

# **A Survey for Threatened Herpetofauna on Albury Environmental Lands**



**Report to the Department of Crown Lands, Albury, NSW**

*by*

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## EXECUTIVE SUMMARY

Ecotone Wildlife and Habitat Assessments was engaged to conduct a frog and reptile (herpetofauna) survey on Albury Environmental Lands between July 2012 and April 2013. The aim of the study was to compile an inventory of herpetofauna with particular focus on procuring records of the threatened Pink-tailed Worm Lizard *Aprasia parapulchella* and Sloane's Froglet *Crinia sloanei*. A further aim was to collect information on threatened species habitat to assist environmental decision making processes.

A total of eight frog species and 14 reptile species were recorded, representing 67% and 46% of the respective number of frog and reptile species known to occur in the Albury Local Government Area. Potential Pink-tailed Worm Lizard habitat was recorded on AEL (e.g. Norris Ridge). However, the species was not detected during the survey and hence the species habitat was not assessed. Sloane's Froglet was detected on 20 AEL parcels (55% of sites), predominantly from farm dams (84% of all wetlands surveyed) followed by natural wetlands and gilgai grassy woodland. Sloane's Froglet (determined by the presence of calling males) were generally detected calling from shallow water, near pond margins, while supported by inundated vegetation. Higher numbers of frogs were recorded calling from the inflow and overflow zones. Vegetation structural attributes measured at Sloane's Froglet locations were extremely variable among sites. Tree cover ranged from entirely cleared land parcels to wetlands supporting dense eucalypt regeneration. Ground cover vegetation in the littoral zone consisted of native and exotic grass. Fallen timber surrounding wetlands was noticeably scarce or absent.

This study confirms that AEL supports important habitat for Sloane's Froglet and as such will play an important role in threatened frog conservation in the Albury LGA. Proposed works on AEL will need to consider any potential impacts on Sloane's Froglet habitat. The precautionary principal should be adopted when planning revegetation works within 20 m of farm dams until further research is conducted. Recommended management actions to maintain, improve and enhance Sloane's Froglet habitat on AEL include removing and/or restricting stock access to wetlands, revegetating overstorey species at low densities, restoring fallen timber and controlling woody weeds. Where revegetation is planned appropriate spacing and species selection should be considered based on the topography and ecological vegetation community. Dense tree plantings in shallow depressions and within the littoral zone of farm dams and semi-permanent natural wetlands should be avoided to maintain a structurally open grassy understorey.

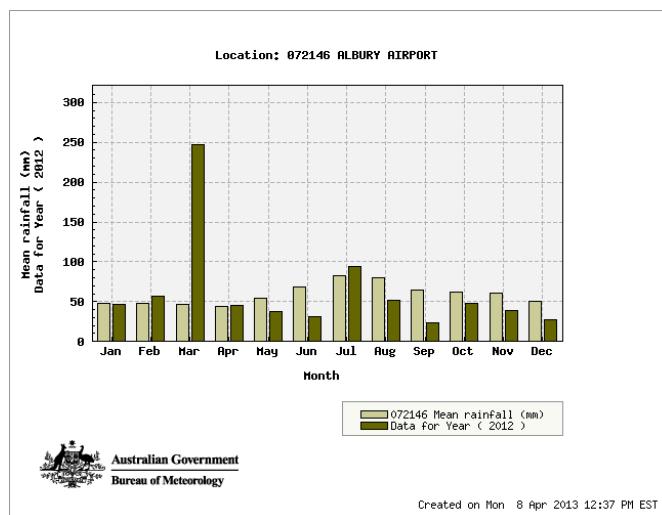
## INTRODUCTION

### *Albury Environmental Land*

Albury Environmental Land (AEL) forms a network of land parcels managed by the Crown Lands Division (CLD) within the NSW Department of Primary Industries, a government agency responsible for managing Crown Reserves in NSW. AEL currently covers approximately 600 ha of land comprising a mixture of riparian vegetation, box gum woodland and tree plantations within Hamilton valley, North Albury and the Thurgoona region. As part of the Deed of Land Transfer, CLD is obliged to manage AEL in accordance with the objectives, requirements and guiding principles of the *Thurgoona and Albury Ranges Threatened Species Conservation Strategies* (Davidson & Datson 2004; Davidson *et al.* 2006). One of the main objectives of the strategy is to ‘*maintain and enhance habitat for threatened species on AEL*’. During the preparation of the *Thurgoona Threatened Species Conservation Strategy* no threatened frog or reptile species were known to occur in the Thurgoona region (Davidson & Datson 2004, NSW NPWS 2004). Since that study was published, Sloane’s Froglet *Crinia sloanei* was listed under NSW threatened species legislation, providing the impetus and rationale for further surveys to be conducted in the Albury region. This report presents the results of preliminary surveys for threatened and non-threatened frogs and reptiles (herpetofauna) on AEL.

### *Albury Climate*

Total annual precipitation averages 709 mm and is generally uniform throughout the year (Figure 1, Bureau of Meteorology 2013). Monthly averages of daily temperatures vary between 2.7°C and 31.2°C (Bureau of Meteorology 2013). Rainfall during March 2012 was well above average (Figure 1).



**Figure 1.** Mean monthly precipitation and 2012 rainfall data in Albury (Bureau of Meteorology 2013).

## ***Aims and objectives***

In accordance with the objectives of the Crown Lands Division, the aims of this study were:

- 1) To conduct surveys for the threatened Pink-tailed Worm Lizard *Aprasia parapulchella*,
- 2) To conduct surveys for the threatened Sloane's Froglet *Crinia sloanei*,
- 3) To compile an inventory of non-threatened herpetofauna on AEL,
- 4) Identify important threatened species habitat to inform proposed environmental works.

## ***Herpetofauna of the Albury Local Government Area***

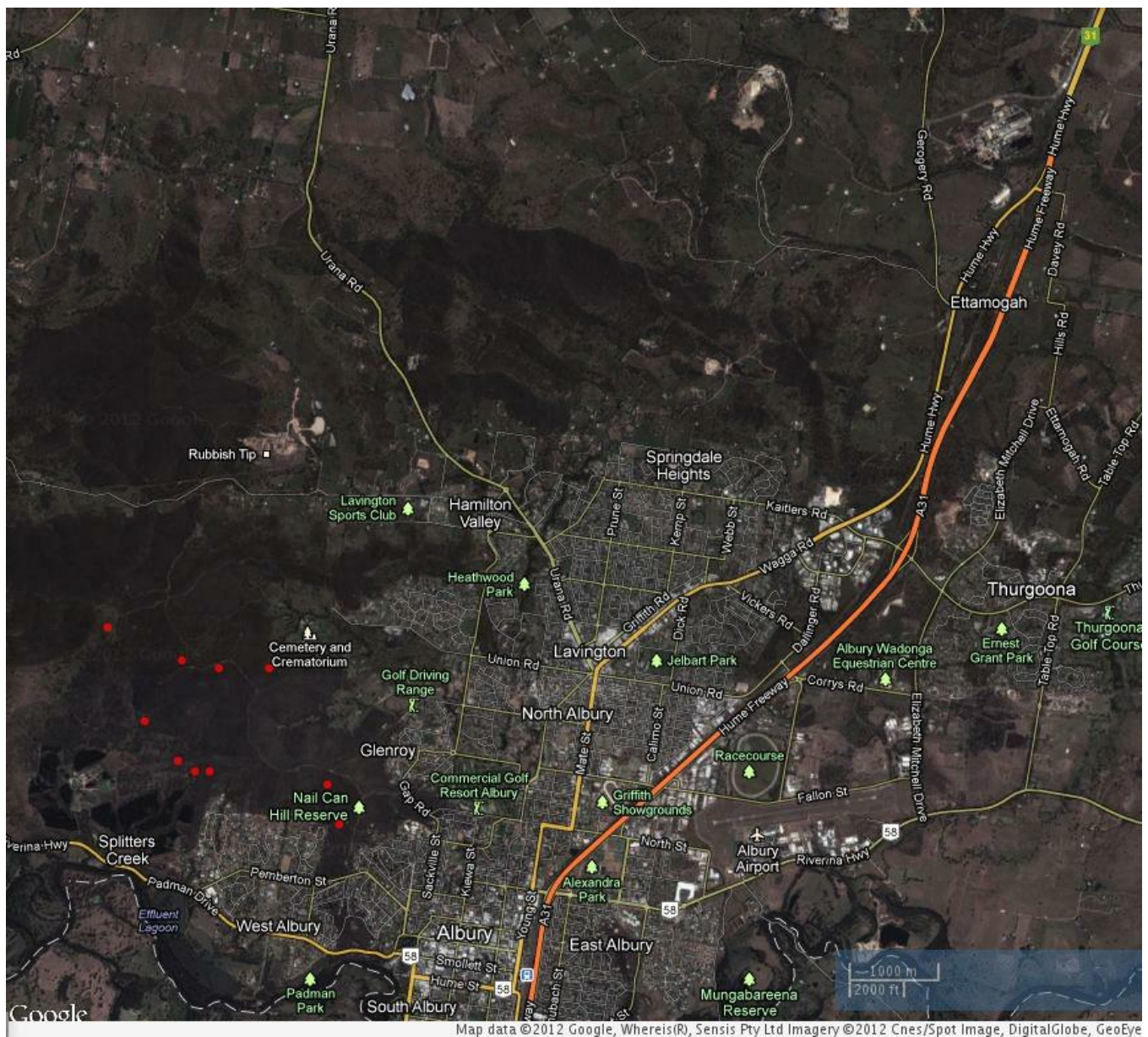
The Albury Local Government Area (LGA) supports 47 species of herpetofauna (35 reptiles and 12 frogs) representing eleven families (Appendix 1). Three species have been accidentally introduced to the area (e.g. Delicate Skink, Shingleback and Asian House Gecko). The Nail Can Hill Flora and Fauna Reserve and adjoining Black Range support 35 species of herpetofauna. Collectively, this area is considered to be an important 'biodiversity hotspot' in the NSW Murray catchment (Michael & Lindenmayer 2010) due to the high species diversity within a relatively small area.

## ***The Pink-tailed Worm Lizard (Aprasia parapulchella)***

The Pink-tailed Worm Lizard *Aprasia parapulchella* (Figure 2) is the only threatened reptile known to occur in the Albury LGA (Atlas of Living Australia 2012). This species is threatened in Victoria under the *Flora and Fauna Guarantee Act 1988*, Vulnerable in NSW under the *Threatened Species Conservation Act 1995*, Vulnerable in the ACT under the *Nature Conservation Act 1980* and nationally Endangered under the *Environment Protection and Biodiversity Conservation Act 1999*. In the Albury LGA, the Pink-tailed Worm Lizard has a restricted range and is known only from ten locations on the Nail Can Hill range (Figure 3). The species shelters beneath shallowly embedded 'dinner plate-sized' surface rocks, often within the brood chambers of *Iridomyrmex* and *Pheidole* ant species (Michael & Herring 2005, Wong *et al.* 2012). The Albury population is of National significance due to the paucity of records in southern NSW (Atlas of Living Australia 2012). Populations close to Albury included Howlong, Walbundrie, Holbrook and Tarcutta (Atlas of Living Australia 2012).



**Figure 2.** Pink-tailed Worm Lizard *Aprasia parapulchella* and habitat on Nail Can Hill Flora Reserve, Albury. Left to right: adult specimen showing dark head, longitudinal dark spots on each scale and pinkish tail. Two individuals in aggregation sequestered in the brood chamber of *Iridomyrmex* sp. Typical habitat showing native grass understorey and open canopy. A dinner plate-sized surface rock specifically used by the ants and lizards for shelter and thermoregulation (Photos: D. Michael).



**Figure 3.** Location (red dots) of the Pink-tailed Worm Lizard *Aprasia parapulchella* in the Albury Local Government Area (Source Atlas of Living Australia [www.ala.org.au](http://www.ala.org.au)).

### ***Sloane's Froglet (Crinia sloanei)***

Sloane's Froglet *Crinia sloanei* (Figure 4) is the only threatened frog species known to occur in the Albury LGA (Atlas of Living Australia 2012). This species is listed as Vulnerable in NSW under the *Environment Protection and Biodiversity Conservation Act 1999* and data deficient on the IUCN Red List (Hero *et al.* 2004a). The species calls from the water while supported by vegetation. It breeds between July and October and lays eggs individually or as loose clumps on the bottom of ponds ([www.frogs.org.au](http://www.frogs.org.au)). The autoecology and biology of Sloane's Froglet is poorly known and requires further investigation.



**Figure 4.** Adult male Sloane's Froglet *Crinia sloanei* and an example of winter breeding habitat in the Albury LGA (Photos: D. Michael).

## Other significant species

One species of conservation concern is Bibron's Toadlet *Pseudophryne bibroni* which is listed as threatened on the IUCN Red List (Hero *et al.* 2004b). This species is not listed under NSW threatened species legislation but may warrant consideration in the future. Several additional threatened species occur in the Murray catchment, including the Heath Monitor *Varanus rosenbergi* (Mount Lawson and Khancoban), Booroolong Frog *Litoria booroolongensis* (Jingellic region and Mount Lawson) and the Southern Bell Frog *Litoria raniformis* (Tallangatta Valley). Interestingly, the Victorian Museum holds a specimen of a male Southern Bell Frog that was collected in 1964, 4.8 km west of Albury on the Victoria side of the border (Atlas of Living Australia 2012). This species is presumed to be locally extinct in the Albury-Wodonga LGA.

Several species of herpetofauna are rare or near the limits of their natural geographical range in the Albury region (Michael & Lindenmayer 2010). As such, their occurrence on AEL would be considered significant. These species include Burton's Legless Lizard *Lialis burtonis*, Nobby Dragon *Diporiphora nobbi*, Woodland Blind Snake *Ramphotyphlops proximus*, Yellow-faced Whip Snake *Demansia psammophis*, Dwyer's Snake *Parasuta dwyeri* and the Common Spadefoot *Neobatrachus sudelli*.



Figure 5. Threatened or regionally significant herpetofauna recorded in the NSW Murray catchment or considered locally rare within the Albury LGA (Left to right: Bibron's Toadlet, Booroolong Frog, Common Spadefoot, Heath Monitor, Burton's Legless Lizard, Nobby Dragon, Bandy Bandy, Woodland Blind Snake, Yellow-faced Whip Snake, Inland Carpet Python and Dwyer's Snake. Photos: D. Michael).

## **SURVEY METHODOLOGY**

### ***Frog Surveys***

#### **Site Selection**

Aerial photography and field assessments were used to select AEL parcels which contained suitable wetland environments such as farm dams, ephemeral wetlands (including gilgai land formations), creek systems and depressions in grassy woodland). In total, 38 AEL parcels were identified as containing suitable wetland habitat and were included in the study (Appendix 2).

#### **Survey Protocol**

The survey protocol used was based on the guidelines recommended by the Department of Environment and Climate Change for surveying threatened amphibians (DECC 2009). This involved using a combination of diurnal active searches, nocturnal searches, call surveys and call play back. To increase the chance of detecting winter breeding species (e.g. Sloane's Froglet) and summer breeding species, surveys were conducted during winter and summer. Between July 2012 and August 2012, 38 sites were surveyed following rain, and in January 2013 a subset of nine sites were surveyed following a brief storm. At each site, 15 minutes was spent passively listening for calling males 30 minutes after sun down until no later than 2300 hours. Each wetland and creek system was traversed to ensure the entire area was surveyed. If after 15 minutes Sloane's Froglet was not detected, a pre-recorded call of the species was amplified and played through a loud speaker for a further 5 minutes.

#### **Data Collection**

Presence and abundance data for all frog species was collected from each wetland along with several environmental and climatic variables (wetland type, survey time and temperature). If Sloane's Froglet was present, the number and location of calling males was marked on an aerial photograph and then mapped using GIS software. All records were lodged with the NSW National Parks and Wildlife Service wildlife atlas database ([www.bionet.nsw.gov.au](http://www.bionet.nsw.gov.au)).

## **Habitat Assessments**

At each wetland that Sloane's Froglet was recorded, a range of categorical and continuous environmental variables were collected for use in habitat assessment and analysis. The variables selected were chosen to reflect broad (macrohabitat) attributes of the site. It was not the intention of this study to investigate causal relationships between Sloane's Froglet occupancy and environmental variables, or evaluate factors effecting detectability. However, some analysis was conducted to explore relationships between Sloane's Froglet abundance estimates and macrohabitat variables. A list of all variables collected at each site is described below:

- Wetland type: 1) dam and 2) natural wetland.
- Wetland area (m<sup>2</sup>): Area of dam calculated from aerial photography. Natural wetland area was not calculated due to the difficulty of delineating the boundary of the water body from aerial photography.
- Overstorey stem count within 10 m radii of all wetlands: 1) regrowth = trees with a stem diameter at breast height (DBH) < 20 cm, and 2) remnant trees with a stem DBH > 20 cm
- Dominant (>50%) vegetation growth-form within 10 m radii of all wetlands based on stem counts: 1) regrowth, 2) remnant, and 3) forward tree planting (FTP).
- Percentage composition of growth-forms based on stem counts.
- Projected foliage cover based on aerial photography: 1) low (< 10% cover), 2) medium (10 – 25% cover) and, 3) high (> 20% cover).
- Cover abundance estimates of native and exotic ground cover species within 2 m radii of all wetlands (i.e. the littoral zone).
- Notes on invasive exotic species and woody weeds, erosion and livestock grazing were collected.

## **Reptile Surveys**

### **Site Selection**

Aerial photography and field assessments were used to select AEL parcels which contained suitable Pink-tailed Worm Lizard habitat, typically open grassy woodland areas with high amounts of surface rocks. In total, four Pink-tail Worm Lizard sites were identified and included in the study. An additional four lowland sites were selected to inventory other reptile species. Throughout this report a reptile survey site represents discrete AEL parcels containing suitable reptile habitat and was not defined by a standardized patch size.

### **Survey protocol**

Reptiles were surveyed using time-unlimited active searches of natural habitat on clear sunny days between August and March 2013. Active searches involved inspecting beneath logs, rocks, leaf litter, grass tussocks and behind the bark of large trees, as well as scanning the ground, tree trunks, fence posts, rocky outcrops and fallen trees for basking animals (Michael *et al.* 2012). In addition, signs of animal presence were noted, such as discarded sloughs (shed reptile skin which can often be identified to species level), turtle shells, lizard eggs and monitor lizard scratch marks on tree trunks.

The surveys were not limited to a defined search area. Instead, the random meander method was used. This method involved walking and scanning the entire land parcel in search of specific habitat features, which in the case of the Pink-tailed Worm Lizard includes a particular rock type harboring specific ant species. The presence of other species was determined by targeting large trees (e.g. arboreal gecko), fallen timber (e.g. most skinks) or raking through leaf litter beneath shrubs to locate fossorial (soil-dwelling) snakes and lizards.

To increase the chance of detecting the Pink-tailed Worm Lizard, several sites which contained suitable habitat were surveyed on multiple occasions between August and December 2012.

### **Data Collection**

Presence and abundance data for all reptile species was collected from each site along with several environmental and climatic variables (habitat type, survey time and temperature). All records were lodged with the NSW National Parks and Wildlife Service wildlife atlas database ([www.bionet.nsw.gov.au](http://www.bionet.nsw.gov.au)).

## RESULTS

### *Frog Surveys*

A total of eight frog species representing two families were recorded on 38 AEL parcels, including the threatened Sloane's Froglet (Tables 1 & 2). The inventory constitutes 67% of the Albury LGA frog fauna. Species not recorded during the surveys include the Eastern Banjo Frog (although several individuals were observed incidentally on 5 January 2013 crossing Wignell Road), Wrinkled Toadlet, Bibron's Toadlet and Southern Brown Tree Frog.

Six species were recorded during the winter survey (Table 1). An additional two species were recorded during the summer survey (Table 2). The most widely distributed and abundant species recorded during the winter survey was Plain's Froglet, which was detected on 92% of sites. Sloane's Froglet was the second most widely distributed and abundant species recorded during the winter survey and was detected on 58% of sites (Appendix 2). Sloane's Froglet was also heard calling incidentally from several water-logged paddocks on private property adjacent to AEL. These records were submitted to the NSW NPWS atlas but are not discussed in this report. Peron's Tree Frog was the most widely distributed and abundant species recorded during the summer survey and was detected on 89% of sites. (NB: abundance values are underestimates as they are based on calling males)

**Table 1.** Frog species recorded on AEL during July /August 2012.

Species	No. of AEL sites	% of sites	Total abundance	Mean abundance
MYOBATRACHIDAE				
Plain's Froglet	35	92	461	13.2
Sloane's Froglet	22	58	175	7.6
Spotted Marsh Frog	7	18	32	4.6
Common Froglet	6	16	27	4.5
Smooth Toadlet	2	5	3	1.5
HYLIDAE				
Plain's Brown Tree Frog	14	37	50	3.57

**Table 2.** Frog species recorded on AEL during January 2013.

Species	No. of AEL sites	% of sites	Total abundance	Mean abundance
MYOBATRACHIDAE				
Spotted Marsh Frog	2	22	2	4.9
Giant Banjo Frog	3	33	3	1
HYLIDAE				
Peron's Tree Frog	8	89	8	1

## Reptile Surveys

A total of 14 reptile species representing five families were recorded on 8 AEL parcels (Table 3). An additional two species (Nobby Dragon and Dwyer's Snake) have previously been recorded on AEL bringing the total number to 16 species. The inventory constitutes 46% of the Albury LGA reptile fauna. The most widely distributed and abundant species recorded were the Large Striped Skink, Ragged Snake-eyed Skink and Boulenger's Skink (Table 3). These three species accounted for 80% of all reptile observations.

**Table 3.** Reptile species recorded on AEL between June 2012 and March 2013 (Additional species previously recorded on AEL (#) based on Davidson 2000; Michael 2004, 2005a, 2005b, 2007).

Species	No. of sites	% of sites	Total observations	Mean No. obs. / site
<b>CHELUIDAE</b>				
Long-necked Turtle	1	13	1	1
<b>AGAMIDAE</b>				
Eastern Bearded Dragon	1	13	3	3
Nobby Dragon#	1	13	1	1
<b>GEKKONIDAE</b>				
Southern Marbled Gecko	2	26	2	1
<b>SCINCIDAE</b>				
Southern Rainbow Skink	3	39	5	1.6
Ragged Snake-eyed Skink	5	63	40	8
Large Striped Skink	7	88	51	7.14
Boulenger's Skink	7	88	31	4.42
Grey's Skink	1	13	2	2
Tree Skink	2	26	7	3.5
Three-toed Skink	1	13	1	1
Eastern Blue-tongue	3	39	3	1
<b>VARANIDAE</b>				
Lace Monitor	1	13	1	1
<b>ELAPIDAE</b>				
Dwyer's Snake#	1	13	1	1
Red-bellied Black Snake	1	13	1	1
Eastern Brown Snake	3	39	3	1

## ***Threatened Species Habitat Assessments***

The Pink-tailed Worm Lizard was not detected during the surveys. As such, habitat assessments were not conducted and the species is not discussed further in this report. A detailed description of the species habitat in the Albury LGA has previously been published (see Michael and Herring 2005) and can be used as a model to identify and map potentially suitable habitat on AEL.

Sloane's Froglet was recorded on 25 wetlands from 20 AEL parcels (Appendix 2), predominantly from farm dams (80% of sites), followed by gilgai grassy woodland, an oxbow depression and a natural wetland. Habitat assessments identified considerable variation in vegetation structure and condition among sites (Appendix 3). Approximately 30% of sites supported low levels of canopy cover, 42% of sites supported moderate levels of canopy cover and 30% of sites supported high levels of canopy cover. Remnant vegetation was the dominant growth type on 42% of sites, followed by forward tree plantings (29%) and eucalypt regrowth (25%).

Littoral zone ground cover vegetation was dominated by a mixture of native and exotic grass species. Natives species included water couch *Paspalum disticum*, wallaby grasses *Rytidosperma* spp., plains grass *Austrostipa aristiglumis* and redleg grass *Bothriochloa macra*, whereas exotic species included phalaris *Phalaris aquatica*, paspalum *Paspalum dilatatum*, kikuyu *Pennisetum clandestinum* and African lovegrass *Eragrostis curvula*.

The relationships between Sloane's Froglet abundance, wetland surface area and other vegetation variables was investigated using correlation statistics (a correlation of  $R^2 > 0.6$  signified a strong relationship, highly skewed variables were log transformed to meet the assumption of normally distributed data). The analysis revealed a weak positive relationship ( $R^2 = 0.31$ ) between the abundance of Sloane's Froglet and water surface area (Figure 6) (NB: one dam was excluded from the analysis due to extensive flooding obscuring the dam boundary).

The equation for the relationship was of the form:  $y = 0.0015x + 2.9393$ , where  $x$  = dam area and  $y$  = frog abundance. This relationship may be useful for predicting the carrying capacity of newly constructed dams. For example, all else being equal, a dam with a surface area of 500 m<sup>2</sup> could potentially support 3.65 males, whereas a dam with a surface area of 10,000 m<sup>2</sup> could potentially support 18 males. This assumes other criteria are also taken into consideration such as wetland design and distance to source populations.

No other significant correlations between the abundance of Sloane's Froglet and vegetation variables were found. Importantly, no negative relationships were found between Sloane's Froglet abundance and vegetation attributes such as stem density, % regrowth or canopy cover.

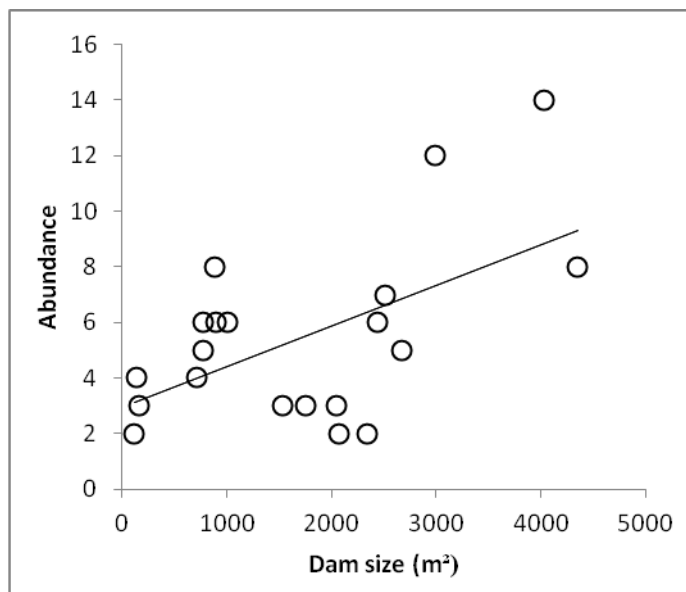


Figure 6. The relationship between Sloane's Froglet abundance (males only) and the size of farm dams (m<sup>2</sup>) on AEL. Circles represent abundance estimates for each dam and the straight line represents a weak but positive trend for increasing frog numbers with increasing area of water body.

## THREATENING PROCESSES

Several key threatening processes listed on Schedule 3 of the NSW *Threatened Species Conservation Act 1995* (TSC Act) that are known to cause a decline in frog populations are particularly relevant to Sloane's Froglet conservation in the Albury LGA. These include: 1) the spread of the infectious disease chytrid fungus *Batrachochytrium denrobatidis*, 2) predation by the plague minnow *Gambusia holbrooki*, 3) predation by feral cats *Felis catus*, and 4) alteration to the natural flow regimes of floodplains and wetlands. Many of these processes require further investigation to assess their impacts on population viability of Sloane's Froglet in the Albury LGA. However, regarding chytrid fungus, the Department of Environment and Climate Change have developed hygiene protocols for the control of disease in frogs (Department of Environment and Climate Change 2008) which have implications for contractors and staff working on AEL. The main issue to consider is to take precautions to minimize the transfer of potential disease by disinfecting footwear, equipment and vehicles travelling between sites. Several other processes that have the potential to threaten the viability of Sloane's Froglet on AEL include soil erosion caused by livestock accessing water bodies, inappropriate revegetation and invasive woody weeds. These are discussed in more detail below.

## ***Livestock Grazing***

During the survey, Sloane's Froglet were detected calling from the water's margin and particularly from emergent vegetation near inflow and overflow areas. Wetland characteristics such as bank gradient, water depth, water quality, water temperate and emergent vegetation play important roles in the ecology of many frog species (Hazel *et al.* 2001) and are likely to be equally important to Sloane's Froglet. AEL has experienced a long history of grazing and it is clear from this study that Sloane's Froglet has some capacity to persist with some level of grazing pressure. However, several studies have found strong causal links between livestock grazing, a reduction in emergent vegetation, reduced frog reproductive success and increased risk of frog predation by exotic fish (Healy 1998, Jansen and Healy 2003). Furthermore, cattle cause substantial soil damage when accessing water bodies and contribute to increased turbidity and water pollution. Sloane's Froglet habitat would therefore be improved by removing, restricting or regulating grazing pressure on AEL. Some grazing management options to consider include:

- 1) Exclude livestock from AEL where Sloane's Froglet has been recorded and monitor the outcomes,
- 2) Restrict livestock access by fencing out wetlands and establish alternative watering points,
- 3) Regulate livestock by excluding grazing during Sloane's Froglet core breeding season (May – Oct).

All of these, or combinations of these actions are likely to improve wetland condition and the long-term viability of frog populations on AEL.

## ***Woody Regrowth***

Tree cover in the surrounding landscape is an important predictor of frog occurrence in agricultural regions (Hazel *et al.* 2001). Sloane's Froglet locations in this study varied in the amount of tree cover related variables ranging from completely cleared land to sites supporting dense eucalypt regrowth (presumably as a result of reduced grazing pressure in the past). Several sites also contained forward tree plantings with high stem density. An important finding of this study was that no negative relationships between frog abundance and vegetation cover variables were detected. However, dense eucalypt regrowth and invasive woody weeds (e.g. Honey Locust) may affect Sloane's Froglet habitat by altering flow regimes, rates of water loss and levels of solar radiation. Further research is required to evaluate the effects of tree cover (and associated structural variables) on wetland hydrology and Sloane's Froglet breeding success. A management recommendation is to selectively thin dense stands of eucalypt regeneration and remove woody weeds to maintain a structurally open habitat, and then monitor Sloane's Froglet abundance to evaluate changes in abundance over time.

## HABITAT RESTORATION

### ***Revegetation***

Although this study found no negative relationship with Sloane's Froglet abundance, stem density and canopy cover, revegetation on AEL should consider the potential impacts dense tree plantings may have on wetland hydrology and other process important to frog breeding success. It is recommended that revegetation be undertaken in areas that have been cleared of native overstorey vegetation, with low overstorey vegetation cover, or where corridor links have been identified as being important for other threatened species (e.g. Squirrel Glider). Eucalypt species recorded during this study which should be considered in revegetation programs on Sloane's Froglet sites include yellow box *Eucalyptus melliodora*, Blakely's red gum *E. blakelyi*, white box *E. albens*, river red gum *E. camuldulensis* and apple box *E. bridgesiana*. Tree density should be low (10 – 20 trees/ha) and widely spaced. As a precaution, trees should not be planted within 20 m of a wetland until further research is conducted to evaluate potential negative impacts on frog breeding success. Similarly, shrubs should be planted in small clumps away from the water's edge.

### ***Coarse Woody Debris***

Several studies have identified the importance of retaining coarse woody debris (fallen timber) to preserve populations of small vertebrates such as frogs and reptiles in agricultural landscapes (Dorrough *et al.* 2012, Michael *et al.* 2012). Coarse woody debris is important for shelter during non-breeding periods, facilitating dispersal and protection from predators and livestock. Frogs will often shelter beneath logs during non-breeding periods and these shelter sites are likely to play important roles in the dispersal behavior and meta-population dynamics of Sloane's Froglet in the Albury LGA. In this study, a general lack of fallen timber on Sloane's Froglet sites was identified, particularly within 20 m of the wetland. Several studies have shown that small vertebrates, particularly frogs and reptiles, will readily utilize timber that has been added to landscapes devoid of this critical resource (Michael *et al.* 2004, Michael *et al.* 2012). Thus, a management recommendation is to enhance coarse woody debris on AEL by either actively redistributing logs from heavily timbered AEL parcels or by introducing artificial habitat (e.g. fence posts or railway sleepers). Introduced railway sleepers also provide a valuable tool for passively monitoring frog and reptile populations (Michael *et al.* 2012).

## MANAGEMENT RECOMMENDATIONS

Several key management actions that would enhance Sloane's Froglet habitat on AEL are listed in Table 4. It is recommended that a grazing management strategy and revegetation plan be developed for AEL. Such documents would greatly assist in identifying priority areas for grazing exclusion, grazing management and revegetation in the context of other threatened species habitat requirements and conservation priorities.

**Table 4.** Site specific management recommendations required to maintain and improve Sloane's Froglet habitat on AEL.

AEL No.	Grazing management	Eucalypt regrowth management	Woody weed control	Revegetation	Timber enhancement	Monitoring required	Specific notes
3	✓				✓	✓	Restrict horses, evidence of recent fire, tire tracks on low depression south of dam.
4			✓		✓	✓	Remove willow, sweet briar, honey locust and white cedar. Erosion control required between dams.
8						✓	No immediate management required
11					✓	✓	No immediate management required.
12						✓	No immediate management required.
13	✓			✓	✓	✓	Realign fence and restrict livestock, control horehound.
13	✓				✓	✓	Restrict livestock, heavy soil pugging around dam.
15	✓		✓	✓	✓	✓	Plant eucalypts and shrubs in low density, remove sweet briar.
16	✓	✓			✓	✓	No immediate management required.
17						✓	No immediate management required.
18		✓				✓	Potentially thin eucalypts.
22			✓		✓	✓	Remove willows and non-indigenous shrubs around wetland.

26						✓	No immediate management required.
38					✓	✓	Control St John's wort, erosion control required below dam.
45		✓	✓			✓	Potentially thin eucalypts, control woody weeds along roadside.
46					✓	✓	Dam bank stabilization required, restrict stock access.
54					✓	✓	No immediate management required.
81				✓	✓	✓	Plant eucalypts in low density (may have to thin existing planting)
82	✓				✓	✓	Restrict stock access and establish alternative watering point
82						✓	No immediate management required.
86	✓	✓		✓	✓	✓	Plant eucalypts in low density
91						✓	No immediate management required.
91						✓	No immediate management required.

### ***Threatened Herpetofauna Monitoring***

Ongoing monitoring of threatened herpetofauna is a key recommendation of this report. There are several attributes of an effective long-term monitoring program that should be considered (see Lindenmayer and Likens 2010 for an appraisal of effective ecological monitoring). These include: 1) setting clear objectives and carefully formulated questions, 2) building into the design an experimental component, 3) ensuring there is enough replication to make statistical inference possible, 4) reducing issues associated with species detectability (this point is particularly important when attempting to monitor rare or cryptic species), and 5) ensuring there is continuity in field observers collecting the data to reduce observer bias effects.

One of the main objectives of designing a long-term monitoring program on AEL is to evaluate the potential impacts of proposed environmental works on the distribution and abundance of threatened species. However, species such as the Pink-tailed Worm Lizard are notoriously cryptic and difficult to survey and may require considerable time and effort over several years to adequately determine true

absence. Future reptile surveys on AEL should continue to target sites with high habitat potential such as Norris Ridge and Red Light Hill before a monitoring program can be established.

In regards to monitoring Sloane's Froglet on AEL, the experimental design should be flexible enough to be able to answer specific questions that are important to the management of Crown Lands, but also be flexible enough to integrate with an LGA or regional-wide frog monitoring program. Thus, a fundamental objective and key evaluation question of AEL is to evaluate the potential impacts of proposed environmental works on the distribution and abundance of Sloane's Froglet, but a regional-wide program might focus on evaluating population dynamics in response to changes in climatic conditions. To evaluate management effects, it will be important to ensure that environmental works such as revegetation and/or livestock exclusion (or management) are not implemented on all Sloane's Froglet sites. Incorporating control sites in the experimental design is a fundamental component of an effective, scientifically credible, monitoring program. Along with incorporating treatments and controls, a level of stratification is also desirable. For example, one level of stratification on AEL could involve wetland type, whereby natural wetlands are compared with constructed wetlands (e.g. farm dams). Detectability issues may be reduced by conducting two or more site visits during the peak breeding season. Taking into account these design parameters, a proposed monitoring program on AEL could involve a two x two factorial experiment, whereby wetland type is crossed with management intervention type (Table 5). The monitoring program could be further strengthened if several years of data are collected before management interventions occur, thereby provide a before and after contrast. However, finding enough sites on AEL to populate all of the cells to ensure a balanced design may not be possible at this stage. Therefore, monitoring the complete suite of Sloane's Froglet sites on AEL is proposed until a LGA-based monitoring program is designed.

**Table 5.** A proposed two x two factorial experimental design which could be used as the basis for implementing a long-term frog monitoring program on AEL.

Stratification and treatment type	Natural wetland	Constructed wetland
Management intervention (e.g. revegetation and/or grazing exclusion)	6	6
No management intervention	6	6

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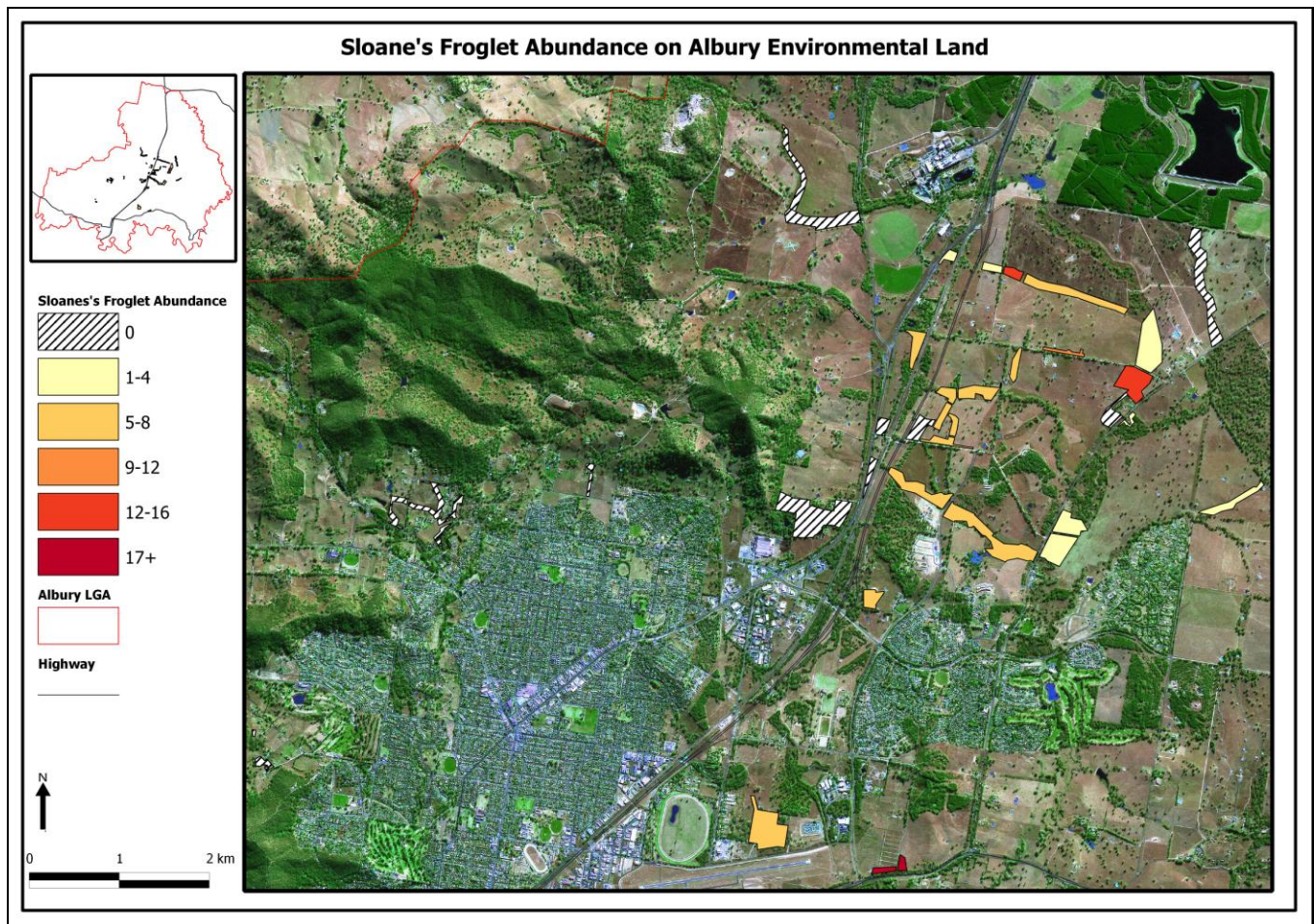
**Appendix 1.** A list of herpetofauna recorded from the Albury Local Government Area (LGA). NCH = Nail Can Hill Flora and Fauna Reserve, \* = threatened species, # = presumed to be introduced.

Common Name	Scientific Name	Range in LGA and Habitat
MYOBATRACHIDAE		
Plain's Froglet	<i>Crinia parinsignifera</i>	Widespread, most types of wetland
Common Froglet	<i>Crinia signifera</i>	Widespread, most types of wetland
Sloane's Froglet*	<i>Crinia sloanei</i>	Localised, dams, inundated woodland
Inland Banjo Frog	<i>Limnodynastes interioris</i>	Localised, dams, urban gardens
Eastern Banjo Frog	<i>Limnodynastes dumerilii</i>	Localised, most types of wetland
Spotted Marsh Frog	<i>Limnodynastes tasmaniensis</i>	Widepread, most types of wetland
Bibron's Toadlet*	<i>Pseudophyrne bibroni</i>	Restricted, NCH, Black Range, seepage areas
Smooth Toadlet	<i>Uperoleia laevigata</i>	Localised, dams, woodland
Wrinkled Toadlet	<i>Uperoleia rugosa</i>	Restricted, NCH, dams
HYLIDAE		
Southern Brown Tree Frog	<i>Litoria ewingii</i>	Restricted, East Albury, wetlands
Plain's Brown Tree Frog	<i>Litoria paraewingii</i>	Widepread, most types of wetland
Peron's Tree Trog	<i>Litoria peronii</i>	Widepread, most types of wetland
CHELUIDAE		
Broad-shelled Turtle	<i>Chelodina expansa</i>	Restricted, Wonga wetlands, riparian
Long-necked turtle	<i>Chelodina longicollis</i>	Widespread, riparian, dams, wetlands
Murray Turtle	<i>Emydura macquarii macquarii</i>	Widespread, riparian, dams, wetlands
AGAMIDAE		
Jacky Lizard	<i>Amphibolurus muricatus</i>	Restricted, NCH, woodland
Nobbi Dragon	<i>Diporiphora nobbi</i>	Restricted, NCH, woodland
Eastern Bearded Dragon	<i>Pogona barbata</i>	Localised, woodland, farmland
GEKKONIDAE		
Southern Marbled Gecko	<i>Christinus marmoratus</i>	Widespread, woodland, urban areas
Eastern Stone Gecko	<i>Diplodactylus vittatus</i>	Restricted, NCH, woodland
Asian House Gecko#	<i>Hemidactylus frenatus</i>	Restricted, Albury CBD
PYGOPODIDAE		
Pink-tailed Worm-lizard*	<i>Aprasia parapulchella</i>	Restricted, NCH, woodland

Olive Legless Lizard	<i>Delma inornata</i>	Localised, woodland, farmland
Burton's Snake-lizard	<i>Lialis burtonis</i>	Restricted, NCH, woodland
SCINCIDAE		
Southern Rainbow Skink	<i>Carlia tetradactyla</i>	Localised, woodland, farmland
Ragged Snake-eyed Skink	<i>Cryptoblepharus pannosus</i>	Widespread, woodland, farmland, urban areas
Large Striped Skink	<i>Ctenotus robustus</i>	Widespread, woodland, farmland, urban areas
Copper-tailed Skink	<i>Ctenotus taeniolatus</i>	Restricted, NCH, rocky outcrops
Cunningham's Skink	<i>Egernia cunninghami</i>	Restricted, Black Range, 9 mile TSR, outcrops
Tree Crevice Skink	<i>Egernia striolata</i>	Localised, rocky outcrops, woodland, farmland
Yellow-bellied Water Skink	<i>Eulamprus heatwolei</i>	Localised, Wonga wetlands, riparian
Three-toed Skink	<i>Hemiergis talbingoensis</i>	Localised, woodland, farmland
Delicate Skink#	<i>Lampropholis delicata</i>	Localised, Albury Botanic Gardens
Garden Skink	<i>Lampropholis guichenoti</i>	Localised, riparian, urban areas
Grey's Skink	<i>Menetia greyii</i>	Restricted, NCH, grasslands
Boulenger's Skink	<i>Morethia boulengeri</i>	Widespread, woodland, farmland, urban areas
Eastern Blue-tongue	<i>Tiliqua scincoides scincoides</i>	Widespread, woodland, farmland, urban areas
Shingleback #	<i>Trachydosaurus rugosa</i>	Restricted, Urban areas, escapees
VARANIDAE		
Lace Monitor	<i>Varanus varius</i>	Localised, woodland, farmland
TYPHLOPIDAE		
Woodland Blind Snake	<i>Ramphotyphlops proximus</i>	Localised, woodland, farmland
PYTHONIDAE		
Inland Carpet Python	<i>Morelia spilota metcalfei</i>	Restricted, Splitters Creek, woodland
ELAPIDAE		
Yellow-faced Whipsnake	<i>Demansia psammophis psammophis</i>	Restricted, NCH, woodland
Eastern Tiger Snake	<i>Notechis scutatus</i>	Restricted, Wonga wetlands, riparian
Dwyer's Snake	<i>Parasuta dwyeri</i>	Localised, NCH, woodland
Red-bellied Black Snake	<i>Pseudechis porphyriacus</i>	Localised, riparian, woodland, farmland
Eastern Brown Snake	<i>Pseudonaja textilis</i>	Widespread, woodland, farmland
Bandy Bandy	<i>Vermicella annulata</i>	Restricted, Splitters Creek, farmland

(Sources: Michael 2004, 2005; 2007; Michael & Lindenmayer 2010; Atlas of Living Australia [www.ala.org.au](http://www.ala.org.au))

**Appendix 2.** Location and abundance of male Sloane's Froglet on Albury Environmental Land, NSW  
(Map produced by Liam Grimmet, 2013).



**Appendix 3.** Location and abundance of male Sloane's Froglet on AEL and macrohabitat attributes.

AEL No.	Location	Sloane's Froglet Abundance	Wetland Type	Wetland Area (m <sup>2</sup> )	Canopy cover	Growth form	Ground cover
3	Wagga Road (Rail overpass)	4	1 x Dam	140	High	Regrowth	Native and exotic
4	Wagga Road (Twynan Ct)	2	1 x Dam (Nth)	2075	Moderate	Forward tree planting	Native and exotic
4	Wagga Road (Twynan Ct)	6	1 x Dam (Sth)	2442	Low	Forward tree planting	Native and exotic
8	8 Mile Ck via Davey Rd west	3	Wetland/Riparian	160	Moderate	Remnant	Exotic perennial
11	FTP 7 Mile Ck via Davey Rd east	5	1 x Dam	2678	Low	Remnant	Exotic perennial
12	8 Mile Ck via Williams Rd	2	1 x Dam	120	High	Forward tree planting	Native and exotic
13	Via Old Sydney Rd	12	1 x Dam (East)	2990	Low	Remnant/FTP	Native perennial
13	Via Williams Rd	4	1 x Dam (West)	720	Moderate	Forward tree planting	Native and exotic
15	Cnr Wignell / Williams Rd	8	1 x Dam (Top Dam)	4356	None	None	Native and exotic
15	Cnr Wignell / Williams Rd	3	1 X Dam (Middle Dam)	2048	None	None	Native and exotic
16	Wignell Rd (7 Mile Ck)	5	1 x Dam (Bottom Dam)	770	Moderate	Regrowth	Native and exotic
17	Ettamogah Road	6	Natural wetland	3900	Moderate	Remnant	Native and exotic
18	Ettamogah Road	6	1 x Dam	1008	High	Regrowth	Native perennial
22	Old Sydney Rd	3	1 x Dam	1760	Moderate	Forward tree planting	Native and exotic
26	8 Mile Ck via Old Sydney Rd (H & H)	3	Wetland/Ox bow	306	High	Forward tree planting	Native perennial
38	6 Mile Ck, Trinity College	7	2 x Dam (West Dam)	2508	High	Forward tree planting	Native perennial
45	Ava Avenue	6	1 x Dam	780	High	Regrowth	Exotic perennial
46	6 Mile Ck, CSU	8	4 x Dam (West Dam)	880	Moderate	Regrowth	Native perennial

54	"The Gilgai"	7	1 x Dam	893	Moderate	Remnant	Native and exotic
81	8 Mile Ck via Davey Rd east	14	1 x Dam	4032	Low	Remnant	Native perennial
82	Williams Rd (Op training centre)	3	1 x Dam	1534	Low	Remnant	Native perennial
82	Williams Rd	6	Wetland/Depression	903	Moderate	Regrowth	Exotic perennial
86	Kerr Rd	2	1 x Dam	2340	Low	None	Native and exotic
91	Hume/Hovel Tk Riverina Hwy	35	1 x Dam	576	High	Remnant	Native and exotic
91	Hume/Hovel Riverina Hwy	15	Gilgai	1443	Moderate	Remnant	Exotic perennial