Warragul Burrowing Crayfish Translocation Proposal

Wills St Warragul

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PREPARED FOR

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Terrestrial Invertebrate Consulting

Report for	**Advantage All Development Group**
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Title	Invert-Eco 2022 Warragul Burrowing Crayfish translocation proposal

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1 BACKGROUND

In July 2019, INVERET-ECO undertook a Warragul Burrowing Crayfish (WBC) (*Engaeus sternalis*) assessment at the corner of King St and Wills St, Warragul where a 32 Lot industrial development is proposed by Advantage All Pty Ltd. The WBC is listed as Critically Endangered under the *Victorian Flora and Fauna Guarantee Act 1988* (FFG Act).

During this assessment, evidence of WBC was identified from three locations within the subject land (Figure 1). One was associated with a small drainage channel to the west (Site 2) while the other two were in the better drained sections of floodplain to the north (Site 1) and south (Site 3). Improvement of the waterway and drainage of the land, requires the reconstruction of Hazel Creek and development of wetlands. This makes the in-situ conservation of two areas of WBC habitat unfeasible.

In response to these findings, a concept plan has been designed to incorporate crayfish friendly features into the constructed waterway to be included with the realignment of Hazel Creek. A WBC translocation program is proposed to move the largest crayfish colony (Site 1) impacted by the proposal into the new habitat surrounding the wetland. The one colony to the west will remain in the green wedge created to accommodate their survival.

1.1 Project Aims and Justification

While in-situ conservation is always the first priority for threatened species, there are some circumstances where this is not feasible due to site and engineering restrictions and predetermined utility requirements that service the area. The WBC is found over an area of less than 20 square kilometres in west Gippsland. The township of Labertouche is on the western edge of their range which extends eastward toward Drouin and Warragul. These towns are surrounded by cleared farmland used primarily for dairying and some cultivation. Almost all of their habitat occurs on privately owned land in areas currently being developed for urban expansion. Their range is within the Baw Baw Shire, with development guided by the Warragul and Drouin Precinct Structure Plans (Victorian Planning Authority 2014). This includes the construction of drainage assets such as retardation basins and wetlands, located in predetermined areas to mitigate flooding as well as to improve the quality of stormwater runoff (SKM, 2008).

In 2015, Baw Baw Shire Council (BBSC) engaged INVERT-ECO to develop a guide to protect crayfish habitat being impacted by Planned Wetlands and Retardation Basins (Van Praagh 2015). This guide provides design principles to avoid or mitigate impacts to the species during development of these drainage assets. The production of the guide included consultation with the scientific literature and experts, particularly those in Tasmania where considerable progress has been made in the conservation of burrowing crayfish (See Section 3). However, the information provided was based on somewhat limited knowledge of the habitat requirements of WBC. It has therefore been established within an adaptive management framework through experimental design and relies upon the monitoring of project outcomes to appraise their effectiveness and guide future protection mechanisms. To date, these design principles have

not been tested. Given the colony within the proposed development at Wills St will be lost without intervention and the proposed establishment of a wetland as part of the development, this project provides an opportunity to implement the principles of the "crayfish friendly design" and serve as a demonstration model to inform future projects where new wetlands when WBC habitat cannot be protected during developments projects.

To assess the outcomes of the wetland design and translocation of the WBC, a minimum three-year monitoring program will be undertaken.

The translocation site will be a BBSC reserve, and an agreement with Council will be established to create an Environmental Protection Zone. The Protection Zone will be maintained and monitored by the developers for a period of 2 years, after which, the maintenance will be transferred to Council. The developers will continue to fund the monitoring for a period of 3-5 years.

1.2 Conservation Outcomes of translocation

- Establish a model and evaluate its success to inform future projects where new wetlands are created within or adjacent to WBC habitat and when WBC habitat cannot be protected during disturbance works. This may be applicable to other burrowing crayfish within Victoria.

- Information obtained during the collection of the crayfish and translocation will contribute to the understanding of the biology and habitat requirements of this species and will contribute to future conservation opportunities.

- Improve the habitat condition and landscape connectivity for adjacent WBC colonies which will potentially be impacted by future development.

- Serve as a future translocation or offset site

- The improved waterway and creation of wetland habitat will support other species of common burrowing crayfish (Engaeus hemicirratulus, E. cunicularius & E. quadrimanus) that may be displaced by the development.

- The site will be protected from vegetation removal, earthworks, drainage works and any form of stock grazing in the future thus providing on-going protection.

- At present there is no instream habitat in Hazel Creek or the minor tributary within the Wills Street development property that is suitable for the Dwarf Galaxias (Streamline Research 2022). The realigned Hazel Creek reserve will be constructed with attributes that are favourable to the dwarf galaxias. If conditions are suitable, this may support

movement of Dwarf Galaxias through the waterway, allow for the introduction of the species and potentially for the survival of a self- sustaining a local population.

2 Warragul Burrowing Crayfish *Engeaus sternalis*

Conservation Status:
FFG Act 1988 Threatened List 2022 - Critically Endangered
DELWP Advisory List of Threatened Invertebrate Fauna 2009: Critically Endangered

2.1 Distribution

The Warragul Burrowing Crayfish is a small burrowing crayfish, with adults having a carapace length of about 20 mm and a total length of about 70 mm (Horwitz 1990). The species is characterised by its very small eyes and fine downy hairs covering its carapace. It is usually a pale, cream colour but may also present in shades of blue and grey (Plate 1).

The species was originally described in 1886 from the Warragul area although no precise locality data was given. However, up until late 2010, this species was only known from a 4 km stretch of creek bank along Labertouche and Wattle Creek, Labertouche (Horwitz 1990, Morey & Hollis 1997). In 2011 the species was collected from a number of sites in Warragul and Drouin (Van Praagh 2011a), representing the first recording for this species in Warragul for over 75 years. It was originally thought that WBC did not build chimneys around their burrows (Horwitz 1990) which may explain why it was not identified from Warragul for such a long time.

The current distribution includes an area of approximately 30 x 20 kms in west Gippsland. This includes a 4 km stretch of creek bank along Labertouche and Wattle Creek in Labertouche (Horwitz 1990, Morey & Hollis 1997, & Shaw 1996) and in and around the township of Drouin and Warragul (Van Praagh 2011a) (Figure 2).

2.2 Habitat

The habitat at Labertouche is remnant Swampy Woodland where the species can be found within the clayey creek banks. This contrasts with their habitat in Warragul and Drouin where it is typically found within open pasture along edges of creek banks, smaller drainage lines and within floodplains. The crayfish tends to be found in the less saturated areas of flood zones. On occasion it can be found some distance from open waterways in low-lying pasture if the water-table is high and soil moist. WBC builds small chimneys, composed of small, spherical balls of soil and small openings (Plate 2).

2.3 Life Cycle

While the specific life cycle of WBC is unknown, in most burrowing crayfish, breeding occurs over spring and summer (Doran 1999). Males come to the surface during late spring and early summer in search of mates. Males enter burrows of females to mate and the female carries

clusters of eggs under the abdomen throughout summer. By February juveniles have hatched and become independent but may remain in the maternal burrow for some time (Doran 1999). Several generations of WBC have been recorded within the same burrow system (Van Praagh 2011a). WBC are likely to have some ability to disperse locally into suitable habitat considering their movement overland to search for mates.

Warragul Burrowing Crayfish density can vary substantially from very small areas of less than 5 m2 to much higher, particularly when inhabiting extensive flood plains. For example, approximately 5-7 chimneys per m2 have been recorded fairly consistently over an area of some 7535 square metres (Van Praagh 2011b). They are often found in clusters with other common species of Engaeus found adjacent. At least four other species of burrowing crayfish (Engaeus sp) have been found within the same area as WBC (Table 1). These species often occupy slightly different niches within the landscape (see above) but chimneys may be found in close proximately to WBC.

Table 1 Common Species found within the range of WBC

Common Name	Species
Granular Burrowing Crayfish	*E. cunicularius*
Lowland Burrowing Crayfish	*E. quadrimanus*
Gippsland Burrowing Crayfish	*E. hemicirratulus*
Richards Burrowing Crayfish	*E. laevis*

2.4 Threats

Many burrowing crayfish are relatively sedentary with poor powers of dispersal, relatively long life cycles and maturation rates leading to narrow endemic ranges, rendering them highly vulnerable to threatening processes. Key threats relate to changes in the quality and quantity and seasonal regime of water, soil and food availability (Doran 1999, March and Robson 2006, Honan 2010). Significant impacts to WBC colonies are likely to occur where there is alteration to the water table, drainage patterns or surface flows: permanent or long-term change (increase or decrease) outside of the natural annual variation.

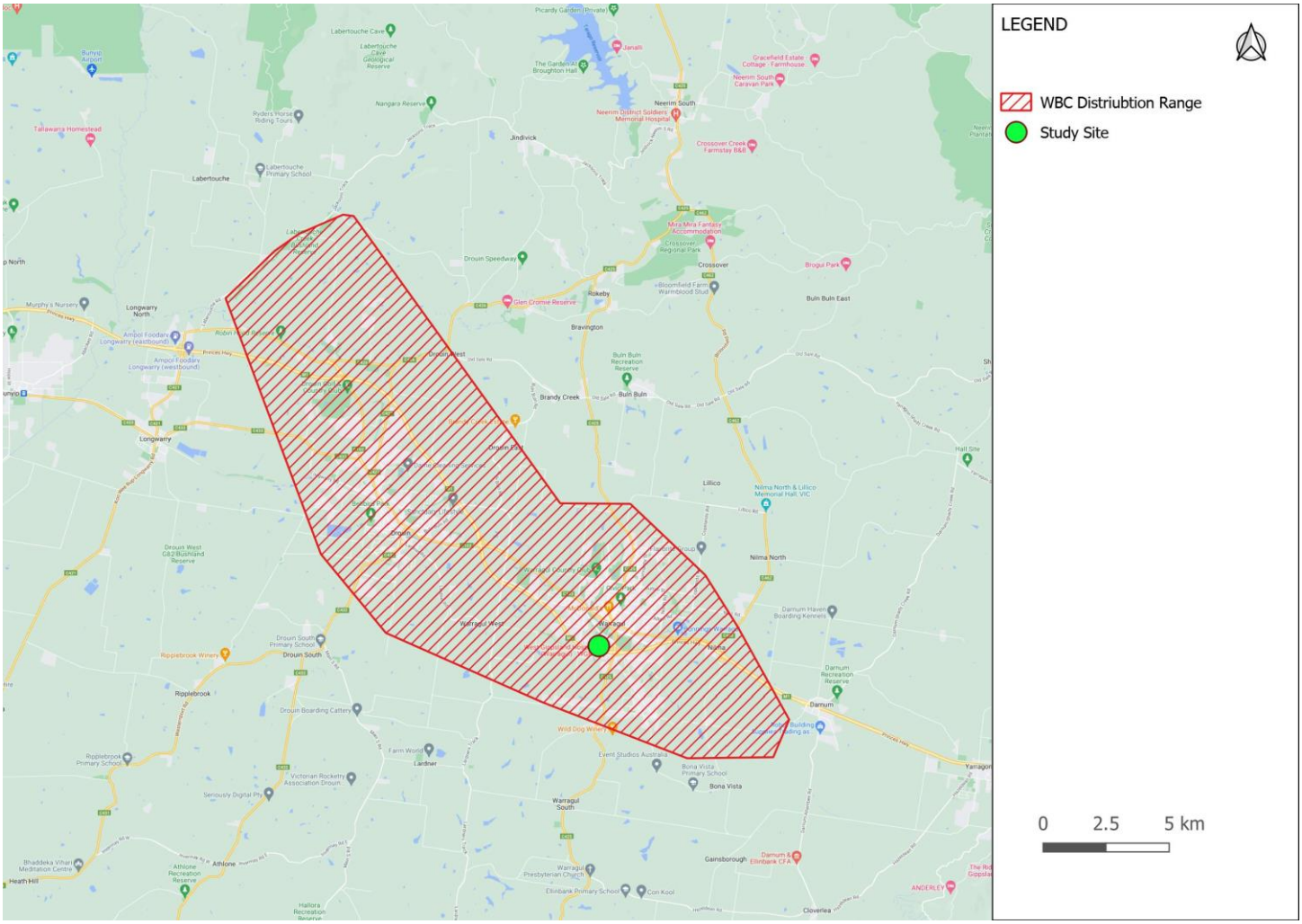
Further information can be found at http://www.burrowingcrayfish.com.au/


Plate 1 WBC Cream and blue colouration of WBC


Plate 2 Typical WBC habitat around edges of floodplains


Plate 3 WBC Chimneys

Figure 1 WBC Distribution



3 Studies on habitat creation and translocation of crayfish

Creating suitable crayfish habitat to allow adjacent colonisation from disturbed areas or as a receptor site for translocated individuals has been the subject of a small number of studies. There is evidence to suggest that inadvertent creation of habitat occurs in areas occupied by burrowing crayfish. For example, additional habitat was created for the *EPBC Act* listed Central North Burrowing Crayfish in the form of a large wet area close to the water table following the construction of a water retention basin in Tasmania to regulate peak flows of a housing estate (Davenport City Council 2013). Nelson discusses the re-creation of habitat for the Central North Burrowing Crayfish at the Miandetta wetlands in Tasmania. http://www.disjunctnaturalists.com/articles1/crayfish.htm.

A small colony of this species was known to occur within Miandetta Park where a spring -fed pond overflowed into a drain underground and to the Mersey River. Additional habitat for the species was created by excavating some saturation areas with small berms to slow the flow of the water and back it up to saturate more ground.

Translocation of threatened species may be proposed as mitigation, compensation or offset for impacts on a species or its habitat. (http://www.environment.gov.au/system/files/resources/c0463a3b-cf06-44a7-a7c6-76b488321561/files/epbc-act-policy-translocation.pdf).

Translocation involves the relocation of animals from an area adversely affected by development to an area reserved and protected from ongoing impacts. The success of long-term outcomes of translocation is not well known. The Action Statement for the WBC was written in 2004 (Morey 2004). At this time the species was only known from Labertouche and Wattle Creek in Labertouche, predominantly within Crown Reserve, later gazetted as the Janet Clark Nature Reserve. The threatening processes such as urban expansion within Drouin and Warragul were not identified as threats as the species was not known to occur there. Therefore, the possibility of translocation was not considered in the actions. There is no Recovery Plan for this species.

Translocation of burrowing crayfish has been attempted for the Central North Burrowing Crayfish (*Engaeus granulatus*) (Devonport City Council 2012) and Hairy Burrowing Crayfish, (*Engaeus sericatus)* (Van Praagh 2013). The Central North Burrowing Crayfish was translocated as part of an Offset for the Sheffield Rd Safety and Flood Mitigation Upgrade undertaken by Davenport City Council. Habitat was created by constructing a perched soak and seeps at an Offset site owned by Council. Over 200 individuals were translocated and after six months of monitoring almost 80 % of burrows showed signs of activity indicating an exceptionally high success rate (Davenport City Council 2013). However subsequent monitoring has revealed a decrease in the number of burrows counted due to a drought and drying of the soil (Phil Murray pers.com. 2014).

WBC have been recorded in areas of disturbance such as roadside verges and along edges of a recently constructed drains (INVERT-ECO personal observations). This indicates that they have potential to adapt and colonise new or disturbed environments where conditions are suitable.

4 TRANSLOCATION

It is proposed that the translation will be undertaken with collaboration and support from Baw Baw Shire Council, Adam Dunn, West Gippsland Catchment Management Authority (WGCMA), Ecologist Paul Kelly & Associates and by crayfish/aquatic experts Dr Beverley Van Praagh (INVERT-ECO) and John McGuckin (Stream Research).

4.1 Site Description and Biodiversity Values

The site includes 4 parcels of land with a total area of approximately 9.75 ha:

- 14-40 Wills St
- 42-69 Wills St
- 62-70 Wills St &
- 110 King St

It is situated on the corner of King St and Wills Street, Drouin (Figure 1). The Princes Freeway abuts the southern boundary with a vegetated buffer. The site is zoned Industrial Zone 1 (IN1Z) The site contains established industrial infrastructure including two large buildings and associated vehicles and machinery.

The site has been grazed and supports permanent pasture and swampy vegetation to the south. Hazel Creek flows east west through the land with associated tributaries and drains. The southern portion of the site is regularly inundated and considered a flood zone.

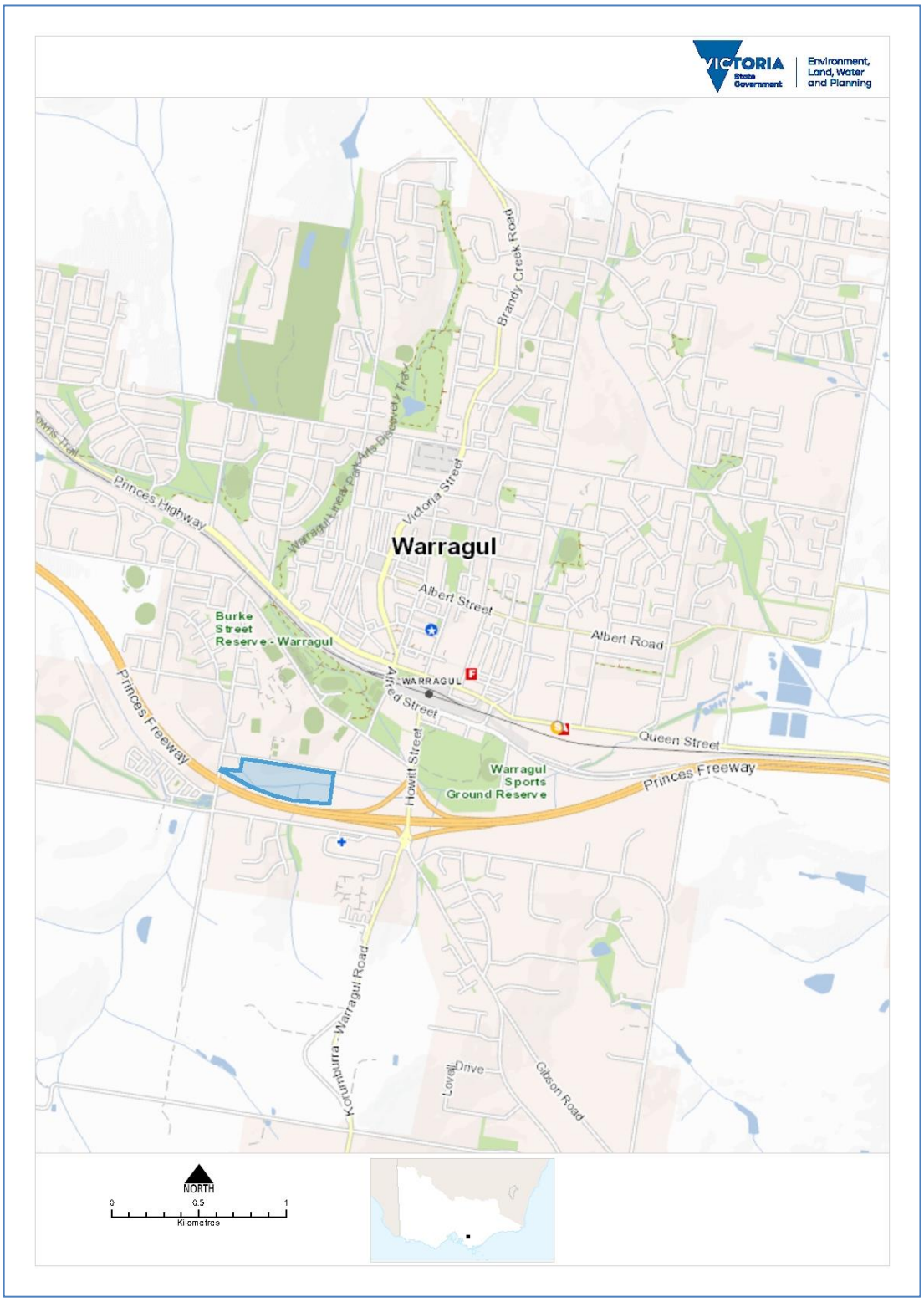
A flora assessment of the site by PKA (2022) determined the 2005 modelled EVC mapping (DELWP 2021) indicates that the site contains only fragmented patches of EVC 29 Damp Forest generally associated with the road reserves of the Princes Freeway and Wills Street. The flora assessment determined the vegetation quality (DSE 2004b) of the site is generally low and has been significantly modified over a long period of time and more recently by willow removal works along Hazel Creek. Weedy pasture and scattered sedges occur on the undisturbed areas.

An assessment for Dwarf Galaxias was undertaken by John McGuckin (Stream Research in October 2022). While no evidence of the species was found, the constructed wetland may provide opportunistic habitat for the species or support a translocated colony.

4.2 Proposed Development

It is proposed to rezone and develop part of subject site into a range of lot sizes for industrial purposes. A drainage reserve will be established along the realigned Hazel Creek. This reserve is principally a meandering regular flow channel within the flood plain. The channel is proposed to contain several online ponds and riffles. The banks and riparian areas will provide opportunity for GGE and WBC habitat. The eastern section of the drainage reserve is proposed to provide a constructed wetland system. This constructed wetland will provide opportunistic habitat for Dwarf Galaxias and two of the WBC sites will be retained.

Figure 2 Location of project site



4.2 Translocation Site

The translocation site is in close proximity to the source population (within 100 m) and within the same landscape of low lying, disturbed pasture. It has similar elements to the area of the source colony (Figure 2). The concept plan for the wetland is given in Attachment 2.

A Gant Chart for the timing of the development of the wetland and translocation is provided in Attachment 2. This assumes a construction start through summer to autumn 2022/23 then relocation in winter/spring 2023

4.3 Colony to be translocated

The WBC colony to the north-east of the study area, along Wills St (See Figure 2, Plate 4) will be translocated to the new, created wetland located within 100m to the south of site. A high density of chimneys and burrows were observed, extending over an area of approximately 100m in length and 20 m in width. The number of crayfish to be translocated is difficult to estimate and won't be known until the collection phase of the project. Given the size of the area, it is likely to be in the order of 50 plus individuals.

Figure 3 Location of WBC colony to be translocated and wetland translocation site

Plate 4 WBC site proposed for translocation

4.4 Crayfish Habitat Design

The proposed wetland design will include crayfish friendly features to by protecting and enhancing the habitat surrounding the wetland. This includes creating complex shorelines such as inlets or protrusions to increase habitat availability around the periphery, creation of peninsulas to provide refuge during periods of high-water retention and ensuring that a surrounding floodplain is maintained (or additionally created).

The final habitat design will form part of the detailed engineering hydrology design for the site.

The following crayfish friendly design features to be considered include:

Based on current observations, WBC often occupy areas of a floodplain with slightly better drainage. These sites are generally seasonally wet and mildly water-logged but dry out to some degree in the summer when the water table drops.

- Creation of boggy areas for WBC habitat around drainage infrastructure would require consultation with an ecological or hydrological consultant to determine most appropriate method for achieving suitable conditions.

Potential methods for habitat creation may include:

- slowing down the water from an existing waterway and diffusing it laterally by constructing berms to intersect stream flow.
- filling parts of waterway or wetland with stones of various sizes to a level to slow and diffuse water flow but not to impede the flow so that it is retained.
- construction of low earth banks to divert or temporarily hold water using the natural morphology of the site
- excavation of low-lying land/within or adjacent to waterway or soaks to create boggy area.
- leaky pipes for outlet and inlet flows

- Consider several smaller, linked wetlands incorporating the suggested design elements;

- Design wetlands and retardation basins to include a complex shape that increases the surface area around the periphery so that a greater area of suitable WBC habitat is available;

- Include raised peninsulas of less saturated areas in design, that may provide habitat or refuge for crayfish during times of high-water retention within the system;

- Design shaping and gradient of edges to provide suitable WBC habitat e.g. shallow, sloping gradient along edges. This can be modified if required to direct seepages into adjacent area for habitat creation

- Establish a Conservation Zone around WBC habitat identified. This zone will be protected by a primary and secondary buffer as described in the Baw Baw Shire –West Gippsland CMA Draft **Waterway Management Plan Guidelines**

- Planting areas surrounding the waterway with appropriate wetland species such as Matt Rush (Juncus sp.)

4.5 Crayfish collection methods

A crayfish assessment will be undertaken several weeks pre translocation works to mark and flag chimneys.

Crayfish collection will be undertaken during late winter/spring when chimneys are visible and they are more easily collected as they are closer to the soil surface. This will only occur when the wetland has been created and the planting has had some time to settle (2-3 months?).

Crayfish traps

Crayfish traps based on the design by Bryant *et. al*. 2012 (Bryant et al. 2012,. 2014) can be used to collect crayfish (Plate 5). However, given they return an average capture rate of 10% with overnight deployment (Bryant *et al.* 2014), it Is proposed that a combination of traps, bait pump and excavation by hand (or machine) is used to collect as many crayfish as possible from the site in a timely manner. This would not be possible using traps alone.

The bait pump is known to be successful in capturing burrowing crayfish in wet areas or within burrows containing water.

As the WBC is a small species of crayfish (<70 mm), the bait pump has not caused fatal injury during Invert-Eco's experience with this method. Bait pumps can only be used to sample crayfish in 'wet' burrows (i.e. contain enough water for the pump to be effective) and is required for bait pumps to function effectively. The bait pump is a stainless- steel tube with internal plunger attached to a handle used by fishers for collecting sediment burrowing bait (Plate 5). The pump is inserted into the burrow which extracts contents of the burrow. Once withdrawn from the burrow the collected sediment is carefully expunged by depressing the plunger.

Excavation (digging) –with hand trowels or small excavator – may be required to collect any crayfish remaining after traps and bait pump use. This is achieved by excavating layers of soil and inspecting burrows and removed soil for individuals. The soil is removed in sections by a large excavator down to approximately 30 cm. When burrows are uncovered, excavation is halted and the burrow checked for crayfish. Each burrow is then excavated to the water table where possible, and a bait bump can used in an attempt to collect any resident crayfish.

Plate 5 Modified Norricky Trap (left) and bait pump

4.6 Handling of animals

Only authorised/trained persons will handle crayfish

Once a burrowing crayfish is collected, will be:

- examined to check that they have not been compromised by the collection process;
- washed free of dirt and mud by placing them into a container of dechlorinated potable water (tap water that has been allowed to sit in a vented container for at least 72 hours;
- rinsed clean in a second container of dechlorinated potable water and;
- Stored in a cool location out of direct sunlight in an open plastic container lined with damp paper towel or sponges ready for translocation
- When 12 animals have been captured, cleaned and stored pending translocation, or when the animal that was captured first in the group has been in captivity for 90 minutes, they will be transported to the receptor site;

  Where possible, certain parameters will be recorded:

  -Size of specimen (OCL -occipital carapace length and TL-total length)
  -Reproductive status
  -Colour
  -Depth where crayfish found
  -Burrow structure/depth to water-table
  -photographed

4.7 Welfare and Euthanasia Protocols

Compromised animals, in the opinion of a suitably qualified person, described in table x, may include animals that have lost both their front claws (but not animals that retain one front claw unless they have other injuries), have sustained an injury to their thorax, head or abdomen from which they are unlikely to recover or are only partially complete (e.g. have been decapitated or cut in half by the excavation process). These animals will be euthanised using Clove Oil (Table 2), placed into preserving jars containing 90% ethanol for preservation. Specimens will be lodged (including the appropriate collection details) with the Museum Victoria and/or Federation University for addition to the collection for future research opportunities. Specimens will be lodged within 3 months of the translocation project being completed.

Table 2 Welfare and determination of level of damage requiring euthanasia

Procedure step for monitoring	Welfare	Method (and frequency) of welfare monitoring
1. Capture of animals	Animals caught: 1a. Examine individual for injury. If injured, determine level of injury (See 4). 1b Observe crayfish for normal movement in container (e.g. upright position, alert)	Observation of individual on collection of traps Observation (continuous) – for bait pump or excavation
2. On site identification of captured animals	Gentle handling for identification, Check under tale for eggs	Observation (continuous)
3 Release to area of capture (for identified animals or those not required for further analysis)	If uninjured or non-fatal injury (See 4-Level 1), release into burrow.	Observation (continuous) – Continuous monitoring to ensure they safely descend into burrow.
4 Euthanasia of injured or diseased animals or those unable to be identified in the field and require laboratory examination	Level of injury to determine fate of individual. LEVEL 1. Animals that retain one front claw with no other major injuries (Can be released) LEVEL 2 Animals that have lost both their front claws (Fatal-Euthanised) LEVEL 2 Have sustained an injury to their thorax, head or abdomen from which they are unlikely to recover (Fatal-Euthanised) LEVEL 2 are only partially complete (e.g. have been decapitated or cut in half by the excavation process). (Fatal-Euthanised)	Observation (continuous observation for first two minutes then at 5 minutes, followed by intervals of 5 minutes until euthanased). Animals are immersed in clove oil solution until movement has ceased for > 5 minutes. If using Aqui-S, animals are immersed in the solution until movement has ceased for >5 minutes. Aqui-S solution at this concentration (and duration) is an overdose and will progress the animal through sedation to death.

Table 3 Method of Euthanasia

Euthanasia	Method	Route of administration	Dose	How will death be confirmed
Fatal Injury or disease	Clover Oil Solution Museum Victoria Standard Operating Procedure (SOP) for aquatic animals (Museum Victoria 2010)	Immersion in Clove Oil Solution	10 mg/L	When movement stops. Usually less than 5 minutes

4.8 Preparation of translocation site

Creation of artificial release burrows

- Artificial burrows will be constructed down to water table where possible or to very wet clay using a small screw type soil auger/bait pump or shovel
- Any juvenile (<15 mm) should be placed in holes that go into the ground diagonally to give them some support.
- Holes will be at least 25 mm wide and filled with dechlorinated water (preferable) if water table not reached or water from wetland. Dechlorinated water is water left in a vented container for 72 hours.
- Created holes will be at least 30 cm from existing crayfish chimneys or other created burrows
- Only one individual will be released into each created hole unless they are juveniles that have been collected from the same burrow
- Each burrow location will be recorded with a GPS, marked with a small flag and photographed.

4.9 Release procedure

The crayfish is gently placed tail first into the burrow. If the animal does not retreat quickly then a leaf or similar will be placed over the crayfish to ensure a safe environment for retreating into the burrow and simultaneously obscure the animal from potential predators. Animals will be observed until they have safely retreated into the burrow.

A 'map' of the translocation area will be prepared post-translocation of all the animals noting the –

- occupied burrows
- burrows were inhabited by injured, but not compromised, animals (e.g. one front claw missing); and
- burrows occupied by gravid females (if present).

5 Monitoring Program

An important aspect of adaptive management framework is to evaluate the outcomes of the translocation, to assess their effectiveness and to adjust as necessary. This requires assessment of the response of WBC colonies to the wetland design principles and to any rescue and release/translocation programs through crayfish surveys at designated intervals after project completion.

As the translocation site will consist of creating a new wetland habitat, it can be assumed that any WCB chimneys are most likely to be from the source crayfish although it is hopeful that adjacent colonies will also recolonise the site over time.

Photopoints will be established to record empirical and visual data against which the management actions conducted.

The presence of burrowing crayfish is generally noted by the mud chimneys they build around their burrow entrances, particularly during the wetter months of the year. In general, it is very difficult to identify burrowing crayfish by their chimneys. However, INVERT-ECO has developed a passive technique to identify WBC by using characterises of their chimney structure (Plate 6). While some chimneys can be ambiguous, using this method has returned excellent results. Observation of chimneys will be used where possible for WBC monitoring.

Crayfish will be monitored by the presence of chimneys either at the site of the constructed burrow or new chimneys. This indicates whether the crayfish has successfully adapted to its new environment.

Burrow counts will be conducted at the translocation site at varying intervals over a minimum 3 years. The intervals and duration may be informed by results.

Year 1 - Burrow counts will be conducted at 2, 4, 6, 8, 10, 12, 24, 36 and 52 weeks from translocation. Photo-point records will also be taken at these times. (This may be modified to include less sampling outside the chimney building season (summer and autumn)

Year 2- Burrow counts 3 times during chimney building season (winter, spring, early summer)

Year 3- Burrow counts 3 times during chimney building season (winter, spring, early summer)

An additional two years monitoring may be included depending on previous results

Burrow counts will include a visual search for WBC chimneys using the following characteristics (see Plate 6).

- Small and compact chimneys generally < 8 cm
- Chimney comprised of small, spherical balls of soil < 5mm
- Small burrow entrance opening < 2 cm

All WBC burrows at a site will be counted. If a cluster or burrows are together e.g., chimneys joined (see Plate 4) they will be counted as one burrow.

Burrow belonging to other species will also be recorded.

Several soil parameters will also be monitored at various intervals during the project including soil moisture and depth to the water table.

Plate 6 Variety of WBC Chimneys

6 Indicators of Success

Indicators of success will be based on survival rate as determined by the by the presence or absence of fresh chimney activity compared with the number of crayfish translocated. Assumptions will need to be made around the occupancy of burrows but fresh activity indicates the burrow is being utilised.

7 References

Bryant, D., Crowther, D. and Papas, P. 2012. Improving survey methods and understanding the effects of fire on burrowing and spiny crayfish in the Bunyip and South Gippsland catchments. Department of Sustainability and Environment, Heidelberg, Victoria http://www.depi.vic.gov.au/__data/assets/pdf_file/0017/203930/VBRRA-P17-revised-web.pdf

Bryant *et al.* 2014 Bryant, D., Crowther, D. and Papas, P. (2014). Engaeus Erichson (Decapoda: Parastacidae) capture using two versions of a Norrocky trap. *Australian Zoologist* 37(2), 188-192.

Davenport City Council. 2013 Piping of Open Drain & Translocation of Burrowing Crayfish at Sheffield Road, Devonport, Tasmania (EPBC 2011/6095) Annual Compliance Report Environment Protection Biodiversity Conservation Act 1999.

Department of State Growth 2014. A guide to managing threatened burrowing crayfish in the Department of State Growth road reserves. Department of State Growth, Hobart.

Doran, N. 1999. *Burrowing Crayfish* (Engaeus) *Group Recovery Plan 2001-2005*. [Online]. Parks and Wildlife Service, TAS DPIWE. Available from: http://www.environment.gov.au/biodiversity/threatened/publications/recovery/burrowing-crayfish/index.html.

Doran, N. & Horwitz, P. 2010. *Engaeus sternalis*. The IUCN Red List of Threatened Species. Version 2014.3. <www.iucnredlist.org>. Downloaded on **18 December 2014**.

Honan, J. 2010. *Draft Guidelines for management of burrowing crayfish in south-west Victoria*. Biodiversity Services, DSE Warrnambool (unpublished report).

Horwitz, P. 1990. *The conservation status of Australian freshwater crustacea*. Australian National Parks and Wildlife Service, Management Report No. 14.

March, T.S. and Robson, B.J. 2005. Association between burrow densities of two Australian freshwater crayfish (*Engaeus sericatus* and *Geocharax gracilis*:Parastacidae) and four riparian land uses. Aquatic conservation: Marine and Freshwater Ecosystems. 16, 181–191.

McGuckin, J. 2022 Dwarf galaxias targeted investigation - Wills Street development, Warragul Streamline Research Pty. Ltd. Unpublished Report prepared for Advantage All Development Group

Museum of Victoria (2010). *Manual of Standard Operating Procedures (SOPs) for the ethical use of live aquatic animals – fishes, cephalopods (octopus, cuttlefish, nautilus, squid and their allies) and decapod crustaceans (crabs, crayfish, lobsters, prawns, shrimps and their allies)*. Prepared by staff and associates of Museum Victoria. Approved by the Museum Animal Ethics Committee on 12 November 2010.

Morey 1994 Action statement Flora and Fauna Guarnetee Act 1988. No 91. Sustainability and Environment, Victoria.8 Nicholson Street, East Melbourne, Victoria

Morey, J, & Hollis, G. 1997. Australia's most diverse crayfish habitat*? Memoirs of the Museum of Victoria* 56(2):667-669.

Norrocky M.J. (1984). Burrowing crayfish trap. Ohio Journal of Science 84: 65-66.

O'Brien, M. 2007. Freshwater and terrestrial crayfish (Decapoda, Parastacidae) of Victoria: status, conservation, threatening processes and bibliography. *The Victorian Naturalist*. 124 (4) pp. 189-283

Richardson, A., Doran, N., and Hansen, B., 2006. The geographic ranges of Tasmanian crayfish: extent and pattern. *Freshwater Crayfish 15*.

Shaw, J (1996). Australia's rarest crayfish? – A survey of the Labertouche Creek and tributaries in West Gippsland to extend the known range of the Warragul burrowing crayfish (*Engaeus sternalis*). Department of Natural Resources and Environment, Victoria, Australia.

SKM, 2008. Warragul Urban Drainage Strategy. Report prepared for Baw Baw Shire Council, Armadale VIC

Van Praagh, B.D. 2010. Warragul Burrowing Crayfish Surveys within the Janet Clarke Reserve and surrounding areas, South Gippsland**.** Unpublished Report to Melbourne Water.

Van Praagh, B.D. 2011a Baw Baw Shire Urban Growth Area Biodiversity Assessment and Mapping. Targeted survey for Warragul Burrowing Crayfish (*Engaeus sternalis*) and Narracan Burrowing Crayfish (*E. phyllocercus*). Unpublished report for GHD Pty Ltd on behalf of Baw Baw Shire Council.

Van Praagh, B.D. 2011b. Giant Gippsland Earthworm and Warragul Burrowing Crayfish assessment at Dawson Drive, Warragul. Unpublished report for Duran Investments Pty Ltd. Beaconsfield Victoria. November 2011.

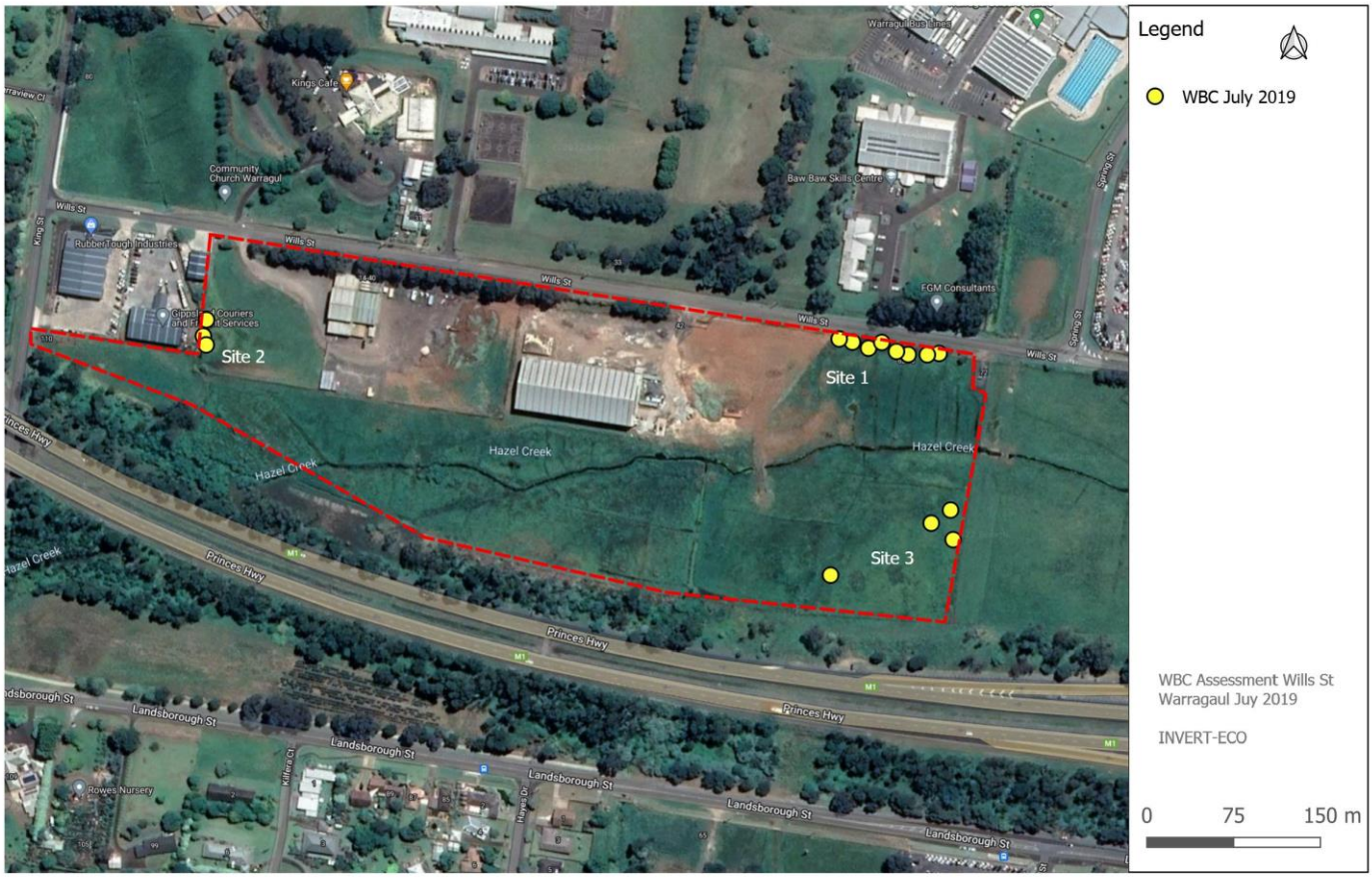
Van Praagh, B.D. 2013 Capture and relocation of burrowing crayfish in areas impacted by construction of an access road at Marengo Basin, Apollo Bay WTP. Unpublished report to Barwon Water Alliance, Geelong, Victoria.

Victorian Department of Sustainability and Environment (2009) Advisory List of Threatened Invertebrate Fauna in Victoria - 2009. Department of Sustainability and Environment, East Melbourne, Victoria.

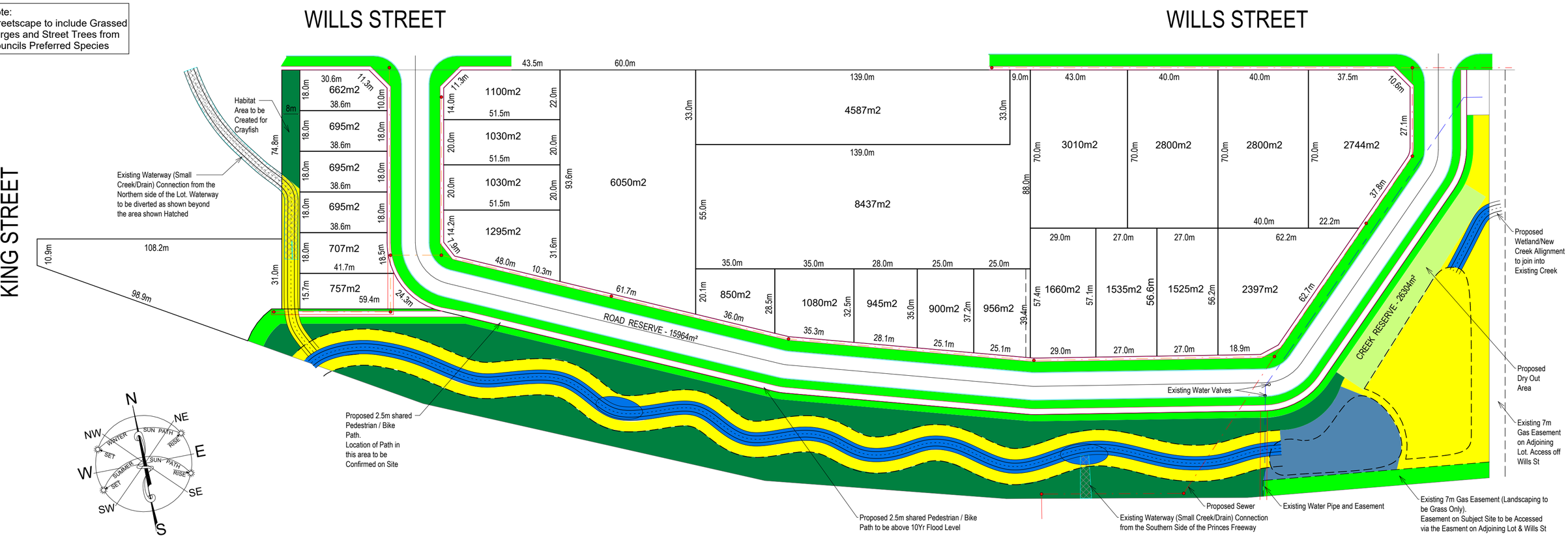
Victorian Planning Authority (2014). 'Drouin Precinct Structure Plan.' (Metropolitan Planning Authority: Melbourne).

Victorian Planning Authority (2014). 'Warragul Precinct Structure Plan.' (Metropolitan Planning Authority: Melbourne).

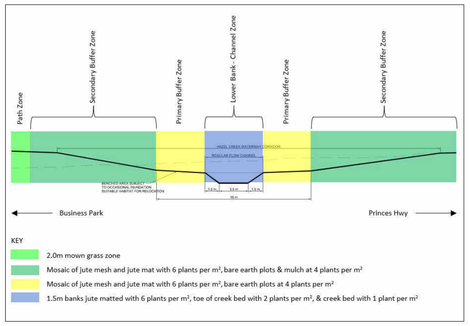
Appendix 1 Location of WBC colonies at Will St



Note:
Streetscape to include Grassed Verges and Street Trees from Councils Preferred Species



DESIGN FEATURES



Wetland & Sediment Pond

Botanical Name	Common Name	Pot Format
Terrestrial/Littoral Zone – 4 plants per m²		
Tall canopy		
Acacia melanoxylon	Blackwood	200cm³
Eucalyptus strzeleckii	Strzelecki Gum	200cm³
Eucalyptus ovata	Swamp Gum	200cm³
Eucalyptus viminalis	Manna Gum	200cm³
Eucalyptus obliqua	Messmate	200cm³
Understorey		
Acacia dealbata	Silver Wattle	200cm³
Acacia verticillata	Prickly Moses	200cm³
Bursaria spinosa	Sweet Bursaria	200cm³
Cassina aculeata	Common Cassinia	200cm³
Coprosma quadrifida	Prickly Currant-bush	200cm³
Goodenia ovata	Hop Goodenia	200cm³
Leptospermum continentale	Prickly Teatree	200cm³
Leptospermum lanigerum	Woolly Teatree	200cm³
Melaleuca ericifolia	Swamp Paperbark	200cm³
Melaleuca squarrosa	Scented Paperbark	200cm³
Olearia lirata	Snowy Daisy-bush	200cm³
Ozothamnus ferrugineus	Tree Everlasting	200cm³
Pomaderris aspera	Hazel Pomaderris	200cm³
Prostanthera lasianthos	Victorian Mint-bush	200cm³
Groundcovers/grasses/sedges/lilies/climbers		
Aceana novea-zelandiae	Bidgee-widgee	200cm³
Carex appressa	Tall Sedge	200cm³
Clematis aristata	Mountain Clematis	200cm³
Dichondra repens	Kidney Weed	200cm³
Dianella tasmanica	Tasman Flax-lily	200cm³
Gahnia sieberiana	Red-fruit Saw-sedge	200cm³
Lomandra longifolia	Spiny-headed Mat-rush	200cm³
Poa ensiformis	Purple-sheath Tussock-grass	200cm³
Poa labillardieri	Common Tussock-grass	200cm³
Microlaena stipoides	Weeping Grass	200cm³
Viola hederacea	Native Violet	200cm³
Ephemeral Marsh – 6 per m²		
Carex appressa	Tall Sedge	90cm³
Carex fascicularis	Tassel Sedge	90cm³
Carex tereticaulis	Hollow Sedge	90cm³
Cyperus lucidus	Leafy Flat-sedge	90cm³
Juncus amibilis	Hollow Rush	90cm³
Juncus australis	Austral Rush	90cm³
Juncus flavidus	Yellow Rush	90cm³
Juncus gregiflorus	Green Rush	90cm³
Juncus pallidus	Pale Rush	90cm³
Juncus pauciflorus	Loose Flower Rush	90cm³
Juncus procerus	Tall Rush	90cm³
Juncus subsecundus	Finger Rush	90cm³
Shallow Marsh – 2 per m²		
Alisma plantago-aquatica	Water Plantain	550cm³
Baloskion tetraphyllum	Tassel Cord-rush	550cm³
Bolboschoenus caldwellii	Salt Club-rush	550cm³
Bolboschoenus medianus	Marsh Club-rush	550cm³
Crassula helmsii	Swamp Stonecrop	550cm³
Eleocharis acuta	Common Spike Rush	550cm³
Lycopus australis	Australian Gypsywort	550cm³
Lythrum salicaria	Purple Loose-strife	550cm³
Neopaxia australasica	White Purslane	550cm³
Persicaria decipiens	Slender Knotweed	550cm³
Persicaria praetermissa	Spotted Knotweed	550cm³
Ranunculus inundatus	River Buttercup	550cm³
Deep Marsh – 2 per m²		
Baumea articulata	Jointed Twig - Sedge	550cm³
Cladium procerum	Leafy Twig-rush	550cm³
Myriophyllum crispatum	Water-milfoil	550cm³
Myriophyllum simulans	Amphibious Milfoil	550cm³
Eleocharis sphacelata	Tall Spike Rush	550cm³
Schoenoplectus tabernaemontani	River Club-rush	550cm³
Triglochin procera	Water Ribbons	550cm³
Submerged Marsh – 1 per m²		
Potamogeton crispus	Curly-leaf Pondweed	550cm³
Potamogeton ochreatus	Blunt Pondweed	550cm³
Vallisneria australis	Eel Grass	550cm³

Pot Notes:
90cm³ Hiko cell
200cm³ Forestry tube
550cm³ Aquatic pot

Lower Bank Channel

Botanical Name	Common Name	Pot Format
Ephemeral Marsh – 6 per m²		
Aceana novea-zelandiae	Bidgee-widgee	90cm³
Carex appressa	Tall Sedge	90cm³
Carex fascicularis	Tassel Sedge	90cm³
Cyperus lucidus	Leafy Flat-sedge	90cm³
Juncus amibilis	Hollow Rush	90cm³
Juncus australis	Austral Rush	90cm³
Juncus flavidus	Yellow Rush	90cm³
Juncus gregiflorus	Green Rush	90cm³
Juncus pallidus	Pale Rush	90cm³
Juncus procerus	Tall Rush	90cm³
Juncus subsecundus	Finger Rush	90cm³
Poa ensiformis	Purple-sheath Tussock-grass	90cm³
Poa labillardieri	Common Tussock-grass	90cm³
Shallow Marsh – 2 per m²		
Alisma plantago-aquatica	Water Plantain	550cm³
Crassula helmsii	Swamp Stonecrop	550cm³
Eleocharis acuta	Common Spike Rush	550cm³
Lycopus australis	Australian Gypsywort	550cm³
Lythrum salicaria	Purple Loose-strife	550cm³
Persicaria decipiens	Slender Knotweed	550cm³
Persicaria praetermissa	Spotted Knotweed	550cm³
Deep Marsh – 2 per m²		
Baumea articulata	Jointed Twig - Sedge	550cm³
Schoenoplectus tabernaemontani	River Club-rush	550cm³
Triglochin procera	Water Ribbons	550cm³
Submerged Marsh – 1 per m²		
Vallisneria australis	Eel Grass	550cm³

Pot Notes:
90cm³ Hiko cell
550cm³ Aquatic pot

Primary Buffer Zone

Botanical Name	Common Name	Pot Format
Ephemeral Marsh – 6 per m²		
Aceana novea-zelandiae	Bidgee-widgee	90cm³
Carex appressa	Tall Sedge	90cm³
Dichondra repens	Kidney Weed	90cm³
Juncus australis	Austral Rush	90cm³
Juncus flavidus	Yellow Rush	90cm³
Juncus gregiflorus	Green Rush	90cm³
Juncus subsecundus	Finger Rush	90cm³
Lomandra longifolia	Spiny-headed Mat-rush	90cm³
Lycopus australis	Australian Gypsywort	90cm³
Lythrum salicaria	Purple Loose-strife	90cm³
Poa ensiformis	Purple-sheath Tussock-grass	90cm³
Poa labillardieri	Common Tussock-grass	90cm³
Persicaria decipiens	Slender Knotweed	90cm³

Pot Notes:
90cm³ Hiko cell

Secondary Buffer Zone

Botanical Name	Common Name	Pot Format	Quantity
Terrestrial/Littoral Zone – 4 plants per m²			
Tall canopy			
Acacia melanoxylon	Blackwood	200cm³	
Eucalyptus strzeleckii	Strzelecki Gum	200cm³	
Eucalyptus ovata	Swamp Gum	200cm³	
Eucalyptus viminalis	Manna Gum	200cm³	
Eucalyptus obliqua	Messmate	200cm³	
Understorey			
Acacia dealbata	Silver Wattle	200cm³	
Acacia verticillata	Prickly Moses	200cm³	
Bursaria spinosa	Sweet Bursaria	200cm³	
Cassina aculeata	Common Cassinia	200cm³	
Coprosma quadrifida	Prickly Currant-bush	200cm³	
Goodenia ovata	Hop Goodenia	200cm³	
Leptospermum continentale	Prickly Teatree	200cm³	
Leptospermum lanigerum	Woolly Teatree	200cm³	
Melaleuca ericifolia	Swamp Paperbark	200cm³	
Melaleuca squarrosa	Scented Paperbark	200cm³	
Olearia lirata	Snowy Daisy-bush	200cm³	
Ozothamnus ferrugineus	Tree Everlasting	200cm³	
Pomaderris aspera	Hazel Pomaderris	200cm³	
Prostanthera lasianthos	Victorian Mint-bush	200cm³	
Groundcovers/grasses/sedges/lilies/climbers			
Aceana novea-zelandiae	Bidgee-widgee	200cm³	
Carex appressa	Tall Sedge	200cm³	
Clematis aristata	Mountain Clematis	200cm³	
Dichondra repens	Kidney Weed	200cm³	
Dianella tasmanica	Tasman Flax-lily	200cm³	
Gahnia sieberiana	Red-fruit Saw-sedge	200cm³	
Juncus australis	Austral Rush	200cm³	
Juncus gregiflorus	Green Rush	200cm³	
Juncus pauciflorus	Loose Flower Rush	200cm³	
Lomandra longifolia	Spiny-headed Mat-rush	200cm³	
Poa ensiformis	Purple-sheath Tussock-grass	200cm³	
Poa labillardieri	Common Tussock-grass	200cm³	
Microlaena stipoides	Weeping Grass	200cm³	
Viola hederacea	Native Violet	200cm³	

Pot Notes:
90cm³ Hiko cell
200cm³ Forestry tube
550cm³ Aquatic pot

A11

ADVANTAGE DEVELOPMENT GROUP ALL EST. 2019
Advantage All Consulting P/L
Ph: 03 5625 5294
Email: info@advantageall.com.au
ABN: 16 587 630 031 ACN: 631 617 699
CCB-L-71635 CDP-AD72766

CONTRACTOR MUST VERIFY ALL DIMENSIONS AND LEVELS AT THE JOB PRIOR TO COMMENCING ANY WORK OR MAKING ANY SHOP DRAWINGS.

DO NOT SCALE DRAWINGS. ALWAYS USE WRITTEN DIMENSIONS.

Date:_____

Builders Signature:_____

Signature 1:_____

Signature 2:_____

JOB ADDRESS: Wills Street, Warragul, 3820

CLIENT: Freeway Business Park P/L

JOB No: 01001

DRAWN: Lincoln

4/05/2022 3:53:18 PM

SHEET (A2): A11

REVISION: Planning

SCALE: 1 : 1250

DESIGN TYPE: Proposed Development

Drawing: Landscape Concept Plan

WBC RELOCATION PROGRAM

Creek/ Wetlands

TASKS	WEEK 1							WEEK 2							WEEK 3							WEEK 4						
Date (TBC)	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S
Council Approval to start																												
Site Establish																												
Pre Start Meet																												
Establish Enviro Controls																												
Dig Out Creek																												
Build Wetlands																												
Create Habitats																												
Plant Out Wetlands & Creek area																												
Divert creek to new																												
Relocation WBC Winter/Spring																												

TASKS	WEEK 5							WEEK 6							WEEK 7							WEEK 8							WEEK 9							WEEK 10							Winter/Spring							Winter/Spring						
Date (TBC)	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S
Council Approval to start																																																					
Site Establish																																																					
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