

# Pacific Highway Upgrade: Nambucca Heads to Urunga.

Underpass Monitoring – Year 1  
(Construction Phase – Year 3)



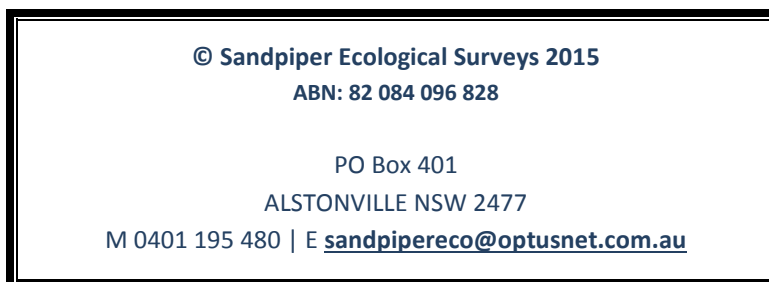
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**Cover Photo:** A red-eyed green tree frog (*Litoria chloris*) observed near the centre of a dedicated RCBC at chainage 75250. The individual was observed moving in an east to west direction. (Photo: T. St Vincent Welch)

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# 1. Introduction

Sandpiper Ecological Surveys (Sandpiper) was contracted by Lend Lease Engineering (LLE) to conduct monitoring of fauna underpasses located along stage 1 of the Warrell Creek to Urunga Pacific Highway Upgrade. Stage one extends from Nambucca Heads to Urunga (NH2U). Monitoring of fauna underpasses is a requirement of the Ecological Monitoring Program (BEM 2013) which was developed in accordance with Ministerial Condition of Approval (MCoA) B10 for the proposed highway upgrade.

The Ecological Monitoring Program (EcMP) provides details on selection of control sites, timing of monitoring, fauna census techniques and potential indicators of success. The EcMP states that monitoring is to occur during the construction phase (year 3) and the operational phase (years 2, 3, 5, 7 and 9). The following report presents results of construction phase (year 3) monitoring conducted during spring 2014 and autumn 2015. The report includes information on the background to the monitoring program and its methods, discussion of the results and makes recommendations relevant to future surveys and management of the NH2U fauna underpasses.

## 1.1 Background

The EcMP (BEM 2013) states that the purpose of the fauna underpasses and associated exclusion fencing is to maintain the viability of local populations of terrestrial fauna by facilitating wildlife movement between proximate areas of habitat either side of the upgrade corridor. Further, the fauna underpasses should be designed to accommodate use by several threatened fauna species including the spotted-tail quoll (*Dasyurus maculatus*), brush-tail phascogale (*Phascogale tapoatafa*), giant barred frog (*Mixophyes iteratus*) and koala (*Phascolarctos cinereus*). Targeted surveys for giant barred frog in summer 2013 found no evidence of the species within the NH2U upgrade corridor and it was concluded that the corridor does not contain potential habitat for that species (Lewis 2013). Consequently, giant barred frog was no longer regarded as a target species for underpass monitoring.

The intent of the monitoring program is to assess use of underpasses by threatened and common fauna before and after installation of the exclusion fencing and to assess the effect of exclusion fencing on movement of small mammals, reptiles and frogs. The EcMP proposed monitoring seven sites with an additional site (between chainage 19500-19820) to be assessed prior to commencement. After detailed discussions between Sandpiper, LLE, Roads and Maritime Services (RMS) and the Environment Protection Authority (EPA) it was decided that construction phase monitoring should focus on use of underpasses only and breaches of exclusion fence would be monitored during the operational phase.

### 1.1.1 Selection of impact sites

The EcMP recommends that the monitoring program follow a BACI design (i.e. before – after – control – impact) with impact sites being those underpasses receiving exclusion fencing and control sites being underpasses without exclusion fencing. Seven impact sites were specified in the EcMP. These and possible alternative sites were assessed for suitability during August and September 2014. Some underpasses proposed by the EcMP were deemed unsuitable because of inappropriate design for monitoring (chainage 72720 & 74810), delayed construction (76300) and presence of temporary exclusion fence on the existing highway (70400). These were replaced by four alternative sites. The final list of impact sites included: one underpass featuring a railway line; two underpasses crossing a vegetated median; one underpass

adjoining the old highway that features culverts; one underpass adjoining a large service road that features pipes; and two underpasses in potential koala habitat (refer Table 1 and Figure 1).

**Table 1:** Location and features of fauna underpasses assessed for the monitoring program. SF = swamp forest; MOF = moist open forest; DOF = dry open forest; R = riparian forest; CI = cleared.

Chainage & Habitat	Location	Type	Length	No. & Size (# x W x H)	Comment
<b>Sites specified in the EcMP</b>					
68470 (SF/MOF/DOF)	South Burkes Lane	RCBC	72.4	1 x 3.6 x 2.4 4 x 3.6 x 1.2	Cleared on east side; adjoins existing highway.
70400 (SF/DOF)	Jacksons Road	RCBC	66.6	1 x 3.6 x 3.0	Cleared on east side; adjoining existing highway. Features temporary fence. <b>Not suitable for monitoring.</b>
72720 (DOF)	North Ballards Rd	RCBC	130	1 x 2.4 x 0.9	Key koala area but low culvert. <b>Not suitable for monitoring</b>
73800 (R/DOF)	Dalhousie Creek	RCBC	36.5 (SB) 42 (NB)	1 x 2.4 x 2.4	Situated in vegetated median
74810 (MOF)	South cut 27	Arch	42	1 x 9 x 4	Changed to bridge so no longer satisfies requirement for monitoring. <b>Not suitable for monitoring</b>
75250 (MOF)	South Martells Rd	RCBC	67.4	1 x 3 x 3	
76300 (SF/DOF)	North School Hill Road	RCBC	83.8	1 x 3.6 x 3.6	Delay in construction. <b>Not suitable for monitoring.</b>
<b>Alternative Sites</b>					
61800 (MOF)	Railway line corridor	Rail Bridge	90	2 x 25.7 x 7.2	
75800 (MOF)	North Martells Rd	RCBC	75.7	1 x 3 x 3	Substitute for u'pass at ch.76300
78800 (MOF/CI)	North Access Rd G	RCBC	58.9	2 x 2.4 x 3.0	Situated on edge of forest.
80220 (MOF)	North Tysons Flat	RCBC	27 (SB) 25 (NB)	2 x 3 x 2.1	Situated in vegetated median
<b>Control Site</b>					
Off site (MOF/R)	McGraths Ck	RCBC	18	3 x 2.4 x 1.5	Crosses under old highway.

### 1.1.2 Selection of control sites

The EcMP states that use of the BACI monitoring design requires inclusion of control sites to enable comparison between treated (impact sites) and untreated (control sites) both before and after treatment or management has occurred (i.e. installation of exclusion fence). Whereas the EcMP acknowledges a variety of logistical constraints facing selection of suitable control sites, it does suggest that a sufficient number of control sites should be chosen to represent threatened fauna targeted by the underpasses and that these should be located within 10km of the project.

After a number of potential control sites were proposed and scoped (e.g. Dalhousie Ck, Pacific Hwy south of Martells Rd, McGraths Ck, Pacific Hwy south of Nambucca Heads), it was decided by LLE and RMS and



agreed to by EPA that only a single control site (McGraths Creek) would be monitored. McGrath’s Creek underpass crosses the Pacific Highway approximately 280m east of the project boundary (Figure 1).

### 1.1.3 Selection of timing of underpass monitoring

The EcMP directs that sampling should occur during the breeding seasons and likely dispersal periods of threatened fauna species targeted by the underpass structures. The times recommended are: autumn (mid-march to mid-may) and spring (mid-September to mid-November). These times include the breeding and dispersal period of koala but not quoll and the autumn sample is too late in the season to effectively record movement by frogs and reptiles. An alternative to cover all target species was proposed but it was agreed to adopt the 8-week autumn and spring monitoring periods, as noted in the EcMP, but shift the timing of these events to Feb/Mar and Oct/Nov.

### 1.1.4 Selection of underpass monitoring methods

The EcMP specifies that sampling should occur within each underpass structure and its entrances and in retained habitat adjacent to each underpass entrance. Monitoring should include hair tubes, sand pads, automated cameras, scat and track searches and use of artificial groundcover (e.g. plywood sheeting). The efficacy of these methods were discussed on a number of occasions with LLE, EPA and RMS and alternative methods that would likely prove more effective were proposed. A comparison of methods described in the EcMP and those proposed by Sandpiper are shown in Table 2.

**Table 2:** Comparison of methods for monitoring fauna underpasses described in EcMP with alternative proposal.

Component	EMP Methods & Effort	Proposed Methods & Effort
Underpasses	<ol style="list-style-type: none"> <li>1. Sand pads – eight sample nights/pad/event<sup>+</sup></li> <li>2. Hair tubes - 20 nights/tube/event*</li> <li>3. Automated cameras – 40 sample nights/camera/event**</li> <li>4. Scat &amp; track search – no effort stated.</li> <li>5. Artificial ground cover – no effort stated.</li> </ol>	<ol style="list-style-type: none"> <li>1. 2 x infrared cameras/site; 12 weeks sampling 2 time periods.</li> <li>2. Scat &amp; track – 3 samples/period (combined with camera install, check &amp; removal).</li> <li>3. 10 nocturnal surveys targeting frogs</li> </ol>
Adjacent Forest	<ol style="list-style-type: none"> <li>1. Spotlighting – no effort stated.</li> <li>2. Arboreal &amp; ground trapping – no effort stated.</li> <li>3. Pitfall trapping – no effort stated.</li> <li>4. Hair tube sampling – no effort stated.</li> <li>5. Diurnal active search – no effort stated.</li> <li>6. Nocturnal Active search – no effort stated.</li> <li>7. Scat &amp; track search – no effort stated.</li> </ol>	<ol style="list-style-type: none"> <li>1. 2 spotlight surveys/site/site – 60 person minutes in 1ha area/survey; 4 samples in total.</li> <li>2. 1 infrared camera/site/site for 2x 3 week periods; 6 weeks total.</li> <li>3. 2 diurnal searches/site/site – 60 person minutes in 1ha area/survey; 4 samples in total.</li> <li>4. Habitat assessment &amp; data collation</li> </ol>

+ EcMP suggests that pads would be sampled once/event but this is contrary to standard methods which require inspection at weekly intervals and sampling for entire 8 week period i.e. 7 inspections + installation.

\* number of tubes/underpass not stated.

\*\* number of cams/culvert not stated.

After consideration of the Sandpiper proposal, it was decided that the suggested monitoring methods would be revised and that cameras, scat/track searches and nocturnal traverses would be used to sample the underpasses and that targeted camera surveys, active searches, collation of existing data and habitat assessments would be used to both sample and predict species likely to be using the underpasses. In total, a minimum of 40 camera nights and 20 sampling days/visits for spotlighting and searches would be conducted across the two monitoring sessions. The revised survey method and effort was agreed to by EPA and is detailed in Table 3.



**Table 3:** Revised survey methods and effort for monitoring fauna underpasses.

Sample Area	Method	Effort
Culvert (species recorded using underpass)	<ol style="list-style-type: none"> <li>1. Cameras installed on ceiling.</li> <li>2. Scat &amp; track search.</li> <li>3. Nocturnal traverse.</li> </ol>	<ol style="list-style-type: none"> <li>1. 2 cams/culvert for 12 weeks.</li> <li>2. 3 traverses.</li> <li>3. Timed spotlight survey of culverts focused on suitable weather events; 10 surveys in total.</li> </ol>
Adjacent forest (list of species likely to use underpass)	<ol style="list-style-type: none"> <li>1. Collate existing data.</li> <li>2. Habitat assessment.</li> <li>3. Targeted camera survey.</li> <li>4. Active search.</li> </ol>	<ol style="list-style-type: none"> <li>1. Review species recorded in EA, clearing surveys &amp; baseline quoll survey.</li> <li>2. Assess habitat within 1ha area at entrance to each culvert – data used to predicted species occurrence.</li> <li>3. 1 cam/side each with bait station for 6 week period (3 in Oct/Nov &amp; 3 in Feb/Mar).</li> <li>4. Nocturnal &amp; diurnal search in 1ha area at entrance to each culvert; 1 person hour/period; 4 sample periods (4 in Oct/Nov &amp; 4 in Feb/Mar).</li> </ol>

## 2. Study area

### 2.1 Impact and control sites

The single control and seven impact sites were spaced along the NH2U Pacific Highway upgrade alignment between chainage 61800 (railway) and 80220 (Tyson’s Flat) (Figure 1). The context of each impact site differed and included: a railway corridor; vegetated median (Dalhousie Ck & Tyson’s Flat); adjoining the old highway that features culverts (Burkes Ln); adjoining a large service road that features pipes (Martells Rd North) and two dedicated underpasses in potential koala habitat (Access Rd G & Martells Rd South). The control site at McGraths Creek was located under the existing Pacific Highway, 280m east of the alignment (Figure 1).

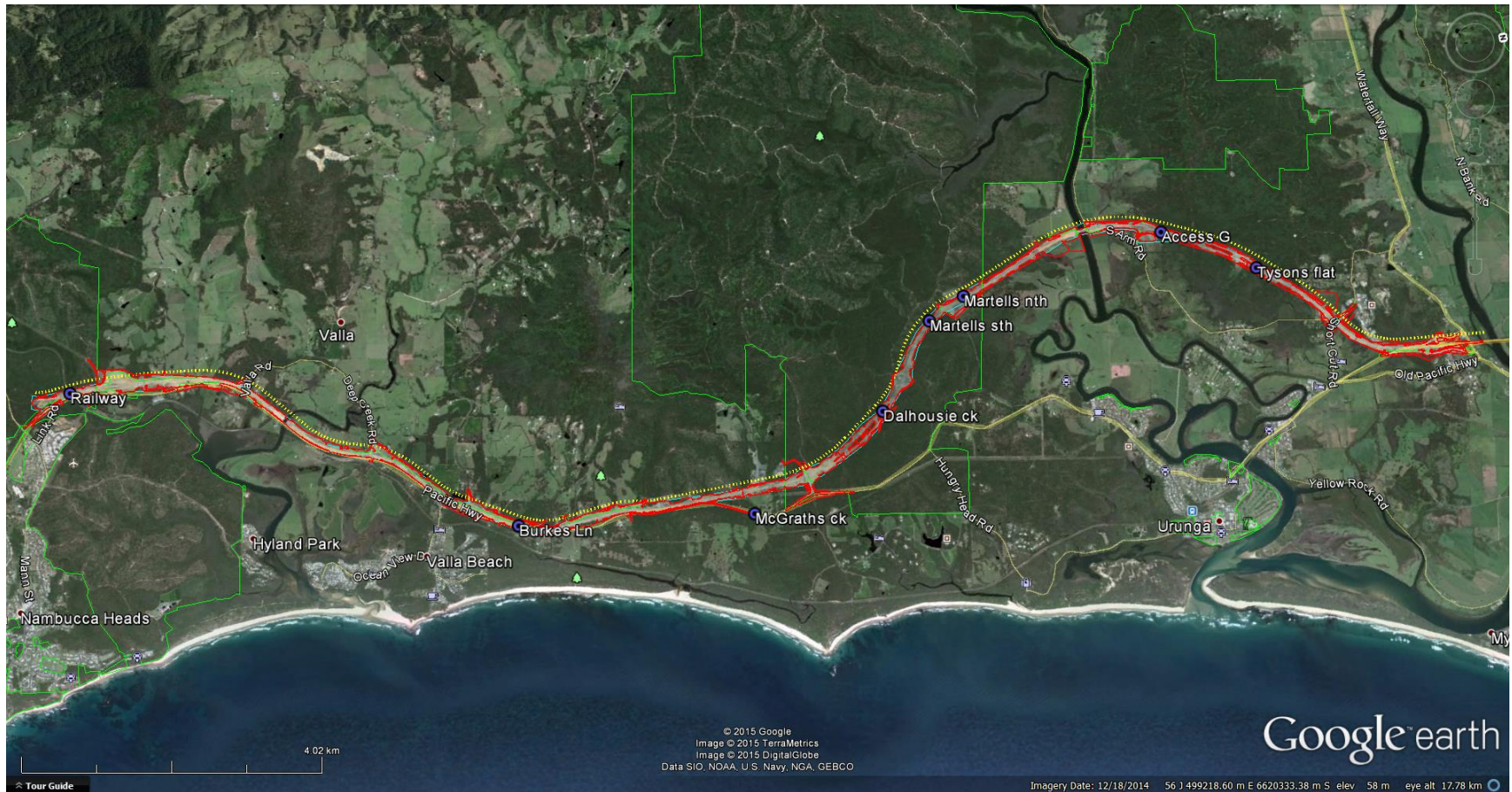


Figure 1. Location of fauna underpass monitoring sites along the NH2U Pacific Highway Upgrade (Source: Google Earth).

Fauna underpasses were largely positioned in drainage lines featuring moist open forest habitat (Table 4; Plates 1-8). Dalhousie Creek (Plate 3) and McGraths Creek (Plate 8) also contained riparian vegetation elements. All sites featured varying amounts of vegetation clearing and rock ballast (scour protection) around culvert entrances (Table 4; Plates 1-8). The distance between underpass entrance and adjoining forest varied from 1m at McGraths Creek (Plate 8) to 90m at Martells Road North east (Plate 5) where a service road separated the east entrance from nearby forest. Twin 1200mm diameter pipes passed under the service road linking forest to the east (Plate 5). Similarly, Burkes Lane adjoined the existing Pacific Highway that featured 3-cell culverts enabling linkage with forest to the east (Plate 2).

**Table 4:** Location and habitat features of impact and control fauna underpasses. SF = swamp forest; MOF = moist open forest; DOF = dry open forest; R = riparian vegetation; Cl = cleared; E = east; W = west

Chainage	Location	Type	Adjoining Habitat (Distance from entrance to adjoining forest)
<b>Impact Sites</b>			
61800	Railway corridor	Rail Bridge	E (~30): MOF W (17): MOF
68470	Burkes Ln	RCBC	E (36): MOF/DOF; obstructed by old Pac Hwy featuring 3x 1200x3000 RCBC W (36): MOF/DOF
73800	Dalhousie Ck (veg median)	RCBC	E (27): R/MOF W (33): R/MOF/DOF
75250	Martells Rd South	RCBC	E (23): MOF W (27): MOF
75800	Martells Rd North	RCBC	E: (90): MOF; obstructed by Service Rd featuring 2x 1200 RCP W (25): MOF/DOF
78800	Access Rd G	RCBC x2	E (44): MOF W (29): MOF
80220	Tysons Flat (veg median)	RCBC x2	E (15): MOF W (28): MOF
<b>Control Site</b>			
East of alignment	McGraths Ck (under old Pac Hwy)	RCBC x3	E (1): R/MOF W (1): R/MOF





**Plate 1:** Habitat adjoining railway corridor underpass (ch.61800) on east side. Habitat was similar on both sides of the alignment.



**Plate 2:** Habitat adjoining the east (left) and west (right) entrance of Burkes Lane fauna underpass (ch.68470).



**Plate 3:** Habitat adjoining the east (left) and west (right) entrance of Dalhousie Creek fauna underpass (ch.73800). Habitat was similar on both sides of the alignment.





**Plate 4:** Habitat adjoining the east (left) and west (right) entrance of Martells Road south fauna underpass (ch.75250).



**Plate 5:** Habitat adjoining the east (left) and west (right) entrance of Martells Road north fauna underpass (ch.75800).



**Plate 6:** Habitat adjoining the east (left) and west (right) entrance of Access Road G fauna underpass (ch.78800).





**Plate 7:** Habitat adjoining the east (left) and west (right) entrance of Tyson's Flat fauna underpass (ch.80220).



**Plate 8:** Habitat adjoining the east (left) and west (right) entrance of McGraths Creek fauna underpass (off site).

## 2.1 Fauna underpasses

All fauna underpasses were Reinforced Concrete Box Culverts (RCBC) of varying dimensions (Plates 10-16) except railway, which was a bridge underpass (Table 5). Culverts at impact sites varied in width from 2.4 - 3.6m and in height from 2.4 - 3.0m. Continuous culvert lengths ranged between 58.9m (Access Rd G) and 75.7m (Martells Road north). Combined lengths of culverts crossing vegetated medians were 52m (Tyson's Flat) and 78.5m (Dalhousie Creek). All impact site culverts were single cell except Tyson's Flat and Access Road G were twin cells (Table 5). The bridge underpass at railway extended for 90m and is 25.7m wide by 7.2m high. The McGraths Creek control site featured a 18m long triple cell RCBC with each cell 2.4 wide by 1.5 high (Table 5). Wooden rails for arboreal fauna within impact culverts were at various stages of construction during the spring sample and reached completion stage during summer 2015 at Dalhousie Creek, Access Road G and Tyson's Flat north bound (Table 5). Railway and McGraths Creek control site did not feature timber rails.

**Table 5:** Design features of impact and control fauna underpasses.

Chainage	Location	Type	Length	No. & Size (# x W x H)	Underpass construction phase at end of monitoring
<b>Impact Sites</b>					
61800	Railway corridor	Rail Bridge	90	2 x 25.7 x 7.2	Retaining walls complete; no landscaping.
68470	Burkes Ln	RCBC	72.4	1 x 3.6 x 2.4 (4 x 3.6 x 1.2)	Partially landscaped; scour protection; no wooden rail.
73800	Dalhousie Ck (veg median)	RCBC	36.5 (SB) 42 (NB)	1 x 2.4 x 2.4	Partially landscaped; scour protection; wooden rail
75250	Martells Rd South	RCBC	67.4	1 x 3 x 3	Scour protection; no landscaping; no wooden rail.
75800	Martells Rd North	RCBC	75.7	1 x 3 x 3 (2 x 1200 diam.)	Scour protection; no landscaping; no wooden rail.
78800	Access Rd G	RCBC	58.9	2 x 2.4 x 3.0	Scour protection; wooden rail; no landscaping.
80220	Tysons Flat (veg median)	RCBC	27 (SB) 25 (NB)	2 x 3 x 2.1	Scour protection; partial landscaping; partial wooden rail.
<b>Control Site</b>					
East of alignment	McGraths Ck (old Pac Hwy)	RCBC	18	3 x 2.4 x 1.5	NA



**Plate 9:** Design features and construction progress for railway bridge underpass. Left photo was taken during spring 2014 sampling and right photo taken during summer/autumn 2015 sampling.





**Plate 10:** Design features and construction progress for Burkes Lane fauna underpass. Photo on top row was taken during spring 2014 sampling and photos on the bottom row taken during summer/autumn 2015 sampling.



**Plate 11:** Design features and construction progress for Dalhousie Creek fauna underpass. Photos on top row were taken during spring 2014 sampling and photos on the bottom row taken during summer/autumn 2015 sampling.



**Plate 12:** Design features and construction progress for Martells Road south fauna underpass. Photos on top row were taken during spring 2014 sampling and photos on the bottom row taken during summer/autumn 2015 sampling.

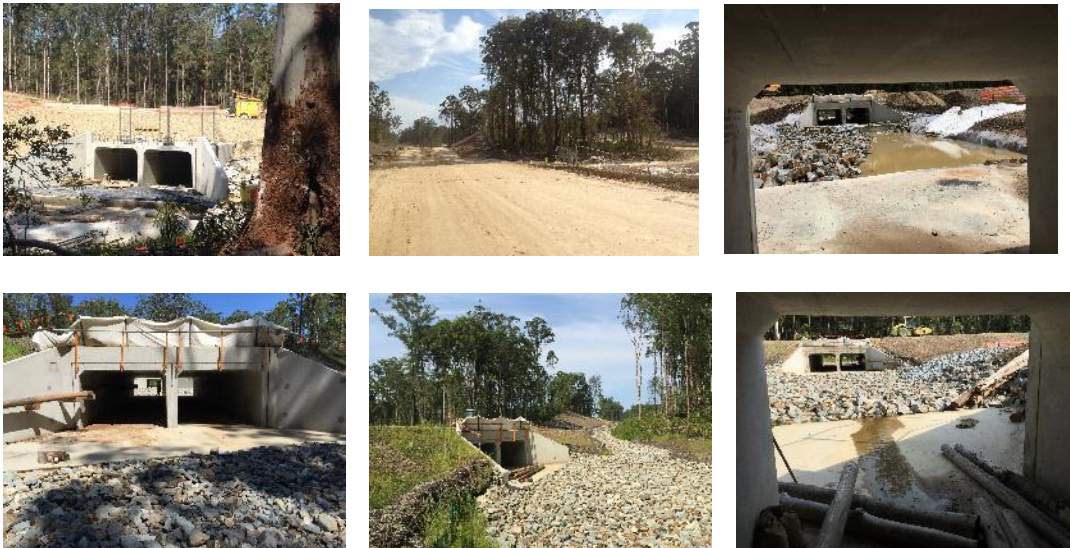


**Plate 13:** Design features and construction progress for Martells Road north fauna underpass. Photos on top row were taken during spring 2014 sampling and photos on the bottom row taken during summer/autumn 2015 sampling.





**Plate 14:** Design features and construction progress for Access Road G fauna underpass. Photos on top row were taken during spring 2014 sampling and photos on the bottom row taken during summer/autumn 2015 sampling.



**Plate 15:** Design features and construction progress for Tyson's Flat fauna underpass. Photos on top row were taken during spring 2014 sampling and photos on the bottom row taken during summer/autumn 2015 sampling.



**Plate 16:** Design features of triple-cell culverts at McGraths Creek.

## 3. Methods

### 3.1 Survey timing, effort and constraints

Surveys were completed during spring 2014 and summer/autumn 2015. Underpass cameras operated for eight weeks and those in adjacent habitat for four weeks during each sampling period. Sand pads were inspected approximately weekly for four weeks during each sampling period. During summer sampling, pads were washed out on a number of occasions. Despite replacing sand wash outs on two occasions, underpasses continued to experience frequent inundation and loss of all or part of their sand during the summer period. Sand was not washed away at Railway but tracks were erased by rainfall events. The third (sand pad) inspection at Railway did not occur because of site access restrictions.

Scat/track traverses were conducted on six occasions throughout the combined sampling periods though access restrictions limited this to five occasions at the Railway site. Night/targeted traverses were conducted on seven occasions during the two sampling periods. An eighth traverse was abandoned due to persistent rain events restricting site access and delaying final surveys beyond appropriate conditions for frog activity (i.e. low night time temperatures). Active day and night searches of adjoining habitat were completed on three occasions each. Details of survey effort, timing and duration are shown in Table 6.

**Table 6:** Sampling effort, timing and duration of spring 2014 and summer/autumn 2015 underpass monitoring. IR = infra-red

Method	Spring 2014		Summer/autumn 2015		Total Effort
	Period	Effort	Period	Effort	
<b><u>Underpass</u></b>					
IR cameras	3/10 - 10/12/14	8 wks	9/2 - 10/4/15	8 wks*	16 wks
Sand pads	1/10 - 5/12/14	4 visits	9/3 - 10/4/15	4 visits**	8 visits
Scat/track traverse	13/10 - 29/10/14	2 visits	10/3 - 7/5/15	4 visits***	6 visits
Targeted/night traverse	29/10 - 10/11/14	3 visits	11/2 - 7/5/15	4 visits****	7 visits
<b><u>Adjoining Habitat</u></b>					
IR cameras	2/10 - 29/10/14	4 wks	10/2 - 10/3/15	4 wks	8 wks
Active day search	13/10 - 5/11/14	1 visit	12/2 - 6/4/15	2 visits	3 visits
Active night search	1/10 - 15/10/14	1 visit	12/2 - 6/4/15	2 visits	3 visits

\* Theft of cameras at east end of Martells Rd south twin-cells during spring reduced monitoring to 5 weeks.

\*\* Sand pads were affected by inundation on multiple occasions during summer resulting in some loss of data.

\*\*\* Due to access restrictions, Railway was sampled on 3 occasions during summer.

\*\*\*\* Due to access restrictions, Railway was sampled on 2 occasions during summer.

Cameras at the east end of the Martells Road south twin-cell culvert were stolen during the later part of the spring sampling period resulting in loss of three weeks of monitoring data. Camera malfunction occurred on three occasions throughout sampling - Burkes Lane the adjacent habitat camera west side during spring (operational for 1/25 days); Tyson's Flat north-east underpass camera during spring (operational 32/63 days); and McGraths Creek north-east underpass camera during summer/autumn (operational 27/50 days).

Construction material littered both the entrance areas and interiors of impact site culverts during spring sampling and culvert aprons were generally under construction. Despite this, no cells were effectively blocked and thoroughfare was maintained. Construction was well advanced by the beginning of the summer/autumn monitoring and the culvert apron and surrounding earthworks were mostly complete. By the end monitoring, landscaping had commenced at Burkes Lane, Dalhousie Creek and Tyson's Flat (refer Plates 9-16). At the railway site, completion of bridge retaining walls during the early stages of the summer/autumn 2015 sample period limited completion of targeted traverses due to night access restrictions.

### 3.2 Sampling fauna in habitat adjacent to underpasses

A number of methods were used to sample the fauna community on each side of the upgrade at monitoring sites. Sampling during each period focused on habitat within 100m of underpass entrances and included use of IR cameras, active day searches and active night searches (spotlighting). Fauna recorded during pre-clearing surveys and rescued during clearing within 100m of each site and fauna recorded during a targeted spotted-tailed quoll survey within 500m of each site were also compiled (Sandpiper Ecological 2014; Owner & Rohweder 2014).



### 3.2.1 Infra-red (IR) camera bait stations

Camera bait stations were installed on both sides of impact and control sites to sample fauna in adjoining habitat. Bait stations were positioned ~50m from each culvert entrance. Each station featured a Scoutguard KG680V infra-red (IR) camera strapped to a tree or post at ~1m high and focused on a bait chamber ~2m away (Plate 17). Bait chambers were 150mm long PVC pipe (50mm diameter) capped at both ends and perforated with numerous holes. Chambers were baited with chicken wings and anchored to the ground with a tent peg. Fish sauce was drizzled over bait chambers to serve as an additional attractant (Plate 17). Cameras were set on med-high sensitivity and programmed to take 3 pictures/activation.

Camera bait stations were active for four weeks during each sampling period and conducted during the period of underpass monitoring. Cameras were checked on a number of occasions during monitoring and retrieved at the end of the four-week sampling period. Photos were downloaded from camera SD cards to a laptop and analysed by a senior ecologist. Fauna detected in photographs were identified to species level (where possible) and assigned a level of certainty: Possible (60-75% certainty); Probable (75-90% certainty); or, Definite (+90% certainty).



**Plate 17:** Camera bait stations featured a Scoutguard KG680V strapped to a tree at ~1m high and focused on a bait chamber containing chicken wings ~2m away (L & M). Chambers were drizzled with fish sauce to serve as an additional attractant (R).

### 3.2.2 Day and night habitat searches

Day and night active searches were conducted in habitat within 100m of each underpass entrance. Day searches were focused on detecting herpetofauna (i.e. reptiles and frogs) and were generally conducted during late morning/early afternoon. Sampling involved two ecologists moving throughout the search area investigating large rocks and logs, decorticating bark and ground hollows to uncover resting herpetofauna. Any animals observed or captured were identified to species level (if possible) and released at point of capture. A search of each side of an underpass would continue for 30 minutes (i.e. 60 person-minutes). Day searches of all sites were conducted on three occasions during the combined sampling periods.

Night spotlight searches to detect nocturnal fauna in adjoining habitat were conducted on three occasions during the combined sampling periods. Each search involved two ecologists spotlighting the search area for 30 minutes (i.e. 60 person-minutes). Any fauna observed were identified to species level (if possible) and their position and behavior recorded.

### 3.3 Sampling fauna using underpasses

A number of methods were used to determine fauna species using underpasses at monitoring sites during each sampling period. Monitoring focused on underpasses and within 20m of their entrances. Methods included infra-red cameras, sand pads, targeted night traverses and scat/track searches.

#### 3.3.1 IR cameras

A Scoutguard KG680V IR camera was positioned inside both entrances of each culvert cell at the beginning of each eight-week sampling period. Cameras were mounted to the cell wall with a steel bracket at a height of 1800-2600mm. Cameras were positioned 5-10m from the culvert entrance and orientated inwards. At the vegetated median sites (Dalhousie Ck and Tyson's Flat), each cell received a single camera in the centre of the culvert (Plate 18). At railway, a camera mounted on a star picket (or equivalent) at ~1200mm height was positioned on the north and south side of the rail lines next to where the retaining walls were proposed to be (spring) and where they were constructed (summer; Plate 18). At McGraths Creek, a camera mounted on a star picket at ~1200mm height was positioned 5m north-east and 5m south-east of the culvert entrance (Plate 18). Cameras could not be positioned inside the culvert cells at McGraths Creek due to risk of inundation. Cameras were checked on a number of occasions during each sampling period and retrieved after 8 weeks.



**Plate 18:** Underpass cameras were mounted on steel brackets & orientated to capture fauna moving along either the floor or rail (if present) of the culvert (L). Cameras were positioned either side of the rail track and inside the retaining walls during summer underpass monitoring (M). Underpass cameras needed to be positioned outside of the McGrath's creek culverts due to risk of inundation (R).

#### 3.3.2 Sand pads

Sand pads to detect fauna tracks were installed within culverts at the beginning of each eight-week monitoring period. A single sand pad consisting of a 1:1 mix of washed river sand and 'brickies' sand was positioned near the centre of each cell. Each pad was ~1000mm wide and ~50mm deep and spread across the width of the culvert. At the commencement of each sampling period and after each inspection, sand



pads were spread/shaped using a nail rake and broom and smoothed using a trowel. Pads were inspected and re-set on four occasions, generally weekly, during each sampling period.

### **3.3.3 Targeted traverses and scat/track searches**

Targeted night traverses to detect frogs were conducted at impact and control sites during and/or after rainfall events. Two ecologists would spend 20 minutes (i.e. 40 person-minutes) at each site searching and listening for frogs both inside and within 20m of culvert entrances. The species, number of individuals, location and behaviour of frogs detected during the traverse would be recorded. Targeted traverses were conducted on seven occasions during the combined sampling periods.

Scat and track searches to detect predators and signs of other animals were conducted during daylight hours at impact and control sites. Two ecologists would spend 10 minutes (i.e. 20 person-minutes) at each site searching for predator and other scats and tracks and signs of animal activity both inside and within 20m of culvert entrances. Scats, tracks or other signs detected were identified and the location recorded. Predator scats were sent to a recognized expert (B.Triggs) for analysis. Scat and track searches were conducted on six occasions during the combined sampling periods. Due to restrictions on night access after construction of bridge retaining walls, only five searches were conducted at Railway.

## **4. Results**

### **4.1 Weather conditions**

Weather conditions varied considerably between the two sampling periods. According to the closest weather station (Coffs Harbour airport), daily temperatures for Oct/Nov 2014 (i.e. spring sampling period) were just above average and rainfall was below average (BOM 2015). Daily rainfall totals above 20mm were only experienced on two occasions during the period. The highest daily rainfall total for the period was 60.4mm (BOM 2015).

By contrast, daily temperatures for Feb/Mar/Apr 2015 (i.e. summer/autumn sampling period) were generally average and rainfall above average (BOM 2015). Rainfall figures for February, in particular, were more than double the long-term average (i.e. 539.4mm compared to 224.8mm). Daily rainfall totals above 20mm were experienced on 15 occasions during the period. The highest daily rainfall total for the period was 183.4mm (BOM 2015).

Full details of weather conditions during habitat searches and targeted traverses are provided in Table A1 and Table A2 (Appendix A).

### **4.2 Fauna in habitat adjacent to underpasses**

#### **4.2.1 Active searches**

Thirty seven species of vertebrate were detected in habitat adjacent to impact and control underpasses during active day and night (spotlighting) searches (Table 7; Plate 19). Despite a greater proportion of surveys occurring during the summer/autumn period, the diversity of species recorded for the two periods was similar (26 spp. in spring compared to 28 spp. in summer). Martells Road north (15 spp.) and

Burkes Lane (16 spp.) were the most species rich sites and Martells Road south (7 spp.) and McGraths Creek (8 spp.) the least.

A number of species listed as vulnerable under the NSW *Threatened Species Conservation (TSC) Act 1995* were detected during searches, including koala (east side of Dalhousie Creek), yellow-bellied glider (east side of Railway), grey-headed flying fox (most sites) and powerful owl (Tyson's Flat & Access Rd G). The most commonly detected species was garden sun skink, which was recorded on both sides of all underpasses (Table 7; Plate 19). Full details of habitat searches are provided in Table A1 (Appendix A).

**Table 7:** Fauna recorded during spring 2014 (1) and summer/autumn 2015 (2) active daytime and nighttime searches of habitat adjoining impact and control underpasses. Searches were conducted within 100m of each underpass entrance.

Species	Tyson's Flat (8022)		Acces Rd G (78800)		Martells Rd Nth (75800)		Martells Rd Sth (75250)		Dalhousie Ck (73800)		Burkes Ln (68470)		Railway (61800)		McGraths Ck (Control)	
	E	W	E	W	E	W	E	W	E	W	E	W	E	W	E	W
Koala									1							
Long-nosed b'coot											1					
Bandicoot sp.		2									1	2				
Sh-ear b-tail possum													1			
Cmn b'tail possum											2					2
Cmn r'tail possum											2					
Sugar glider	2	2							2(veg med)		2	1,2				2
Yellow-bellied glider													2			
Feathertail glider												2				
Swamp wallaby											2					
Wallaby sp.					1	1						2		1		
Water rat											1					
Grey-hd Flying Fox		1	1	1,2	2	2	1,2	1,2	2	1	2	1,2			1	
Melomys sp.														2		
Heron/egret					2											
Tawny frogmouth					1	2		2				2				
Owlet-nightjar		1	2	1		1	1	1	2	2			1			
White thr nightjar					1	1										
Powerful owl		2		2												
Noisy pitta						2										
Lace monitor			2									1				
Eastern water dragon												2				1
Dragon sp.	1															
Garden sun skink	1,2	1,2	1,2	1,2	1,2	1,2	1,2	1,2	1,2	1,2	2	1,2	1,2	1,2	1,2	1,2
Skink sp.									2						1	
Common tree snake										2						
Marsh snake					1											
Red-bellied bl snake											1					
Small-eyed snake													1			
Peron's tree frog	2		2					1								
Dwarf tree frog	2		1,2			2			2	2	1				1	1
Rocket frog					2											
Striped marsh frog			1			2		1								
Great barred frog			1,2													
Red-backed toadlet	1,2	1,2	1,2	1,2	1	1			1,2	1			1			
Common froglet	2		1,2		2	2			2							
Tusked frog		1	1,2	1	2	2	1						1		1	1
<b>Species/site</b>	<b>7</b>	<b>8</b>	<b>11</b>	<b>6</b>	<b>11</b>	<b>11</b>	<b>4</b>	<b>6</b>	<b>9</b>	<b>7</b>	<b>13</b>	<b>7</b>	<b>7</b>	<b>3</b>	<b>5</b>	<b>6</b>
<b>Species/site</b>	<b>12</b>		<b>12</b>		<b>15</b>		<b>7</b>		<b>10</b>		<b>16</b>		<b>9</b>		<b>8</b>	
<b>Spp/season/site (sp\su)</b>	<b>6\8</b>		<b>9\11</b>		<b>7\10</b>		<b>6\3</b>		<b>4\9</b>		<b>9\11</b>		<b>7\3</b>		<b>6\3</b>	



**Plate 19:** Thirty-seven species of vertebrate were detected during active searches of habitat adjoining underpasses, including garden sun skink (L), red-bellied black snake (M) and tracks of water rat (R).

#### 4.2.2 Camera bait stations

Thirty five species of vertebrate were identified from 22619 photographs taken by cameras in habitat adjacent to impact and control underpasses during bait station surveys across the two survey periods (Table 8). All cameras were operational during both monitoring periods except the west habitat camera at Burkes Lane only functioned for one day during the spring survey. A greater number of species were detected during spring (30 spp.) compared to summer/autumn 2015 (25 spp.). McGraths Creek (23 spp.) and Railway (17 spp.) recorded the greatest species diversity and Tyson's Flat (11 spp.) the least.

Two species listed as vulnerable under the NSW *TSC Act* were photographed by cameras - koala (west side of Martells Road south) and long-nosed potoroo (west side Dalhousie Creek). The long-nosed potoroo is also listed as vulnerable by the Commonwealth *Environment Protection and Biodiversity Conservation (EPBC) Act 1999*. The most commonly detected species were northern brown bandicoot and lace monitor, which were both recorded at all sites (Table 8; Plate 20). Full details of camera bait station effort are provided in Table A3 (Appendix A).

**Table 8:** Fauna recorded in spring 2014 (1) and summer/autumn 2015 (2) during camera bait station surveys of habitat adjoining impact and control underpasses. One camera station was positioned in forest habitat 50-100m from each underpass entrance.

Species	Tyson's Flat (8022)		Acces Rd G (78800)		Martells Rd Nth (75800)		Martells Rd Sth (75250)		Dalhousie Ck (73800)		Burkes Ln (68470)		Railway (61800)		McGraths Ck (Control)		
	E	W	E	W	E	W	E	W	E	W	E	W	E	W	E	W	
Echidna		1,2				2	1							1	1		
Antechinus sp.			1[Pr]	1						2	1		1	1		1	
Koala								1									
Long-nosed bandicoot	2		2	1			1,2		1				1		1		
Northern brown b'icoot		2	1	1	1,2	1,2	1	1	1	1	1,2	1	1	1	1,2	1,2	
Short-eared b-tail possum	2	2	1	1,2			2		2		1,2		1	2	1,2	2	
Long-nosed potoroo										1,2							
Red-necked wallaby																1	
Swamp wallaby			1,2	1,2	1	1,2	1,2	1	1,2	1,2	1,2	2	1,2	1,2	1,2	1,2	2
Water rat					2									2			
Bush rat												2[Pr]		1[Pr]			
Black rat		1[Pr]		1			1		1,2	1	1,2	2	2			1,2	
Rodent sp.				1	2		1	1	1,2	1,2	1	1	1	1,2	1,2	1	1
Mouse sp.											1		1[Pr]			1	
Dog	2					1			1,2	1						1,2	1,2
Red fox	1,2		1	1		1							1	1	1		
Cat	1	2						2		1							
Cow																	1
Australian brush-turkey							1	1	1					1			
Pacific black duck																	2
Wonga pigeon	1		1	2												2	
Emerald dove					2												
Bar-shouldered dove					2											1	
Wedge-tail eagle	1																
Laughing Kookaburra																2	
Eastern whipbird																2	1
Eastern yellow robin				1								1					1
Pale yellow robin					2												
Green catbird							2							1			
Superb fairy wren																	1
Yellow-thr scrub wren														1			
Pied currawong									1								
Lace monitor	1,2	1,2	1,2	1,2	2	1,2	1,2	1,2	1,2	1,2	1		1,2	1,2	1,2	1,2	1,2
Eastern water dragon											2					1	1,2
Land mullet				1	1	1	1				1	2		1	1,2		
<b>No. spp/site</b>	<b>8</b>	<b>6</b>	<b>8</b>	<b>12</b>	<b>9</b>	<b>7</b>	<b>11</b>	<b>7</b>	<b>10</b>	<b>9</b>	<b>11</b>	<b>6</b>	<b>10</b>	<b>14</b>	<b>17</b>	<b>14</b>	
<b>No. spp/site</b>	<b>11</b>		<b>12</b>		<b>12</b>		<b>13</b>		<b>13</b>		<b>12</b>		<b>17</b>		<b>23</b>		
<b>No. spp/season/site (sp\su)</b>	<b>6\8</b>		<b>12\5</b>		<b>5\9</b>		<b>10\6</b>		<b>11\8</b>		<b>10\7</b>		<b>15\6</b>		<b>20\13</b>		



**Plate 20:** Thirty-five vertebrate species were captured by IR cameras focused at bait stations within habitat adjoining underpasses. Photo detections included the threatened long-nosed potoroo at Dalhousie Creek (top L), swamp wallaby (top M), short-eared brushtail possum (top R), northern brown bandicoot (bottom L), *Antechinus* sp. (bottom M) and lace monitor (bottom R).

#### 4.2.3 Fauna recorded in adjacent habitat – methods combined

Pooling records from spring 2014/summer 2015 surveys (including fauna detected around underpass entrances during targeted traverse – refer 4.3) and additional records from pre-clearing surveys (Nov 2013 – Jul 2014) and quoll surveys using camera bait stations (Dec 2013 - Jan 2015) revealed 66 vertebrate species within habitat adjacent to impact and control sites (Table 9). The overall number of recorded species varied across the impact sites with the greatest diversity recorded at Tyson’s Flat (34 spp.) and the least at Martells road north and south (26 spp. each) (Table 9; Figure 2). Fewer species were recorded at the McGraths Creek control site (24 spp.) although this site received less survey effort (i.e. no pre-clear surveys or nearby quoll surveys).

Five introduced species were detected within adjacent habitat - fox, dog, cat, black rat and cow. All sites featured at least two introduced species (Figure 2). Fox was the most common and was detected at 5 sites followed by dog (4 sites) and cat (3 sites). The highest number of introduced species (4 spp.) was recorded at McGraths Creek control site, which included the only record of cow. It is possible that some individuals scored as rodent sp. or mouse sp. were introduced species though this could not be confirmed.

Five species listed as vulnerable under the NSW *TSC Act* were detected at a number of sites, including koala (Dalhousie Creek E & W; Martells Road south W), yellow-bellied glider (Railway east), powerful owl (Tyson’s Flat W; Access Rd G W), sooty owl (Tyson’s Flat; Access Rd G) and long-nosed potoroo (Dalhousie Creek W). The koala and long-nosed potoroo are also listed as vulnerable by the Commonwealth *EPBC Act*. The most commonly detected species were the northern brown bandicoot, swamp wallaby, lace monitor and garden sun skink, red-backed toadlet and tusked frog which were each detected at all sites.

Pre-clearing surveys and fauna retrieved during habitat tree removal (Sandpiper 2014) revealed nine additional species not recorded during adjacent habitat surveys. This included southern boobook, sooty owl, eastern barn owl, pink tongue skink, blackish blind snake, carpet python, brown tree snake, bandy bandy and green tree frog (Plate 21). Quoll surveys conducted within 500m of some underpasses mostly confirmed many species detected during adjacent habitat surveys and one additional record – logrunner at the Railway site.



**Plate 21:** Nine species in addition to those detected during adjacent habitat surveys were recorded during pre-clearing surveys and habitat tree removal, including carpet python (left), pink-tongue lizard (middle) and bandy bandy (right).

**Table 9:** Fauna recorded in habitat adjacent to underpasses during spring 2014 and summer 2015 surveys (X) and at underpass entrances during targeted traverses (T). Additional records from pre-clearing surveys (C) and quoll surveys (Q) conducted within 500m of underpasses during the clearing phase are also included. E = east habitat; A = alignment clearing; W = west habitat; M = vegetated median; P = probable record.

Species	Tyson's Flat			Acces Rd G			Martells Rd North			Martells Rd South			Dalhousie Ck			Burkes Ln			Railway			McGrath Ck (Cont)	
	E	A	W	E	A	W	E	A	W	E	A	W	E	A	W	E	A	W	E	A	W	E	W
Echidna		Q	X		Q				X	X											X	X	
Antechinus sp.				P		X								X	X			X		X			X
Koala											X	X		T									
Northern br B'coot		Q	X	X		X	X		X	X		X	X	C	X	X		X	X		X	X	X
Long-nosed b'coot	X	C		X		X			X			X	C		X	C		X				X	
Bandicoot sp.			X												X		X						
Cmn b'tail Possum					Q							Q			X	C			C	Q	Q	Q	X
Sh-ear b'tailpossum	X	C	X	X		X			X			X	C		X	C		X		X	X	X	X
Cmn r'tail possum					C								C		X	C							
Y-bellied glider																		X					
Sugar glider	X	C	X		C								M		X	C	X		C				X
Feathertail glider		C			C					C			C			C	X						
Long-nosed potaroo														X									



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Red-neck wallaby									C				C							X	
Swamp wallaby		Q		X		X	X		X	X			X	X	C	X	X	C	Q	X	X
wallaby sp.						X	X									X			X		
Water rat						X	X							X					X		
Melomys sp.																			X		
Bush rat												C				P			P		
Black rat			P		X			X		Q	X			X	X	X	X				X
Rodent sp.					X	X		X		X	X			X	X	X	X		X	X	X
Mouse sp.														X			P			X	
Dog	X							X			X			X						X	X
Red fox	X			X		X		X										X		X	X
Cat	X		X							X				X							
Cow																					X
Heron/egret	X					X															
Brush-turkey								Q	X		X	X							X		
Wonga pigeon	X			X		X															
Emerald dove						X															
Bar-sh dove																					X
Wedge-tail eagle	X																				
Tawny frogmouth		C			C		X	X		X			C			C	X		C		
White-thr nightjar						X		X		C											
Owlet-nightjar		C	X	X	C	X		X	X	C	X	X	C	X				X			
Powerful owl		C	X			X															
Boobook owl													C						C		
Sooty owl		C																	C		
Barn owl		C			C																
Noisy pitta								X								C					
Logrunner																				Q	
Lace monitor	X		X	X	Q	X	X		X	X		X	X		X	X		X	X	X	X
Water dragon					Q			Q						X						X	X
Dragon sp.	X																				
Pink-tongue skink																C					
Garden sun skink	X		X	X		X	X		X	X		X	X		X	X		X	X	X	X
sm. skink sp.											X									X	
Land mullet						X	X		X	X	Q			X	X			X	X	X	X
Blackish blind snake		C																			
Carpet python					C																
Common tree snake													X								
Brown tree snake		C																			X
Marsh snake							X														
Red-bellied bl snake														X							
Small-eyed snake																	X				
Bandy-bandy									C				C								



Peron's tree frog	X	T		X	C							X											
Dwarf tree frog	X	C		X	C				X			X	C	X	X					X	X		
Bleating tree frog																T							
Red-eye grn tree frog									T														
Green tree frog					C																		
Gracefull tree frog		T			T					T													
Rocket frog		T			T		X																
Striped Marsh frog		TC		X	TC			T	X		X		C										
Great Barred frog		C		X	C								C										
Red-backed toadlet	X	TC	X	X	TC	X	X	T	X		TC		X	C	X		C		X	T		T	
Common froglet	X	T		X	TC		X	T				X	C										
Tusked frog		T	X	X	TC	X	X	T	X	X	T			T			C		X			X	X
Species/site		<b>34</b>		<b>33</b>		<b>26</b>		<b>26</b>		<b>31</b>		<b>28</b>		<b>29</b>		<b>24</b>							

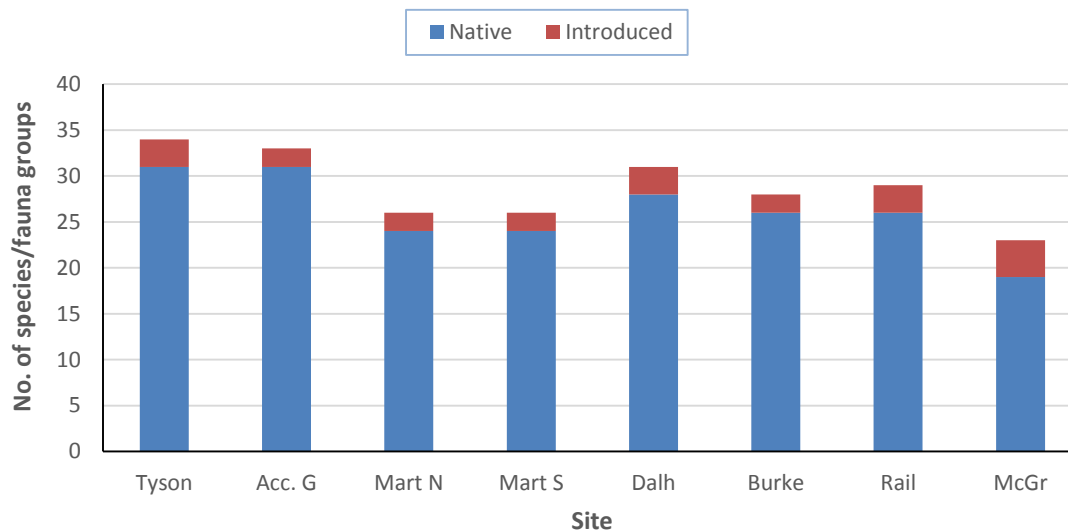


Figure 2. Number of native and introduced species detected in habitat adjacent to underpass monitoring sites.

### 4.3 Fauna using underpasses

#### 4.3.1 Fauna detected by IR cameras

All IR cameras were operational during both monitoring periods except camera malfunction occurred at Tyson's Flat north-east underpass during spring (operational 32/63 days) and at McGraths Creek north-

east underpass during summer/autumn (operational 27/50 days). The combination of camera malfunction and construction activity at Railway curtailed the sampling period during summer 2015 to 41/52 days (north cam) and 31/52 days (south cam). Cameras at the east end of the Martells Road south twin-cell culvert were stolen during the later part of the spring sampling period resulting in loss of three weeks of monitoring data.

Cameras detected seven vertebrate species using underpasses at the seven impact sites and 13 at the control site. Species detected at impact sites included eastern water dragon, swamp rat, black rat (probable), northern brown bandicoot, lace monitor, fox and cat (Table 10; Plate 22). The cat was the most commonly detected user and was recorded at five of the seven impact sites. Native vertebrates were each recorded at a single site only except lace monitor which was recorded at Martells Road north and Railway. By comparison, at least 10 native vertebrate species were detected at the McGraths Creek control site (Table 10). While crossings could only be confirmed for cat, it is likely that native species made complete crossings except yellow-face whip snake and northern brown bandicoot which were only photographed near the underpass entrance.

A greater diversity of species were detected during spring monitoring (12 spp.) compared to summer (8 spp.). Amongst impact sites, species diversity was greatest during summer (5 spp.) compared to spring (4 spp.). The mean number of fauna crossings (confirmed and probable) per site was greater in spring ( $8.38 \pm 6.54$  se) than summer ( $3.88 \pm 1.83$  se), though the difference wasn't significant (paired *t*-test,  $t_{14}=0.66$ ,  $P=0.52$ ). Three species were photographed using a rail (all at Tyson's Flat) - cat, swamp rat and eastern water dragon. All rail detections occurred during summer.

Full details of underpass IR camera fauna detections and effort are provided in Table A4 and A5 (Appendix A).

**Table 10:** Fauna recorded by IR cameras positioned in underpasses during spring 2014 and summer/autumn 2015. One camera was installed at each end of each underpass cell, except a single camera was placed in the middle of each cell at vegetated median sites (Tyson's Flat twin cells & Dalhousie Ck single cell). Side: SB = south bound carriageway; NB = northbound carriageway. Movement Direction: e = east; w = west; n = no defined movement; t = turned around at entrance. Pr = Probable (i.e. 75-90% certainty); Po = Possible (i.e. 60-75% certainty). \* = photographed on rail.

Site	Carriageway	Season	Species	Movement Direction	Confirmed Crossing	Comments		
Tyson's Flat (twin cells)	SB	Spr	Cat	1w	Yes	No confirmed crossing of full alignment (i.e. concurrent crossing of NB & SB culverts); At least 2 cats during both periods;		
		Sum	Nil					
	NB	Spr	Estn water dragon (Pr)	1w	Pr			
			Cat	1w	Pr			
			Cat	2e,2w*	Yes			
		Sum	Estn water dragon (Pr)	3e*,1w*	Pr			
	Swamp rat	1w-e-w*	Pr					
Access Rd G (twin cells)	SB/NB	Spr	Cat	1e,3w	Yes	At least 2 cats; Eastern cams stolen during Spr sampling		
		Sum	Nil					
Martells Rd North	SB/NB		Cat	2e	Yes	1 cat		
		Spr	Nthn brown b'coot (Pr)	1e	Pr			
		Sum	Lace monitor	1w	Pr			
Martells Rd South	SB/NB	Spr	Cat	1w	Yes			
		Sum	NIL					
Dalhousie Creek	SB	Spr	Nil					
		Sum	Nil					
	NB	Spr	Nil					
		Sum	Nil					
Burkes Ln	SB/NB	Spr	Nil					
		Sum	Cat	5w	Yes	At least 2 cats		
Railway	SB/NB	Spr	Lace monitor	2w	Pr			
			Fox	5e,3w,6n	Pr			
		Sum	Cat	1w	Pr			
			Black rat (Pr)	1e	Pr			
McGraths Creek (Control)	SB/NB	Spr	Short-beaked Echidna	1e,1w,1n	Pr			
			Sh-ear b-tail possum	3e,2w,2n	Pr			
			Long-nosed b'coot	1e,1w	Pr			
			Swamp wallaby	3w,4n	Pr			
			Water rat	1e	Pr			
			Black rat (Pr)	1e	Pr			
			Rodent sp.	1e	Pr			
			Fox	2e,5w,2n,2t	Pr			
			Lace monitor	6e,3w,1n,2t	Pr			
			Estn water dragon	1w,1n	Pr			
			Land mullet	1e,3w,3n	Pr			
			Y-face whip snake(Pr)	1n	Po			
			Sum	Nthn-brown b'coot	1n		Po	1 camera malfunctioned 15/2>11/3/15
				Swamp wallaby	1n		Po	



**Plate 22:** A range of fauna were detected using fauna underpasses along the N2U upgrade. Swamp rat (top L) and eastern water dragon (top R) were photographed on the wooden rail in the southbound underpass at Tyson’s Flat. Cat (middle L) and northern brown bandicoot (middle R) were photographed using the Martells Road north underpass. Lace monitor was photographed at Railway (bottom L) and short-eared brushtail possum was observed exiting one of the cells of the McGraths Creek underpass (bottom R).

#### 4.3.2 Fauna tracks detected in sand pads

Sand pads remained in-tact during the spring sampling period although regular drying out of sand occurred at all sites except Access Road G, Martells Road south and McGraths Creek. Sand pads typically form hard crusts as they dry out reducing their receptiveness to foot prints. During summer sampling, regular rain events caused sand wash-out at all sites resulting in loss of some track data. Sand pads were regularly reinstalled.

A total of 272 tracks were recorded during the two sand track sampling periods (Table 11; Plate 23). A similar number of tracks were recorded for spring (138) and summer (134) and the diversity of species/fauna groups was equivalent for the two periods (13). Some species were only recorded in one season, including wallaby and medium lizard (spring only) and dog, frog and heron/egret (summer only). The most frequently recorded track was mouse (73) followed by rodent (53) and water rat (39). The most frequently recorded spp./group across all sites was mouse and cat with each detected at six sites (Table 11).

The McGraths Creek control site featured the highest fauna diversity (14 spp./groups) and highest number of tracks (140). Amongst impact sites, Tyson's Flat was the most diverse (8 spp./groups) and featured the highest number of tracks (48). Martells Road south was the least diverse/traversed site with no tracks albeit repeated washout compromised much of the survey effort there during summer. Native species diversity (inc. mouse & rodent) was highest at McGrath's control site (11 spp./groups). At impact sites, native species diversity was much lower with the highest recorded at Tyson's Flat (6 spp./groups) followed by Access Road G and Martells Road north (3 spp./groups each). It should be noted that whereas rodent and mouse tracks have been attributed to native species, it is not possible to reliably distinguish between native and introduced rodents and mice from tracks. Both native and introduced rodents were confirmed from IR cameras. IR cameras did not detect mice but mouse tracks are most likely those of the introduced house mouse (*Mus musculus*).

Full details of underpass sand pad detections and effort are provided in Table A6 (Appendix A).

**Table 11:** Tracks recorded in sand traps within underpasses during spring 2014 and summer/autumn 2015. A single 1 meter-wide sand strip was positioned in each underpass cell. SB = south bound carriageway; NB = northbound carriageway. Movement Direction: e = east; w = west.

Species	Tyson's Flat*		Access Rd G		Martells Rd Nth		Martells Rd Sth		Dalhousie Ck		Burks Ln		Railway		McGraths Ck	
	Spr	Sum	Spr	Sum	Spr	Sum	Spr	Sum	Spr	Sum	Spr	Sum	Spr	Sum	Spr	Sum
Brush-tail Possum															8e, 5w	3e, 1w
Bandicoot															2w	1e, 2w
Wallaby															1e, 1w	
Mouse	SB:2e NB:4e, 2w	SB:1w NB:1e, 3w	2e, 2w	2e	2e, 2w	3e, 2w			8e, 6w	11e, 11w		2e, 3w			1e	3e, 1w
Rodent	SB:1e, 3w	SB:1e, 1w NB:1w	1e, 2w								1e			3e, 5w	9e, 13w	6e, 6w
Water rat		SB:1e, 1w NB:1w				1e, 1w									1e, 2w	16e, 15w
Cat	SB:1w NB:2e		1w	1e	1e, 1w							1e, 4w		1w	1w	
Fox	SB:1e															1w
Dog												1w		1e, 1w		
Rabbit															1e	
Lace Monitor															4e, 10w	2e, 2w
Dragon	NB:1w	SB:1e, 3w; NB:1e													6e, 6w	1w
Med lizard			2w		1w										4e, 2w	
Sm lizard	SB:11	SB:1; NB:1													3w	
Frog		NB:2w														
Heron/ Egret																1e





**Plate 23:** A range of fauna were detected in sand traps placed in the center of fauna underpasses along the N2U upgrade, including cat (top L), frog (top M), lace monitor (& water dragon & rodent) (top R), wallaby (& rodent & water dragon) (bottom L), water rat (bottom M) and brushtail possum (bottom R).

### 4.3.3 Fauna detected during scat and track searches

Nine species and/or fauna groups were detected during track (not sand pads) and scat searches of underpasses and their entrances during spring and summer monitoring (Table 12). Mouse and rodent tracks and scats were the most commonly detected signs. Rodent scat was detected on the arboreal rail within the Tyson's Flat and Dalhousie Creek underpasses. Scat/track detections provided additional site records for a number of species/fauna groups not detected by sand traps or underpass cameras including bandicoot at Railway, mouse at Martells Road south, rodent at Dalhousie Creek, water rat and small lizard at Access Rd G, water dragon at Martells Road north, medium lizard at Burkes Lane and heron/egret at Tyson's Flat.

Full details of scat and track searches are provided in Table A7 (Appendix A).



**Table 12:** Fauna scats and tracks (not sand pad tracks) within underpasses and their entrances during spring 2014 and summer/autumn 2015. T = track; S = scat; O = individual fauna observed. \* = scat detected on rail inside underpass.

Species	Tyson's Flat*		Access Rd G		Martells Rd Nth		Martells Rd Sth		Dalhousie Ck		Burks Ln		Railway		McGraths Ck	
	Spr	Sum	Spr	Sum	Spr	Sum	Spr	Sum	Spr	Sum	Spr	Sum	Spr	Sum	Spr	Sum
Bandicoot														T		
Mouse		T,O		S,T		S		S		T		S				
Rodent		S*,T								S*						S
Water rat				T												
Cat				T												
Dragon						O										
Med lizard												S				
Sm lizard		T		T												
Heron/egret		T														

#### 4.3.4 Fauna detected during targeted traverses

Ten species of frog and reptile were detected during targeted searches of underpasses and their entrances during spring and summer monitoring (Table 13; Plate 24). At least one search/site occurred either during or immediately after rain. A similar number of species were recorded during spring (7 spp.) and summer (8 spp.) although survey effort was greater in summer. Some species were only detected during one season, including graceful tree frog and eastern water dragon (spring only) and red-eyed green tree frog, bleating tree frog and brown tree snake (summer only). The most commonly detected species were tusked frog and red-backed toadlet which were heard calling near underpass entrances at six sites each.

The most active sites were Tyson's Flat and Access Road G, each featuring six species. All detections were of individuals near underpass entrances except one red-eyed green tree frog was observed in the center of the underpass at Martells Road south and a rocket frog was observed 2m inside the east end of the north-west cell at Tyson's Flat. Full crossing of the underpass by either individual could not be confirmed though it is highly likely the red-eyed green tree frog at Martells Road south completed a crossing.

Full details of targeted traverses are provided in Table A2 (Appendix A).

**Table 13:** Fauna detected during targeted traverses within underpasses and their entrances during spring 2014 and summer/autumn 2015. E = entrance/apron area; U = inside underpass.

Species	Tyson's Flat*		Access Rd G		Martells Rd Nth		Martells Rd Sth		Dalhousie Ck		Burks Ln		Railway		McGraths Ck		
	Spr	Sum	Spr	Sum	Spr	Sum	Spr	Sum	Spr	Sum	Spr	Sum	Spr	Sum	Spr	Sum	
Tusked frog		E		E		E	E	E		E						E	E
Common estn froglet	E	E	E	E		E											
Brown-striped frog	E	E	E			E											
Red-backed toadlet		E	E			E		E						E			E
Red-eyed tree frog								E,U									
Bleating tree frog												E					
Graceful tree frog	E		E														
Rocket frog	E	E,U	E														
Estn water dragon																E	
Brown tree snake																	E



**Plate 24:** A number of frog and reptile species were detected at the entrances to underpasses during targeted traverses, such as the rocket frog (L) and the brown-striped frog (M). Notably, a red-eyed green tree frog was observed in the center of the Martells Road south underpass (R).

#### 4.3.5 Fauna recorded in adjacent habitat and underpasses

Of the 56 species/fauna groups recorded in adjacent habitat across all sites during the two monitoring periods 22 species/groups were recorded within underpasses (Table 14). Forest birds detected in adjacent habitat have been excluded from analyses because they are not targeted or recorded using underpasses and potentially confound comparisons. Most species recorded in an underpass were also detected in habitat adjacent to the respective underpass. Exceptions to this were: water rat, rodent and mouse at Tyson’s Flat; water rat and cat at Access Rd G; cat at Martells Road north; cat and dog at Burkes Lane; cat and dog at Railway; and water rat, rabbit, cat and heron/egret at McGraths Creek.

The proportion of native species detected at a site and recorded using an underpass varied (Figure 3). A considerably higher proportion was recorded at the McGraths Creek control site (57%) than any impact

site where the proportion ranged between 4% (Dalhousie Creek) and 27% (Tyson's Flat). Most introduced species detected at a site were recorded using the underpass (Figure 3). At least one introduced predator (i.e. dog, fox, cat) was recorded in each underpass (Table 14; Figure 3). Cat was recorded in all underpasses except Dalhousie Creek despite being detected in adjacent habitat. Fox was recorded in three underpasses and dog in two. The McGraths Creek control site, the least disturbed site, recorded fox and cat using the underpasses and dog in adjacent habitat.

No threatened arboreal or terrestrial species were confirmed using underpasses despite being recorded in adjoining habitat.

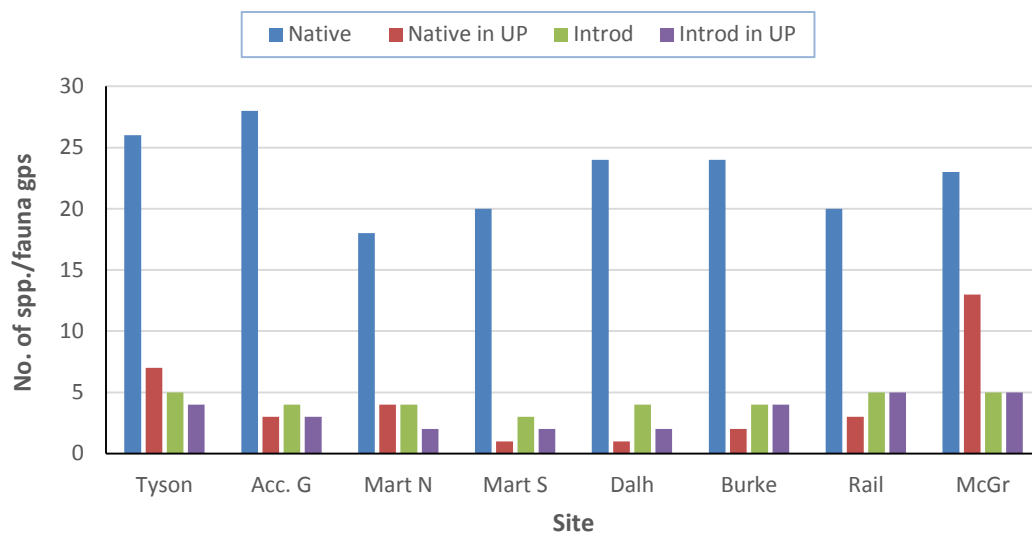
**Table 14:** Compilation of species/fauna groups recorded in adjacent habitat (X & T) and species/fauna groups recorded within underpasses (shaded) during spring 2014 and summer 2015 surveys (excluding forest birds). Additional records from pre-clearing surveys (C) and quoll surveys (Q) conducted within 500m of underpasses during the clearing phase are also included. E = east habitat; A = alignment clearing; W = west habitat; M = vegetated median; P = probable record.

Species	Tyson's Flat			Acces Rd G			Martells Rd North			Martells Rd South			Dalhousie Ck			Burkes Ln			Railway			McGrath Ck (Cont)	
	E	A	W	E	A	W	E	A	W	E	A	W	E	A	W	E	A	W	E	A	W	E	W
Echidna		Q	X		Q				X	X											X	X	
Antechinus sp.				P		X								X	X				X		X		X
Koala												X	X		T								
Northern br B'coot		Q	X	X		X	X		X	X		X	X	C	X	X		X	X		X	X	X
Long-nosed b'coot	X	C		X		X			X			X	C		X	C		X				X	
Bandicoot sp.			X												X		X						
Cmn b'tail possum					Q							Q				X	C			C	Q	Q	X
Sh-ear b-t possum	X	C	X	X		X			X			X	C		X	C		X		X		X	X
Brushtail possum sp.																							
Cmn r'tail possum					C								C		X	C							
Y-bellied glider																		X					
Sugar glider	X	C	X		C								M		X	C	X		C				X
Feathertail glider		C			C					C			C			C	X						
Long-nosed potoroo														X									
Red-neck wallaby										C			C										X
Swamp wallaby		Q		X		X	X		X	X		X	X		X	X	C	X	X	C	Q	X	X
Wallaby sp.						X		X								X					X		
Water rat						X		X							X						X		
Melomys sp.																					X		
Bush rat													C				P				P		
Black rat			P		X				X		Q	X			X	X	X	X					X
Swamp rat																							
Rodent sp.						X	X		X		X	X		X	X		X	X		X	X	X	X
Mouse sp.															X			P				X	

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Dog	X							X			X	X						X	X
Red fox	X			X		X		X							X		X	X	
Cat	X		X							X		X							
Cow																			X
Rabbit																			
Heron/egret	X					X													
Lace monitor	X		X	X	Q	X	X	X	X	X	X	X	X		X		X	X	X
Water dragon					Q			Q					X					X	X
Dragon sp.	X																		
Pink-tongue skink														C					
Med lizard																			
Garden sun skink	X		X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X
sm. skink sp.										X								X	
Land mullet					X	X	X	X	Q			X	X		X	X		X	X
Blackish blind snake		C																	
Carpet python					C														
Common tree snake												X							
Brown tree snake		C																	X
Marsh snake						X													
Y-faced whip snake																			X
Red-bellied black snake													X						
Small-eyed snake														X					
Bandy-bandy									C		C								
Peron's tree frog	X	T		X	C					X									
Dwarf tree frog	X	C		X	C			X			X	C	X	X				X	X
Bleating tree frog														T					
Red-eyed tree frog									T										
Green tree frog					C														
Gracefull tree frog		T			T					T									
Rocket frog		T			T		X												
Striped Marsh frog		TC		X	TC			T	X		X		C						
Great barred frog		C		X	C								C						
Red-backed toadlet	X	TC	X	X	TC	X	X	T	X		TC	X	C	X	C	X	T		T
Common froglet	X	T		X	TC		X	T				X	C						
Tusked frog		T	X	X	TC	X	X	T	X	X	T		T		C	X		X	X
Frog sp.																			
<b>Spp.-gps /site</b>		<b>31</b>			<b>32</b>			<b>22</b>		<b>23</b>		<b>28</b>		<b>28</b>		<b>25</b>		<b>30</b>	





**Figure 3.** A site comparison of number of native and introduced species/fauna groups detected at each site and number recorded using the respective underpass.

## 5. Discussion

### 5.1 Fauna use of underpasses

Underpass monitoring of Pacific Highway upgrades have largely occurred during the operational phase. As such, construction phase monitoring of underpasses within the N2U upgrade provides a unique opportunity to establish a baseline of both the fauna composition in adjacent habitat and species recorded using underpasses. Such information will provide an important reference with which to compare operational stage monitoring.

Construction phase monitoring of underpasses at N2U across two seasons revealed use by a similar yet smaller range of vertebrates to that reported at other Pacific Highway upgrade locations (e.g. AMBS 2002; Taylor & Goldingay 2003; Hayes & Goldingay 2009; Sandpiper 2009, 2010, 2015). As noted above, other reported monitoring programs have been conducted during operational phase. It is likely that construction work is a deterrent to underpass use by some species, particularly during the early phases of construction. Importantly, the range of fauna detected in adjoining habitat is similar to that reported at other Pacific Highway upgrades (Taylor & Goldingay 2003; Sandpiper 2015). This is to be expected as most Pacific Highway upgrade sites reside within the north coast bioregion and feature similar coastal forest landscapes (NSW NPWS 2003).

Amongst the six impact and one control underpasses, species diversity in adjacent forest ranged between 24 (McGraths Creek) and 34 (Tyson's Flat) albeit survey effort was least at McGraths control site due to inclusion of pre-clearing and clearing fauna records for impact sites. Further, the west side of McGraths Creek is highly disturbed and largely cleared. Of the impact sites, the lowest species diversity was

recorded at Martells Road north and south, with 26 species. Adjoining forests at these sites have been disturbed by intensive logging operations which may adversely affect species abundance.

The proportion of native species detected at a site and recorded using an underpass was higher at the McGraths Creek control site (57%) compared to impact sites (range 4% to 27%). This is likely attributed to both the level of disturbance at impact sites compared to the control site and the likely level of habituation to the culverts at the control site. The only native species confirmed using an impact site underpass were bandicoot (Martells Road north, Railway), water rat (Tyson's Flat, Access Road G, Martells Road north), swamp rat and heron/egret (Tyson's Flat), large/medium/small reptiles at all sites except Martells Road south and Dalhousie Creek and frogs at Tyson's Flat and Martells Road south. Species most commonly recorded at other upgrade sites, including wallabies, possums and bandicoots (e.g. Taylor & Goldingay 2003; AMBS 2002; Sandpiper 2010) were detected at the control site underpass but not impact site underpasses, apart from a small number of bandicoot records at Martells Road north and Railway. It is expected that after completion of construction and vegetation restoration of underpass entrance areas that native species would be more likely to use underpasses (Clevenger and Waltho 2005). This also applies to the two threatened terrestrial species detected near the Dalhousie Creek underpass. Both koala and long-nosed potoroo have been recorded using Pacific Highway underpasses (Taylor & Goldingay 2003; AMBS 2002; Sandpiper 2010, 2015). Installation of fauna exclusion fence is also likely to direct more mobile species such as wallabies into underpasses.

A taxa group specifically targeted during N2U underpass monitoring was frogs. Frogs were a specific target because they are vulnerable to road impacts and are rarely detected using highway underpasses (see Sandpiper 2015). Despite the lack of wet conditions during the monitoring period to encourage movement and dispersal, a rocket frog was observed 2m inside the north-west cell at Tyson's Flat and a red-eyed green tree frog was recorded in the center of the Martells Road south underpass after a rain event in summer. This later record is important as it suggests a willingness of an arboreal frog species to use a RCBC to move across a highway corridor.

Installation of timber rails within underpasses (e.g. Plate 11, 14, 15) was completed at Dalhousie Creek, Access Road G and Tyson's Flat (northbound side only) during summer monitoring. While the influence of timber rails on use of underpasses by arboreal fauna is largely unknown, there are reports of a koala, lace monitors and brown antechinus using versions of them (Goldingay & Taylor 2014; AMBS 2011). At N2U, swamp rat and eastern water dragon (and cat) were photographed using the rail at Tyson's Flat. Use by the swamp rat is interesting as this species is not recognised as being particularly arboreal. Timber post and rail systems at N2U largely target koala.

## 5.2 Introduced predator use of underpasses

Introduced predators are commonly encountered during underpass monitoring though their impact on use by native species remains equivocal (e.g. Fitzgerald 2005; Taylor & Goldingay 2014). At least one introduced predator (i.e. dog, fox, cat) was recorded in each underpass and cat was recorded in all underpasses except Dalhousie Creek despite being detected in adjacent habitat. Fox was recorded in three underpasses and dog in two. The McGraths Creek control site, the least disturbed site, recorded fox and cat using the underpasses and dog in adjacent habitat.

Despite the proposition that underpasses may function as prey traps being largely unsubstantiated (see Chambers & Bencini 2014), the prevalence of use by introduced predators across all sites is concerning. Use by introduced predators shortly after construction suggests that they habituate to the structures more rapidly than native species and may require control, particularly around culverts that target high risk (i.e. critical weight range <5000g) species. No signs of predation within or near underpasses was evident during either monitoring period.

### 5.3 Site enhancements and operational phase monitoring

The primary site enhancement recommended for N2U is encouragement of habitat restoration to link forest edge and underpass entrances. This has been shown to increase use of underpasses by native fauna (see Clevenger and Waltho 2005). Other site enhancements, such as including hollow logs and rocks to provide refuge from predators and mulch and gravel to encourage use by amphibians, rodents and small reptiles may compromise the hydraulic function of combined culverts and are therefore not recommended at N2U. However, such enhancements should be considered for dedicated culverts on future highway upgrades.

An intention of the monitoring program was to assess use of underpasses by threatened and common fauna before and after installation of the exclusion fence (Benchmark 2013). The current monitoring program provides a baseline of before data. It is important that fence installation is complete and site enhancements undertaken prior to commencement of monitoring during year two of the operational phase.

## 6. Recommendations

1. Encourage vegetation restoration near culvert entrances;
2. Provide local land management agencies responsible for pest management (i.e. NSW National Parks and Wildlife Service; Local Land Services NSW; Forestry Corporation NSW) relevant information from the report on the incidence and location of pest vertebrates, particularly foxes.
3. Liaise with and enable access for local land management agencies pest management actions adjacent to road upgrades.

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## Appendix A – Survey Data

**Table A1:** Results for active day and night searches of habitat adjoining underpass entrances conducted during spring 2014 and summer 2015.

Site	Date	Side	Day/Night (survey no.)	Observers	Start Time	Finish Time	Wind	Rain	Visibility	Air Temp	Humidity	Species (no. of individuals / behaviour)	Comments
Tysons flat (ch:80220)	1/10/14	E	Night(1)	Tw/np	1932	2005	Msb	Nil	Dark	18.9	53.2	Ps. coriacea(20+/C)	
	1/10/14	W	Night(1)	Dr	1932	2005	Msb	Nil	Dark	18.9	53.2	Ps. coriacea(5/C); A. brevis(1/C); GHFF(1/F); ONJ(1/C)	
	13/10/14	E	Day(1)	BT/tw	1330	1332	MLB	Nil	DAY	30.5	55	Lamprapholis sp. (3/F), dragon sp (1/T)	
	13/10/14	W	Day(1)	BT/tw	1420	1448	MLB	Nil	DAY	30.5	55	Lamp. delicata (5/F)	
	12/2/15	W	Night(2)	Tw/Gm	2103	2145	Nil	Nil	Dark	25.2	81	<b>POWERFUL OWL</b> (1/C: juv? Trill call); P. coriacea (10+/C); SuG (1/C:50m w),	
	12/2/15	E	Night(2)	Tw/Gm	2150	2220	Nil	Nil	Dark	25.2	81	P. coriacea(5+/C), Lit. fallax(1/C), SuG (1/C:50m se)	
	10/3/15	W	Day(2)	Bt/Gm	1512	1541	MLB	Nil	Day	26.9	89	Lamp. delicata (9/F)	
	10/3/15	E	Day(2)	Bt/Gm	1428	1459	MLB	Nil	Day	26.9	89	Lamp. delicata (15/F)	
	11/3/15	W	Night(3)	Bt/Gm	1955	2027	MSb	Nil	Dark	24.3	82	Ps. coriacea(5/C)	
	11/3/15	E	Night(3)	DO/ST	1955	2027	MSb	Nil	Dark	24.3	82	C signifera (3/C); Lit peroni (5/C)	
	24/04/2015	W	Day(3)	DO; GM	12.30	13	Nil	Nil	Day	25.2	67.7	Lamp del (2/C); bandicoot diggings.	
	24/04/2015	E	Day(3)	DO; GM	13.2	13.5						Lamp. delicata (13/F)	
	21/10/14	E	Day(1)	BT/np	1557	1624	MLB	Nil	Clear	21.1	65.2	Lamp. delicata (1/F)	

Access rd G (ch:78800)	21/10/14	W	Day(1)	BT/np	1626	1654	MLB	Nil	Clear	21.1	65.2	Lamp. delicata (1/F)	
	1/10/14	E	Night(1)	Tw/np	2040	2115	Nil	Nil	Dark	17.2	54.1	Ps. Coriacea(20+/C); A. brevis(2/C), Lit. Fallax(30+/C), Cr. Signifera(4/C), Lim. Peronii(2/C), Mix. Fasciolatus(1/C), Sacred Kingfisher(1/R), GHFF(2/F),	some L.fallax near wing wal
	1/10/14	W	Night(1)	Dr	2040	2115	Nil	Nil	Dark	17.2	54.1	Ps. coriacea (5/C); A. brevis (1/C); ONJ (1/C); GHFF (1/F)	
	12/2/15	W	Night(2)	Tw/Gm	2300	2330	Nil	Nil	Dark	21.6	93.1	Ps.coriacea(10+/C)	
	12/2/15	E	Night(2)	Tw/Gm	2330	2400	Nil	Nil	Dark	21.6	93.1	ONJ(1/C), Ps. coriacea(5+/C), A. brevis (2/C)	
	10/3/15	W	Day(2)	Bt/Gm	1329	1400	MLB	Nil	Day	27.6	90.7	Lamp. delicata (11/F)	
	10/3/15	E	Day(2)	Bt/Gm	1243	1315	MLB	Nil	Day	27.6	90.7	Lamp. delicata (19/F); goanna(1/F)	
	11/3/15	W	Night(3)	Bt/Gm	2045	2116	MSb	Nil	Dark	23.9	86.9	<b>POWERFUL OWL</b> (1/C:50m ne); Ps. coriacea(10/C); GHFF (1/F)	
	11/3/15	E	Night(3)	DO/ST	2045	2116	MSb	Nil	Dark	23.9	86.9	C signifera (10/C); Lit peroni (5/C); M fasciolatus (2/C)	
	24/04/2015	W	Day(3)	DO; GM	14.05	14.35	Msb	Nil	Day	26.5	61	Nil	
24/04/2015	E	Day(3)	DO; GM	14.55	15.3	Msb					L. fallax(1/C); C. signifera(3/C); Lamp delicata (7/F)		
Nth martells (ch:75800)	21/10/14	E	Day(1)	BT/np	1506	1535	Mlb	Nil	l'cast	21.1	62.7	Lamp. delicata (4/F); marsh snake(1/R)	
	21/10/14	W	Day(1)	BT/np	1436	1503	Mlb	Nil	l'cast	21.1	62.7	Lamp. delicata (1/F); wallaby sp(1/T)	

	1/10/14	E	Night(1)	Tw/np	2204	2058	Nil	Nil	Dark	13.1	80.2	Ps. coriacea, (20+/C), Wh-thr NJ (1/C), tawny F'mouth (1/R), wallaby sp. (1/F)	
	1/10/14	W	Night(1)	Tw/np	2204	2058	Nil	Nil	Dark	13.1	80.2	Ps. coriacea, (10+/C), Wh-thr NJ (1/C), ONJ (1/C)	
	13/2/15	W	Day(2)	Tw/Gm	1022	1052	MSb	Nil	Day	28.4	76.5	Ad. brevis(4/C), Lamp. delicata(2/F)	
	13/2/15	E	Day(2)	Tw/Gm	1056	1126	Nil	Nil	Day	28.4	76.5	Ad. brevis(1/C), Lamp. delicata(1/F)	
	11/3/15	W	Night(2)	Bt/Gm	2140	2209	MSb	Nil	Dark	20.6	92.8	Limno peroni (3/C)	
	11/3/15	E	Night(2)	DO/ST	2140	2209	MSb	Nil	Dark	20.6	92.8	Nil	
	12/3/15	W	Day(3)	Bt/Gm	1025	1054	MSb	Nil	Day	29.7	60.5	Lamp. delicata (4/F)	
	12/3/15	E	Day(3)	Bt/Gm	1107	1136	MSb	Nil	Day	29.7	60.5	Heron/egret tracks @ pipe entr East	
	22/04/2015	W	Night(3)	DO; GM	19.45	20.15	Nil	<24hrs	Night	15.9	90.5	Noisy pitta (1/C); Lit. fallax (1/C); tawny f'mouth(1/C)	GHFF feeding on M. Quinn; tawny FM perched on refuge pole.
		E	Night(3)	DO; GM	20.35	21.05	Nil					GHFF(1/F); C. signifera(2/C); L. nasuta (1/C)	
<b>Sth martells (ch:75250)</b>	21/10/14	E	Day(1)	BT/np	1402	1430	MLB	Nil	O'cast	22.3	51.2	L. delicata (1/F)	
	21/10/14	W	Day(1)	Bt/np	1328	1356	MLB	Nil	O'cast	22.3	51.2	L. delicata (2/F)	
	1/10/14	E	Night(1)	Tw/np	2306	2358	Nil	Nil	Dark	16.5	72.9	GHFF (3/F), ONJ(1/C); A.brevis(2/C);	All frogs observed within or adjacent pools near entrance the of culvert. Many tadpoles (unid.) in pools at entrance of culvert.
	1/10/14	W	Night(1)	Tw/np	2306	2358	Nil	Nil	Dark	16.5	72.9	GHFF (3/F), ONJ(1/C); Lit peroni(2/C), Lim. peronii(2/C).	

	11/3/15	E	Night(2)	DO/ST	2231	2300	MSb	Nil	Dark	20.8	94.6	GHFF (2/F)	
	11/3/15	W	Night(2)	Bt/Gm	2231	2300	MSb	Nil	Dark	20.8	94.6	GHFF (3/F)	
	12/3/15	E	Day(2)	Bt/Gm	1220	1252	MSb	Nil	Day	31	63	Lamp. delicata (5/F)	
	12/3/15	W	Day(2)	Bt/Gm	1142	1208	MSb	Nil	Day	31	63	Lamp. delicata (4/F)	
	22/04/2015	E	Night(3)	DO; GM	22.00	22.30	Nil	<24hrs	Night				
	22/04/2015	W	Night(3)	DO; GM	21.1	21.40	Nil	<24hrs	Night	14.8	94.5	Tawny f'mouth(1/T: flew in & perched).	
	23/04/2015	E	Day(3)	DO; GM	12.4	13.10	MSb	Nil	Day	22.6	65.7		
	23/04/2015	W	Day(3)	DO; GM	13.30	14.00	MSb	Nil	Day				
<b>Dalhousie ck (ch:73800)</b>	21/10/14	E	Day(1)	BT/np	1233	1301	Mc	Nil	Day	23.1	56.8	Lamp. delicata (4/F)	
	21/10/14	W	Day(1)	Bt/np	1152	1228	Mc	Nil	Day	23.1	56.8	Lamp. delicata (5/F)	
	15/10/14	E	Night(1)	Bt/tw	2037	2105	Nil	<24hr	Dark	17.3	65.8	<b>KOALA</b> (1/C: 499770-6622079); P.coreacea(6/C);	
	15/10/14	W	Night(1)	Bt/tw	2107	2135	Nil	<24hr	Dark	17.3	65.8	P.coreacea(1/C); G-hFF(1/C)	
	13/2/15	E	Day(2)	Tw/Gm	924	954	Nil	Nil	Day	24.5	83.4	Lamp. delicata(9/F)	
	13/2/15	W	Day(2)	Tw/Gm	850	920	Nil	Nil	Day	24.5	83.4	Lamp. delicata(3/F) Green tree snake(1/R:in stump)	
	11/3/15	E	Day(3)	Bt/Gm	1047	1120	Nil	Nil	Day	24.5	85.8	L. Delicate (11/F); unid. Skink(1/T)	
	11/3/15	W	Day(3)	Bt/Gm	959	1030	Nil	Nil	Day	24.5	85.8	L. Delicate (15/F)	
	11/3/15	E	Night(2)	DO/ST	2316	2348	MSb	Nil	Dark	22.7	88.8	P.coreacea(1/C); C signifera(2/C); GHFF(2/F)	
	11/3/15	W	Night(2)	Bt/Gm	2316	2348	MSb	Nil	Dark	22.7	88.8	<b>SuG</b> (1/F: in pink b'wood in VEG MEDIAN north edge of culv); Lit fallax (5/C);	
	22/04/2015	E	Night(3)	DO; GM	22.4	23.1	Nil	<24hr	Dark	14.5	95.2	L. fallax(1/C); ONJ(1/C)	
	22/04/2015	W	Night(3)	DO; GM	23.3	0.00	Nil					ONJ(1/C)	



<b>Burkes Ln (ch:68470)</b>	13/10/14	E	Night(1)	Tw/bt	1924	1956	Msb	<24hr	Dark	22.3	81.2	L.fallax(1/C), Goanna(1/T), B.coot(1/T), Water rat(1/T)	
	13/10/14	W	Night(1)	Tw/bt	2002	2035	Msb	<24hr	Dark	22.3	81.2	SuG(1/F), GHFF(3/F), LN.Bcoot(1/C)	
	5/11/14	E	Day(1)	Tw/bt	1216	1248	MLB	Nil	Day	27.2	42	R-b bl snake(1/R: incid, 50m s of cam)	
	5/11/14	W	Day(1)	Tw/bt	1142	1210	MLB	Nil	Day	27.2	42	Lamp. delicata (4/F)	
	12/2/15	E	Day(2)	Tw/Gm	1532	1603	Nil	<24hr	Day	28.1	76.3	Lamp. delicata(3/F)	
	12/2/15	W	Day(2)	Tw/Gm	1502	1533	Msb	<24hr	Day	28.1	76.3	small mammal?	
	12/3/15	E	Night(2)	BT/GM/DO	2131	2154	MSb	Spitting	Dark	25	85	SuG (1/T: 20m E of old hwy)	
	12/3/15	W	Night(2)	BT/GM/DO	2100	2121	MSb	Spitting	Dark	25	85	Tawny Fmouth	
	27/03/2015	E	Day(3)	DO; TW	10.3	11	Msb	Nil	Day	22.4	58.4	Water Dragon(1/T); Lampropholis sp.(2/T)	
	26/03/2015	W	Day(3)	DO; TW	12.25	12.55	SB	Nil	Day	27	83.3	Bandicoot diggings; macropod scats; Lampropholis sp.(4/F).	
	23/04/2015	E	Night(3)	DO; GM	21.4	22.1						Swamp wallaby (1/F); CBtP (1/F); CRTP(2/T); GHFFOX (1/F).	
23/04/2015	W	Night(3)	DO; GM	20.35	21.05	Nil	Nil	Night	17.6	86.2	SuG (1/F); FtG(1/T); GHFF(2/F).	Flowering P Bloodwood and Coastal Banksia.	
<b>Railway (ch:61800)</b>	15/10/14	Se	Day(1)	Bt/tw	1358	1432	Msb	<24hr	DAY	21.4	36	L. delicata (7/F); sm-eyed snake (1/R)	
	14/10/14	Sw	Day(1)	Bt/tw	1420	1450	Man	<24hr	DAY	23.5	62	Lamp. delicata (3/F)	
	14/10/14	Se	Night(1)	Bt/tw	1936	2016	Mlg	<24hr	Dark	18.2	53.6	SeBtP(1/F); Ad brevis (1/C); p coriacea(2/C); ONJ (1/C)	
	14/10/14	Sw	Night(1)	Bt/tw	2029	2101	Msb	<24hr	Dark	18.2	53.6	Wallaby sp (2/F),	

	12/2/15	Se	Day(2)	Tw/Gm	1418	1448	Nil	<24hr	Day	27.6	78.4	Lamp. delicata(1/F)		
	12/2/15	Sw	Day(2)	Tw/Gm	1345	1415	Nil	<24hr	Day	27.6	78.4	Lamp. delicata 4/F)		
	12/3/15	Se	Night(2)	BT/GM/DO	2231	2248	MSb	<1hr	Dark	23.2	100	Nil		
	12/3/15	Sw	Night(2)	BT/GM/DO	2209	2230	MSb	<1hr	Dark	23.2	100	Melomys sp.(prob; 1/F); P coriacea(4/C)		
	27/03/2015	Se	Day(3)	DO; TW	08.55	09.25	Nil	Nil	Day	23.1	56	Nil		
	27/03/2015	Sw	Day(3)	DO; TW	11.1	11.4	MSb	Nil	Day	24.5	58	Nil		
	23/04/2015	Se	Night(3)	DO; GM	18.45	19.25	Nil	Nil	V dark	18.9	85.4	YbG (1/T: moved up trunk into canopy)		
	23/04/2015	Sw	Night(3)	DO; GM	19.4	20.1	Nil	Nil	Dark	17.5	87.1	Nil		
<b>Mcgraths Ck (control)</b>	15/10/14	E	Day(1)	Bt/tw	1106	1138	MSb	<24hr	DAY	18.8	35	L. delicata (6/F), sm skink (1/F), Adel brevis(1/C)		
	15/10/14	W	Day(1)	Bt/tw	1142	1215	MSb	<24hr	DAY	18.8	35	L. delicata (1/F); Estn water dragon (1/R: UP entr)		
	15/10/14	E	Night(1)	Bt/tw	1957	2024	RL	<24hr	Dark	17.9	60.4	GHFF(1/C), Ad brevis (2/C); L fallax(2/C)		
	15/10/14	W	Night(1)	Bt/tw	1925	1953	RL	<24hr	Dark	17.9	60.4	Ad brevis (1/C); L fallax(1/C)		
	11/3/15	E	Day(2)	Bt/Gm	1155	1228	MSb	Nil	Day	29.1	77.5	Lamp. delicata(7/F)		
	11/3/15	W	Day(2)	Bt/Gm	1244	1315	MSb	Nil	Day	29.1	77.5	Lamp. delicata(4/F)		
	12/3/15	E	Night(2)	BT/GM/DO	2025	2045	MSb	Spitting	Dark	27.5	80.2	P coriacea(1/C)		
	12/3/15	W	Night(2)	BT/GM/DO	1950	2012	MSb	Spitting	Dark	27.5	80.2	SuG (1/T: 60m nw)		
	26/03/2015	E	Day(3)	DO; TW	13.05	13.35	Nil	Nil	Day	27	82	Lampropholis sp. (20/F)		
	27/03/2015	W	Day(3)	DO; TW	9.55	10.25	Nil	Nil	Day	22.4	62	Lampropholis sp.(2/F)		
	23/04/2015	E	Night(3)	DO; GM	22.30	23.00	RL	Nil	Dark	16.5	89.5	Nil		
	23/04/2015	W	Night(3)	DO; GM	23.20	23.50							CBtP (1/F)	

**Table A2:** Results for targeted traverses of underpasses and their entrances during spring 2014 and summer 2015.

Location	Date	Obs. No.	Observers	Start Time	Finish Time	Species (entrance)	Species (culvert)	Wind	Rain	Visibility	Air Temp	Humidity
<b>Tysons flat (80220)</b>	29/10/14	1	BT&NP	2203	2216	Nil	Nil	Nil	Nil	Dark	20.3	73
	4/11/14	2	Bt&tw	2210	2225	SuG(c) 50m ne	Nil	Msb	Nil	Dark	20.3	60
	10/11/14	3	Bt&tw	2212	2229	L.nasuta(c6), L.gracilenta(c2); C.signifera(c1); Lperoni(3c)	Nil	Msb	Lt Rain	Dark	21.6	82
	12/2/15	4	Tw/Gm	2043	2103	P.coriacea(c3), Lim. peronii(c/2), Lit. peronii(c/1), small mouse(1/T: in rock field), A.brevis(c/2), Lit. nasuta(t/1)	Lit. nasuta (2m in from E end of W culvs)	Nil	Nil	Dark	25.2	81
	11/3/15	5	BT/GM/DO/ST	2028	2040	Nil	Nil	MSb	Nil	Dark	24.3	82
	22/04/2015	6	GM/ DO	18.45	19.05	C. signifera x 3 calling	Nil	Nil	Nil	Dark	16.4	92
	7/05/2015	7	GM/ DO	18	18.2	C. signifera x 2 calling; Lim. peroni x 1 obs.	Nil	Nil	Nil	Dark	17.4	91.3
<b>Access rd G (78800)</b>	29/10/14	1	BT&NP	2218	2234	Nil	Nil	Nil	Nil	Dark	20.3	73
	4/11/14	2	Bt&tw	2228	2243	C signifera(c); P coriacea(c)	Nil	Msb	Nil	Dark	20.3	60
	10/11/14	3	Bt&tw	2233	2258	L.nasuta(c10), L.gracilenta(c2); C.signifera(c1);L.peroni(2c); P.coriacea(c4)	Nil	Mlb	Lt rain	Dark	21	81
	12/2/15	4	Tw/Gm	2230	2300	A.brevis(c4)	Nil	Nil	Nil	Dark	21.6	93.1
	11/3/15	5	BT/GM/DO/ST	2117	2128	Nil	Nil	MSb	Nil	Dark	23.9	86.9
	22/04/2015	6	GM/ DO	19.1	19.3	Water rat track (both directions); house mouse scats numerous; small lizard track; house mouse track (East)			Nil	Dark	17.0	86.8
	7/05/2015	7	GM/ DO	18.45	19.05	1 x C. signifera callin west side	Nil	Nil	Nil	Dark	14.5	89.4
<b>Nth martells (75800)</b>	29/10/14	1	BT&NP	2141	2157	Nil	Nil	Nil	Nil	Dark	22	64
	4/11/14	2	Bt&tw	2145	2158	Nil	Nil	Msb	Nil	Dark	20.1	63
	10/11/14	3	Bt&tw	2142	2159	Nil	Nil	Mlb	Nil	O'cast	21	81
	11/2/15	4	TW&GM	2404	2424	Ad. brevis (5c), P coriacea(3c)	Nil	Nil	<2hrs	Dark	22.4	96.3
	11/3/15	5	BT/GM/DO/ST	2210	2220	Lim peroni (3C)	Nil	MSb	Nil	Dark	20.6	92.8

	22/04/2015	6	DO;GM	20.15	20.35	Nil	Nil	Nil	<24hrs	Dark		
	7/05/2015	7	DO;GM	19.3	19.50	C. signifera x 2 (1c; 1obs)	Nil	Nil	Nil	Dark	14.3	93
<b>Sth martells (75250)</b>	29/10/14	1	BT&NP	2120	2138	Ad brevis(c)	Nil	Nil	Nil	Dark	22	64
	4/11/14	2	Bt&tw	2130	2142	Ad brevis(c)	Nil	Msb	Nil	Dark	20.1	63
	10/11/14	3	Bt&tw	2122	2139	Nil	Nil	Msb	Nil	O'cast	21.6	80
	11/2/15	4	TW&GM	2325	2353	Ad.brevis(7c), 1xLit.chloris(on log in pond @E.). P. Coriacea (6c)	1xLit. Chloris E to W in mid culvert	Nil	<2hrs	Dark	24.3	94
	11/3/15	5	BT/GM/DO/ST	2301	2310	Nil	Nil	MSb	Nil	Dark	20.8	94.6
	22/4/15	6	DO;GM	21.40	22.00	Nil	Nil	Nil	<24hrs			
	7/05/2015	7	DO;GM	20.00	20.2	Nil	Nil	Nil	Nil	Dark	13.8	90.2
<b>Dalhousie ck (73800)</b>	29/10/14	1	BT&NP	2056	2117	Koala(c)-50m nw	Nil	Nil	Nil	Dark	20.2	81
	4/11/14	2	Bt&tw	2110	2125	Nil	Nil	Msb	Nil	Dark	20.4	58
	10/11/14	3	Bt&tw	2102	2119	Nil	Nil	Mlb	Nil	O'cast	21	79
	11/2/15	4	TW&GM	2245	2306	Ad.brevis(2c)	Nil	Nil	<24hr	Dark	22.6	84
	11/3/15	5	BT/GM/DO/ST	2349	2358	Nil	Nil	MSb	Nil	Dark	22.7	88.8
	22/4/15	6	DO/GM	23.10	23.30	Nil	Nil	Nil	<24hrs			
	7/05/2015	7	DO/GM	20.3	20.5	Nil	Nil	nil	Nil	Dark	12.5	92
<b>Burkes In (68470)</b>	29/10/14	1	BT&NP	1959	2015	Nil	Nil	Nil	Nil	Dark	20.6	73.7
	4/11/14	2	Bt&tw	2004	2020	Nil	Nil	Msb	Nil	Dark	20.5	59
	10/11/14	3	Bt&tw	2031	2050	Nil	Nil	Msb	Nil	Dark	21.3	79
	11/2/15	4	TW&GM	2130	2152	L.dentata (c1)	Nil	Nil	Nil	Dark	22.3	91.2
	12/3/15	5	BT/GM/DO	2122	2130	Nil	Nil	MSb	Spitting	Dark	25	85
	23/04/2015	6	DO; GM	21.05	21.25	Nil	Nil	Nil	Nil	Dark	15.4	87.3
	7/05/2015	7	DO; GM	21.35	21.55	Nil	Nil	Nil	Nil	Dark	12.8	87.8
<b>Railway (61800)</b>	29/10/14	1	BT&NP	1937	1950	Nil	Nil	Nil	Nil	Dark	20.6	73.7
	4/11/14	2	Bt&tw	1941	1956	Nil	Nil	Msb	Nil	Dark	20.5	59
	10/11/14	3	Bt&tw	2005	2022	Nil	Nil	Nil	Nil	O'cast	21.8	79



	11/2/15	4	Tw&gm	2047	2006	P.coriacea (c3)	Nil	Nil	Nil	Dark	22.8	93.8			
	12/3/15	5	BT/GM/DO	2215	2228	Nil	Nil	MSb	<1hr	Dark	23.2	100			
		6	<b>Restriction on night access to railway &amp; completion of construction of bridge retaining walls prohibited surveys.</b>												
		7													
		8													
<b>Mcgraths (control)</b>	29/10/14	1	BT&NP	2025	2045	Estn water dragon (wing wall)	Nil	Nil	Nil	Dark	20.2	81			
	4/11/14	2	Bt&tw	2030	2050	Estn water dragon (wing wall)	Nil	MSb	Nil	Dark	20.4	58			
	10/11/14	3	Bt&tw	1927	1950	Ad.brevis(c)2@E	Nil	MSb	Nil	Dark	22.3	77			
	11/2/15	4	TW/GM	2203	2224	Ad.brevis(c)2@E, Brown tree snake.	Nil	Nil	Nil	Dark	23.2	87.6			
	12/3/15	5	BT/GM/DO	2013	2025	P.coriacea (c1)	Nil	MSb	Spitting	Dark	27.5	80.2			
	23/04/2015	6	DO; GM	23	23.2	Nil	Nil								
	7/05/2015	7	DO; GM	21	21.20	Nil	Nil	Nil	Nil	Dark	12.7	91.8			

**Table A3:** Results for IR camera bait stations positioned in forested habitat approximately 50m from underpass entrances during spring 2014 and summer 2015 sampling periods

Site	Side	Easting	Northing	Date in	Date out	No. of Pics	Days Active	Notes
Tyson's Flat	W	498628	6627439	3/10/14	28/10/14	4115	25	
	E	498744	6627382	3/10/14	28/10/14	105	25	
	W	498609	6627474	10/2/15	10/3/15	48	28	
	E	498742	6627362	10/2/15	10/3/15	60	28	
Access Road G	W	497888	6626280	2/10/14	28/10/14	312	26	
	E	498074	6626234	2/10/14	28/10/14	339	26	
	W	497894	6626273	10/2/15	10/3/15	281	28	
	E	498074	6626240	10/2/15	10/3/15	138	28	
Martells Road North	W	498247	6623341	2/10/14	29/10/14	2259	27	
	E	498484	6623481	2/10/14	29/10/14	3047	27	
	W	498254	6623350	11/2/15	9/3/15	306	26	
	E	498476	6623470	11/2/15	9/3/15	69	26	
Martells Road South	W	498500	6622818	2/10/14	29/10/14	207	27	
	E	498635	6622947	2/10/14	29/10/14	315	27	
	W	498519	6622803	11/2/15	9/3/15	807	26	
	E	498621	6622923	11/2/15	9/3/15	87	26	
Dalhousie Ck	W	499628	6621957	2/10/14	29/10/14	1626	27	
	E	499799	6622033	2/10/14	29/10/14	410	27	
	W	499614	6621972	11/2/15	9/3/15	255	26	

	E	499805	6622035	11/2/15	9/3/15	297	26	
<b>Burkes Lane</b>	W	500225	6616815	2/10/14	29/10/14	1836	1	Cam malfunction
	E	500364	6616711	3/10/14	29/10/14	951	26	
	W	500246	6616830	12/2/15	9/3/15	1236	25	
	E	500364	6616711	12/2/15	9/3/15	285	25	
<b>Railway</b>	W	497385	6611062	2/10/14	29/10/14	627	27	
	E	497538	6611145	2/10/14	29/10/14	1614	27	
	W	497356	6611047	12/2/15	9/3/15	120	25	
	E	497533	6611144	12/2/15	9/3/15	63	25	
<b>Mcgraths Ck</b>	WS	500709	6620004	3/10/14	28/10/14	372	25	
	WN	500720	6620080	3/10/14	28/10/14	498	25	Cam knocked by cow
	ES	500788	6619932	3/10/14	28/10/14	267	25	
	EN	500812	6619962	3/10/14	28/10/14	612	25	
	WS	500701	6620022	11/2/15	10/3/15	63	27	
	WN	500730	6620039	11/2/15	10/3/15	69	27	
	ES	500724	6619948	11/2/15	10/3/15	57	27	
	EN	500812	6619962	11/2/15	10/3/15	132	27	

**Table A4:** Survey effort for IR camera monitoring of underpasses during spring 2014 and summer 2015 sampling periods.

Location	Cam Location	Date in	Date check	Pics	Days Active	Date out	Pics	Days Active	Total Days Active	Comment
Tyson's Flat	En	3/10/14	4/11/14	132	32/32	5/12/14	Nil		32	Cam malfunction in 2nd session
		9/2/15	na	na	na	2/04/15	43	52	52	
	Es	3/10/14	4/11/14	193	32/32	5/12/14	90	31/31	63	
		9/2/15	na	na	na	2/04/15	15	52	52	
	Wn	4/11/14	Na	Na	Na	5/12/14	1155	31/31	31	
		9/2/15	na	na	na	2/04/15	225	52	52	
	Ws	4/11/14	Na	Na	Na	5/12/14	294	31/31	31	
		9/2/15	na	na	na	2/04/15	225	52	52	
Access Rd G	En	3/10/14	4/11/14	774	32/32	5/12/14	Stolen Nov14		32	
		9/2/15	na	na	na	2/04/15	145	52	52	
	Es	3/10/14	4/11/14	186	32/32	5/12/14	Stolen Nov14		32	
		9/2/15	na	na	na	2/04/15	396	52	52	
	Wn	3/10/14	4/11/14	447	32/32	5/12/14	84	31/31	63	
		9/2/15	na	na	na	2/04/15	145	52	52	
	Ws	3/10/14	4/11/14	285	32/32	5/12/14	120	31/31	63	
		9/2/15	na	na	na	2/04/15	972	52	52	
Martells Rd Nth	E	3/10/14	4/11/14	120	32/32	5/12/14	90	31/31	63	
		10/2/15	na	na	na	2/04/15	157	51	51	
	W	3/10/14	4/11/14	120	32/32	5/12/14	90	31/31	63	
		10/2/15	na	na	na	2/04/15	135	51	51	
Martells Rd Sth	E	3/10/14	4/11/14	636	32/32	5/12/14	222	31/31	63	
		10/2/15	na	na	na	2/04/15	342	51	51	
	W	3/10/14	4/11/14	639	32/32	5/12/14	198	31/31	63	
		10/2/15	na	na	na	2/04/15	237	51	51	
Dalhousie ck	W	3/10/14	4/11/14	231	32/32	5/12/14	123	31/31	63	

		10/2/15	na	na	na	2/04/15	885	51	51	
	E	3/10/14	4/11/14	474	32/32	5/12/14	120	31/31	63	
		10/2/15	na	na	na	2/04/15	192	51	51	
Burkes Ln	E	<b>10/10/14</b>	4/11/14	<b>176</b>	<b>25/25</b>	5/12/14	<b>375</b>	<b>31/31</b>	<b>56</b>	
		9/2/15	na	na	na	2/04/15	132	52	52	
	W	10/10/14	4/11/14	185	25/25	5/12/14	480	31/31	56	
		9/2/15	na	na	na	2/04/15	276	52	52	
Railway	N	10/10/14	5/11/14	936	26/26	10/12/14	1428	35/35	61	
		9/2/15	na	na	na	22/03/15	4800	41/52	41	Removed 11/2. Re-installed 12/2; removed 2/3, re-install 6/3;
	S	10/10/14	5/11/14	3840	26/26	10/12/14	2631	35/35	61	
		9/2/15	na	na	na	12/03/15	1938	31/52	31	Removed 11/2. Re-installed 12/2; removed 2/3, re-install 6/3;
Mcgraths Ckl	EN	3/10/14	28/10/14	1255	25/25	5/12/14	921	38/38	63	28/10: shift cams from tree to picket near entr;
		11/2/15	na	na	na	2/04/15	1749	50	27	cam malfuntn 15/2>11/3/15
	ES	3/10/14	28/10/14	195	25/25	5/12/14	2373	38/38	63	
		11/2/15	na	na	na	2/04/15	1305	50	50	



**Table A5:** Fauna recorded by IR cameras positioned within underpasses during spring 2014 and summer 2015 sampling periods.

Site	Side	Date	Time	Species	Accu- racy	Movement	Pic No.	Confirmed Crossing	Concurrent sand detection	Comments
Tyson's Flat	En	Spr14		Nil						<b>Spr14:</b> Cat only detected xing 1 cell & not other cells [didn't X median?]. Xed WS cell then returned via WN cell
		Sum15		NIL						
	Es	18/10/14	1852	Cat	D	W	58-60	Yes	Yes	
		Sum15		NIL						
	Wn	15/11/14	0935	Dragon sp	D	W	1117-19	Pr	Na	
		23/11/14	0316	Cat	D	W	1141-43	Pr	No	
		28/02/15	2009	Cat	D	Rail-W	73-75	Pr	na	tabby?
		8/03/15	1836	cat	D	Rail-W	76-78	Pr	na	tabby?
		20/03/15	1035	Estn water dragon	Pr	Rail-E	160-62	Pr	na	
		20/03/15	1444	Estn water dragon	Pr	Rail-W	163-65	Pr	na	same indiv
		20/03/15	1448	Estn water dragon	Pr	Rail-E,stop	166-68	Po	na	same indiv
		23/03/15	1850	Rattus lutreolus	Pr	Rail-W, E,W	169-180	Pr	na	
		24/03/15	1138	Estn water dragon	Pr	E?	160-62	Po	na	same indiv(Pr)
	Ws	22/11/14	0358	Cat	D	E	278-280	Yes	Yes	
		23/11/14	0312	Cat	D	E	281-283	Yes	Yes	
		Sum15		NIL						

<b>Access Rd</b> <b>G</b>	Ne	5/10/14	2344	Cat	D	W	25-27	Yes	No	At least 2 cats	
		5/10/14	2357	Cat	D	E	28-30	Pr	No		
		21/10/14	0117	Cat	D	W	706-08	Yes	Yes		
		22/10/14	0241	Cat	D	W	712-14	Pr	No		
		Stolen in Nov 14									
		Sum15		NIL							
	Nw	5/10/14	2346	Cat	D	W	25-27	Yes	No		
		Sum15		NIL							
	Se	Spr14		Nil @ mid check							
		Stolen in Nov 14									
		Sum15		NIL							
	<b>Martells Rd</b> <b>Nth</b>	E	31/10/14	2101	Cat	D	E	112-14	Yes	Yes	
		18/11/14	0317	Cat	D	E	69-71	Yes	No		
		23/11/14	2101	nthn br b'coot	Pr	E	76-78	Pr	No		
		Sum15		NIL							
W		31/10/14	2059	Cat	D	E	106-08	Yes	Yes		
		18/11/14	0315	Cat	D	E	49-51	Yes	No		
		8/03/15	1006	Lace monitor	D	W	25-27	Pr	na		
<b>Martells Rd</b> <b>Sth</b>	E	6/11/14	2110	Cat	D	W	73-75	Yes	na		
		Sum15		NIL							
	W	6/11/14	2113	Cat	D	W	76-78	Yes	na		
		Sum15		NIL							
	E	Spr14		Nil							

Dalhousie ck		Sum15		NIL						
	W	Spr14		Nil						
		Sum15		NIL						
Burkes Ln	E	Spr14		Nil						
		12/02/15	o317	cat	D	W	19-21	Pr	na	tabby colour
		8/03/15	o505	cat	D	W	31-33	Pr	na	tabby colour
		16/03/15	2339	cat	D	W	73-75	Pr	Yes	black/white colour
		17/03/15	1946	cat	D	W	76-78	yes	Yes	black/white colour
	W	Spr14		Nil						
		7/03/15	o200	cat	D	W	48-50	Pr	na	black/white colour
	17/03/15	1949	cat	D	W	87-89	yes	yes	black/white colour	
Railway	N	2/12/14	1251	Lace monitor	D	W	1164- 66	Pr	Na	face west
		8/03/15		fox	D	W	2938- 40	Pr	Na	face west
		11/03/15	oo37	fox	D	ND	3106- 08	Po	Na	
		11/03/15	o235	fox	D	E	3115- 20	Pr	Na	
		12/03/15	o413	fox	D	W	3199- 3201	Pr	Na	
		13/03/15	o213	fox	D	E	3268- 69	Pr	Na	
		13/03/15	o320	fox	D	ND	3277- 79	Po	Na	
		13/03/15	2051	fox	D	acrosss S>N	3304- 06	Po	Na	

		14/03/15	o503	fox	D	E	3319-21	Pr	Na	
		17/03/15	o254	fox	D	W	3574-76	Pr	Na	
		17/03/15	2329	fox	D	ND	3853-55	Po	Na	
		19/03/15	oo33	fox	D	E	3997-99	Pr	Na	
		20/03/15	oo48	fox	D	acrosss S>N	4306-08	Po	Na	
		22/03/15	2121	<b>fox</b>	D	acrosss S>N	4474-76	Po	Na	
S		24/10/14	1144	Lace monitor	D	W	1762-64	Pr	No	Face east
		24/10/14	1144	Lace monitor	D	W	1762-64	Pr	No	Face east
		26/02/15	1118	Black rat	Pr	E	934-36	Pr	No	face east
		10/03/15	o100	cat (black)	D	W	1360-62	Pr	No	
		12/03/15	o403	fox	D	E	186-78	Pr	No	Face east
<b>Mcgraths Ck</b>	EN	12/11/14	2114	S-e b-tail possum	Pr	W?(@entr)	304-306	Po	Na	28/10: shift cams from tree to picket near entr
		13/11/14	0239	S-e b-tail possum	Pr	E?(@entr)	307-309	Po	Na	
		14/11/14	2010	Swamp wallaby	Pr	W	400-411	Pr	Na	
		14/11/14	2253	S-e b-tail possum	Pr	E?(@entr)	412-414	Po	Na	

	17/11/14	2046	Swamp wallaby	Pr	W?(@entr)	433-435	Po	Na	
	18/11/14	2040	Fox	D	W?(@entr)	463-465	Po	Na	
	20/11/14	2442	Fox	D	W	493-495	Pr	Na	
	21/11/14	2438	L-n B'coot	D	W	520-522	Pr	Na	
	21/11/14	2034	Swamp wallaby	Pr	W?(@entr)	575-590	Po	Na	
	22/11/14	2245	Fox	D	W, turn around	601-606	No	Na	
	28/11/14	2332	Fox	D	W	601-606	Pr	Na	
	29/11/14	0655	Swamp wallaby	D	W?(@entr)	640-657	Po	Na	
	29/11/14	1155	Lace Monitor	D	W, turn around	658-663	No	Na	
	29/11/14	2019	Fox	D	E	742-745	Pr	Na	
	30/11/14	1057	Lace Monitor	D	Pass entr	748-750	No	Na	
	30/11/14	1951	Fox	D	W, turn, E	817-822	No	Na	
	1/12/14	0322	Fox	D	W	823-825	Po	Na	
	1/12/14	1957	Fox	D	E	826-828	Pr	Na	



	2/12/14	2000	Fox	D	W	892-894	Pr	Na		
	3/12/14	2006	Fox	D	W	916-918	Pr	Na		
	4/12/14	1955	Fox	D	Near entr	919-921	Po	Na		
<i>Summer 2015: cam malfunction between 15/2-11/3/15</i>										
			<i>NIL</i>	<i>culvert inundated (10-80mm) for entirety of monitoring period</i>						
ES	29/10/14	2352	Echidna	D	E	10-12	Pr	Na	28/10: shift cams from tree to picket near entr	
	30/10/14	1301	Land mullet	Pr	E	13-15	Pr	Na		
	30/10/14	2011	S-e b-tail possum	Pr	W	16-19	Pr	Na		
	30/10/14	2332	L-n B'coot	D	E	22-27	Pr	Na		
	31/10/14	0909	Y-f whip snake	Pr	Entr	32-34	Po	Na		
	1/11/14	1419	Lace monitor	D	E	40-42	Pr	Na		
	1/11/14	1419	Lace monitor	D	W	43-45	Po	Na		
	2/11/14	2157	S-e b-tail possum	D	E	46-48	Pr	Na		
	4/11/14	1024	Lace monitor	D	W	52-54	Pr	Na		
	4/11/14	1218	Lace monitor	D	W	70-72	Po	Na		
	6/11/14	2442	Black rat	Pr	E	112-116	Pr	Na		

	7/11/14	0133	S-e b-tail possum	D	E	121-123	Pr	Na	
	8/11/14	1943	Echidna	D	Pass entr	124-126	Po	Na	
	10/11/14	0943	Lace monitor	D	E	208-210	Pr	Na	
	12/11/14	0323	Water rat	D	E	310-312	Pr	Na	
	14/11/14	0954	Estn water dragon	D	W	340-344	Po	Na	
	14/11/14	2209	Echidna	D	W	445-447	Pr	Na	
	14/11/14	2250	S-e b-tail possum	D	W	453-455	Pr	Na	
	16/11/14	0105	Swamp wallaby	D	E,turn,W	463-468	Pr	Na	
	16/11/14	1157	Land mullet	D	W	472-474	Pr	Na	
	16/11/14	1258	Land mullet	D	Pass entr	478-480	No	Na	
	17/11/14	1016	Land mullet	D	W	484-486	Pr	Na	
	17/11/14	2049	Swamp wallaby	D	W	496-500	Pr	Na	
	18/11/14	1950	Swamp wallaby	Pr	W	628-30	Pr	Na	
	23/11/14	0849	Lace monitor	D	E	1054-56	Pr	Na	

	24/11/14	1222	Land mullet	D	Pass entr	1378-80	Pr	Na	
	26/11/14	0223	Rodent sp	D	E	1402-04	Pr	Na	
	26/11/14	2223	S-e b-tail possum	D	E	1405-07	Pr	Na	
	30/11/14	0148	S-e b-tail possum	D	E	1618-20	Pr	Na	
	30/11/14	1053	Lace monitor	D	E	1711-13	Pr	Na	
	1/12/14	0928	Land mullet	D	Pass entr	1849-51	Pr	Na	
	2/12/14	1211	Land mullet	D	W	1957-59	Pr	Na	
	2/12/14	1343	Lace monitor	D	E	1999-2002	Pr	Na	
	4/12/14	0836	Lace monitor	D	E	2251-53	Pr	Na	
	24/02/15	1425	Lace Monitor	D	W, stop	37-39	No	na	
	21/03/15	1650	Swamp wallaby	D	W, stop	37-42	No	washed out	
	24/03/15	2307	nthn br b'coot	D	ND	1028-30	No	washed out	
	26/03/15	1338	Estn water dragon	Pr	at entr	1228-30	No	washed out	

**Table A6:** Tracks recorded on sand pads within underpasses during spring 2014 and summer 2015 sampling periods.

Site	Cell	Date	Check no.	Tracks	Pad condition	Construction phase
Tysons flat	E-n	13/10/14	1-Spr	Rat=1e1w	Dry	Entrances under construction
	E-s	13/10/14	1	Nil	Dry	Entrances under construction
	W-n	14/10/14	0	No sand		Entrances under construction
	W-s	14/10/14	0	No sand		Entrances under construction
	E-n	20/10/14	2	Nil	Slight damp	Entrances under construction
	E-s	20/10/14	2	Rat=2w;cat=1w	Slight damp	Entrances under construction
	W-n	20/10/14	0	No sand	Lot of materials inside	Entrances under construction
	W-s	20/10/14	0	No sand		Entrances under construction
	E-n	28/10/14	3	Sm lizard=2; mouse=2e	Dry	Entrances under construction
	E-s	28/10/14	3	Sm lizard=8	Dry	Entrances under construction
	W-n	28/10/14	0	No sand	Lot of materials inside	Entrances under construction
	W-s	28/10/14	0	No sand	Lot of materials inside	Entrances under construction
	E-n	4/11/14	4	Sm lizard=1e	Dry	Entrances under construction
	E-s	4/11/14	4	Fox(1e)	Dry	Entrances under construction
	W-n	5/11/14	Install	Install sand	Materials removed	Entrances under construction
	W-s	5/11/14	Install	Install sand	Materials removed	Entrances under construction
	W-n	10/11/14	1	Boots	Damp	Entrances under construction
	W-s	10/11/14	1	Mouse=3e2w	Damp	Entrances under construction
	W-n	18/11/14	2	Dragon =1w	Damp	Entrances under construction
	W-s	18/11/14	2	Boots	Damp	Entrances under construction
	W-n	5/12/14	3/4	Nil	Damp; boots	Entrances under construction
	W-s	5/12/14	3/4	Cat-2e; mouse-1e	Damp	Entrances under construction
	E-n	19/03/2015	1-Sum	Lizard=1w ph 4083-84; mouse=1w	Saturated	
	E-s	19/03/2015	1	Rat= 1e, 1w ph 4085	Saturated	
	W-n	19/03/2015	1	Mouse=2w;1e	Damp but firm	
	W-s	19/03/2015	1	Small/medium frog=1w ph 4074-79; rat=1w ph 4080-82	Damp but firm	

	E-n	26/03/2015	2	Washed out	Culvert flooded	
	E-s	26/03/2015	2	Washed out	Culvert flooded	
	W-n	26/03/2015	2	Mouse=1w; small water dragon=1w	Damp but intact	
	W-s	26/03/2015	2	Frog=1w (ph4098-101); water rat=1w	Damp, partially washed out	
	E-n	2/04/2015	3	water dragon=1E,3W; cray fish=1x	50% washed away	
	E-s	2/04/2015	3	water rat=1E,1W; cray fish=4x	50% washed away	
	W-n	2/04/2015	3	nil	50% washed away	
	W-s	2/04/2015	3	nil	50% washed away	
	E-n	10/04/2015	4	cray fish=6x	50% washed away	
	E-s	10/04/2015	4	nil	50% washed away	
	W-n	10/04/2015	4	water dragon=1x	50% washed away	
	W-s	10/04/2015	4	nil	100% washed out	
Access rd G	N	14/10/14	1-Spr	Nil(boots)	Pads wet; dam-effect of some water in cells;created channel	In progress; materials inside
	S	14/10/14	1	Nil(boots)		
	N	20/10/14	2	Nil(boots)	Damp	In progress; materials inside
	S	20/10/14	2	Nil(boots)		
	N	28/10/14	3	Cat=1w;rat=2w1e;med lizard=2w		
	S	28/10/14	3	Nil		
	N	4/11/14	4	Nil		
	S	4/11/14	4	Mouse=2e2w		
	N	19/03/2015	1-Sum	Cat=1e ph 4073		
	S	19/03/2015	1	Nil - boot print	Moist - central third of pad washed out	
	N	26/03/2015	2	Mouse=2e	50% washed away	
	S	26/03/2015	2	Nil	50% washed away	
	N	2/04/2015	3	nil	50% washed away	
	S	2/04/2015	3	nil	50% washed away	



	N	10/04/2015	4	nil	100% washed out	
	S	10/04/2015	4	nil	100% washed out	
<b>Martells Rd Nth</b>	1	14/10/14	<b>1-Spr</b>	Nil	Pads wet; dam-effect of some water in cells;created channel	In progress; near completion; rubble field Eside
	1	20/10/14	2	Nil	Dry/crusty-broke up& reset	Entrances under construction
	1	29/10/14	3	Mouse=1w	Dry/crusty-broke up& reset	Entrances under construction
	1	4/11/14	4	Mouse=2e1w; cat=1e1w; small water dragon=1w	Dry	Entrances under construction
	1	19/3/15	<b>1-Sum</b>	Mouse=2e2w ph 4070	Pads wet; 550mm channel cut in centre by flow.	
	1	26/03/2015	2	Water rat=1e1w; mouse=1e	75% Washed out, remainder wet.	
	1	2/04/2015	3	nil	Washed out	
	1	10/04/2015	4	nil	100% washed out	
<b>Martells Rd Sth</b>	1	14/10/14	<b>1-Spr</b>	Nil	Damp	Entrances under construction
	1	20/10/14	2	Nil(boots)	Dry	Entrances under construction
	1	29/10/14	3	Nil(boots)	Dry	Entrances under construction
	1	4/11/14	4	Nil(boots)	Dry	Entrances under construction
	1	19/03/2015	<b>1-Sum</b>	nil	Washed out/replaced	
	1	26/03/2015	2	nil	Washed out	
	1	2/04/2015	3	nil	Washed out	
	1	10/04/2015	4	nil	100% washed out	
<b>Dalhousie Ck</b>	E	14/10/14	<b>1-Spr</b>		Pads wet; dam-effect of some water in cells;created channel	Entrances under construction
	W	14/10/14	1	Nil	Pads wet; dam-effect of some water in cells;created channel	Entrances under construction
	E	20/10/14	2	Nil	Dry/crusty-broke up& reset	Entrances under construction
	W	20/10/14	2	Nil	Dry/crusty-broke up& reset	Entrances under construction
	E	29/10/14	3	Mouse=5e4w	Dry/crusty-broke up& reset	Entrances under construction
	W	29/10/14	3	Nil	Dry/crusty-broke up& reset	Entrances under construction

	E	4/11/14	4	Mouse=3e2w	Dry	Entrances under construction
	W	4/11/14	4	Nil	Dry	Finished
	E	19/03/2015	<b>1-Sum</b>	Mouse=3e;3w	Wet	
	W	19/03/2015	1	Mouse = 1e, 1w	Damp	
	E	26/03/2015	2	Mouse=1e	75% washed out	
	W	26/03/2015	2	Mouse=2w1e	75% washed out	
	E	2/04/2015	3	nil	100% washed out	
	W	2/04/2015	3	mouse=~10x	75% washed out	
	E	10/04/2015	4	nil	100% washed out	
	W	10/04/2015	4	nil	100% washed out	
<b>Burkes Ln</b>	1	14/10/14	<b>1-Spr</b>	Nil	Pads wet; dam-effect of some water in cells;created channel	Entrances under construction
	1	21/10/14	2	Nil	Dry/crusty-broke up& reset	Entrances under construction
	1	29/10/14	3	Rat=1e	Dry/crusty-broke up& reset	Entrances under construction
	1	4/11/14	4	Nil	Dry	Entrances under construction
	1	19/03/2015	<b>1-Sum</b>	Cat=2w; dog=1w ph 4097	Damp	
	1	26/03/2015	2	Cat=1e1w; mouse=2e1w (ph4102-3)	Wet	
	1	2/04/2015	3	mouse=1w; cat=1w; human	50% washed away	
	1	10/04/2015	4	mouse=1W; human		
<b>Railway</b>	N	14/10/14	<b>1-Spr</b>	Nil	Damp	Bridge not constructed
	S	14/10/14	1	Nil	Damp.	Bridge not constructed
	N	21/10/14	2	Nil	Dry/crusty-broke up& reset	Bridge not constructed
	S	21/10/14	2	Nil	Dry/crusty-broke up& reset	Bridge not constructed
	N	29/10/14	3	Nil	Dry/crusty-broke up& reset	Bridge not constructed
	S	29/10/14	3	Nil	Dry/crusty-broke up& reset	Bridge not constructed
	N	5/11/14	4	Nil	Dry	Bridge not constructed
	S	5/11/14	4	Nil	Dry	Bridge not constructed
	N	19/03/2015	<b>1-Sum</b>	Rat=1w	Dry	

	S	19/03/2015	1	Dog=1e; boot	Dry	
	N	27/03/2015	2	Nil	Dry	
	S	27/03/2015	2	Cat=1w	Dry	
	N	2/04/2015	3	No access - Safety officer absent		
	S	2/04/2015	3	No access - Safety officer absent		
	N	10/04/2015	4	rat=3W,2E		
	S	10/04/2015	4	dog=1W; rat=1W,1E		
<b>Mcgraths Ck (control)</b>	S	14/10/14	<b>1-Spr</b>	Wall=1e,1w; Goanna=1e,1w; btp=1w;rat=3e3w; dragon=2e,2w;	Moist; v good condition	
	M	14/10/14	1	Nil	Moist; v good condition	200mm deep water at ea end
	N	14/10/14	1	Btp=3e,1w; Goanna=2w; rat=3e3w; water rat=1e; dragon=2w; sm liz=3w;	Moist; v good condition	
	S	21/10/14	2	Btp=3e,4w; rat=2e3w	Moist; v good condition	
	M	21/10/14	2	rat=1e2w	Moist; v good condition	
	N	21/10/14	2	Fox=1w;btp=2e3w; rat=2w; dragon=1e1w	Moist; v good condition	
	S	28/10/14	3	Goanna=2e2w; b'coot=1w; rabbit(pr)=1e; med lizard=1e; dragon=1e;rat=1e;	Moist; v good condition	
	M	28/10/14	3	Water rat=1w; rat=1w	Moist; v good condition	
	N	28/10/14	3	Btp=2e; goanna=3w; b'coot=1w; med lizard=1w	Moist; v good condition	
	S	4/11/14	4	Goanna=2w1e; dragon=2e1w	Dry	
	M	4/11/14	4	Med lizard=1e	Dry	
	N	4/11/14	4	Cat=1w; med lizard=2e1w; water rat=1w; rat=1w; mouse=1e	Dry	
	S	19/03/2015	<b>1-Sum</b>	Washed out	Washed out	
	M	19/03/2015	1	Water rat=2e, 2w; heron=1e; lace monitor =1w Ph 4086- 89. Also rat=1e1w.	Saturated	
	N	19/03/2015	1	Water rat = 4w3e; CBP=2e1w; rat=many both ways on Sth wall; fox=1e ph 4090-92	Saturated	

	S	26/03/2015	2	Washed out	Washed out	Sand pads were re-installed in M and N, but pumping out of basins on the project washed them out again later in the day. We observed it when doing DS.
	M	26/03/2015	2	Water rat=2e1w; water dragon 1w	Saturated	
	N	26/03/2015	2	CBP=1e; water rat=7w4e		
	S	2/04/2015	3	nil	100% washed out	
	M	2/04/2015	3	goanna=1E; water rat=1W	50% washed away	
	N	2/04/2015	3	b'coot=2W,1E; goanna=1W,1E; sm mammal=3E,1W; water rat=2E,3W	moist	
	S	10/04/2015	4	nil	100% washed out	
	M	10/04/2015	4	nil	100% washed out	
	N	10/04/2015	4	nil	100% washed out	

**Table A7:** Results of track and scat searchers within underpasses and their entrances during spring 2014 and summer 2015 sampling periods.

Site	Cell	Date	Check no.	Scats/tracks	Construction phase
Tysons flat	E-n	13/10/14	1	Nil	Entrances under construction
	E-s	13/10/14	1	Nil	Entrances under construction
	W-n	14/10/14	1	Nil	Entrances under construction
	W-s	14/10/14	1	Nil	Entrances under construction
	E-n	28/10/14	2	Nil	Entrances under construction
	E-s	28/10/14	2	Nil	Entrances under construction
	W-n	28/10/14	2	Nil	Entrances under construction
	W-s	28/10/14	2	Nil	Entrances under construction
	E-n	10/3/15	3	Heron/egret? Track 1xE	Construction near completion
	E-s	10/3/15	3	Nil	
	W-n	10/3/15	3	Rodent scat on rail	
	W-s	10/3/15	3	Nil	
	E-n	19/03/2015	4	Nil	
	E-s	19/03/2015	4	Nil	
	W-n	19/03/2015	4	Nil	
	W-s	19/03/2015	4	Nil	
	E-n	26/3/15	5	Nil	
	E-s	26/3/15	5	Nil	
	W-n	26/3/15	5	Nil	
	W-s	26/3/15	5	Nil	
E-n	24/04/2015	6	Nil		
E-s	24/04/2015	6	Rattus sp. Track X 1; 1 x small reptile track.		
W-n	24/04/2015	6	Small lizard track x 1		
W-s	24/04/2015	6	mouse x 1 track		
Access rd G	N	14/10/14	1	Nil	In progress; materials inside



	S	14/10/14	1	Nil	
	N	28/10/14	2	Nil	
	S	28/10/14	2	Nil	
	N	10/3/15	3	Nil	Construction near completion
	S	10/3/15	3	Nil	
	N	19/03/2015	4	Nil	
	S	19/03/2015	4	Nil	
	N	26/3/15	5	Nil	
	S	26/3/15	5	Nil	
	N	24/04/2015	6	1 x mouse, water rat and cat track west direction.	
	S	24/04/2015	6	1 x small reptile, cat and mouse track west direction.	
<b>Martells Rd Nth</b>	1	14/10/14	1	Nil	In progress; near completion; rubble field Eside
	1	29/10/14	2	Nil	
	1	12/3/15	3	Nil	12/3: emptying adjoining basin & flowing into culvert & washing sand away
	1	19/3/15	4	Mouse scats ph 4071-72 East side of pad only	
	1	26/3/15	5	Nil	
	1	24/4/15	6	Small water dragon stuck in space between culvert sections.	
<b>Martells Rd Sth</b>	1	14/10/14	1	Nil	Entrances under construction
	1	29/10/14	2	Nil	
	1	12/3/15	3	Nil	
	1	19/03/2015	4	Nil	
	1	26/3/15	5	Nil	
	1	23/04/2015	6	mouse scat	
<b>Dalhousie ck</b>	E	14/10/14	1	Nil	Entrances under construction
	W	14/10/14	1	Nil	Entrances under construction

	E	29/10/14	2	Nil	
	W	29/10/14	2	Nil	
	E	11/3/15	3	Rat scat on rail; mouse tracks	Construction near completion
	W	11/3/15	3	Nil	
	E	19/03/2015	4	Nil	
	W	19/03/2015	4	Nil	
	E	24/04/2015	5	Nil	
	W	24/04/2015	5	Nil	
	E	24/04/2015	6	Nil	
	W	24/04/2015	6	Nil	
<b>Burkes Ln</b>	1	14/10/14	1	Nil	Entrances under construction
	1	29/10/14	2	Nil	
	1	19/03/2015	3	Nil	
	1	26/3/15	4	Nil	
	1	23/04/2015	5	Reptile/Frog scat X11; mouse track (1w)	Entrances under construction
	1	7/05/2015	6	nil	
<b>Railway</b>	N	14/10/14	1	Na	Bridge not constructed
	S	14/10/14	1	Na	Bridge not constructed
	N	29/10/14	2	Nil	Bridge not constructed
	S	29/10/14	2	Nil	Bridge not constructed
	N	9/3/15	3	Nil	Bridge walls complete
	S	9/3/15	3	Nil	
	N	19/03/2015	4	Bandicoot tracks=1e	
	S	19/03/2015	4	Nil	
	N	27/3/15	5	Nil	
	S	27/3/15	5	Nil	
	N		6		
	S		6		

Mcgraths Ck (control)	S	14/10/14	1	Rodent scats	
	M	14/10/14	1	Nil	200mm deep water at ea end
	N	14/10/14	1	Nil	
	S	28/10/14	2	Nil	
	M	28/10/14	2	Nil	
	N	28/10/14	2	Nil	
	S	11/3/15	3	50mm flowing water	
	M	11/3/15	3	Nil	Floor wet
	N	11/3/15	3	Nil	Floor wet
	S	19/03/2015	4	Nil	Flowing water through entire width of culvert
	M	19/03/2015	4	Nil	Floor wet
	N	19/03/2015	4	Nil	Floor wet
	S	26/3/15	5	Nil	
	M	26/3/15	5	Nil	
	N	26/3/15	5	Nil	
	S	23/04/2015	6	Nil	
	M	23/4/15	6	Nil	
	N	23/4/15	6	Nil	