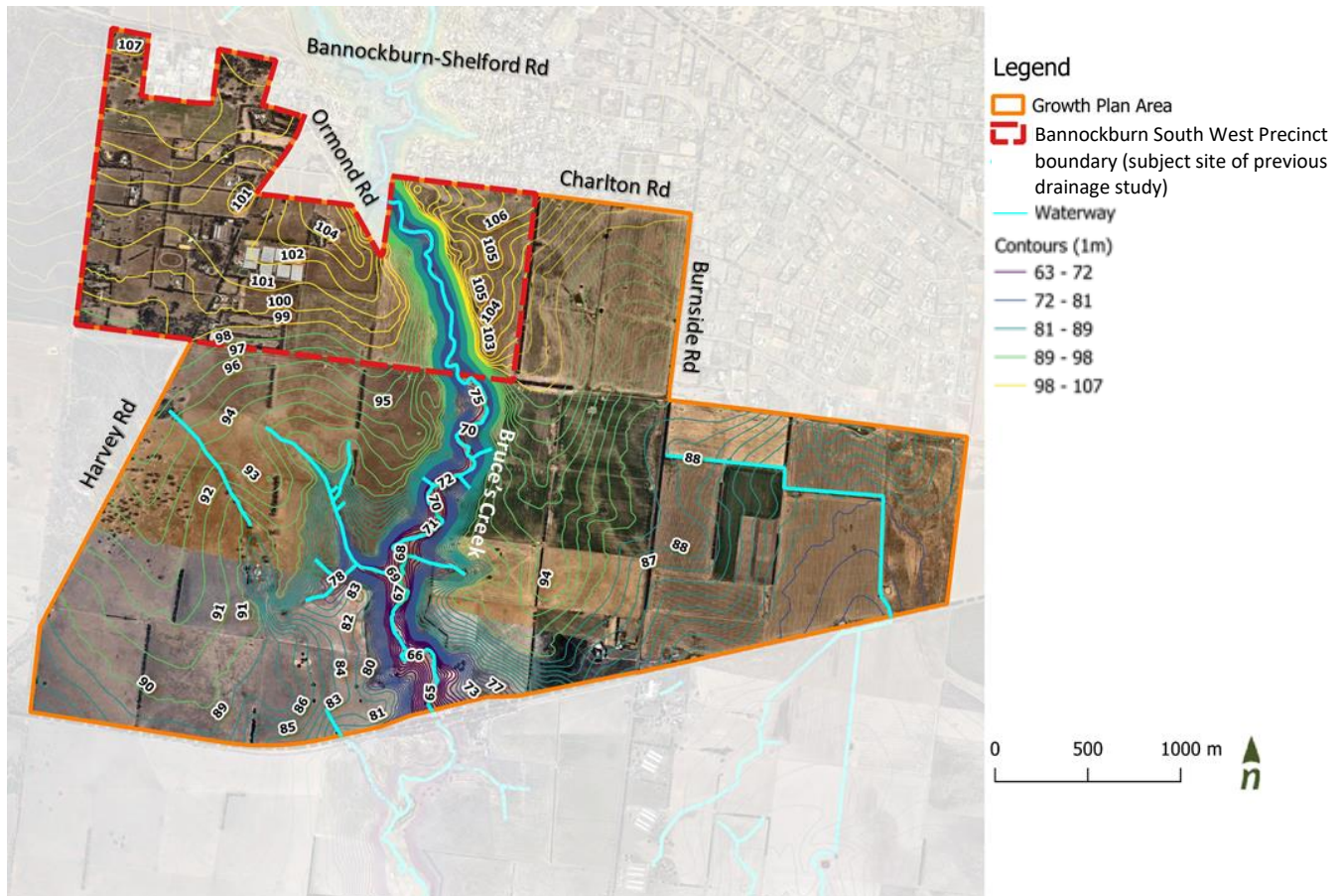


Figure 5. Topography of the Bannockburn Growth Plan Area

2.4 Existing services and infrastructure

As the site is mainly used for agricultural purposes, only local farm drains and dams exist, with swale drains along the frontage of properties along Harvey Road. Sewer and water mains are located within existing developments to the north of the investigation area. A high voltage overhead powerline running in an east – west direction along the southern boundary of south west precinct. The power lines are about 30m south of the precinct boundary.

Along the southern boundary of the investigation area exists a railway running in an east – west direction (Figure 6).

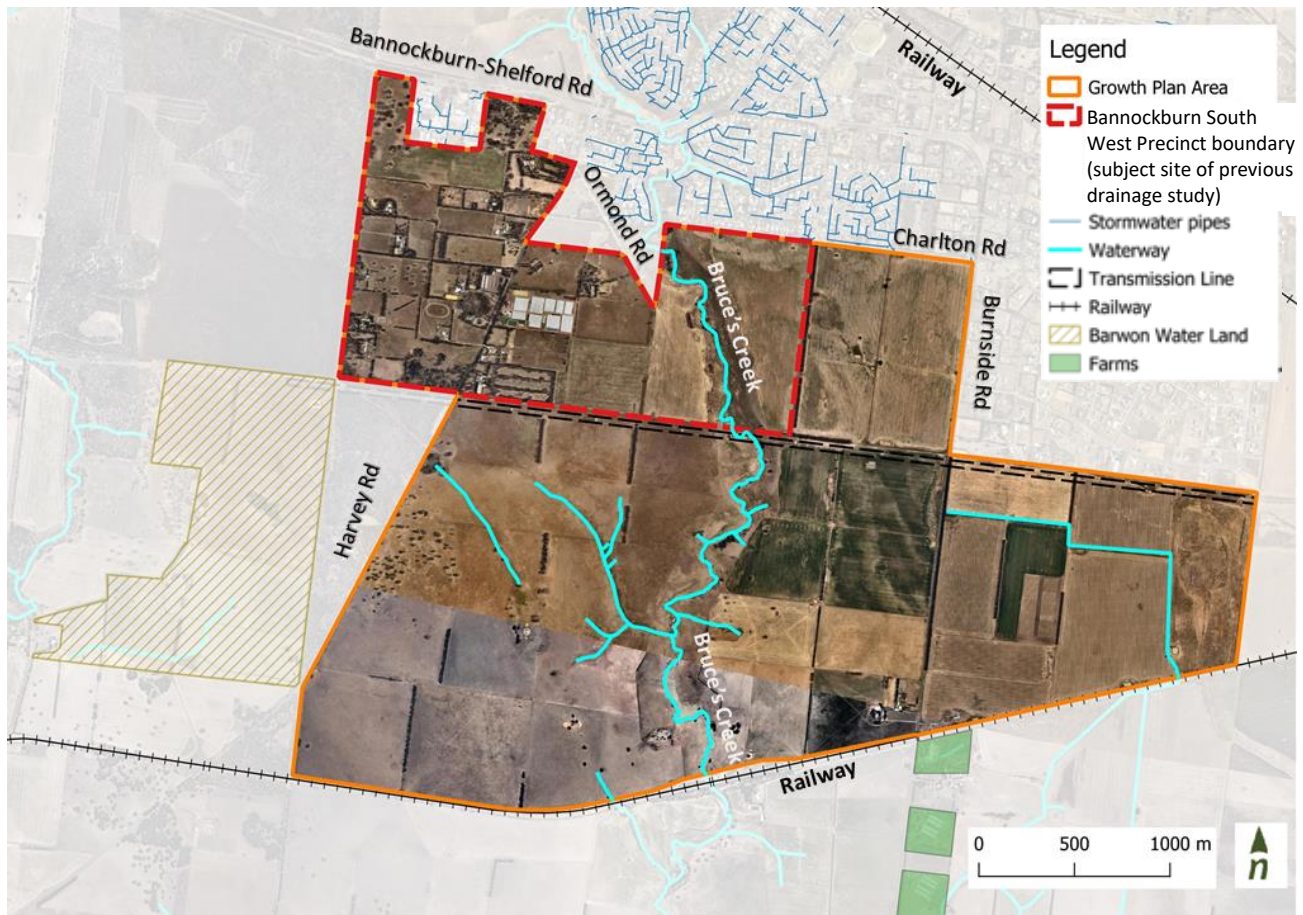


Figure 6. Existing services and infrastructure within the Bannockburn Growth Plan Investigation Area

In July 2018 Barwon Water provided some preliminary servicing advice to the Golden Plains Shire for the future Bannockburn South West precinct. Indicative sewer servicing is shown in Figure 7. This is relevant to the assessment in that proposed drainage should be cognisant of other services so not to interfere.

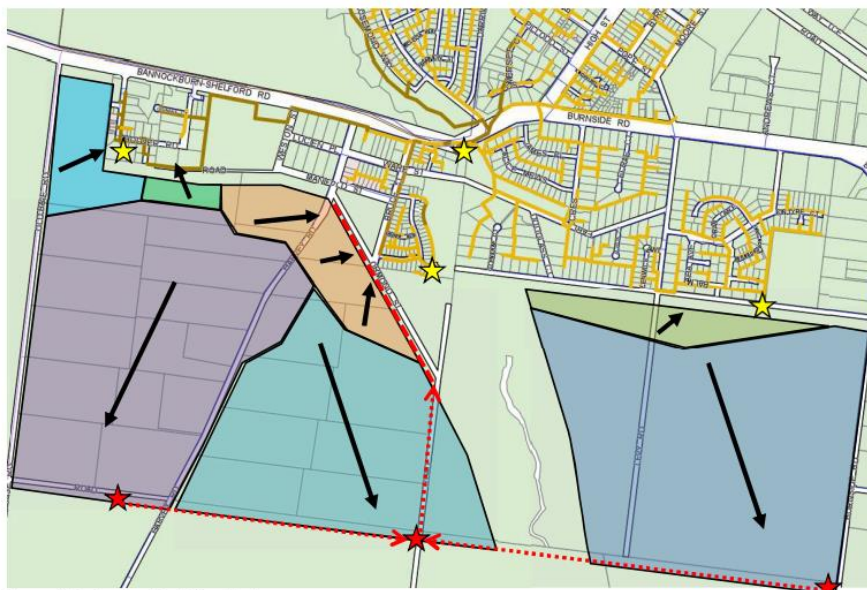


Figure 7. Indicative sewer servicing strategy (proposed pump stations indicated by red star, existing pump stations indicated by yellow star) (Barwon Water 2018)

Barwon Water also indicated that Class C recycled water is available from the Bannockburn Water Reclamation Plant (WRP) located north west of the investigation area, and is transferred to an irrigation site to the south via a pipeline in Old Base Road. Barwon Water have proposed that this water could potentially be used to irrigate open space areas within the development. This should be investigated further considering whether there are sufficient volumes of recycled water to irrigate the open space reliably, whether recycled water and stormwater harvesting could both be adopted (i.e. recycled water ‘topping up’ stormwater storages in dryer times) and the waterway health benefits associated with stormwater harvesting (i.e. the reduction in volume of stormwater entering Bruce’s Creek).

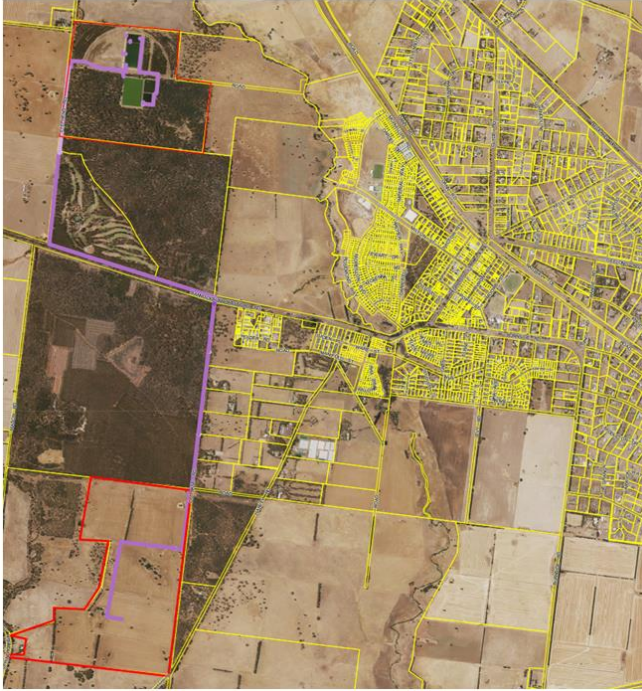


Figure 8. Map showing existing Barwon Water WRP (top left) and recycled water pipeline (purple) to Barwon Water property south west of the precinct (Barwon Water 2019)

Further investigation of the existing services and infrastructure is required in the later stages of design to incorporate any possible design constraints.

2.5 Flooding

The CCMA was contacted by the VPA for flood information and advice for the proposed Bannockburn Growth Plan Area. The CMA reviewed the Draft Issues and Opportunities report and Briefing Note provided by the VPA with regards to the Bannockburn Growth Plan. The report identified two key issues and opportunities with respect to the Bannockburn Growth Area plan which are most relevant to the CMA. These included:

- **Section 7.3.1** Flat topography creates challenges for drainage, with flooding occurring in many areas of the region.
- **Section 7.3.5** Enhance the environmental and recreational opportunities associated with Bruce’s Creek

Bruce’s Creek and a small tributary are identified as designated waterway (Water Act 1989) and sit within the Mid Barwon River Landscape Zone (Figure 9). The CMA recognises Bruce’s Creek as having ecological, cultural and social importance with key threats to this area including encroachment of the waterway within the expanding urban area, degrading water quality, bank erosion and native vegetation degradation. There are several smaller drainage lines also within the area.

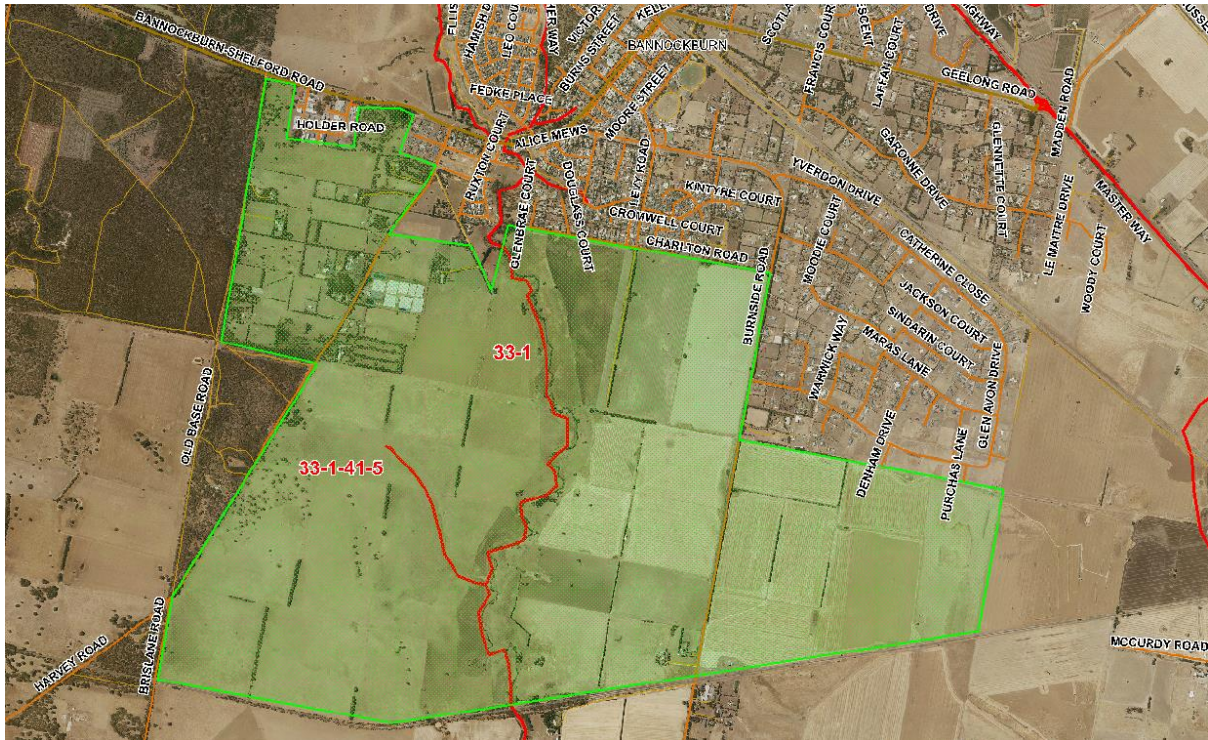


Figure 9. Growth Area (green shaded area) and designated waterway (red line and designated waterway no.) (source: CCMA 2020)

Figure 10 shows the 1% AEP flood extent throughout the investigation area, as established from rain on grid and riverine flood modelling from DELWP. The flood modelling indicates that flooding within Bruce's Creek is contained within the waterway. This is unsurprising given the steep escarpments on either side of the waterway.

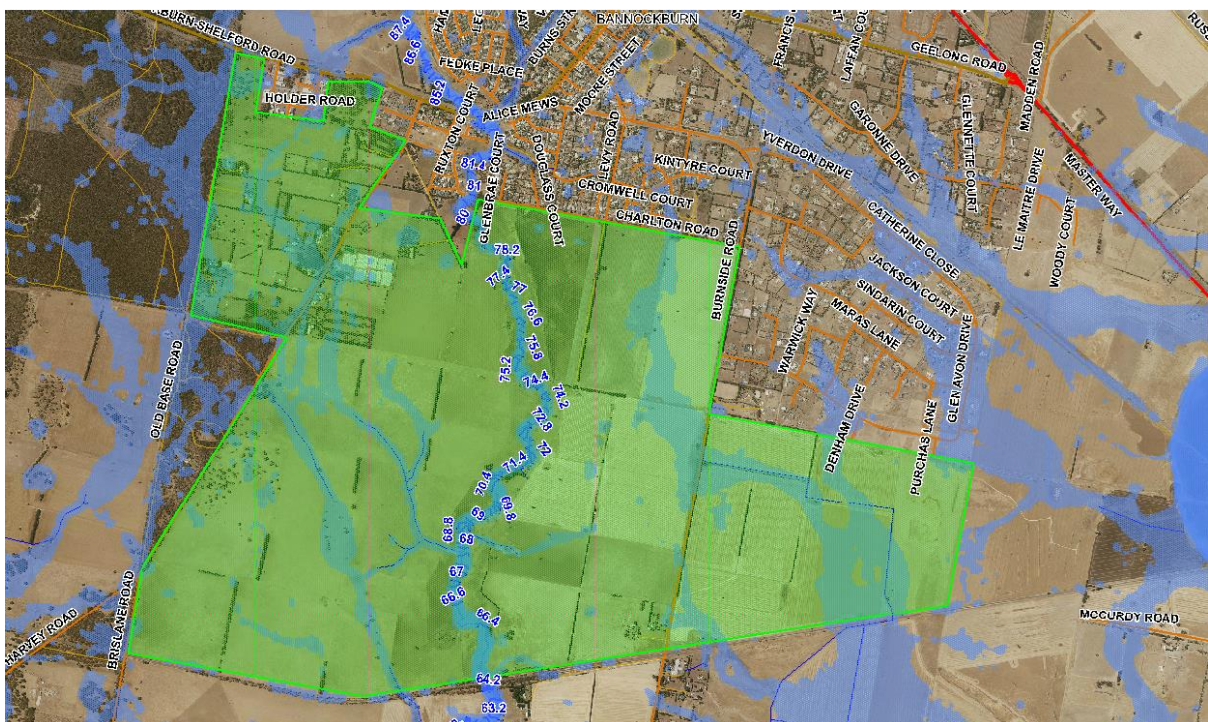


Figure 10. Growth Area (green shading) showing 1% AEP flood extent (blue shading)

The modelling indicates flood risk throughout the investigation area, including

- along the tributaries to the west of Bruce's Creek
- a significant valley line in the south west of the investigation area
- another significant valley to the east of Bruce's Creek which starts to the north of the investigation area, and runs all the way south past the train line, via some channels.

The flood risks are very much where we would expect them having assessed the topography (Figure 5).

The following additional actions were recommended/suggested by CCMA to better understand the flooding risk as part of the process and ensure floodplain management and stormwater planning is integrated whilst preserving the natural landscape value of the area.

- Ensure ecological condition and functionality of waterways, wetlands and floodplains will be protected, restored, enhanced and maintained. Where possible there is a strong preference to retaining the natural waterway characteristics and drainage alignments of major overland flow paths.
- Complete detailed flood mapping of the existing flooding risk (including the 1% AEP flood events and floods of varying flood magnitudes) for the Bruce Creek catchment, overland flow paths and the local stormwater network. This should consider existing stormwater infrastructure including as constructed retarding basins, wetlands and drainage network etc.
- Deliver best practice Integrated Water Management planning and a drainage scheme that outlines the detailed design of stormwater management infrastructure and flood impact assessment as part of the planning.
- Consider future climatic conditions and catchment sensitivity (resilience) as part of flood and stormwater planning

2.6 Biodiversity

The Ecological Vegetation Class (EVC) varies throughout the investigation area, with majority of the site classed as plains grassland and some areas of grassy woodland plains according to Ecology and Partners' Biodiversity Assessment undertaken in March 2020 (Figure 11). To the west of the investigation area, a heavily dense woodland exists with significant vegetation. This vegetation is to remain, and Old Base Road is not going to be developed.

Bruce's Creek remains a significant value of the site, with extremely steep escarpments and a meandering watercourse. The creek currently contains an environmental significance overlay (ESO) (see Appendix B).

There are some locations within the growth plan area with existing vegetation which have been identified by Council and are to be protected in the development of the site. In particular, the trees and vegetation in the north west corner of the site, and the vegetation surrounding the Bannockburn Lagoon.

There is also a wetland connected to a drainage line in the south west corner of the investigation area. However, Ecology and Partners ground truthing could not ascertain its presence or absence, but acknowledge that there is potential for this wetland to align with the nationally significant Seasonal Herbaceous Wetlands ecological community. Further assessment was recommended to confirm the quality and extent of this community.

If this is confirmed to be present, any future development works would need to ensure that the watering regime of this wetland is maintained to ensure the long-term viability of this wetland. An ecohydrology assessment could be conducted to understand the watering requirements of this wetland, and the drainage infrastructure that could meet this requirement and allow development to proceed.

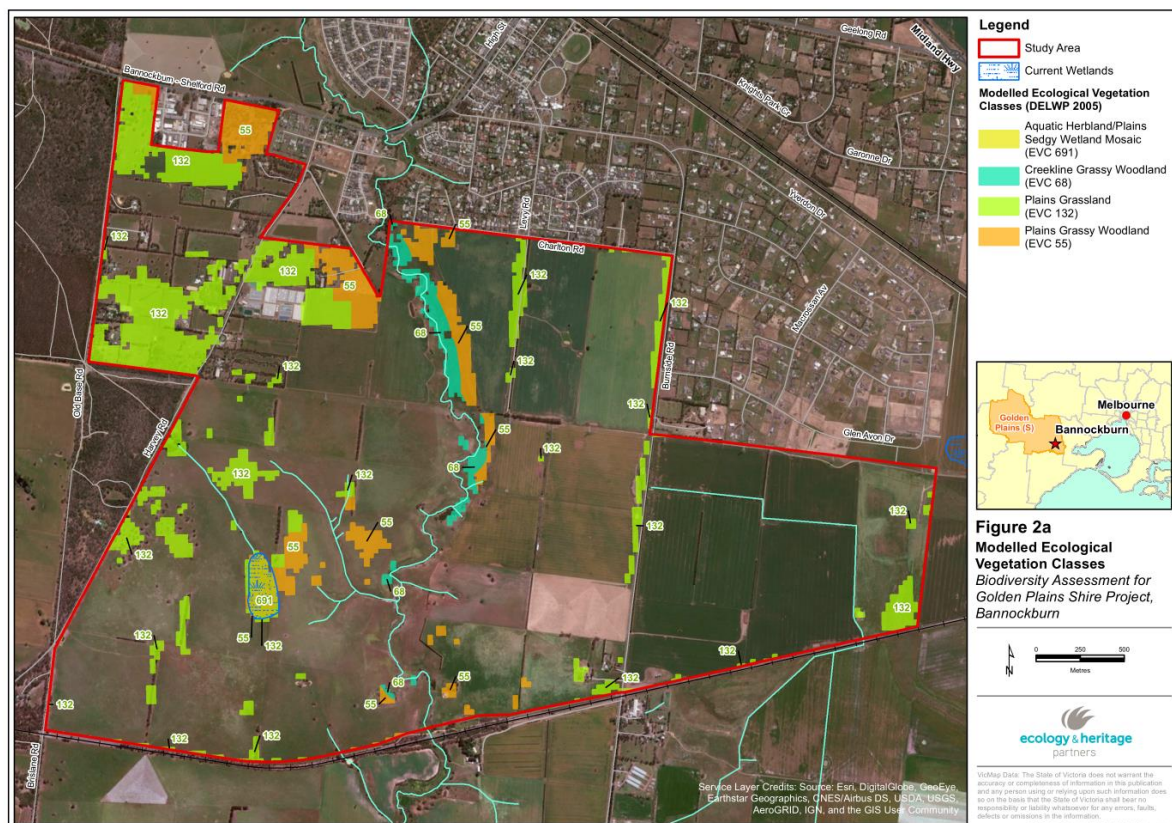


Figure 11. Modelled Ecological Vegetation Classes (Ecology and Partners, 2020)

The Biodiversity Assessment also identified remnant patches and scattered trees (a native canopy tree that does not form part of a remnant patch) which should be protected under a developed scenario (Figure 12).

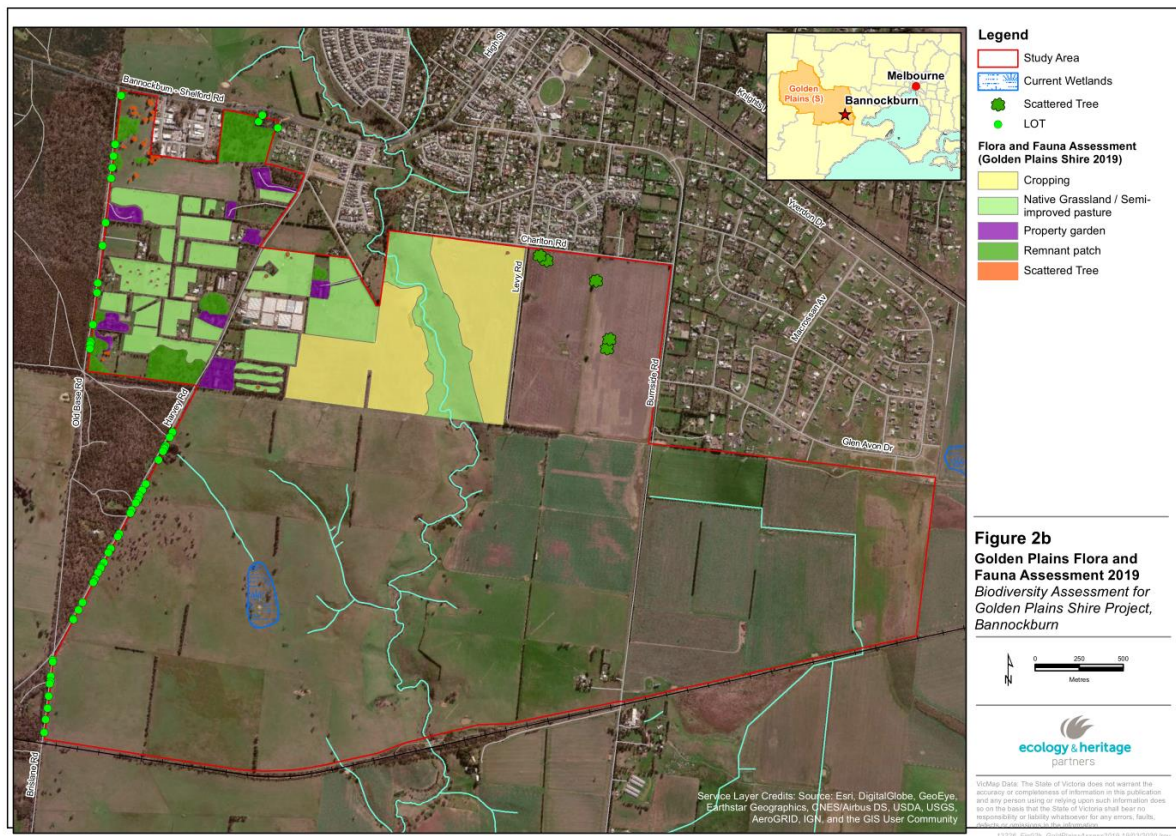


Figure 12. *Flora and fauna assessment (Ecology and Partners, 2020)*

2.7 Geology

The geology of the site consists mostly of basalt capping, with clayey to sandy soils along the course of Bruce's Creek. The clayey to sandy soils appear highly dispersive and erode the banks of the creek, which has heavily incised the creek overtime.

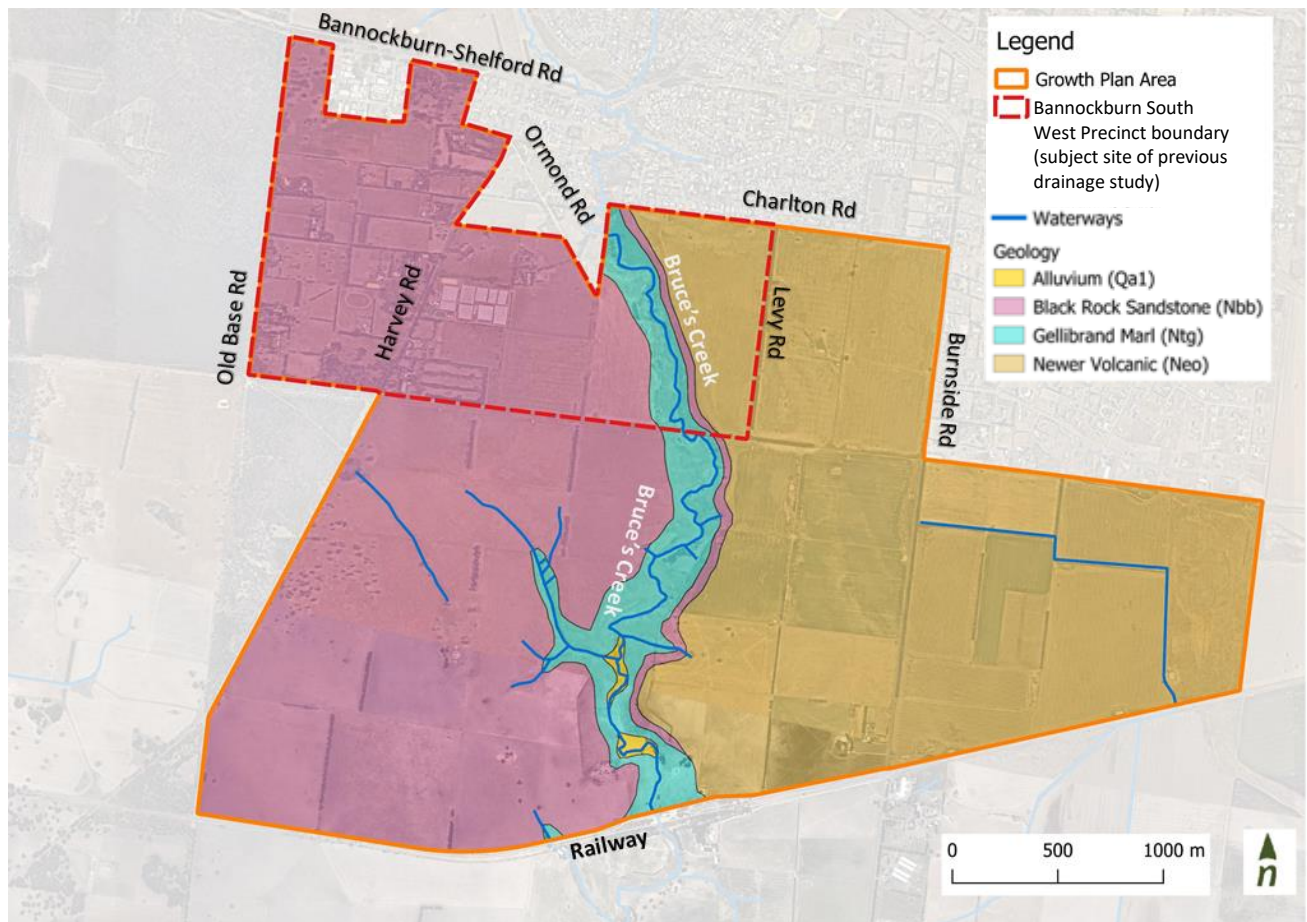


Figure 13. *Geology of the Bannockburn Growth Plan Area*

3 Catchment analysis

The site is located within the Barwon River catchment, which flows in a south-easterly direction. The catchment is generally rural upstream with some urbanised areas, mostly to the east of Bruce's Creek.

With an understanding of existing site conditions, an analysis was undertaken to define the internal catchments and flow directions. The investigation area generally drains in a southerly direction (Figure 14). A ridge line runs adjacent to the creek on the western side, which splits flows that fall down into Bruce's Creek and those that fall in a southerly direction. Overland flows are directed into several tributaries of Bruce's Creek. A minor ridge exists in the south-west corner of the investigation area, resulting in a small area flowing away from the Bruce Creek system. Ultimately the receiving waterway for this catchment is a tributary to the south of the investigation area which feeds into another wetland.

To the east of Bruce's Creek is a similar story. A ridge line splits flows down toward Bruce's creek, and south-easterly. A significant depression runs south-easterly as previously seen in the flood modelling results.

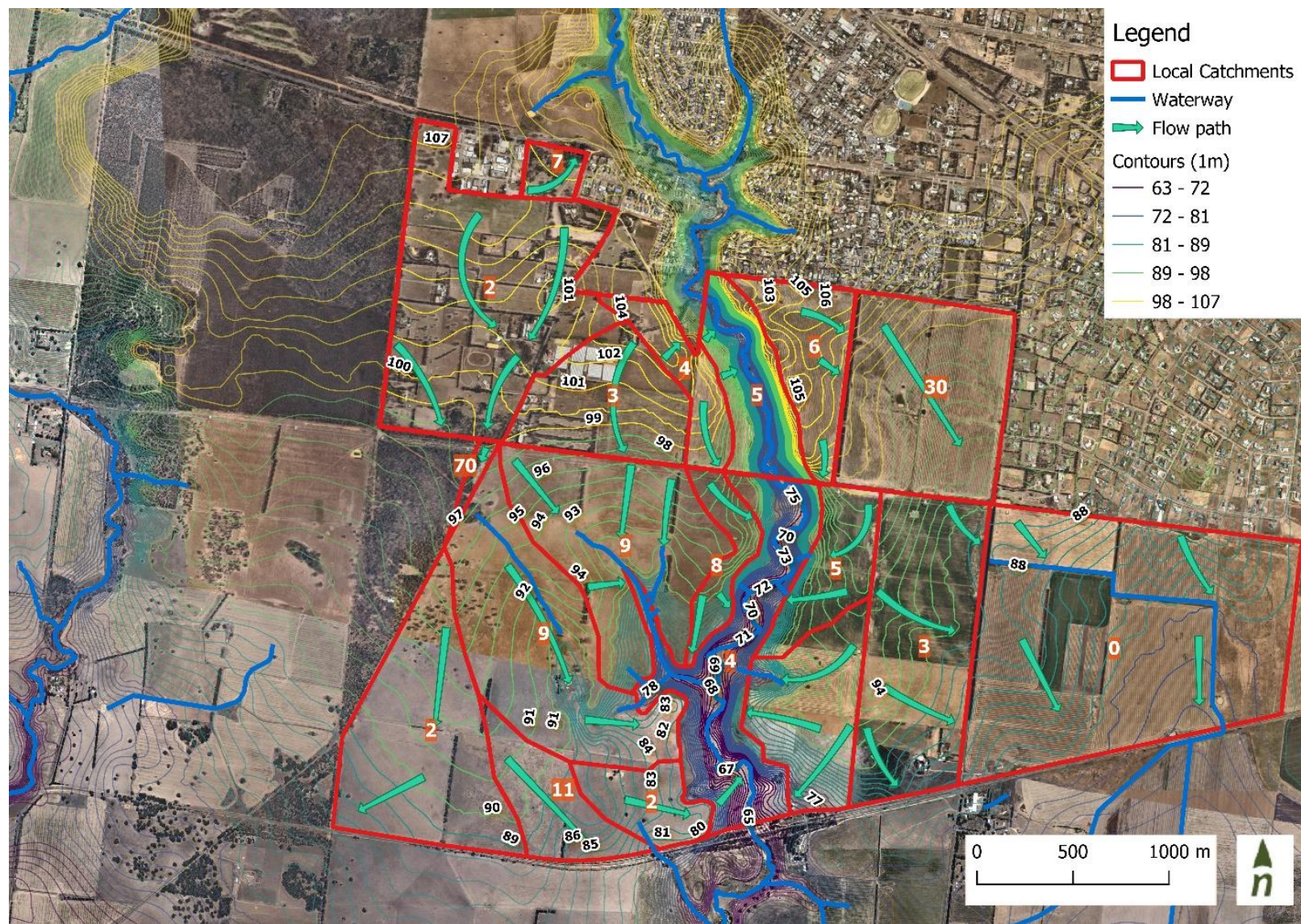


Figure 14. Existing localised catchments and flow directions through the growth investigation area

3.1 Catchments

There are two major catchment types considered in this report; these are referred to as the “External Catchment” and the “Internal Catchment.” For the purposes of this report, the term “external catchment” refers to any land outside the Bannockburn growth plan investigation area. External catchments must be considered from a flow perspective, but stormwater assets within the growth area do not have to treat this water.

Figure 15 provides the catchment mapping and direction for both internal and external catchments; the size and description of these catchments is given in Table 1.

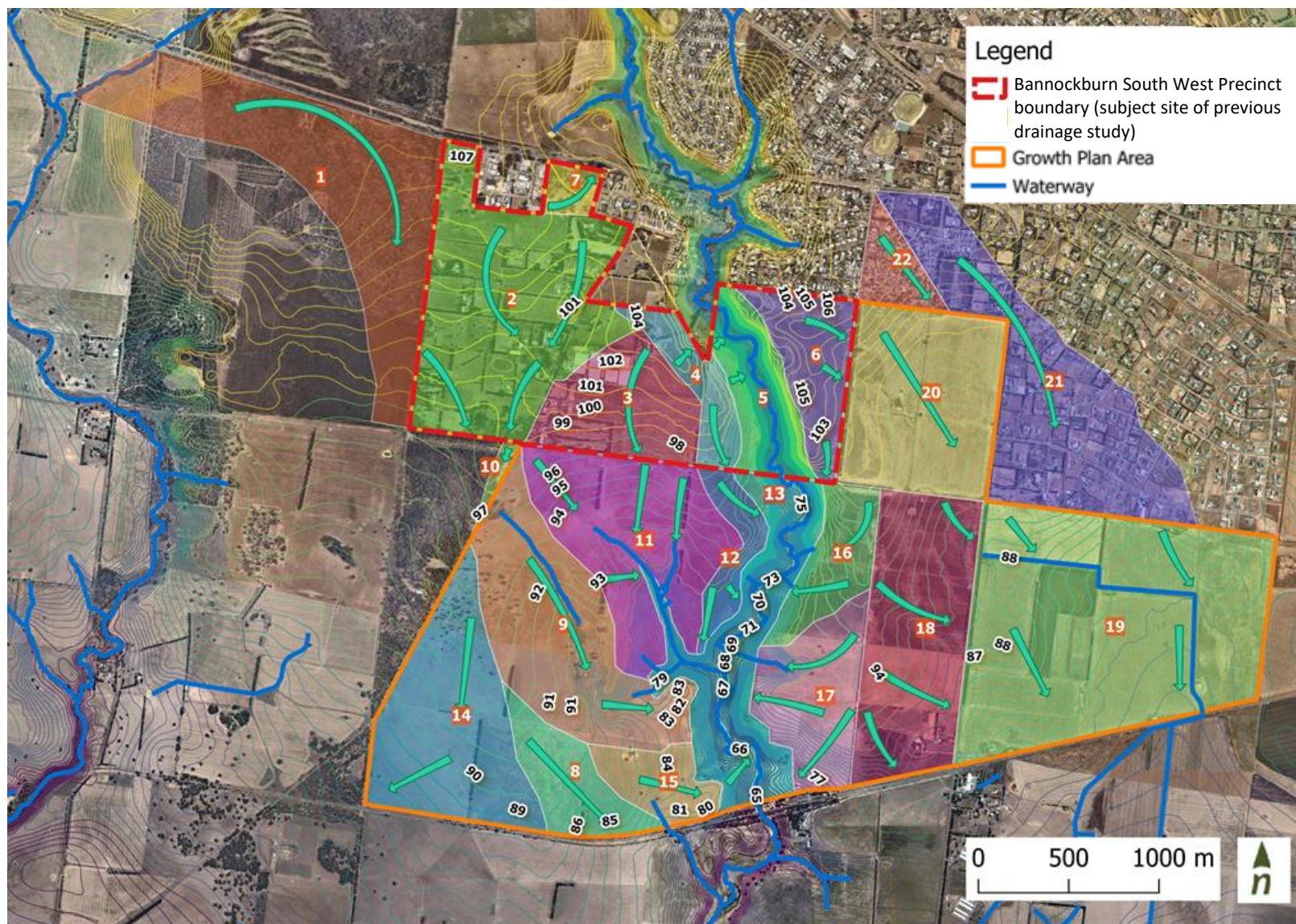


Figure 15. Major catchments within the Bannockburn Growth Plan Area

Table 1. Major catchments

Catchment type	Catchment label	Area (ha)	Notes
External	1	125.4	External catchment in Flora & Fauna reserve. Runoff 'sheet' flows across Old Base Road and contributes to catchment 2 at the south western corner of the Bannockburn South West Precinct. No stormwater management or stormwater quality works are required for this catchment.
Internal	2	124.1	Generally, 'sheet' flows in a southern direction before outfalling at the south west corner of the Precinct. Sits within the Bannockburn South West Precinct.
Internal	3	47.2	Drains across the southern boundary of the site, into a tributary of Bruce's Creek, located on the downstream property, before ultimately outfalling into Bruce's Creek. Sits within the Bannockburn South West Precinct.
Internal	4	22.8	Catchment generally 'sheet' flows in an eastern direction, outfalling into Bruce's Creek. Sits within the Bannockburn South West Precinct.
Internal	5	31.8	The catchment is defined by the steep escarpments along Bruce's Creek. The catchment is considered difficult to develop, as the land consists of dispersive soils. Sits within the Bannockburn South West Precinct.
Internal	6	34.7	Drains in a south eastern direction into a channel along Levy Road. Sits within the Bannockburn South West Precinct.
Internal	7	7.9	Drains in a north eastern direction in the existing Bannockburn lagoon. The Bannockburn lagoon outfalls across Bannockburn – Shelford Road before discharging into Bruce's Creek. Sits within the Bannockburn South West Precinct.
Internal	8	30.2	Drains in a south easterly direction towards a tributary of Bruce's Creek. The catchment's outfall is located across the southern boundary of the growth plan area.
Internal	9	92.2	Flows in a south easterly direction into an ephemeral wetland. The catchment drains into a tributary of Bruce's Creek.
External	10	3.4	A very small external catchment which contributes to catchment 9. No stormwater quality works are required for this catchment but external flows into the site should be assessed and managed.
Internal	11	85.2	Drains in a south eastern direction into a tributary of Bruce's Creek. The main tributary is a designated CMA waterway. A smaller tributary also exists in this catchment, feeding into the designated tributary.
Internal	12	16.8	Flows in an eastern direction, outfalling into Bruce's Creek (the catchment sits east of a ridge line).
Internal	13	72.4	Downstream catchment 5, with a similar steep escarpment along Bruce's Creek. It is difficult to develop given the steep terrain and dispersive soils.
Internal	14	85.6	Flows in a south westerly direction before outfalling at the south west corner of the growth plan investigation area. Eventually outfalls into a tributary which connects to another wetland.
Internal	15	21.3	Drains in a south easterly direction into a tributary of Bruce's Creek. Some may outfall directly into Bruce's Creek.
Internal	16	28.1	Drains in a south westerly direction into Bruce's Creek.
Internal	17	46.2	Drains in a south westerly direction into Bruce's Creek.
Internal	18	88	Drains south easterly and in the opposite direction of its neighbour catchments 16 and 17 (a ridge line separates them). Flows towards catchment 19. The south west corner of this catchment flows towards the rail line.

Internal	19	194.3	The largest catchment within the Bannockburn Growth Plan Investigation Area. Drains generally in a south easterly direction. A channel runs through the catchment, picking up some of these overland flows. The channel heads east before heading south across the railway line via pipe culverts. The tributary traverses farmland before eventually outfalling into Bruce's Creek near the Hamilton Hwy.
Internal	20	85	Drains in a south easterly direction towards catchments 18 and 19.
External	21	111.4	Catchment 21 covers existing residential areas, contributing to the internal catchment 19. No stormwater quality works are required for this catchment. The minor flows here should be managed by an existing drainage network, however overland flows would flow down toward catchment 19. This can be seen in the flood modelling (Figure 10).
External	22	16.3	Another small external catchment in the existing residential area to the north of the investigation area. Drains into the internal catchment 20 in a south easterly direction. No stormwater quality works are required for this catchment. The minor flows here should be managed by an existing drainage network, however overland flows would flow down toward catchment 20. This can be seen in the flood modelling (Figure 10).

4 Stormwater quality treatment

A key principle for the development of any growth area is that all stormwater is to be treated to BPEMG (Best Practice Environmental Management Guidelines) before being discharged from the study area and into receiving waterbodies. As such, the investigation area will require numerous treatment techniques in order to achieve the targeted reduction in pollutant load concentrations.

Although the purpose of this assessment is not to undertake stormwater quantity and quality modelling we believe that initial treatment modelling will help provide a concept-level sizing of the potential assets. The following BPEMG targets have been adopted for treatment modelling:

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

A MUSIC (Model for Urban Stormwater Improvement Conceptualisation) model was developed to estimate the pollutant loads generated from the investigation area in a post-development scenario. This then allows us to size potential WSUD assets, including wetland and sediment basins required to meet the pollutant reduction targets.

Based on the land use layout provided for the Bannockburn south west precinct, and the assumption that the rest of the precinct will be general residential, a model was built for the investigation area. For ease of assessing the catchment and treatment requirements at a concept-level, only one treatment configuration was investigated - a 'centralised' approach, that aims to have one large wetland at the bottom of a catchment. A 'distributed' approach, where a greater number of treatment assets are distributed across the site to treat sub-catchment flows, can be investigated at a later stage should the planning for this area progress.

Proposed assets were located at the bottom of catchments, and some catchments were further broken down to ensure feasible wetland sizing and outfall arrangements.

4.1 Modelling inputs

The key modelling inputs for the MUSIC model are meteorological data:

- Rainfall
- Evapotranspiration

The MUSIC template 'Melbourne Airport 1971 – 1980' was selected as being geographically most appropriate for the Bannockburn site. A comparison was conducted to ensure the MUSIC template provides similar average rainfall data to local meteorological data sourced from the BoM website (including the 'Bannockburn' rainfall station no. 087009). Table 2 provides a comparison of the meteorological data for both Bannockburn and the Melbourne Airport rainfall station. The Melbourne Airport template was deemed appropriate to use for modelling at a concept design level given the similarities.

Table 2. Comparison of meteorological data averages per year for MUSIC input

Location	Average Annual Rainfall (mm)	Average Evapotranspiration (mm/Day)
Bannockburn	509	2.91
Melbourne Airport station	511	2.86

For the purposes of surface water modelling, each land use type assumes a fraction impervious. The fraction impervious assumes the proportion of land that is likely to be impervious or paved. This impacts the volume of stormwater runoff generated in a specific rainfall event for a specified land size. The land use types proposed have been sourced from the Urban Design Framework and advice from the VPA/GPS.

The adopted fraction impervious values were sourced from Melbourne Water’s MUSIC guidelines (2016) and has been summarised in Table 3.

Table 3. Adopted fraction impervious values for each proposed land use type

PSP proposed Land use	Adopted zone description	Adopted zone code	Fraction imperviousness
Medium Density Residential	General Residential Zone –Standard densities (Allotment size 300-600 m ²) *	GRZ	0.70
Industrial	Industrial 1 Zone	IN1Z	0.90
Road Zone – Category 1	Major roads and freeways	RDZ1	0.70
Local Park	Public Park and Recreation Zone	PPRZ	0.10
Public Conservation and Resource Zone	Protection of natural environment or resources	PCRZ	0.05

*As advised by Golden Plains Shire Council, allotment sizes are expected to be 500 – 800 m²

Other details of the MUSIC modelling include:

- MUSIC model run at a 6-minute timestep.
- Wetlands designed to not exceed 72.0 hours detention time, to prevent terrestrial and aquatic vegetation from ‘drowning’.

4.2 Centralised treatment

The catchment nodes used in the model have been calculated based on the values for area and fraction impervious from Table 1 and Table 3. The MUSIC model layout is shown in Figure 16 and Figure 17.

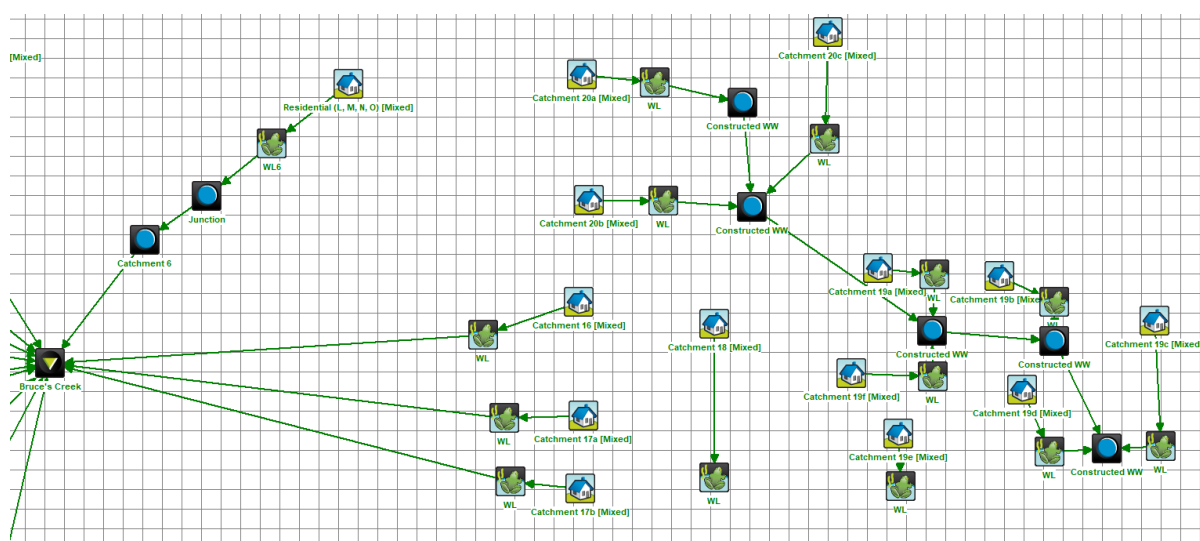


Figure 16. MUSIC model layout – east of Bruce’s Creek

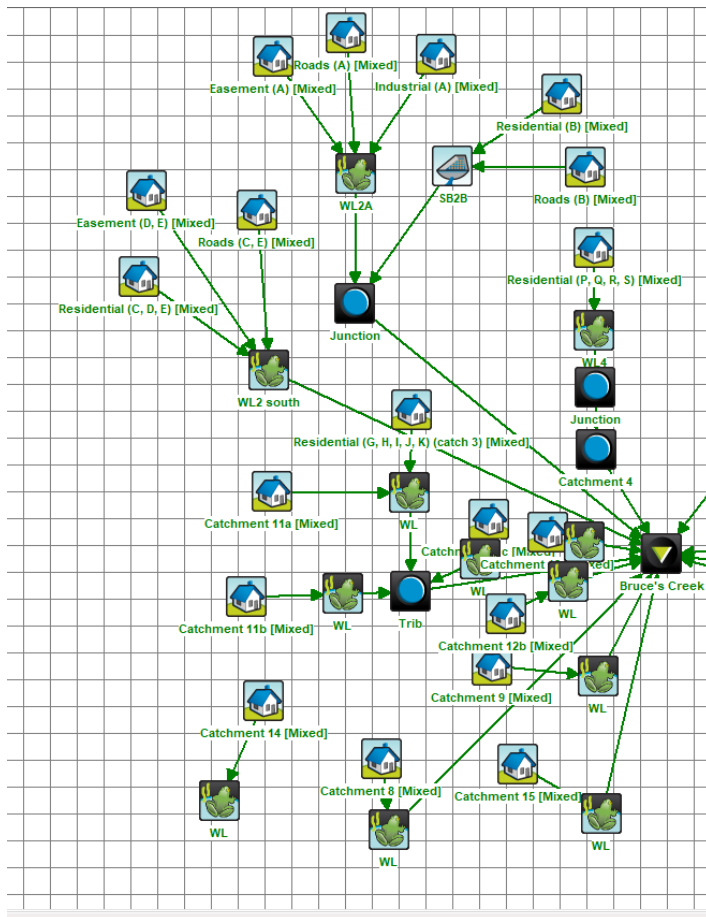


Figure 17. MUSIC model layout – west of Bruce's Creek

The Bannockburn South West precinct assets were largely kept the same as those prepared in the staged option presented in the drainage assessment (Figure 18). These options were based on outfalling to Bruce's Creek via pipes, avoiding the need to naturally outfall south through properties that were outside of the developable area (most relevant for WL2 south and WL3). However, this assessment investigated how those options may change should the properties south of the electricity easement be developed.

In the options that were investigated, WL3 from the Bannockburn South West precinct was shifted south towards an existing tributary, enabling it to receive flow from a larger catchment. This also allows the outfall from this wetland to enter the tributary instead of piping east towards Bruce's Creek. This is discussed further in Section 5 where the concept options are presented with the approximate treatment areas and land take.

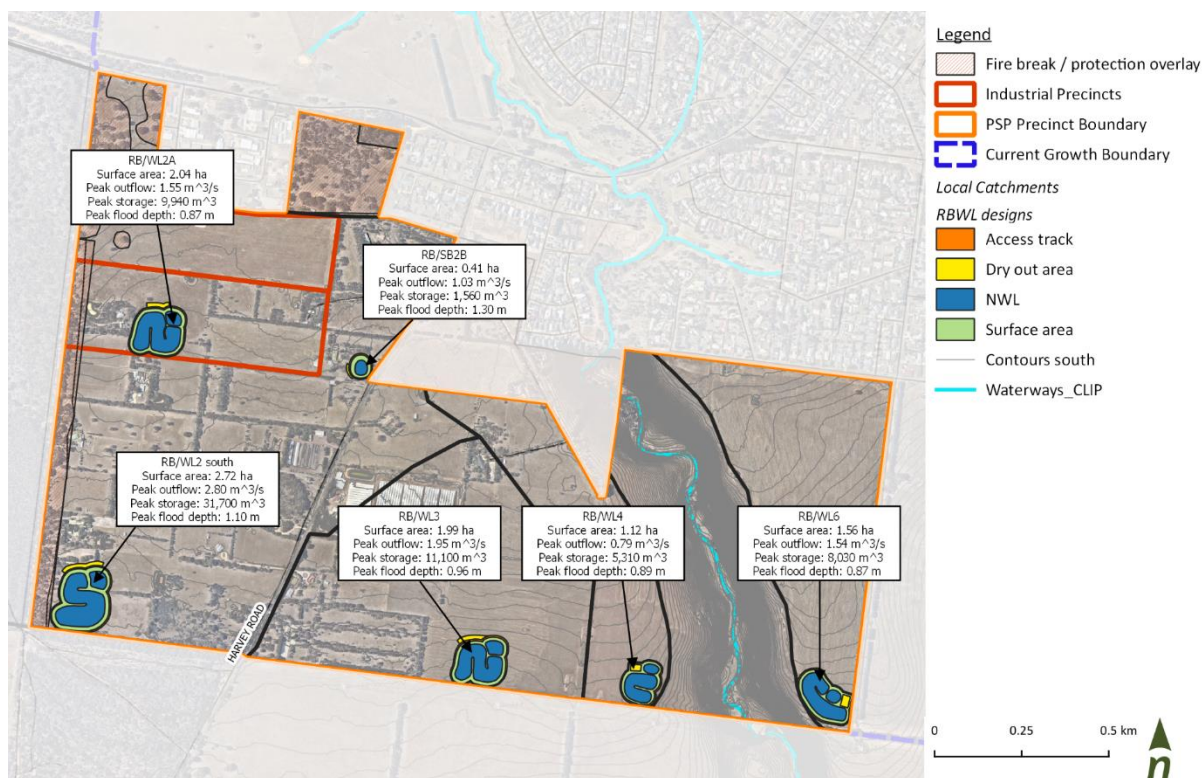


Figure 18. Concept drainage options (Option 2 – staged approach) presented in the Bannockburn South West precinct drainage strategy (Alluvium 2019)

Asset Performance

The MUSIC modelling determined the sizing required for the wetland assets required at each of the catchment low points. The details of treatment systems are shown in Table 4 for the assets within the Bannockburn South West precinct, and Table 5 to Table 7 for those outside of the south west precinct. Some catchments have been left out as they are external to the site (i.e. do not require treatment).

Table 4. Treatment asset parameters for investigation area (inside the Bannockburn South West precinct)

	WL2 south	WL2A	SB2B	WL4	WL6
NWL area, m ²	14,000	11,000	1,200	5,000	8,000
Inlet pond area, m ²	2,000	1,500	-	800	1,200
Average depth, m	0.40	0.40	1.50	0.40	0.40
Extended detention, m	0.35	0.35	0.35	0.35	0.35
Extended detention time, hr	70.9	71.7	0.94	72.0	71.2

Table 5. Treatment asset parameters for investigation area (outside South West precinct) (catchments 8-12)

Catchment	8	9	11a*	11b	11c	12a	12b
NWL area, m ²	6200	18,500	15,500	5000	6,400	1800	1800
Inlet pond area, m ²	1000	2800	2350	750	2600	300	300
Average depth, m	0.40	0.40	0.40	0.4	0.4	0.40	0.40
Extended detention, m	0.35	0.35	0.35	0.35	0.35	0.35	0.35
Extended detention time, hr	73.8	71.6	73.4	72.0	72.3	72.0	72.0

* Receives catchment from Bannockburn South West precinct

Table 6. Treatment asset parameters for investigation area (outside South West precinct) (catchments 14-18)

Catchment	14	15	16	17a	17b	18
NWL area, m ²	17,000	4,500	5,700	4,800	4,800	18,000
Inlet pond area, m ²	2,500	700	600	700	700	2000
Average depth, m	0.40	0.40	0.40	0.40	0.40	0.40
Extended detention, m	0.35	0.35	0.35	0.35	0.35	0.35
Extended detention time, hr	73.2	72.9	73.4	73.2	73.2	72.9

Table 7. Treatment asset parameters for investigation area (outside South West precinct) (catchments 19-20)

Catchment	19a	19b	19c	19d	19e	19f	20a	20b	20c
NWL area, m ²	4000	4000	7000	8000	9900	6000	6000	6000	5000
Inlet pond area, m ²	800	800	1000	1200	1500	900	1000	1000	800
Average depth, m	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
Extended detention, m	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
Extended detention time, hr	73.4	73.4	73.4	72.9	72.7	73.3	71.4	71.4	72

The results of the MUSIC modelling analysis demonstrate that BPEMG targets are met with the performance of those assets, as shown in Table 8. TSS could be refined to be slightly higher to 80% reduction through sediment capture efficiency sizing of sediment basins (beyond the scope of this assessment).

Table 8. Overall MUSIC modelling results – centralised treatment system

	Source load	Residual load	% Reduction
Total Suspended Solids (kg/yr)	676,000	150,000	78
Total Phosphorus (kg/yr)	1390	463	67
Total Nitrogen (kg/yr)	9790	5250	46
Gross Pollutants (kg/yr)	136,000	0	100

5 Concept assets summary

Based on the catchment assessment and treatment modelling, a high-level concept map of potential assets was put together (Figure 19). The land take has been based on the required treatment area as established in MUSIC, and a nominal buffer of 14m around this. This would need to be refined in a drainage assessment to ensure storage requirements are being met (i.e. retardation), as well as access requirements. It is important that peak flows that discharge from the wetland retarding basins are no greater than pre-development peak flows for the 1% AEP.

Key points on the proposed layout include:

- Numerous wetlands have been placed at the low points in the catchments (noting some catchments have been further divided for optimum asset locating and sizing). Most of these outfall directly into Bruce's Creek, or via a tributary of Bruce's Creek.
- The Bannockburn South West precinct assets have been kept the same as those presented in the drainage assessment for Option 2, which was the option which allowed for a staged development, (Alluvium 2019) except for the following changes:
 - WL3 has been removed and incorporated into a larger wetland further south that can treat stormwater from a larger catchment, and outfall directly into a tributary of Bruce's Creek.
 - WL2 south can now outfall south instead of piping large distance east towards Bruce's Creek. The wetland pipe outfall could hug the developable boundary and outfall into the existing depression/tributary of Bruce's Creek.

If the staged option did not go ahead (i.e. there was no imperative for the industrial areas to develop first), then the two smaller assets (WLRB2A and SB2/RB) could be incorporated into WL2, making this a larger asset. This was Option 1 that was presented as part of the Bannockburn South West Precinct drainage assessment. In the staged approach, WLRB2A and SB2RB (for naming see Figure 18) currently need to outfall east towards Bruce Creek.

- The main tributary south of the electricity easement on the western side of Bruce's Creek (a CMA designated waterway) would be maintained in a developed scenario. Various treatment assets could outfall into this tributary. This waterway may need to become more formalised (constructed) and will require a waterway corridor where no development can occur. Consideration must be given to preserving the existing alignment and the ecological value of the waterway. Given the dispersive nature of the soil here and the steep topography, the volumes of water outfalling into these waterways will need to be managed. Any IWM strategies could help with capturing and reusing treated stormwater.
- The tributary to the west of the CMA-designated waterway could also be made into a constructed waterway. Outfall from WL2 South (Bannockburn South West precinct) would outfall into this. Further work would be required to understand the importance of the wetland that is online to this depression, and its watering requirements. A constructed waterway could go around the existing wetland should this need to be preserved, with the ability to divert water into the wetland according to the required watering regime.
- To the east of Bruce's Creek, a constructed waterway is proposed through the existing depression and channel that traverses the site. This depression is very evident in the flood modelling (see Figure 10). Formalising the waterway here could help alleviate flooding, provide an outfall for future development, and provide amenity and recreational opportunities. Constructed waterways provide localised cooling opportunities through the creation of a blue-green grid (water and parkland), as well as creating habitat opportunities. A number of wetlands are shown along this proposed waterway. It should be noted that no waterway sizing has been done as part of this assessment.
- There are several wetlands which will need to have their outfall confirmed in further drainage assessments should the growth investigation progress (catchments 14, 18 and 19e). These wetlands

all border the rail line and it is unclear where culverts under the rail currently exist, and therefore where there may be potential outfall opportunities to the south. Alternatively, they would need to outfall to Bruce's Creek (or the proposed constructed waterway in the east) via pipes. All flows exiting the site (whether via Bruce's Creek or otherwise) will need to be maintained to pre-development 1% AEP peak flow rates in line with current planning policy. Volume and frequency of flows leaving the urban environment should be mitigated where possible through harvesting and reuse opportunities.

- As a principle, the number of outfalls into the creek should be minimised where possible and integrated into the natural landscape.
- All of these wetlands present IWM opportunities in that the treated stormwater could be harvested off the back of the wetlands and used for irrigating open space. This would aid in greening and cooling opportunities, reduce potable water consumption and help reduce flow volumes into Bruce's Creek.

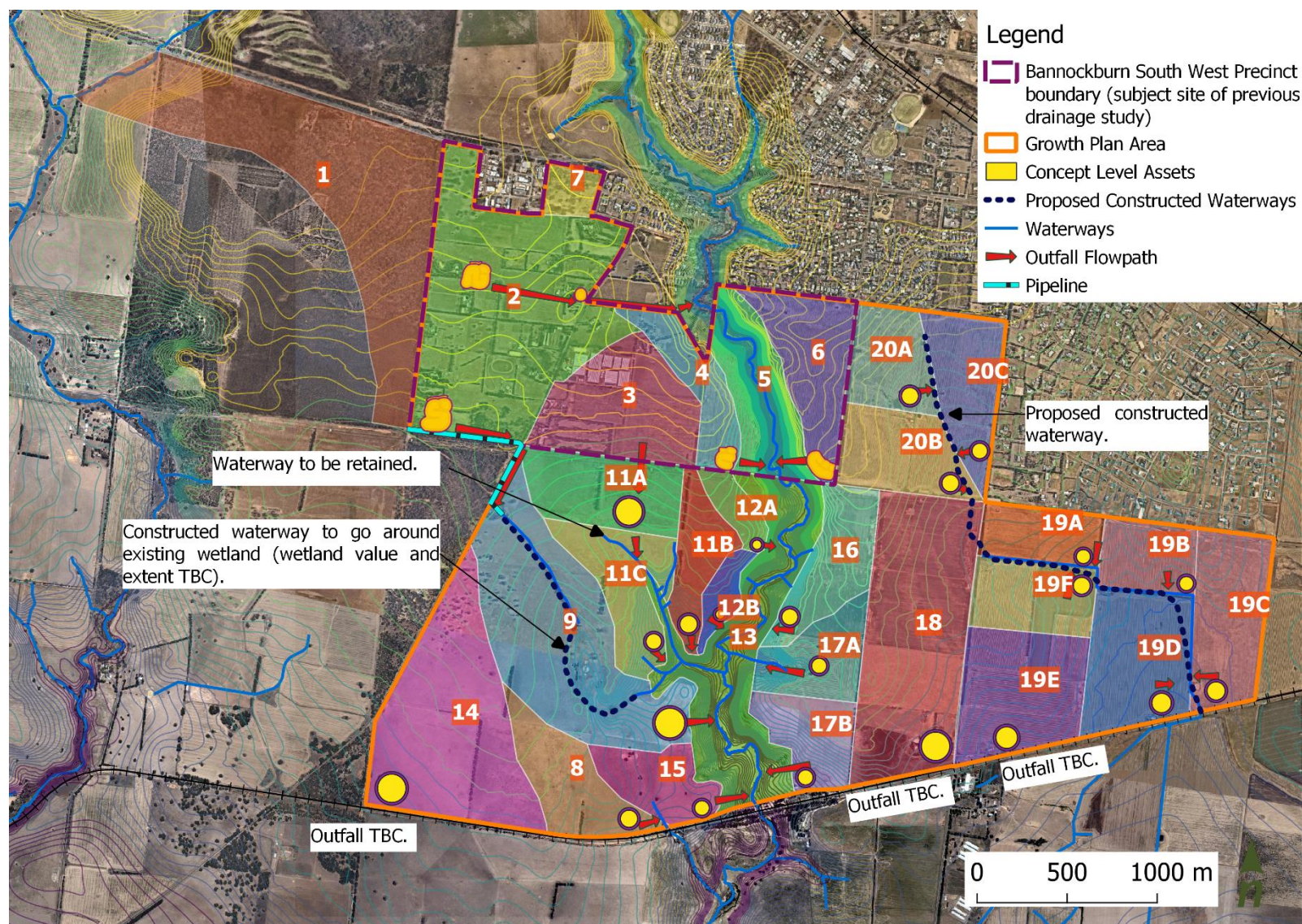


Figure 19. *Bannockburn growth investigation area concept assets*

6 Conclusion and recommendations

The catchment assessment for the Bannockburn Growth Investigation Area has focussed on:

- Existing conditions – site values and constraints
- Catchment analysis – flow direction, subcatchments and outfall locations
- High-level treatment modelling to treat post development stormwater volumes to meet pollution reduction targets

In a standard drainage assessment, the modelling undertaken to size assets includes treatment modelling as well as hydrologic modelling for peak flow estimation and determination of storage requirements. This assessment was not intended to be a comprehensive drainage assessment, rather an initial catchment assessment to identify how the assets proposed as part of the Bannockburn South West Precinct drainage study may change should the growth area extend south of the electricity easement. The study was also intended to provide a high-level understanding of drainage catchments (size, outfall locations and flow direction) and potential stormwater management treatments and locations. As such, no hydrologic modelling was undertaken. High-level treatment modelling was undertaken as this is a straight-forward task to give a first sense of the treatment footprint, with the understanding that the overall land take will likely be larger than this to meet storage requirements.

The next phase of planning will need to build off this work and undertake hydrologic modelling to estimate peak flows and ensure the assets are sized to retard flows back to pre-developed flow rates for the 1% AEP. Consideration around the increase in the volume of water in post-development conditions is also required. Reducing the overall volume of stormwater discharged into the creek can be achieved through harvesting and reuse.

Key take-aways from the analysis include:

- Wetland/retarding basins will manage flows back to pre-developed flow rates and treat stormwater to best practice.
- As was presented in the Bannockburn South West precinct drainage assessment, assets are not proposed down the bottom of the steep escarpments, adjacent to Bruce's Creek. They are instead proposed up in the catchments where the land is more stable, and steep asset battering is not required.
- Development of the land south of the Bannockburn South West precinct would alter the drainage recommendations presented in the drainage assessment for this precinct. Notably:
 - WL3 would shift south and be incorporated into a larger wetland
 - The outfall of WL2 South could be via a pipe south into a tributary/constructed waterway rather than piping long distances east to Bruce's Creek.
- Development of this investigation area could result in several constructed waterways through the site. This will depend on the values of the existing tributaries/channels. Constructed waterways can help formalise flow paths and alleviate widespread flooding, as well as enhancing amenity and recreational opportunities. Constructed waterways provide localised cooling opportunities through the creation of a blue-green grid (water and parkland), as well as creating habitat opportunities. They can also provide outfall opportunities for surrounding residential developments.
- The existing wetland in the west of the investigation area should be investigated as to its value and required watering regime should any development in this area go ahead. If this needs to be retained the proposed constructed waterway will need to go around it but be designed to divert water into the wetland according to the required volume and inundation frequency.

- All flows exiting the site (whether via Bruce's Creek or otherwise) will need to be maintained to pre-development 1% AEP peak flow rates in line with current planning policy. Volume and frequency of flows leaving the urban environment should be mitigated where possible through harvesting and reuse opportunities.
- The number of outfalls into the creek should be minimised where possible and integrated into the natural landscape.
- There could also potentially be an opportunity to use recycled water from Barwon Water's Bannockburn Water Reclamation Plant (WRP) located north west of the investigation area during the establishment periods for the wetlands to ensure plant survival. It would be better to use this water than potable water.
- The main IWM opportunity is to harvest treated stormwater from the wetlands and using this to irrigate open space. Harvesting and reusing this water will further reduce pollutants entering receiving waterways. An IWM plan is proposed to be prepared for Bannockburn which could further consider this.

7 References

Alluvium (2019). Bannockburn South West Precinct Drainage Strategy.

CSIRO (1999), Urban stormwater best practice environmental management guidelines.

Ecology and Partners (2020). Biodiversity Assessment: Bannockburn Growth Area.

Melbourne Water (2016), MUSIC modelling guidelines.

Melbourne Water (2018), Flood Mapping Projects Guidelines and Technical Specifications.

Appendix A

Bannockburn Urban Design Framework

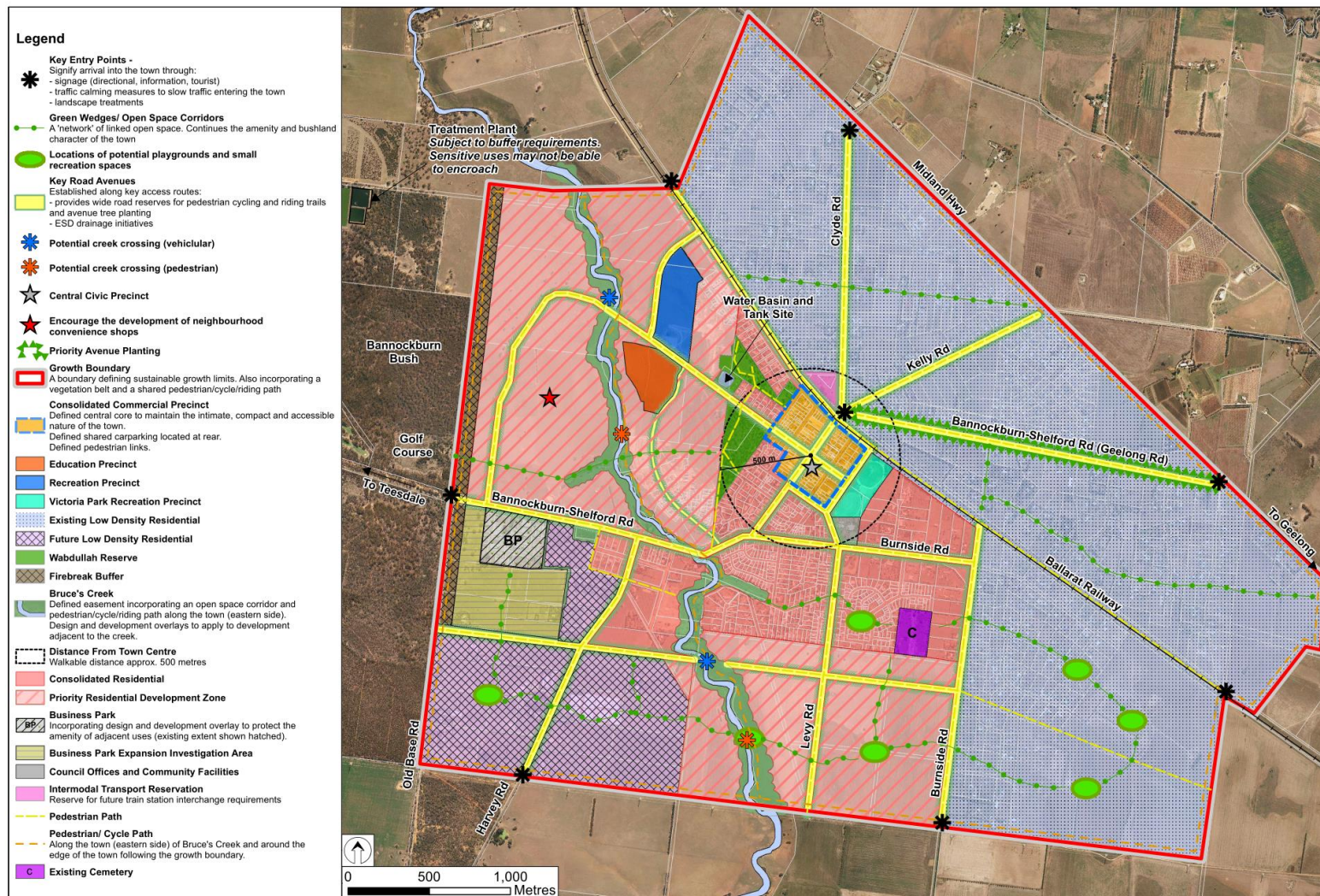


Figure 20. Bannockburn Urban Design Framework overall principles (Parsons Brinckerhoff 2011) -

Appendix B

Existing planning zones and overlays

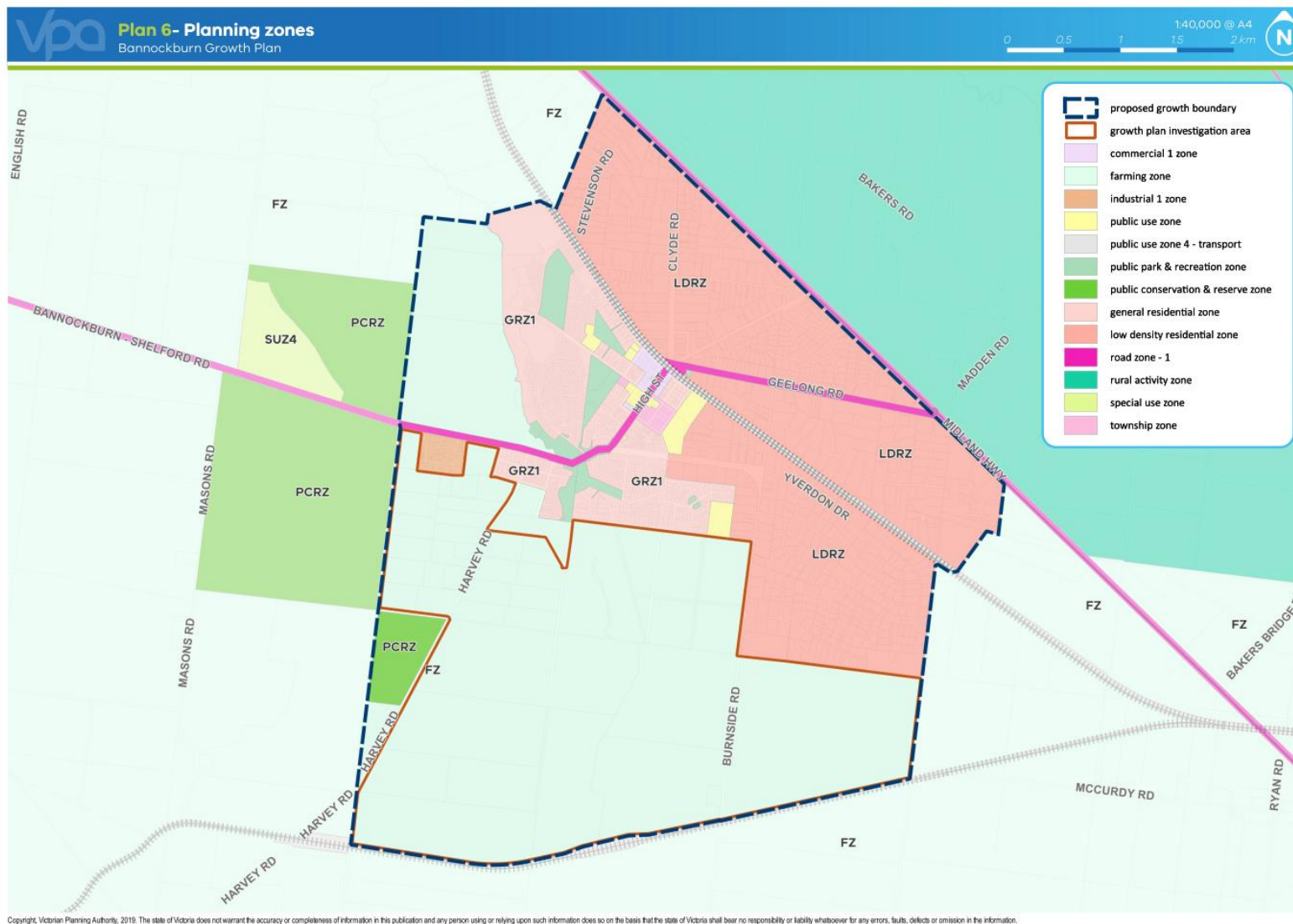


Figure 21. Planning zones (VPA 2020)

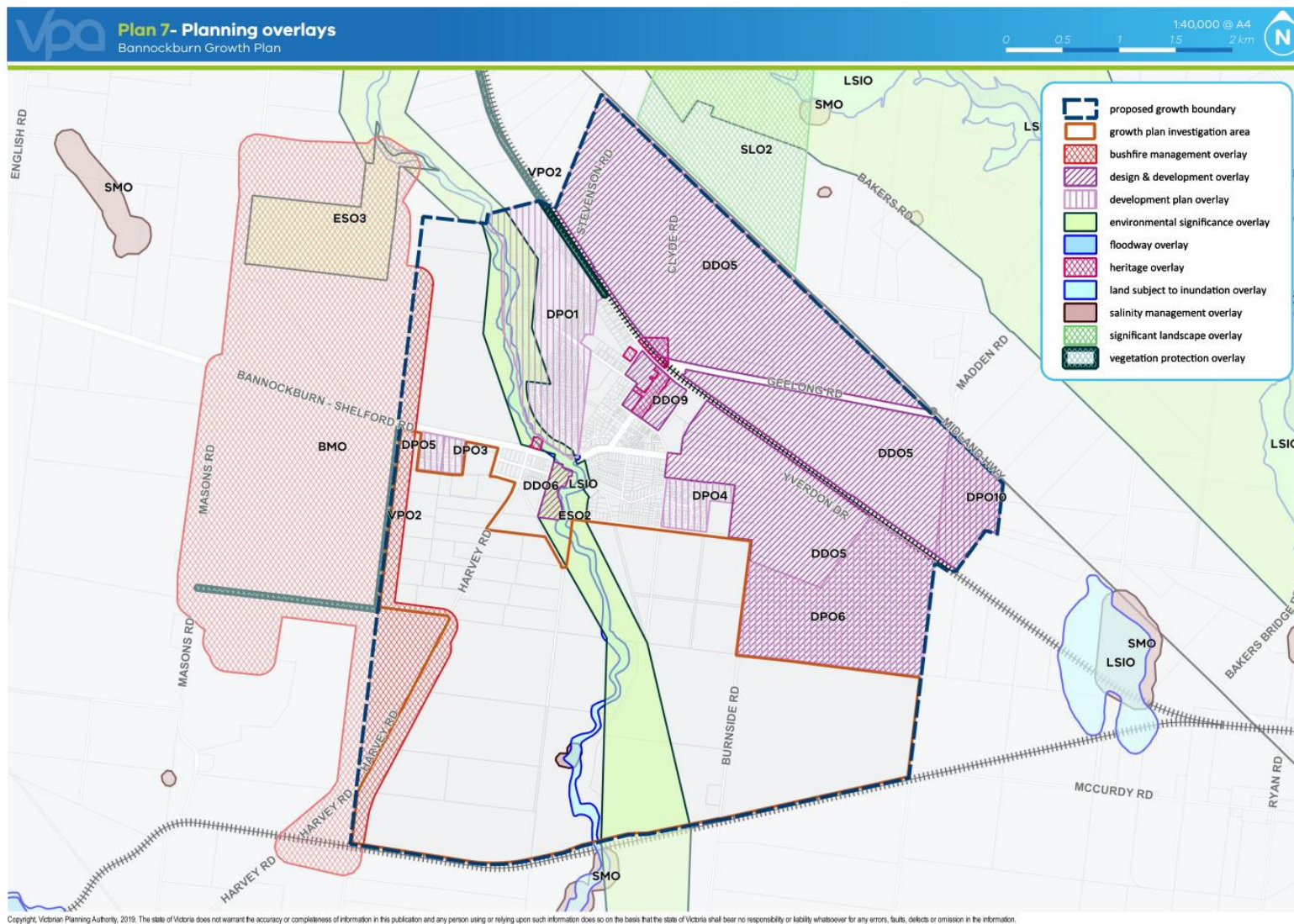


Figure 22. Planning overlays (VPA 2020)