Ballarat West Growth Area -

Conservation Management Plan for the Growling Grass Frog (*Litoria raniformis*)

(Ballarat West Conservation Management Plan)

FOR: CITY OF BALLARAT

20 DECEMBER, 2011

EXECUTIVE SUMMARY

SMEC Australia was engaged by the City of Ballarat to prepare a Conservation Management Plan (CMP) for the Growling Grass Frog (GGF) *Litoria raniformis* within the Ballarat West Growth Area. The GGF is listed as Threatened under the Victorian *Flora and Fauna Guarantee Act 1987* and Vulnerable under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*. A flora and fauna assessment and targeted surveys for the GGF have previously been conducted in the Project Area.

The Project Area contains a natural creek system and a large number of farm dams with varying amounts of wetland vegetation. These landscape features are known and potential habitat for the GGF in the Project Area. Occupied habitat in the Project Area features a good cover of complex vegetation, which is a known characteristic of GGF habitat. Other areas of apparently suitable habitat were comprehensively surveyed and found to be unoccupied. These waterbodies exist in a cleared landscape dominated by pasture and are, accordingly, poorly connected to one another. These sites are considered no further by this plan.

The Project Area is intended to be the primary focus for urban growth in Ballarat over the next 30 years. This would require the Project Area to be cleared of vegetation to allow the construction of housing, associated infrastructure and recreational opportunities. As such, the Project triggers a number of known threatening processes affecting this species, principally habitat loss via the removal of known GGF habitat to consolidate the Project's layout. Thus, without mitigation measures, the Project may compromise the long-term viability of the GGF metapopulation within the Project Area.

The aim of this CMP is to ensure the long-term viability of the GGF in the Project Area. To achieve this, actions required to protect and enhance the GGF metapopulation during the pre-construction, construction and operational stages of the Project are detailed.

A central feature of the CMP is the creation and management of additional habitat for the GGF in the Project Area. This will consist of a series of artificial waterbodies of varying depth, to be installed along floodplains in the Winter Creek catchment and planted with suitable endemic aquatic vegetation. The GGF requires complex vegetation to support its various behavioural requirements. A minimum of two years would be required for vegetation to establish before the compensatory waterbodies will be suitable for occupation by the GGF at all life stages. The waterbodies will be clustered to enable effective movement between them.

The creeks will also be enhanced to provide an effective dispersal corridor. Terrestrial habitat between waterbodies will be planted with endemic floodplain vegetation. Over-wintering shelter sites, such as logs and rocks, will be placed into habitat areas. The area proposed for creation of compensatory habitat is proximate to known GGF habitat areas. Therefore, natural dispersal is likely to enable these created habitats to become occupied.

A 2 year program to monitor the success of the habitat creation is proposed. This would involve both population monitoring and assessments of water quality in an adaptive management framework. Monitoring results would be provided in annual letter reports, with a formal report at the completion of monitoring. Reports will be provided to the City of Ballarat, Victorian Department of Sustainability and Environment and the Commonwealth Department of Sustainability, Environment, Water, Population and Communities.

Provided the measures outlined in this CMP are fully implemented, there is likely to be a significant improvement in the amount and quality of GGF habitat available in the Project Area. As such, the maintenance of links to habitat areas elsewhere in the locality will be assured. The actions specified herein should ensure the long-term viability of the GGF in the Project Area and contribute to its long-term viability in the locality. It is expected that the implementation of the CMP will also achieve broader biodiversity outcomes.

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1 INTRODUCTION

1.1 Background to Project and Purpose of this Report

SMEC Urban (SMU) has been engaged by the City of Ballarat (COB) to prepare Precinct Structure Plans (PSP's) for Precincts 1, 2 and 4 of the Ballarat West Growth Area (BWGA), a 1287 hectare proposed urban release area on the western outskirts of Ballarat (**Figure 1**) (the Project).

Baseline ecological surveys for the PSP's (Ecology Partners 2010; 2011) found that parts of the BWGA support the Growling Grass Frog (GGF, *Litoria raniformis*), a species listed as Threatened under the Victorian *Flora and Fauna Guarantee Act 1987* (FFG Act) and Vulnerable under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). SMEC's ecology team has been commissioned to prepare a Conservation Management Plan (CMP) for the GGF. The CMP will be implemented through the BWGA PSP's[1].

The Project Area extends westward from the suburbs of Alfredton, Delacombe and Sebastopol. It consists of a mix of private (mostly rural and rural residential) and public lands supplied with a low-density road network. Major roads in the Project Area are Ross Creek Road, Smythes Road, Greenhalghs Road and Ballarat-Carngham Road, which are all aligned in approximately an east-west direction. Midland Highway is along the extreme south-eastern boundary of the Project area, while Cuthberts Road is along its northern boundary (**Figure 2**).

The Project Area has been largely cleared, mainly for grazing, and it is well supplied with small to medium farm dams. Native tree cover consists of scattered remnant trees. A permanent creek system, with associated ephemeral drainage lines drains the Project Area. The named creeks within the Project Area are Winter Creek, Kensington Creek and Bonshaw Creek. The topography of the Project Area consists of alluvial flats along the floodplains of these creeks and low, gently sloping hills.

A general flora and fauna assessment and targeted surveys for the GGF have previously been conducted in the Project Area (Ecology Partners 2010, 2011). The targeted surveys (Ecology Partners 2011) found the GGF at seven locations within the Project Area in early 2011 (Ecology Partners 2011). A total of 13 individuals were detected, consisting of four adults, six sub-adult and three metamorphs. All individuals were found in Precinct 1 of the Project area (**Figure 2**).

Suitable habitat for the GGF was also identified in Precincts 2 and 4 of the Project Area, but no frogs were located. Recently, AECOM Australia (2011) recorded the GGF near the southern boundary of the Project Area, in artificial waterbodies near Winter Creek. This location is in reasonable proximity to the occupied habitat in the Project Area. Thus, GGFs within the Project Area are part of a larger metapopulation occurring in the locality. The Project would remove most known and potential GGF habitat from the Project Area. The Project may also sever some movement pathways between the Project Area and the broader locality.

[1] SMEC is also preparing: (i) an *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) Controlled Action referral for the Growling Grass Frog; and (ii) a Native Vegetation Precinct Plan. These reports will cross reference recommendations made by this CMP.

The Project is in the early stages of planning, and as such designs are conceptual. There is no detailed information on the development layout, stormwater management strategy, and landscape and rehabilitation strategy at present. The lack of such detail is acknowledged as a limitation to the current CMP. However, it is demonstrated in this CMP that it is possible to adequately mitigate development impacts on the GGF. Therefore, SMEC believes that the principles established by this plan are sufficient to provide Victorian Department of Sustainability and Environment (DSE) and the Commonwealth Department of Sustainability, Environment, Water, Population and Communities (DSEWPC) with the confidence to issue a preliminary or in-principle approval of the CMP. Approval conditions could include requirements to prepare the more detailed studies and designs suggested by this plan. Subsequently, review and resubmission of the CMP for final approval may be required once additional Project details become available.

2 SPECIES INFORMATION

2.1 Conservation

Until recently, the GGF was an abundant and widespread species throughout south-eastern Australia. However, it has declined markedly in recent decades and now has a fragmented distribution (Clemann and Gillespie 2010). The GGF is currently regarded as a threatened species in all four range States – Victoria, South Australia, New South Wales and Tasmania. It is listed as Threatened in Victoria under the *Flora and Fauna Guarantee Act 1988*, and is listed as Vulnerable under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*. Thus, the GGF has local, State and national conservation significance.

2.2 Habitat Requirements

The GGF prefers waterbodies with still or slow-moving water. Accordingly, it is found in slow-moving streams, swamps, lakes, and lagoons. It also uses artificial habitats, such as farm dams and disused quarries (Clemann and Gillespie 2010). Due to its long larval period, permanent or semi-permanent waterbodies are required. Semi-permanent waterbodies need to be inundated for sufficient time to allow larval development, which is generally 12 – 15 months (Anstis 2002). The GGF breeds in habitats up to 1.5m deep (DSEWPC 2011).

The use of farm dams by the GGF belies its complex habitat requirements. The wetland habitats occupied by the GGF are characterised by dense fringing, emergent, submerged and floating vegetation (Ramamurthy and Coulson 2008; Clemann and Gillespie 2010). These characteristics allow for the various behavioural requirements of this species, such as foraging, basking, calling (males) and egg-laying, as well as tadpole development (DSEWPC 2011). There may be a need for some bare areas of lower structural complexity or rocks within more vertically complex vegetation to facilitate foraging (Heard *et al.* 2008). Thus, some degree of habitat heterogeneity may be important. The GGF does not use waterbodies that do not have the required structural characteristics.

The GGF overwinters beneath thick vegetation, logs, rocks and other ground debris. At such times it can be found some distance from waterbodies (Clemann and Gillespie 2010). Terrestrial habitats may also be used for foraging and basking. Therefore, terrestrial habitat around waterbodies is an important habitat component.

Movement rates between waterbodies are relatively low and are attenuated by distance. Therefore, suitable waterbodies are more likely to be occupied when they are within several hundred metres of other suitable habitat (Hamer and Organ 2008). Thus, populations of the GGF conform to a metapopulation structure, which is a series of populations connected by dispersal. This allows for the recolonisation of waterbodies if they become vacated, for example, due to temporary drying during drought.

2.3 Habitat Characteristics and Occupancy in the Project Area

Occupied habitat within the project area conforms to the known habitat requirements of the GGF, being characterised by fringing, emergent, floating and submerged vegetation (see **Plates 1 – 4**), while the species was not recorded in nearby waterbodies lacking these features (Ecology Partners 2011). All occupied habitat was located in Precinct 1, where a creek system presumably enables dispersal between waterbodies (**Figure 2**). Of the eight identified sites there were five farm dams, one pond and one location along Winter Creek (**Figure 2**). All adults and metamorphs were recorded in farm dams with dense fringing

vegetation and a good cover of emergent vegetation (See **Plates 1 – 4**), suggesting breeding occurs in these waterbodies. These sites also had at least some floating vegetation (Ecology Partners 2011). One sub-adult was located along Winter Creek (Ecology Partners 2011). The pH was neutral at all sites and salinity levels were low (Ecology Partners 2011). Isolated, but otherwise suitable, habitat elsewhere in the project area (Precincts 2 and 4; **Figure 2**) was unoccupied (Ecology Partners 2011).

2.4 Species Occurrence in the Locality

Data presented by Ecology Partners (2011) revealed that the GGF had previously been recorded within 10 km of Precinct 1. Recently, AECOM Australia (2011) recorded four adults in artificial waterbodies near the southern boundary of the Project Area. This location is in reasonable proximity to the occupied habitat in the Project Area. Although the Locality is largely cleared of native vegetation, there is an extensive network of creeks, many small to medium farm dams and some larger waterbodies. While not all of these habitats would be suitable for the GGF, it is likely that there are more populations in the Locality, which would be identified if further targeted surveys were undertaken. Thus, the populations of the GGF in the Project Area are expected to be part of a larger metapopulation occurring in the Locality. The Project Area is likely to contribute to the long-term viability of the broader metapopulation in the Locality.

Plate 1 - GGF Habitat in the Project Area

Plate 2 - GGF Habitat in the Project Area

Plate 3 - GGF habitat in the Project Area

Plate 4 - GGF habitat in the Project Area

3 KNOWN THREATS, PROJECT IMPACTS AND POTENTIAL IMPROVEMENTS

3.1 Threats

A number of threatening process have been implicated in the decline of the GGF and it is possible that several of these processes may be acting together. The most likely threats to the GGF throughout its range include habitat loss, degradation and fragmentation (e.g. land clearing, grazing by stock, altered hydrological regimes, salinity), barriers to movement (fencing, roads, urbanisation), predation by introduced fish, the Red Fox (*Vulpes vulpes*) or Cats (*Felis catus*) at the tadpole or adult stage, disease (in particular chytridiomycosis caused by the fungal pathogen *Batrachochytrium dendrobatidis*), biocides (herbicides, pesticides, etc), and ultra-violet B radiation. These threatening processes are discussed by Clemann and Gillespie (2010).

It is not possible to determine to what extent each threatening process is currently affecting the GGF in the Project Area. However, habitat loss, degradation and fragmentation would appear to be substantial threats here. The continuity of existing land uses and incremental rural residential development in the Project Area are likely to see these threats continue into the future. As such, even in the absence of the proposed development it is likely that the GGF would be vulnerable to extinction in the Project Area due to the incremental and cumulative loss of populations, each of which is likely to be small, around individual waterbodies (Clark *et al.* 1991). The loss of GGF populations within the Project Area would also compromise the viability of the metapopulation in the Locality.

3.2 Project Impacts

A number of known threats to the GGF are associated with the Project, discussed below.

3.2.1 Loss and Degradation of Habitat

Occupied Sites 2, 3, 7 & 8 (**Figure 2**) would be removed to permit a consolidated urban area. The only known occupied habitat that would not be directly impacted is the Winter Creek site. Habitat degradation may occur due to the change of land use proposed. The increased area of impervious surfaces characteristic of urban areas causes hydrological changes, in particular increasing the movement of water. This results in higher flood peaks, increased channel gouging along creeklines and less water being retained in the landscape (increasing the rate at which wetlands dry out). These factors would lower the quality of both on-stream and off-stream habitats. Vulnerability to drought would be increased.

3.2.2 Habitat Fragmentation

GGF populations typically appear to conform to a metapopulation structure, with movement between waterbodies and breeding and non-breeding habitats necessary to maintain population viability. Habitat fragmentation is likely to arise from the Project because areas dominated by housing are inhospitable as living and movement habitat for the GGF. Moreover, roads have the potential to cause a barrier effect and may cause habitat fragmentation within the Project Area. This would prevent or at least lower movement rates within the population in the Project Area. Movement between the Project Area and habitat areas elsewhere in the Locality may also be impeded.

3.2.3 Increased Disease Transmission

The fungal pathogen *Batrachochytrium dendrobatidis*, or chytrid fungus, which causes the amphibian disease chytridiomycosis, is thought to have played an important role in the decline of the GGF (Clemann and Gillespie 2010). Chytrid fungus can be transported from infected areas on footwear (e.g. NSW National Parks & Wildlife Service 2001). The increased presence of people during the occupation stage of the Project has the potential to introduce Chytrid fungus to the Project area and/or increase the movement of this fungus between waterbodies within the Project area.

3.2.4 Predation

Evidence for the impact of predation on the GGF by introduced fish, such as the Eastern Gambusia (*Gambusia holbrooki*), is somewhat ambiguous (Clemann and Gillespie 2010). While Heard *et al.* (2004; cited in Clemann and Gillespie 2010) found evidence for successful breeding and recruitment at a site in the north of Melbourne where Eastern Gambusia were present, Hamer and Organ (2008) found that this introduced species affected recruitment but not habitat occupancy (i.e. sub-adults and adults may disperse to and live in affected habitat). It should be noted that the Eastern Gambusia is an accepted threat to the related Green and Gold Bell Frog (*Litoria aurea*) (reviewed by Goldingay 2008). The Eastern Gambusia can move between waterbodies during floods and humans are known to assist its dispersal (NSW National Parks and Wildlife Service 2003). Therefore, changes to flooding regimes (i.e. increased flood frequency or height) and an increased human presence may assist the Eastern Gambusia to colonise new or vacated habitat. Accordingly, it is possible that the Project would introduce or result in an increased presence of the Eastern Gambusia in the Project Area.

The red fox and the cat are predators of small vertebrates, such as amphibians. While there is currently no direct evidence that they impact on the GGF, being a large frog and with a habit of basking on the margins of waterbodies, it may be more vulnerable to terrestrial predators than many other amphibian species. The red fox would already be present in the Project Area and it is likely that urban development would decrease the overall presence of this species. However, it is likely that some red foxes would persist in the well-vegetated conservation areas proposed.

Some feral and domestic cats would already occur in the Project area. While residential development is likely to lower the number of feral cats, the number of domestic cats would be likely to increase the total number of cats present. It is unclear what impact this would have on the GGF, particularly as its habitat would only be accessible to cats living nearby (i.e. not all cats in the Project Area would be potential predators).

3.2.5 Pollutants

Waterbodies tend to be focal points for the accumulation of pollutants in the environment. Amphibians may be vulnerable to the effects of pollutants due to their semi-permeable skin. As grazing is currently the predominant land use in the Project Area, it is likely that the level of biocides (herbicides, pesticides, etc) and fertilisers is relatively low. While it is likely that some land owners in a residential setting would use biocides and fertilisers, their overall prevalence would be fairly low. Thus, biocides and fertilisers are not likely to be a significant problem during the occupation stage of the Project.

Stormwater runoff during both the construction and operational stages of the Project may, however, affect water quality in receiving waters, both still waterbodies and creeks. During construction, the movement of sediment is likely to be the major concern. During the operational stage, runoff from roads and other hard surfaces would be the primary sources

of pollutants (e.g. oil from roads). A variety of larger debris may be moved into GGF habitat during flood events. These may contain various pollutants, which may slowly leach into the surrounding habitat.

3.2.6 Weeds

Weeds, such as Gorse (*Ulex europaeus*) and Blackberry (*Rubus* spp.) are already well-established in the Project Area, particularly along creek banks. The removal of grazing pressure is likely to allow these weeds to become more abundant. Moreover, the tendency for nutrients to become concentrated in wetlands and the transportation of weed seeds on machinery and by people provide good conditions for weeds to become established in waterbodies. Weed impacts may occur during the construction and occupation stages of the Project. However, recommendations to implement a weed management plan will be sufficient to address the minor threat to the GGF which may arise out of the expansion of weeds in the waterways of the precinct.

3.2.7 Road Impacts

Roads may cause direct mortality to amphibians, with the impact being proportional to the usage of a road (Fahrig *et al.* 1995). However, as it is proposed that compensatory habitat be established along the Winter Creek riparian zone, and roads will be generally excluded from this area, impacts are considered unlikely to be significant.

There is some evidence that traffic noise can interfere with breeding by decreasing the distance of which calling male frogs can be heard. Not only may this lower breeding success, but it can affect the abundance of frogs near a busy road (Hoskin and Goosem 2010). However, it has been shown in some frog species that the pitch of the calls can be increased to overcome the effect of noise (Parris *et al.* 2009; Cunnington and Fahrig 2010). It is possible that roads with heavy traffic could affect the breeding success of the GGF in the Project Area. However, it is unlikely that traffic volumes would be high enough and in sufficient proximity to key breeding habitat for this to be of significant concern.

3.2.8 Potential Improvements

While a number of impacts on the GGF would be associated with the Project, there is also an opportunity to improve habitat quality and population processes. These improvements include:

- An increase in the availability of good quality habitat for living and breeding by constructing waterbodies specifically for this purpose;
- Consolidating the spatial arrangement of waterbodies, making movements between them more efficient;
- The remediation of the creek system within the Project Area to improve habitat quality and movement potential (revegetation, weed removal);
- An increase in the availability of terrestrial movement and over-wintering habitat, including the provision of rocks, logs and other shelter sites;
- The removal of grazing pressure, which currently lowers habitat quality in many waterbodies; and
- The monitoring and management of water quality within designated habitat areas.

The preceding measures will facilitate metapopulation dynamics, which will improve resilience to extinction.

3.3 Synthesis

Most of the threats identified in this report are already operating in the Project Area, at least to some degree. Without appropriate mitigation, the Project is likely to increase the severity of many threatening processes. If this were to be the case, the Project would be likely to lead to the local extinction of the GGF in the Project Area and in the Locality. It is also possible that the Project would contribute broader population extinctions in the Locality due to landscape-scale habitat fragmentation arising from the loss of habitat within the Project Area.

However, the Project provides an opportunity to ameliorate the threats outlined above to a level that would enable the viability of the GGF population in the Project Area to be secured in the long-term. As such, the Project represents an opportunity to improve the prognosis for this population relative to the current situation. One major advantage of the proposal is that it enables a coordinated approach to the conservation of the GGF and avoids the problems of cumulative impacts associated with ad hoc development.

4 CONSERVATION MANAGEMENT PLAN

4.1 Objectives

The overriding objective of the CMP is to ensure the long-term viability of the GGF in the Project Area. More specific objectives are:

- To increase the amount of high quality GGF habitat in the Project Area by the creation of compensatory wetland habitat;
- To improve the spatial arrangement of occupied wetland habitat to promote successful dispersal and colonisation;
- To increase the availability and quality of terrestrial movement and over-wintering habitat;
- To demonstrate the widespread use of compensatory habitat prior to the removal of currently used habitat;
- To provide a framework to maintain habitat quality during the operational stage of the Project; and
- To develop a monitoring program to assess the effectiveness of the CMP and/or provide further management actions that may be required to ensure the objectives are met.

To achieve the preceding objectives, the CMP specifies actions to be undertaken in the pre-construction, construction and operational stages of the Project.

4.2 Pre-Construction

4.2.1 Preparation of Complementary Plans

The success of this CMP will depend upon the development and implementation of several complementary plans, being:

- An Erosion and Sediment Control Plan;
- A Weed Removal and Management Plan;
- A Growling Grass Frog Offset Plan; and
- A Stormwater Management Plan.

It is envisaged that COB would establish guiding principles for these plans, but that responsibility for their preparation would rest with landowners/developers. These would then form sub-plans in an overarching Construction Environmental Management Plan. Preparation of the Growling Grass Frog Offset Plan would be triggered by development in Growling Grass Frog Offset Trigger Area (refer **Figure 3**). The remaining plans would need to be prepared for the entire PSP area.

The above plans will be developed as in-principle plans during the pre-construction phase of the Project, as detailed in **Section 4.6** of the CMP. They will be specifically refined for each stage of the development and should be sufficiently flexible to enable the incorporation of new knowledge as it becomes available. These plans will relate to the establishment of compensatory habitat and the enhancement of existing habitat along Winter, Kensington and Bonshaw Creeks and their floodplains. Individual Erosion and Sediment Control Plans are likely to be required for the development of individual residential land parcels, particularly for land within 200m of the floodplains of the aforementioned creeks.

4.2.2 Compensatory Habitat

The creation of compensatory habitat is proposed to offset the loss of potential and known GGF habitat associated with the Project. An important goal of compensatory habitat creation is to increase the current size and distribution extent of the GGF metapopulation in the Project Area and to ensure the links with potential habitat areas outside the Project Area are maintained. This is consistent with the aims of the draft national recovery plan for the GGF (Clemann and Gillespie 2010). The conservation of the GGF will be the major use of these compensatory waterbodies.

Most GGF records in Precinct 1 came from farm dams with dense fringing, emergent and floating vegetation (Ecology Partners 2011) (see **Plates 1 – 4**). There is evidence of breeding at such sites. Thus, the local population of the GGF is currently dependent on artificial habitat. The intention is to create similar habitat along the floodplain of Winter Creek by maintaining a consistent 35m buffer to the creek to protect existing habitat within the watercourse, and establishing compensatory habitat (frog ponds) on the floodplain.

The compensatory waterbodies would be created by excavation and would be similar in proportion to a farm dam. These waterbodies would be planted with aquatic plant species characteristic of GGF habitat, such as Water Ribbons (*Triglochin* spp.) and Spikerush (*Eleocharis* spp.) and submerged plants such as Water Milfoil (*Myriophyllum* spp.), Marsh-flower (*Villarsia* spp.), and Pondweed (*Potamogeton* spp.) (Hamer and Organ 2008; Ramamurthy and Coulson 2008). The precise planting regime for the compensatory waterbodies will be developed in the Habitat Establishment and Rehabilitation Plan. The GGF breeds in water up to 1.5m deep (DSEWPC 2011). On one hand, there is little point in providing waterbodies of greater depth. However, deeper waterbodies would be more resilient to extended drought conditions. During drier conditions, fringing and emergent vegetation would migrate towards the centre of a waterbody, recolonising the margins during wetter periods.

The depth profiles of the compensatory waterbodies will be varied to ensure that some are permanent, while some others would empty during extended dry periods. This will be done to maintain selective pressure and evolutionary potential within the metapopulation. This should strengthen the ability of the GGF to colonise vacant habitat following the easing of extreme drought conditions. Periodic drying would also make it difficult for exotic fish to colonise these waterbodies. The depth profiles of individual waterbodies will be subject to detailed design.

The compensatory habitat would be provided in Precinct 1, which is the source area of all the GGF records obtained in the Project area (Ecology Partners 2011) (**Figure 2**). This will make colonisation of newly created compensatory habitat more feasible as it would be established in proximity to known habitat, which allows natural dispersal. It is expected that GGF habitat would take a minimum of five years to create, establish and monitor to demonstrate its suitability for living and breeding. Depending upon the timeline of development within known GGF areas, it may be necessary to provide short-term retention with appropriate buffering to enable development to proceed while the compensatory habitat is being established and assessed. Thus, there is sufficient timeframe within which to create, monitor and refine the offset proposal.

The mechanisms to enable the implementation of this CMP are detailed in **Section 4.6**, and will be further refined in consultation with DSE and DSEWPC. It is proposed that funding for the establishment of offsets be the responsibility of parties proposing development on sites containing Growling Grass Frog Habitat Offset Site Trigger Area (**Figure 3**).

Due to the need to maintain a metapopulation structure (Clemann and Gillespie 2010) and the relatively short movements distances that typically occur between suitable waterbodies (up to 200m, but higher rates are achieved over shorter distances) (Hamer and Organ 2008), it is necessary to cluster at least several of the created waterbodies in proximity to one another, a pattern that would be repeated along the lower Winter Creek floodplain (**Figure 4**). This replication would provide buffering against adverse events, such as fire, drought or pollution, The precise spatial distribution of waterbodies will be the subject of future detailed design.

The creek system within the Project Area would also need to be rehabilitated to provide living habitat for the GGF. This would be achieved by slowing in-stream peak flows to prevent channel gouging, as is currently evident (e.g. **Plate 6**) and establishing a series of riffles and pools with native in-stream and bank vegetation (e.g. **Plates 6 and 7**). Logs, rocks and/or reeds could be placed in the creek channels to lower in-stream flow rates. Importantly, the creek system is also a framework that provides dispersal habitat throughout the GGF metapopulation, particularly in conjunction with the rehabilitation of associated terrestrial habitat (see below). The use of the creek system will allow the continuity and connectivity of the GGF population within the Project Area. This will promote metapopulation stability by enabling the rapid colonisation of suitable habitat in the event of a local extinction event in a particular waterbody or cluster of waterbodies.

Plate 5 - Pool on Kensington Creek

Plate 6 - Channel gouging on Winter Creek

Plate 7 - Pool and riffle on Kensington Creek

While some sections of the floodplains in the Project Area would be used for stormwater detention basins, sporting fields and other recreational pursuits (e.g. bike/walking paths, bird watching), remaining terrestrial areas between the compensatory waterbodies and along Winter Creek would be rehabilitated to provide dispersal and overwintering habitat. Specific actions would include the planting of native trees, shrubs and groundcovers and the provision of logs, rocks and other ground debris (see Clemann and Gillespie 2010). This vegetation will also form part of the offsets used to mitigate the loss of native vegetation in the Project Area, as detailed in an associated Native Vegetation Precinct Plan (SMEC 2011). Logs, rocks and other ground debris could be preferably sourced from elsewhere in the Project Area as they become available during the development process. However, sourcing the required material from outside the Project Area is acceptable. Precise specifications of the terrestrial habitat would be developed as part of the Habitat Establishment and Rehabilitation Plan. This Plan will be developed in consultation with the Country Fire Authority (CFA) to ensure that the works do not establish a fire hazard where no such fire hazard presently exists.

4.2.3 Weed Removal and Control

Several weed species, particularly Gorse and Blackberry are infesting known or potential habitat areas within the Project Area. Weed removal and control should commence during the pre-construction phase of the Project in accordance with the requirements of the Weed Removal and Management Plan/s.

4.2.4 Monitoring Existing Habitat

Monitoring of GGF should commence in areas of currently known habitat during the pre-construction phase. These surveys are to provide baseline population data with which to later compare population sizes, survival rates and population fluctuations in the compensatory habitats. The protocol for these surveys is consistent with the requirements of the Biodiversity Precinct Structure Planning Kit guidelines (DSE 2010) and will be conducted as follows:

a) Two to three days must be spent searching for and capturing adult and sub-adult frogs in all areas of known and potential habitat within the conservation zone. Each survey should be at least 90 minutes in duration. Ideally, the surveys should occur between October and November. However, it is permissible for surveys to be conducted through to January. Surveys should commence at sunset and may continue no later than 4am. Ideally, the surveys should occur when the temperature is above 13ºC and preferably within 24hrs of rain;

b) The survey must consist of nocturnal spotlight searches and daytime searches of habitat and shelter sites (e.g. under dense vegetation, under logs and rocks). During the surveys to relocate individual frogs standard hygiene protocols must be adhered to (e.g. NSW National Parks and Wildlife Service 2001) to prevent disease transmission. All GGF encountered must be captured if possible;

c) Prior to release at the capture site the body size (length and weight), sex, age class and reproductive condition of all frogs must be recorded;

d) All captured frogs must also be assessed for the presence of disease (e.g. chytrid fungus). Diseased frogs must not be released. They must be taken to the nearest suitably qualified and experienced veterinary for further diagnosis and for humane disposal if required. The veterinarian should be made aware of timing of the surveys in order to be prepared;

e) To provide recapture data on individuals, a “passive integrated transponder” (PIT tag) must be inserted into all frogs on first capture. The procedure for PIT tagging is

described in the following point. The permanent tagging of individual frogs will enable survival, population size and movement to be determined during subsequent monitoring. These data will require mark-recapture analysis. Program MARK (White and Burnham 1999), for example, allows a wide range of model structures to be fitted to mark-recapture data. Program MARK includes multi-state models, which are required when multiple habitat patches are involved. Available models also allow temporary emigration from the study area, which is typical of frog populations (e.g. during non-breeding periods) (Cooch and White 2007);

f) PIT tags will be inserted beneath the skin along the dorso-lateral line. The skin in this area will be swabbed with iodine solution prior to tag insertion. The PIT tag will be inserted using a tailored sterile syringe. The wound will then be sealed using surgical glue. The PIT tag will be checked for functionality before and after insertion using an electronic tag reader and its unique number recorded;

g) Approval to capture and mark GGF is required under the Victorian *Wildlife Act 1975*;

h) The outcomes of the monitoring program must be reported to DSE and DSEWPC. This report will document factors such as the population census results (including individual age class, sex, size, PIT tags numbers, etc.), estimated population size, survival rates, breeding activity during the pre-construction monitoring period.

4.3 Design Features Of The Project

4.3.1 Road Crossings

There are no road crossings proposed for the GGF offset area (compensatory habitat). There may be a requirement for pedestrian links / bikeways, pipelines and other linear infrastructure to pass through this area. These features should be carefully planned to ensure coordination with proposed GGF Offset Area pond sites. Where pedestrian links/bikeways or other structures are required to span the creek in the GGF Offset Area will be designed in a way that allows GGFs to move under the bridging structures. Groundcover vegetation will be continuous under each structure from one side to the other. The inclusion of rocks and patches of bare ground will add vertical heterogeneity to the under-bridge habitat. This combination of attributes should enable efficient movement and provide sufficient cover during under-bridge movements.

4.3.2 Stormwater Treatment

A stormwater management system is yet to be finalised, but an Integrated Stormwater Management Plan will be for the entire Project area will be prepared during the pre-construction phase. This Plan will be consistent with the Urban Stormwater Best Practice Environmental Management Guidelines (CSIRO 1999). In addition to this, each landowner will need to prepare a Stormwater Management Plan for their individual site/s during the pre-construction phase of site development. An important aim of the stormwater management system will be to support the hydrological regimes required to maintain GGF habitat. Fine mesh screens must be installed between the stormwater management system and the waterbodies used for GGF conservation to ensure no inadvertent transfer of exotic fish, such as the Eastern Gambusia.

The compensatory waterbodies will require protection from untreated stormwater during the construction and operational stages of the Project. During the construction phase, this will be dictated by the Erosion and Sediment Control Plan to be developed. During the operational stage of the Project, stormwater treatment ponds will need to be provided between developed areas and GGF habitat. These would then drain into waterbodies intended for

GGF conservation and be used to control water levels. A mechanism to divert stormwater from GGF habitat will also be devised. Stormwater will receive primary treatment before entering the stormwater treatment ponds habitat by the installation of gutter screens, coarse filters, sediment traps and the like. However, final details will be provided in the Stormwater Management Plan.

4.4 Construction

4.4.1 Sediment Control

Prior to the initiation of construction activities, including the construction of the compensatory waterbodies, housing and associated infrastructure, the sediment control measures specified in the Erosion and Sediment Control Plan will be implemented.

4.4.2 Protection Of Habitat Areas

GGF habitat, including buffer areas, needs to be protected during the construction phase of the Project. To achieve this, buffer areas will be fenced prior to the initiation of any clearing or construction works. Signs indicating the presence of a conservation area will be erected at regular intervals along such fencing to further discourage access by personnel.

Signs will also be erected on the edge of buffer areas during the occupation phase of the Project, however, exclusion fencing will not be required at this stage.

4.4.3 Storage Of Waste And Other Pollutants

During the construction phase of the Project, waste and other pollutants must not be collected or stored within 50m of the buffer area boundaries. Waste must be collected in appropriately-sized bins. Fuel, oil and other chemicals must be stored in approved containers within bunded areas. These issues will be guided by the requirements of the Construction Environmental Management Plan.

4.4.4 Weed Removal And Control

Weed removal and control will continue during the construction phase of the Project in accordance with the requirements of the Weed Removal and Management Plan.

4.4.5 Translocation

Targeted searching for and removal of GGFs must occur prior to clearing in areas of known habitat that will be removed (refer to **Section 4.6** regarding implementation). The following actions must be conducted during the activity period of the GGF (October to January) prior to the commencement of works:

- The suitability of the receiving habitat to support GGFs will be verified by assessing vegetative characteristics using standard assessment criteria for GGF habitat, assessing water quality parameters and conducting surveys to ensure that exotic fish species are not present by conducting surveys with fish traps;
- Approval to capture, collect, mark and relocate GGFs will be required under the Victorian *Wildlife Act 1975*. Ethics approval will also need to be sought from the Department of Primary Industries;
- DSE must be informed that the translocation of GGFs is to commence;

- The translocation must be undertaken by a suitably qualified and experienced zoologist;
- Two to three days must be spent looking for and capturing adult and sub-adult frogs in areas of known and potential habitat within the development footprint. Each survey should be conducted for a minimum of 90 minutes and occur when the temperature is above 13ºC and preferably within 24hrs of rain;
- The survey must consist of nocturnal spotlight searches and daytime searches of habitat and shelter sites (e.g. under dense vegetation, under logs and rocks). During the surveys to relocate individual frogs standard hygiene protocols must be adhered to (e.g. NSW National Parks and Wildlife Service 2001) to prevent disease transmission;
- Refer to steps as per **Section 4.2.4**: b) to d).
- To determine the success of the translocation procedure, a PIT tag must be inserted into all released frogs. Refer to **Section 4.2.4**: e) to f).
- As soon as possible, captured frogs must be re-located to the offset ponds. Suitable micro-habitats for release include under rocks, logs and dense vegetation adjacent to occupied waterbodies with dense fringing, emergent and floating vegetation. The waterbodies used as release sites should be the same as those used in the broader monitoring program to enable to fate of release frogs to be assessed. The location of each release site must be documented with a GPS;
- Immediately following the searches to remove GGFs, the waterbodies must be drained to prevent recolonisation and to encourage any additional frogs to relocate to the compensatory habitats. The existing waterbodies should be infilled two weeks after the draining;
- The outcomes of the translocation program must be reported to DSE and DSEWPC. This report will document factors such as the number of frogs translocated (including age class, sex, size, PIT tags numbers, etc), the number of receiving waterbodies and their characteristics and survival rates determined from at least 5 years of post-translocation monitoring. The survival rates should be compared to the survivorship of the general GGF population obtained during the monitoring program detailed in **Section 4.2.4**.

4.5 Operation

Stormwater management and weed control (4.5.1 and 4.5.2) will be undertaken by each applicable landowner during the operational phase.

4.5.1 Stormwater Management

Stormwater management during the operational phase of the Project will be detailed in the Stormwater Management Plan/s.

4.5.2 Weed Removal and Control

Weed removal and control will continue during the operational phase of the Project in accordance with the requirements of the Weed Removal and Management Plan/s.

4.5.3 Monitoring

The lead time between the establishment of compensatory habitat and the destruction of the current known habitats of the GGF will be used to monitor newly-created habitat and assess

the extent to which they have been naturally colonised. Monitoring would involve population censuses, surveys of pest species and the collection of water quality data (e.g. pH, turbidity, salinity). The collection of water quality data will assist the diagnosis of any problems of population establishment or poor survival rates should such problems arise.

4.5.4 Population Monitoring

Frog populations are known to fluctuate widely in response to climatic conditions. There will also be variance due to variation in habitat quality. These factors also affect detection rates. Thus, there is spatial and temporal variation in the size and detection rates of frog populations. In light of this, if population size and survival rates are to be determined, a mark-recapture framework using marked individuals is necessary. All costs for the proposed monitoring will be met by the proponents of development in the GGF Offset Trigger Area (**Figure 3**).

Population monitoring is divided into two parts. Firstly, as outlined above, population monitoring should commence in habitats that are currently occupied prior to the construction of the compensatory waterbodies. This will serve several purposes by:

i. providing baseline population trends in established habitat, including fluctuations due to climatic variation;

ii. enabling rates of natural migration to areas of compensatory habitat, once established, to be assessed; and

iii. allowing subsequent comparison of survival rates in established and newly-created habitat (fluctuations due to climatic variability should be somewhat correlated) prior to habitat clearing.

Secondly, monitoring must continue in the compensatory habitat during the construction phase of the Project and for at least 5 years into the occupation stage. All compensatory waterbodies are to be surveyed for the presence of the GGF. There would be no opportunity for comparing current habitat and compensatory habitat from the construction phase onwards.

The protocol for these surveys is consistent with the requirements of the Biodiversity Precinct Structure Planning Kit guidelines (DSE 2010) and will be conducted as follows:

- Refer to steps as per **Section 4.2.4**: a) to g);
- For the purposes of estimating population parameters, the tagging and release of frogs as part of the translocation program should not be the first capture occasion. The first capture of these individuals as part of the monitoring program should be considered to be the sampling session in which they were tagged, even though they were previously tagged; and
- The outcomes of the monitoring program must be reported to DSE and DSEWPC. This report will document factors such as the population census results (including individual age class, sex, size, PIT tags numbers, etc), estimated population size, survival rates, breeding activity during a ten post-construction monitoring period.

4.5.5 Habitat Variables

During each survey period, the structure of the vegetation must be assessed. This will consist of estimation of the percent cover provided by fringing, emergent, floating and submerged vegetation. The presence of the GGF is strongly influenced by high cover across all or most of these categories. Photographs documenting habitat condition should also be taken at each waterbody.

4.5.6 Monitoring Pest Species

Although cats and red foxes are known predators of the GGF, there is likely to be little gained by control measures around their habitat. This is because of the presence of these predators in the broader landscape. Any vacuum created would be quickly filled by individuals inhabiting surrounding areas.

Monitoring surveys of exotic fish species, such as the Eastern Gambusia, will be conducted annually following the construction of the compensatory waterbodies. Standarised surveys for these species will be conducted using fish traps. In the event that exotic fish are found, it will be necessary to drain the inhabited waterbodies and allow them to dry out completely. If several waterbodies are found to concurrently support exotic fish, no more than 50% of the waterbodies should be drained at one time. COB will need to be informed of the need to conduct the drainage works.

4.5.7 Monitoring Water Quality

GGF prefers to inhabit waterbodies within a narrow range of water quality parameters. It will be necessary to monitor water quality parameters such as pH, salinity, dissolved oxygen, turbidity, and specific nutrients including nitrogen and phosphorus. Standard methods should be used to assess water quality. Routine water quality assessments should be conducted twice yearly in autumn and spring. Targeted water quality assessments must also occur if major earthworks are conducted within 200m of GGF habitat. This will be done to ensure any ensuing problems do not remain untreated for long periods.

4.5.8 Adaptive Management

Monitoring should occur within an adaptive management framework. In particular, the collection of habitat variables and environmental data, such as water quality and climatic data, will assist in identifying potential causation in the event that the GGF does not adequately establish in areas of compensatory habitat or if survival rates seem unexpectedly low. There is little that can be done about adverse climatic conditions, such as drought, but at least a likely cause of population lows can be explained. If climatic variation does result in populations lows, it would then be expected that population numbers would increase during years of favourable rainfall. If this does not occur, other causative agents must be sought.

If water quality issues, such as salinity or low pH, arise, steps must be taken to mitigate these effects. This would include identification of the source/s of contaminants and preventing them from having further effects on GGF habitat.

4.6 Plan Implementation, Reporting And Review

This CMP will be implemented by the proponents of development in the GGF Offset Trigger Area (**Figure 3**). The CMP will require approval by DSEWPC, DSE and COB prior to implementation.

The proponents of development in the GGF Offset Trigger Area are responsible for the implementation of this CMP, including:

- Preparation of complementary plans;
- The construction of compensatory habitat;
- Translocation of GGF;
- Population, habitat and water quality monitoring;
- Weed and pest animal removal and control;
- Stormwater management implementation;
- Supervision of contractors;
- Development of contingency plans as required.

The responsibilities of contractors and developers is directed by the CMP and other the required plans specified herein. These responsibilities will be more focused on specific areas (e.g. construction areas) and actions, such as erosion and sediment control, containment of pollutants, etc.

4.6.1 Monitoring and Compensatory Habitat

The GGF has complex habitat requirements that are needed to support its various behaviours and life stages (**Section 2.2**). Although it is simple to excavate a waterbody, under favourable conditions it will take at least two years for a sufficient cover of fringing, emergent, floating and submerged vegetation to become established. The collection of population census data from areas of existing habitat will be undertaken during this initial two year period. Establishment of terrestrial habitat around the compensatory waterbodies will also commence during the first two years in accordance with the Habitat Establishment and Rehabilitation Plan.

Subsequently, a further two years will be taken to monitor natural colonisation of the compensatory waterbodies to demonstrate that they are suitable for occupation by the GGF. Existing habitat will continue to be monitored during this time. The translocation of individual frogs and the draining and infilling of the currently occupied waterbodies will occur during the active season (October – January) of the fifth year of this plan's implementation. If drought conditions arise during the establishment of the GGF in the compensatory waterbodies, it is possible that a longer timeframe would be required. As a precaution, therefore, the planning of urban construction within 100m of areas of current habitat should assume a minimum timeframe of two years prior to commencement. The monitoring of the compensatory waterbodies will continue for 5 years following the infilling of currently occupied habitat.

The implementation of the CMP will commence 2 years before the commencement of development in the GGF Offset Trigger Area to establish and assess the effectiveness of the compensatory habitat. Thus, implementation of the CMP would commence once it is approved and the necessary financial mechanisms are in place. The first action to implement will be the monitoring of existing GGF habitat for later comparative purposes. The preparation of all complementary plans should also occur during the first year of implementation of this CMP.

The results of monitoring the existing habitat and the compensatory habitat (first two years) will be concurrently analysed and formally reported to COB, DSE and DSEWPC two years after the creation of the compensatory habitats has been completed. Pending the outcomes of this monitoring, approval will be sought to proceed with the translocation program. If necessary, the failure to meet performance targets in the compensatory habitats (e.g. adequate habitat cover has not established, the waterbodies have not been adequately colonised, water quality parameters are not within the target range) will be reviewed. At this point necessary corrective actions will be implemented and, if necessary, the CMP refined by the proponent.

Approval for the translocation program will only be granted once it can be demonstrated that the compensatory waterbodies provide adequate living and breeding habitat for the GGF. The results of the translocation program will be formally reported to DSE and DSEWPC once it is complete (i.e. when the existing habitat is drained and infilled). The reporting will include individual details on all translocated frogs as specified below.

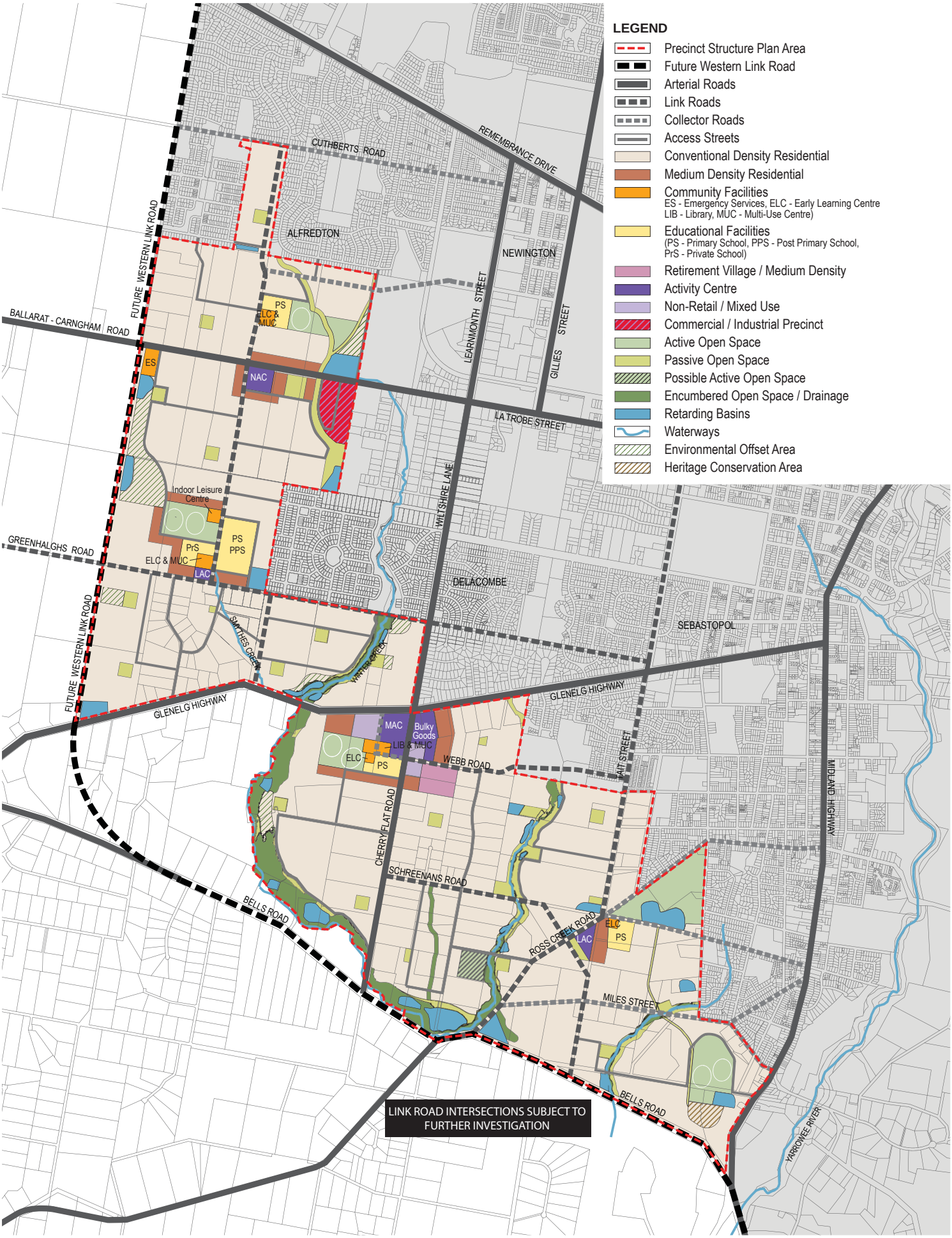
The compensatory waterbodies will continue to be monitored for a further five years, making. These results will be provided to COB, DSE and DSEWPC on an annual basis. During odd-numbered years, the reporting will consist of a straightforward provision of census data (i.e. count data and individual, habitat, exotic fish and water quality data as specified below). In each even-numbered year, the report will also include the outcomes of population modelling details capture probabilities, survival rates and adult population size. These reports will be reviewed on an annual basis and any necessary corrective actions implemented as soon as possible. The annual reports will be submitted in letter report format, with a formal report to be compiled at the finalisation of the monitoring program.

5 CONCLUSIONS

The BWGA is intended to provide for the future urban expansion of Ballarat. Some small populations of the GGF, which is a listed species under State and Commonwealth legislation, have been found within the BWGA. In the absence of impact mitigation and management, development within the BWGA would have a significant impact on this species. As such, the preparation and adoption of a CMP is required. The CMP must be submitted to the DSE and DSEWPC for approval.

The overriding objective of this CMP is to improve the viability of the GGF metapopulation within the BWGA while permitting the planned urban development to occur. The most important strategy proposed is the creation of compensatory habitat, which will increase habitat availability and improve habitat quality. This will enable the metapopulation size to increase, create habitat areas that are more proximate to one another and provide high quality dispersal habitat, including habitats links outside the BWGA. The created habitat areas will be appropriately buffered from development and stormwater management will enable water quantity and quality to be managed. Monitoring of population size, survival rates, habitat variables and water quality will be conducted in an adaptive framework that will allow management strategies to be refined or varied if required by new information.

A long timeframe is required to establish the compensatory habitat and monitor its success (>2 years). Accordingly, there will need to be an on-going commitment from contractors and developers to ensure the success of this CMP. Provided the management of the GGF within the BWGA is consistent with the recommendations given herein, the presence of the GGF within the BWGA will be secure into the future.



Future Urban Structure Plan

Growling Grass Frog Conservation Management Plan _Figure 1

Ballarat West Precinct Structure Plans

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Scale: 1:12,500 @ A1
1:25,000 @ A3

0 250 500 750m

please note:
This plan is based on preliminary information only and may be subject to change as a result of formal Council/Authority advice, detailed site investigations and confirmation by survey

ref.: 3410621P
date: 15 Dec 2011
rev.: A
drawn: SB
checked: WM

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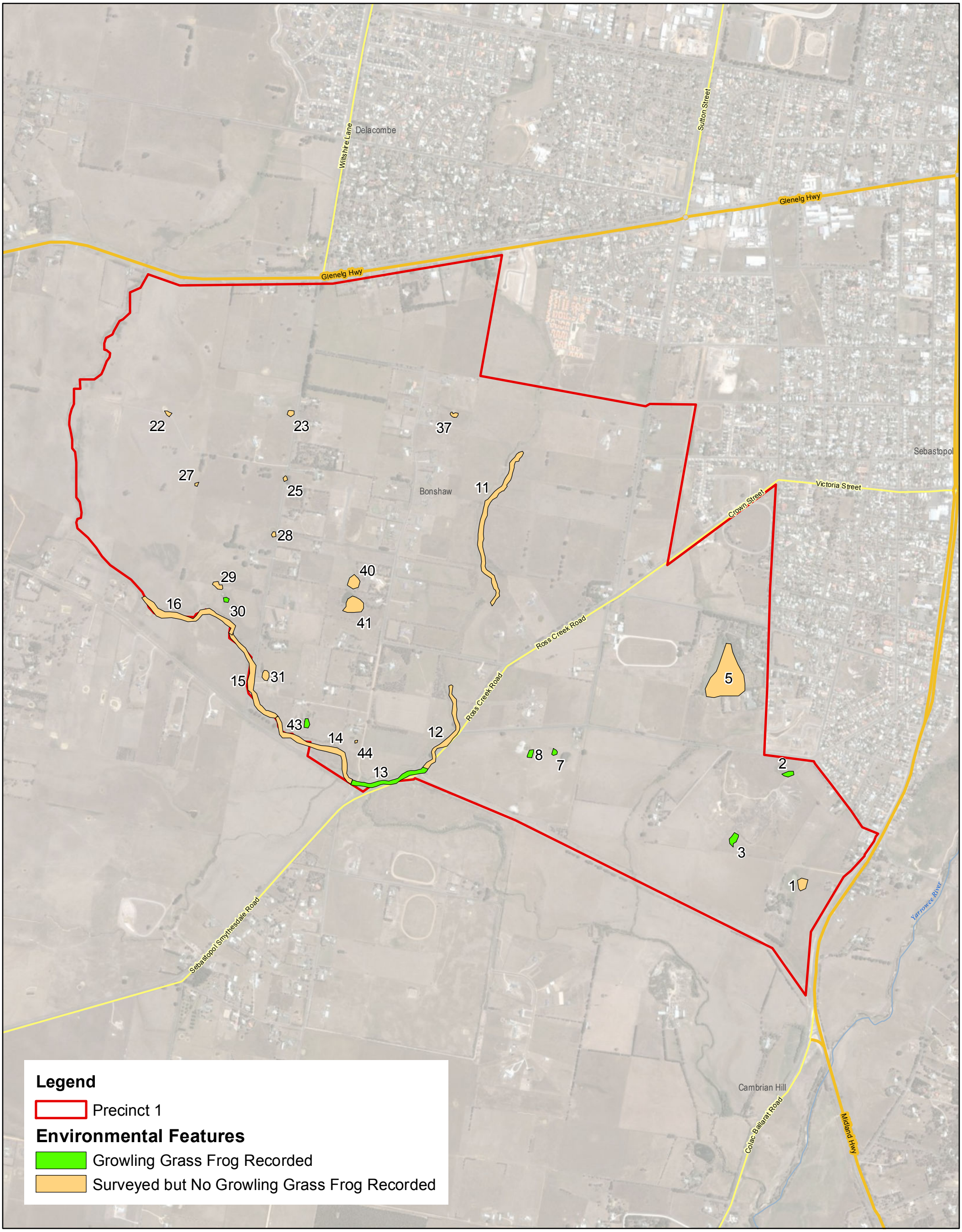

Figure 2 - Precinct Boundaries and Growling Grass Frog Records

N

Scale 1:16,526 @A3

projection: GDA94
datum: MGA Zone 55

please note:
This plan is based on preliminary information only and may be subject to change as a result of formal Council/Authority advice, detailed site investigations and confirmation by survey

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approved:L-JM

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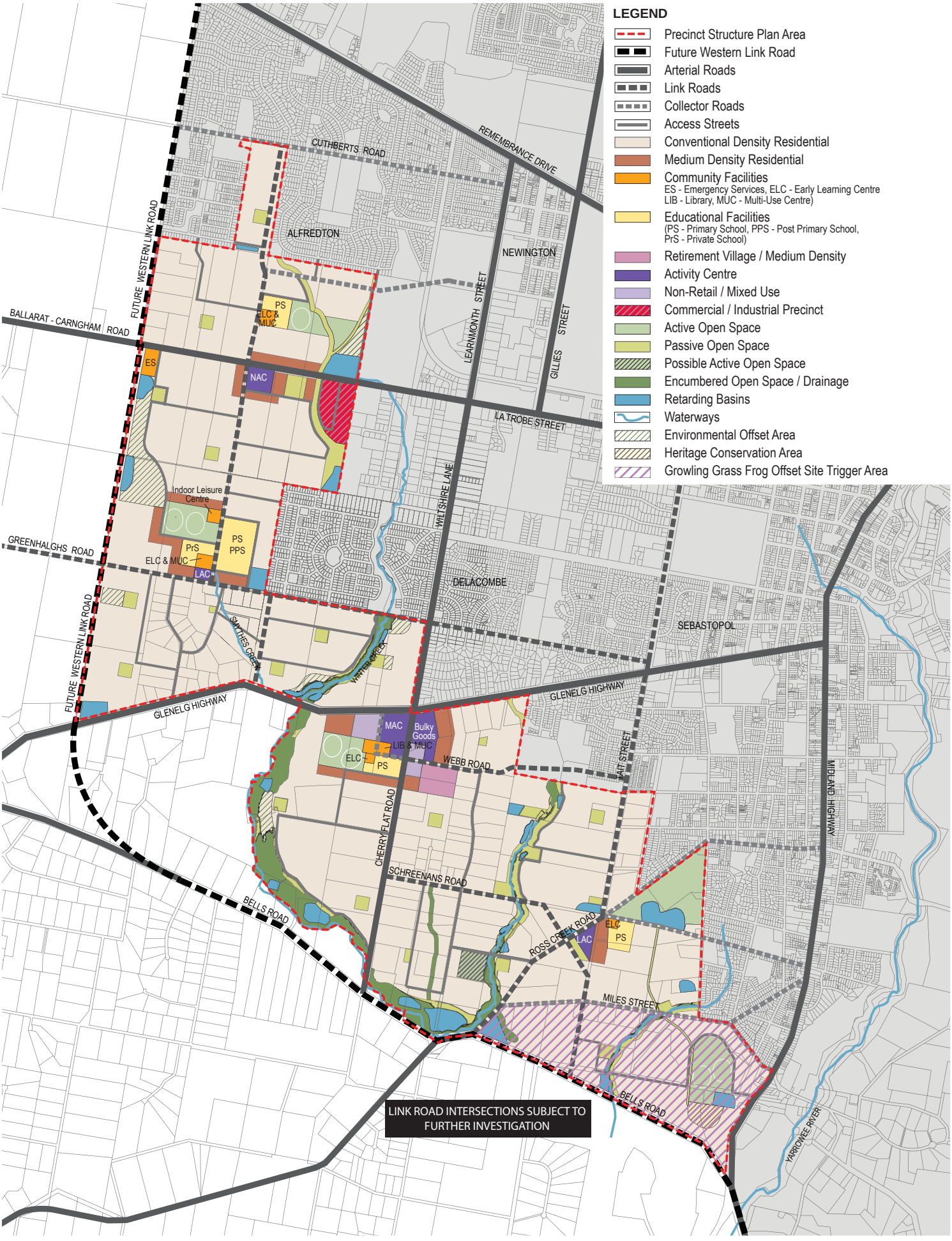

Future Urban Structure Plan

Growling Grass Frog Offset Site Trigger Area_Figure 3

Ballarat West Precinct Structure Plans

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Scale: 1:12,500 @ A1
1:25,000 @ A3

0 250 500 750m

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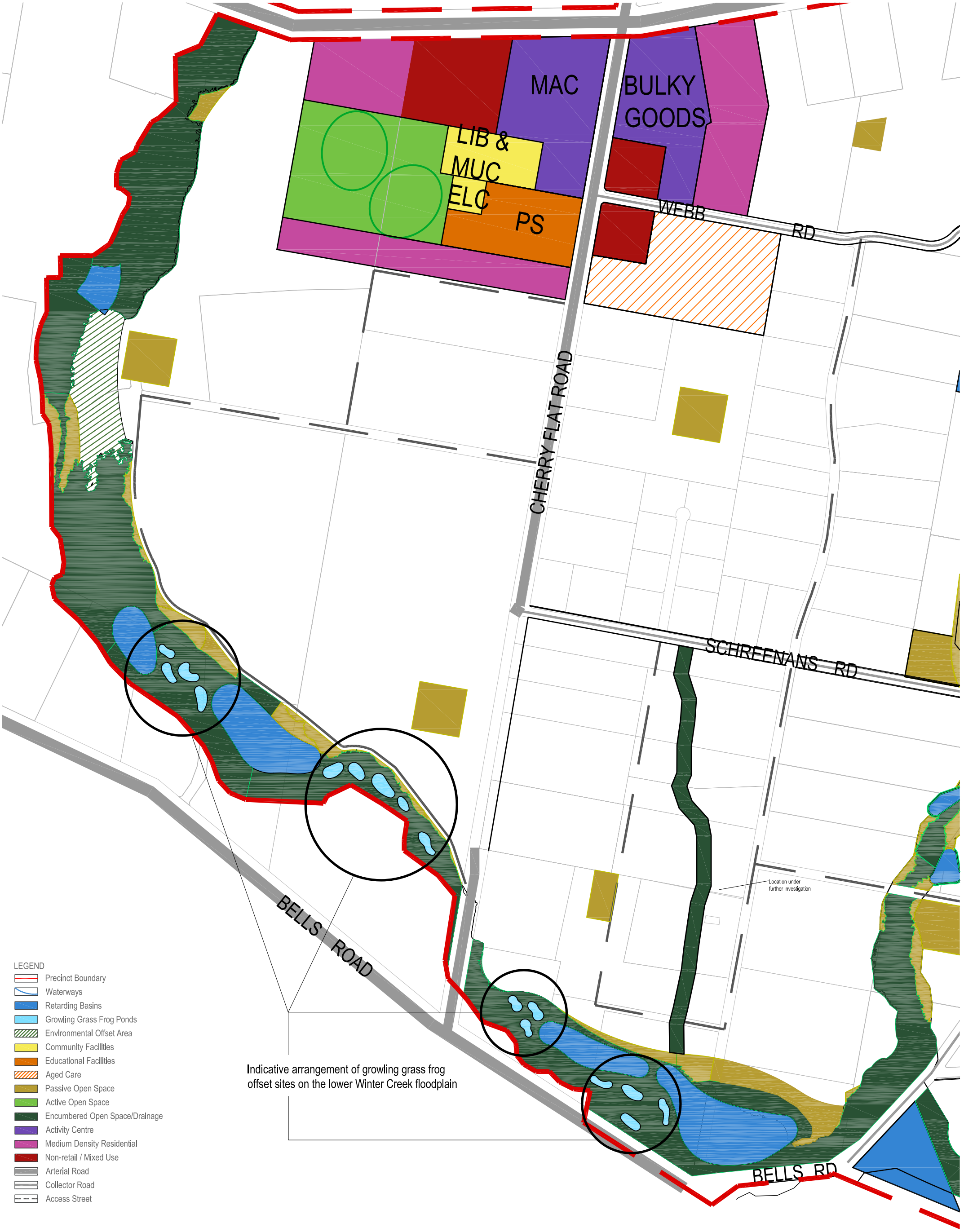

Indicative arrangement of growling grass frog offset sites on the lower Winter Creek floodplain

Indicative arrangement of Growling Grass Frog offset sites on the lower Winter Creek Floodplain_Figure 4 Ballarat West Precinct Structure Plan

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Scale: 1:2,500 @ A0
NTS @ A3

0 25 50 75m

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6 GLOSSARY

Adaptive management:	A framework that uses monitoring results to refine and improve conservation actions.
CMP:	Conservation Management Plan
COB:	City of Ballarat.
DSE:	Victorian Department of Sustainability and Environment.
DSEWPC:	Commonwealth Department of Sustainability, Environment, Water, Population and Communities.
EPBC Act:	Commonwealth Environment Protection and Biodiversity Conservation Act 1999.
FFG Act:	Victorian Flora and Fauna Guarantee Act 1988.
Locality:	the area of land surrounding the project within a 5km radius.
Metapopulation:	a series of populations connected by dispersal.
Project Area:	the area of land subject to the current proposal.

7 REFERENCES

AECOM Australia (2011) *Flora and Fauna Assessment: Ballarat Western Link Road*. Unpublished Report to the City of Ballarat, Ballarat, Victoria.

Anstis, M. (2002) *Tadpoles of South-eastern Australia: A Guide with Keys*. New Holland Publishers, Sydney.

Clemann, N. and Gillespie, G.R. (2010) *National Recovery Plan for the Growling Grass Frog* Litoria raniformis. Department of Sustainability and Environment, Melbourne.

Cooch, E. and White, G.E. (2007) *Program MARK: A Gentle Introduction 5th Edition*. Colorado State University, Fort Collins, CO.

CSIRO (1999) *Urban Stormwater Best Practice Environmental Management Guidelines*. CSIRO Publishing, Melbourne.

Cunnington, G.M. and Fahrig, L. (2010) Plasticity in the vocalizations of anurans in response to traffic noise. *Acta Oecologica-International Journal of Ecology* **36**: 463-70.

Department of Sustainability Environment Water Population and Communities (2011) Litoria raniformis *in Species Profile and Threats Database*. Canberra, Department of Sustainability, Environment, Water, Population and Communities: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=1828

DSE (2010) *Biodiversity Precinct Structure Planning Kit*. Department of Sustainability and Environment, Melbourne.

Ecology Partners (2010) Flora and Fauna Assessment and Aquatic Fauna Review for the Ballarat West Growth Area. Unpublished Report to the City of Ballarat, Ballarat.

Ecology Partners (2011) Targeted Threatened Fauna Surveys Ballarat West Growth Area. Unpublished Report to the City of Ballarat, Ballarat.

Fahrig, L., Pedlar, J.H., Pope, S.E., Taylor, P.D. and Wegner, J.F. (1995) Effect of road traffic on amphibian density. *Biological Conservation* **73**: 177-82.

Goldingay, R.L. (2008) Conservation of the endangered Green and Gold Bell Frog: what contribution has ecological research made since 1996? *Australian Zoologist* **34**: 334-49.

Hamer, A.J. and Organ, A.K. (2008) Aspects of the ecology and conservation of the Growling Grass Frog *Litoria raniformis* in an urban-fringe environment, southern Victoria. *Australian Zoologist* **34**: 393-407.

Heard, G.W., Robertson, P. and Scroggie, M.P. (2006) Assessing detection probabilities for the endangered Growling Grass Frog (*Litoria rainformis*) in southern Victoria. *Wildlife Research* **33**: 557-64.

Heard, G.W., Robertson, P. and Scroggie, M.P. (2008) Microhabitat preferences of the endangered Growling Grass Frog *Litoria raniformis* in southern Victoria. *Australian Zoologist* **34**: 414-25.

Hoskin, C.J. and Goosem, M.W. (2010) Road impacts on abundance, call traits, and body size of rainforest frogs in northeast Australia. *Ecology and Society* **15**: 15.

NSW National Parks and Wildlife Service (2003) *NSW Threat Abatement Plan. Predation by Gambusia holbrooki – The Plague Minnow*. NPWS, Sydney.

Parris, K.M., Velik-Lord, M. and North, J.M.A. (2009) Frogs call at a higher pitch in traffic noise. *Ecology and Society* **14**: 25.

Ramamurthy, S. and Coulson, G. (2008) Assessing the suitability of wetlands for the reintroduction of the Growling Grass Frog *Litoria rainformis*. *Australian Zoologist* **34**: 426-37.

SMEC (2011) *Native Vegetation Precinct Plan - Ballarat West Growth Area*. Unpublished Report to the City of Ballarat, Ballarat, Victoria.

Viggers, K.L., Lindenmayer, D.B. and Spratt, D.M. (1993) The importance of disease in reintroduction programmes. *Wildlife Research* **20**: 687-98.

White, G.C. and Burnham, K.P. (1999) Program MARK: Survival estimation from population of marked animals. *Bird Study* **46**: S120-S39.

Woltz, H.W., Gibbs, J.P. and Ducey, P.K. (2008) Road crossing structures for amphibians and reptiles: Informing design through behavioral analysis. *Biological Conservation* **141**: 2745-50.