



APPENDIX J

EPBC Act Offset Assessment Guide – Carnaby's Black Cockatoo



Offsets Assessment Guide

For use in determining offsets under the Environment Protection and Biodiversity Conservation Act 1999
2 October 2012

This guide relies on Macros being enabled in your browser.

Matter of National Environmental Significance	
Name	Carnaby's Black Cockatoo
EPBC Act status	Endangered
Annual probability of extinction Based on IUCN category definitions	1.2%

Key to Cell Colours
User input required
Drop-down list
Calculated output
Not applicable to attribute

Impact calculator						
Protected matter attributes	Attribute relevant to case?	Description	Quantum of impact		Units	Information source
<i>Ecological communities</i>						
Area of community	No		Area			
			Quality			
			Total quantum of impact	0.00		
<i>Threatened species habitat</i>						
Area of habitat	Yes		Area	207.2	Hectares	Impact site for EPBC 2013-7042
			Quality	6	Scale 0-10	
			Total quantum of impact	124.32	Adjusted hectares	
<i>Threatened species</i>						
Birth rate e.g. Change in nest success	No					
Mortality rate e.g. Change in number of road kills per year	No					
Number of individuals e.g. Individual plants/animals	No					

Offset calculator																															
Protected matter attributes	Attribute relevant to case?	Total quantum of impact	Units	Proposed offset	Time horizon (years)	Start area and quality	Future area and quality without offset	Future area and quality with offset	Raw gain	Confidence in result (%)	Adjusted gain	Net present value (adjusted hectares)	% of impact offset	Minimum (90%) direct offset requirement met?	Cost (\$ total)	Information source															
<i>Ecological Communities</i>																															
Area of community	No				Risk-related time horizon (max. 20 years)	Start area (hectares)	Risk of loss (% without offset)	Risk of loss (% with offset)																							
					Time until ecological benefit	Start quality (scale of 0-10)	Future area without offset (adjusted hectares)	0.0	Future area with offset (adjusted hectares)	0.0																					
							Future quality without offset (scale of 0-10)		Future quality with offset (scale of 0-10)																						
<i>Threatened species habitat</i>																															
Area of habitat	Yes	124.32	Adjusted hectares	Long term protection and management of habitat at Ippolo Road, Chittering, WA	Time over which loss is averted (max. 20 years)	20	Start area (hectares)	673.5	Risk of loss (% without offset)	30%	Risk of loss (% with offset)	5%	Raw gain	168.38	Confidence in result (%)	90%	Adjusted gain	151.54	Net present value	119.37	% of impact offset	121.22	97.51%	Minimum (90%) direct offset requirement met?	Yes	Cost (\$ total)		Information source			
					Time until ecological benefit	10	Start quality (scale of 0-10)	7	Future area without offset (adjusted hectares)	471.5	Future area with offset (adjusted hectares)	639.8	Raw gain	1.00	Confidence in result (%)	90%	Adjusted gain	0.90	Net present value	0.80											
							Future quality without offset (scale of 0-10)	6	Future quality with offset (scale of 0-10)	7																					
<i>Threatened species</i>																															
Birth rate e.g. Change in nest success	No																														
Mortality rate e.g. Change in number of road kills per year	No																														
Number of individuals e.g. Individual plants/animals	No																														

Summary							
Protected matter attributes	Quantum of impact	Net present value of offset	% of impact offset	Direct offset adequate?	Cost (\$)		
					Direct offset (\$)	Other compensatory measures (\$)	Total (\$)
Birth rate	0				\$0.00		\$0.00
Mortality rate	0				\$0.00		\$0.00
Number of individuals	0				\$0.00		\$0.00
Number of features	0				\$0.00		\$0.00
Condition of habitat	0				\$0.00		\$0.00
Area of habitat	124.32	121.22	97.51%	Yes	\$0.00	#DIV/0!	#DIV/0!
Area of community	0				\$0.00		\$0.00
					\$0.00	#DIV/0!	#DIV/0!



APPENDIX K

EPBC Act Offset Assessment Guide – Forest Red-tailed Black Cockatoo



Offsets Assessment Guide

For use in determining offsets under the Environment Protection and Biodiversity Conservation Act 1999
2 October 2012

This guide relies on Macros being enabled in your browser.

Matter of National Environmental Significance	
Name	Forest Red-tailed Black Cockatoo
EPBC Act status	Vulnerable
Annual probability of extinction Based on IUCN category definitions	0.2%

Key to Cell Colours
User input required
Drop-down list
Calculated output
Not applicable to attribute

Impact calculator						
Protected matter attributes	Attribute relevant to case?	Description	Quantum of impact		Units	Information source
<i>Ecological communities</i>						
Area of community	No		Area			
			Quality			
			Total quantum of impact	0.00		
<i>Threatened species habitat</i>						
Area of habitat	Yes		Area	120.5	Hectares	Impact site for EPBC 2013-7042
			Quality	6	Scale 0-10	
			Total quantum of impact	72.30	Adjusted hectares	
<i>Threatened species</i>						
Birth rate e.g. Change in nest success	No					
Mortality rate e.g. Change in number of road kills per year	No					
Number of individuals e.g. Individual plants/animals	No					

Offset calculator																				
Protected matter attributes	Attribute relevant to case?	Total quantum of impact	Units	Proposed offset	Time horizon (years)	Start area and quality	Future area and quality without offset	Future area and quality with offset	Raw gain	Confidence in result (%)	Adjusted gain	Net present value (adjusted hectares)	% of impact offset	Minimum (90%) direct offset requirement met?	Cost (\$ total)	Information source				
<i>Ecological Communities</i>																				
Area of community	Yes		Adjusted hectares		Risk-related time horizon (max. 20 years)	Start area (hectares)	Risk of loss (% without offset)	Risk of loss (% with offset)	0.00		0.00	0.00		#DIV/0!	#DIV/0!					
					Future area without offset (adjusted hectares)	0.0	Future area with offset (adjusted hectares)	0.0												
					Time until ecological benefit	Start quality (scale of 0-10)	Future quality without offset (scale of 0-10)	Future quality with offset (scale of 0-10)	0.00	90%	0.00	0.00								
<i>Threatened species habitat</i>																				
Area of habitat	Yes	72.30	Adjusted hectares	Long term protection and management of habitat at Ippolo Road, Chittering, WA	Time over which loss is averted (max. 20 years)	20	Start area (hectares)	279	Risk of loss (% without offset)	30%	Risk of loss (% with offset)	5%	69.75	90%	62.78	60.32	59.45	82.23%	No	
					Future area without offset (adjusted hectares)	195.3	Future area with offset (adjusted hectares)	265.1												
					Time until ecological benefit	10	Start quality (scale of 0-10)	7	Future quality without offset (scale of 0-10)	6	Future quality with offset (scale of 0-10)	7	1.00	90%	0.90	0.88				
<i>Threatened species</i>																				
Number of features e.g. Nest hollows, habitat trees	No																			
Condition of habitat Change in habitat condition, but no change in extent	No																			
Birth rate e.g. Change in nest success	No																			
Mortality rate e.g. Change in number of road kills per year	No																			
Number of individuals e.g. Individual plants/animals	No																			

Summary							
Protected matter attributes	Quantum of impact	Net present value of offset	% of impact offset	Direct offset adequate?	Cost (\$)		
					Direct offset (\$)	Other compensatory measures (\$)	Total (\$)
					Birth rate	0	
Mortality rate	0				\$0.00	\$0.00	
Number of individuals	0				\$0.00	\$0.00	
Number of features	0				\$0.00	\$0.00	
Condition of habitat	0				\$0.00	\$0.00	
Area of habitat	72.3	59.45	82.23%	No	\$0.00	#DIV/0!	#DIV/0!
Area of community	0	0.00	#DIV/0!	#DIV/0!	\$0.00	#DIV/0!	#DIV/0!
					\$0.00	#DIV/0!	#DIV/0!



APPENDIX L

EPBC Act Offset Assessment Guide – SCP20a





APPENDIX M

Technical Advice on Fauna Issues





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3rd December 2015

Perth-Darwin National Highway (Swan Valley Section) Public Environment Review
Issue 167 Further information on persistence of fauna in relation to fragmentation

The proposed Perth-Darwin National Highway (PDNH) development will pass through several areas of currently intact native vegetation and thus there are concerns with the persistence of these fragmented areas as habitat for fauna, and the ability of fauna to access these areas even if they do persist. Areas of native vegetation that would be fragmented include 4.3 ha of Bush Forever site 97 which will be isolated from the main bushland, and several occurrences of Mound Springs SCP Threatened Ecological Communities (TEC) associated with that site. Indirect impacts and the likely persistence of TECs, threatened fauna and conservation areas and wetlands are discussed further below.

Persistence of small fragments of native vegetation will depend upon management including exclusion of vehicles, weed control and, where possible, rehabilitation and reconnection with other areas of native vegetation. The management of fragments of native vegetation is provided in PER Chapter 8, Flora and Vegetation, Table 8.16 and PER Chapter 9, Terrestrial Fauna, Table 9.7.

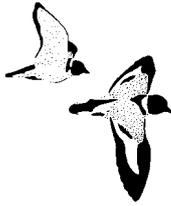
The Bush Forever site 97 is a good example of the potential for rehabilitation. The 4.3 ha fragment is a narrow, outlying section of a much larger area of native vegetation that lies to the west. Through rehabilitation along the road verge, it could be linked to Bush Forever site 100, another fragmented area of native vegetation, located to the south. Bush Forever site 100 will also be bisected by the PDNH in a section where it is currently degraded and where road reserve rehabilitation could be implemented. Management of these areas of fragmentation will require a commitment to rehabilitation (discussed in PER Chapter 12, Rehabilitation and Decommissioning).

Persistence of fragments of native vegetation may be threatened by hydrological change, especially where the fragment is a dampland, wetland or is otherwise groundwater dependent. This is discussed in PER Chapter 10, Hydrological Processes and Inland Water Environment Quality, Section 10.4. The overall conclusion is that the sandy, free-draining substrate for much of the alignment will limit hydrological change, but in the north of the alignment where the soils are clayey there could be some effects due to compaction. Modelling suggests very localised groundwater changes such as +23 cm immediately upstream of the alignment, and -10 cm immediately downstream. These changes are without consideration of the application of management measures. Management measures relating to hydrological processes are provided in PER Chapter 10 Hydrological Processes and Inland Waters Environmental Quality, Table 10.9.

Rehabilitation to enhance connectivity between fragments of native vegetation created by the highway should allow for continued and in some cases enhanced linkage for fauna. This will need to be in conjunction with well-designed wildlife underpasses as are proposed. For example, underpasses are proposed at Bush Forever sites 97 and 100 (PER Chapter 9, Terrestrial Fauna, Figure 9.5C).

There are no underpasses currently proposed for the Reid and Tonkin Highway intersection; this is a large and complex intersection but it falls between Lightning Swamp and Whiteman Park in an area where existing Bush Forever site No. 480 will largely be cleared, and where Quenda (Southern Brown Bandicoots) are already known to be moving along road verges.

Linkage is important for fauna as fragments in isolation may be too small to support some species. Providing the remnant is linked by a corridor such as underpasses and road reserve vegetation, it is likely to remain viable for fauna. Even the largest of local mammals will use underpasses. The long-term ecological function of small fragments may be questionable as, for example, the highway may present a barrier for small insect pollinators. This is a good reason for ensuring road reserve vegetation consists of local native species in order to minimise the gap presented by the road surface.



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25th November 2015

Perth-Darwin National Highway (Swan Valley Section) Public Environment Review
Issue 168 Use of local and regional scale to assess proportional impacts upon habitat of
conservation significant species including the Western Carpet Python, Southern Brown Bandicoot
and Western Brush Wallaby

PER Chapter 9, Terrestrial Fauna, Section 9.4 describes impacts to fauna at local and regional scales. The local scale covers all Bush Forever sites within 1 km of the proposal footprint. The regional scale covers all Bush Forever sites within 10 km of the proposal footprint. Table 9.4 presents the proportion of habitat loss with respect to the Western Carpet Python, Southern Brown Bandicoot and Western Brush Wallaby.

The Environmental Protection Authority Guidance Statement 56 states that “*desktop study should seek to determine the size of remnants and/or habitat condition relative to those in the local surrounds (<15km radius)*” i.e., a nominal 15 km buffer to the nominal centreline. A 15-km buffer for linear infrastructure would encompass vegetation associations and habitat different to those within the proposal footprint given the diversity of vegetation complexes in the Swan Coastal Plain bioregion. The use of 1 km and 10 km study areas is appropriate to determine local and regional context for linear infrastructure respectively. If the IBRA bio-regional classification system is used, the Swan Coastal Plain extends in a coastal strip from near Geraldton to near Busselton. A more restricted definition of the Swan Coastal Plain extends from the Moore River to south of Bunbury. Both definitions are too extensive and cover too great a variety of environments to be useful for regional assessment.

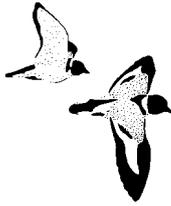
Where information was available, the wider distribution of conservation significant species was described for context (see PER Chapter 9, Terrestrial Fauna, Section 9.4). The species’ distribution in Western Australia (Swan Coastal Plain and Southwest) and across Australia was discussed, where available. This general discussion provides context of impacts to each species’ distribution and populations. It is not linked to the regional assessment which is based on the 10 km study area.

The local and regional assessment only considered habitat in Bush Forever sites. Native vegetation outside Bush Forever sites may be in poor condition, have less security and provide suboptimal habitat. The proportion of habitat loss at a local and regional scale will be higher than if all native vegetation areas were included i.e., a conservative approach.

The Western Carpet Python, Quenda (Southern Brown Bandicoot) and Western Brush Wallaby may be in decline in parts of the Swan Coastal Plain, most likely due to habitat loss (mostly due to clearing for urban development). Predation by feral species may also be a factor. The impact upon these species of proportional loss of habitat from the proposal needs to consider regional patterns of distribution; these are briefly described below (based mostly upon personal experience (M. Bamford)).

On the Swan Coastal Plain immediately north of Perth, the Western Carpet Python appears to be mostly restricted to large areas of intact native vegetation of the Spearwood System, often where limestone is exposed (e.g. Neerabup National Park). It also occurs along the Darling Scarp including in the Bindoon/Chittering area. In ongoing studies in Whiteman Park (since 1992) and the Lexia/Gnangara area (since 2003), the Western Carpet Python has never been encountered so it would appear to be very uncommon in the proposal area. Proportional habitat loss within 1km of the proposal footprint may be a realistic reflection of impact, but when extended to 10km this would include higher value habitat.

Both the Western Brush Wallaby and the Southern Brown Bandicoot (Quenda) are locally abundant in native vegetation within the proposal area and across the Swan Coastal Plain north of Perth, especially where dense, low vegetation occurs such as in damplands. The range of the Western Brush Wallaby extends at least to Dongara, whereas that of the Quenda extends only as far north as about Yanchep and Gingin (although with scattered records further north which are mostly the result of relocations). Proportional habitat loss within 1km and 10km of the proposal footprint may be a realistic reflection of impact.



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25th November 2015

Perth-Darwin National Highway (Swan Valley Section) Public Environment Review
Issue 169 (part) Further information on impacts upon locally or regionally significant fauna

In PER Chapter 9, Terrestrial Fauna, Section 9.2.6, fauna species listed as locally or regionally significant (Bush Forever, Government of Western Australia, 2000b) are discussed. Impacts of the proposal on these species are considered only briefly in Section 9.4.1.14. The species list is not exhaustive. The listed species are (with some other species that could be considered locally/regionally significant in parenthesis):

- Frogs: *Crinia insignifera* (also *Pseudophryne guentheri*).
- Reptiles: *Ctenophorus adalaidensis*, *Hemiergis quadrilineata*, *Varanus tristis*, *Parasuta gouldii* (also several other species with limited distributions in the region, such as *Lerista christinae*, *Pletholax gracilis*, *Aclys (Delma) concinna*, *Varanus rosenbergii*).
- Birds: Common Bronzewing, Splendid Fairy-wren, White-browed Scrubwren, Weebill, Western Thornbill, Yellow-rumped Thornbill, Scarlet Robin, Hooded Robin and Grey Shrike-thrush, Emu, Brown Goshawk, Little Eagle, Wedge-tailed Eagle, Brown Falcon, New Holland Honeyeater, Western Wattlebird and Black-faced Woodswallow (also White-breasted Robin, Variegated Fairy-wren, White-winged Fairy-wren and Inland Thornbill are locally uncommon and declining, although widespread elsewhere).
- Mammals. None mentioned, probably as most significant mammals in the area are on statutory lists (the Honey Possum *Tarsipes rostratus* and South-West Pygmy-possum *Cercartetus concinnus* are present in the project area, uncommon on the Coastal Plain north of Perth but widespread elsewhere).

Whether listed in the Bush Forever report or not, these species may all be at risk to the same factors as could impact species on statutory lists such as: habitat loss, habitat fragmentation, habitat degradation (such as due to hydrological change, weed invasion, changes in fire frequency), increased predation, disturbance due to noise and light, and road kill. These impacting processes are listed in PER Chapter 9 Terrestrial Fauna, Section 9.3). The discussion of impacts on these species (Section 9.4.1.14) states:

“All of the locally and regionally significant fauna recorded in the proposal area are considered common either on the SCP or within other portions of their distributions. As such, the proposal will not increase the level of significance of these species. Impacts to these species due to the loss of habitat in the proposal footprint are expected to be negligible at a regional scale due to the widespread occurrence of suitable habitat for these species. Impacts to these species from the loss of habitat, loss of ecological connectivity and habitat fragmentation caused by the proposal are restricted to the local scale and not expected to be significant.”

The statement made in this section relies upon PER Chapter 9, Terrestrial Fauna, Section 9.4 where impacting processes and their effect upon significant species and on fauna in general are discussed. Management measures are discussed in Section 9.5 and address processes such as fragmentation, predation, habitat loss, habitat degradation as they apply to the entire fauna assemblage; not just significant species on statutory lists. The intention of the management measures is to minimise

impacts upon the entire fauna assemblage, including species of local and/or regional significance. There is further discussion of hydrological impacts and minimisation in PER Chapter 10, Hydrological Processes and Inland Waters Environmental Quality, Section 10.4.

The PER recognises that there will inevitably be some habitat loss that will affect species of local and/or regional significance with residual impacts discussed in PER Chapter 9, Terrestrial Fauna, Table 9.7. This includes the management actions needed to minimise impacts. Rehabilitation to replace lost habitat and enhance connectivity is important and this is addressed through management measures listed in PER Chapter 12, Rehabilitation and Decommissioning, Section 12.5.



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3rd December 2015

Perth-Darwin National Highway (Swan Valley Section) Public Environment Review
Issue 169 (part) Further information on impacts upon wetland fauna and wetland fauna habitats

Damplands and wetlands surveyed as part of the fauna study (PER Appendix G, Level 2 Targeted Fauna Assessment) account for a small part of the total 745.7 ha proposal footprint: 19.0 ha and 15.5 ha respectively (see PER Chapter 9, Terrestrial Fauna, Table 9.1). PER Chapter 10 Hydrological Processes and Inland Waters Environmental Quality, Figure 10.2 illustrates the extent of wetlands within and around the proposal footprint based upon the Geomorphic Wetlands Swan Coastal Plain dataset. This set of maps shows wetlands are extensive within 1 km of the PDNH alignment, with approximately 25 wetlands identified within the proposal footprint and an additional 26 wetlands within 100 m (Table 10.3). The largest portion of wetlands were in the 'multiple use wetland' category, i.e., assessed as possessing few remaining ecological attributes and functions, and classified as palusplain and/or damplands that have been cleared for agriculture. According to the geomorphic wetland mapping, approximately 315.9 ha of the total area of the proposal footprint was mapped as associated with wetland environments (Table 10.5).

As presented in PER Chapter 3, Route Selection and Development, Section 3.2.2, key wetlands such as mound springs and wetlands associated with the Western Swamp Tortoise (*Pseudemydura umbrina*) have been avoided by the PDNH alignment. Several drainage lines of the Ellenbrook system are crossed by the alignment and impacts (and impact mitigation) are discussed in PER Chapter 10, Hydrological Processes and Inland Water Environmental Quality, sections 10.4 and 10.6. Impacts upon damplands/wetlands in the Lightning Swamp area are noted in PER Appendix G, Level 2 Targeted Fauna Assessment, Section 7.2 which states "*The clearing of the Dampland and Eucalypt/Corymbia Woodland at the Tonkin Highway/Reid Highway intersection (Micro Gardens Park) will impact the ecological connectivity between Lightning Swamp Bushland, Malaga Regional Space and Koondoola Regional Bushland to the west and Point Reserve to the East.*"

Intact damplands and wetlands are locally significant because they are limited in extent, provide at least seasonal surface water and support distinctive and often very dense vegetation. Overall, damplands and wetlands are likely to be locations of high and distinctive fauna biodiversity. They are important for fauna groups as follows:

Invertebrates. Some potential for Short-Range Endemic Species (SREs). Damplands and wetlands provide habitat for aquatic species and mesic refugia for terrestrial species that require at least seasonally moist conditions. Some wetland plants flower heavily and are thus important for nectar supply for invertebrates.

Fish. The Priority 3 Black-striped Minnow (*Galaxiella nigrostriata*) was at least until recently present in the Melaleuca Park wetland (EPP173) which is outside the development envelope. The Ellenbrook drainage system supports several native and introduced fish, and all the native species should be considered at least of local conservation significance because of the extent of wetland degradation

in the region. These species include the Black-striped Minnow, Mud Minnow (*Galaxiella munda*), Western Pygmy-perch (*Edelia vittata*) and Western Minnow (*Galaxia occidentalis*), with the latter three species recorded in Lake Chandala just north of Muchea (M. Bamford Unpubl. data).

Frogs. With the exception of the Turtle Frog (*Myobatrachus gouldii*), all frogs in the region rely on wetlands to breed. Frog populations in the region are declining; most noticeably Guenther's Toadlet (*Pseudophryne guentheri*) and the Moaning Frog (*Heleioporus eyrei*), with both these species relying upon early winter rains to fill seasonal wetlands (Bamford and Huang, 2009; Bamford and Everard, 2015).

Reptiles. Several reptile species rely upon or are most abundant around damplands and wetlands in the region. In addition to the Western Swamp Tortoise (*Pseudemydura umbrina*) confined to seasonal wetlands near the development envelope, the Long-necked Tortoise (*Chelodina colliei*) occurs in seasonal and permanent wetlands in the region. Reptiles dependent or largely dependent upon dense vegetation and moist conditions around wetlands and damplands include the Tiger Snake (*Notechis scutatus*) and the skink *Acritoscincus trilineatum*. Some other species appear to be more abundant close to wetlands and damplands than in upland environments, including the legless lizard *Aprasia repens* and the skink *Hemiergis quadrilineata*.

Waterbirds. Natural damplands and wetlands in the region support only small numbers of waterbirds and lack the open environments favoured by migratory shorebirds. Cryptic species of dense rushes such as the conservation significant Australasian Bittern are effectively locally extinct due to habitat loss. Seasonally-damp paddocks can support moderate numbers of herons, egrets, ibis and ducks.

Land birds. A suite of land birds relies heavily upon the dense vegetation around damplands and wetlands; these include the Splendid Fairy-wren (*Malurus splendens*) and White-browed Scrubwren (*Sericornis frontalis*). In addition, dampland and wetland vegetation include plant species that are seasonal producers of nectar and thus attract nectarivorous birds (honeyeaters and occasionally the native Purple-crowned Lorikeet *Glossopsitta porphyrocephala*).

Mammals. The dense vegetation around intact wetlands and damplands are vital for the Quenda (*Isodon obesulus*) in the region, which is at the northern limit of its range around Muchea. Both the Honey Possum (*Tarsipes rostratus*) and Western Pygmy-possum (*Cercartetus concinnus*) have been recorded in dense vegetation close to wetlands in the region (Bamford and Everard, 2015). Although able to live in upland vegetation, these two species may need the seasonal nectar supply of dampland and wetland plants. Similarly, Bamford and Bamford (1999) found the Brush Wallaby (*Macropus irma*) to favour dense vegetation around wetlands in Whiteman Park, and recorded a Chuditch (*Dasyurus geoffroii*) in dampland vegetation in what is now the suburb of Lexia in 2003 (M. Bamford Unpubl. data). The Chuditch was a young male probably dispersing through the area.

From the above outline, it is apparent that dampland and wetland areas in the region, where they are intact and support native vegetation, are likely to be important for biodiversity on at least a local scale. This importance is largely for local species rather than those of national or international significance. Species for which wetlands are important, including those that make seasonal use of a resource such as flowering plants, the continued presence and access to damplands and wetlands may be important for maintaining local populations.

The risk to wetland fauna assemblages has not been discussed specifically in the PER, but impacts to wetlands are discussed in PER Chapter 10, Hydrological Processes and Inland Water Environmental Quality, Section 10.4. This section discusses, by inference, impacts upon wetland fauna due to

habitat loss (sections 10.4.6.1 and 10.4.6.2) and hydrological change, including altered water quality (sections 10.4.4.3 and 10.4.6.3). These sections conclude that impacts upon wetland environments and fauna will be minimal and can be managed through management of drawdown (during construction), and through management and design with respect to compaction and drainage. Section 10.5 discusses the management of hydrological impacts. Habitat fragmentation that may affect species such as the Quenda (Southern Brown Bandicoot) is discussed in PER Chapter 9, Terrestrial Fauna, Section 9.6.2, with wildlife fencing and underpasses located in wetland/dampland areas to facilitate fauna movement and reduce roadkill.

On the basis of the impacts and mitigation measures discussed in the PER, the risk to damplands and wetlands affected by the proposal will be low. In general, only small portions of significant areas will be directly impacted. Key impacts such as hydrological change and fragmentation can be managed through monitoring, design, verge revegetation, fencing and underpasses. The greatest residual risk to wetland fauna may be at the intersection of Reid Hwy and Tonkin Hwy, where almost all of a wetland and a recognised Bush Forever site (No. 480) and most of CCW 15033 will be removed. This wetland area will be predominately lost however the viability of the remaining fragment will depend on connectivity and water supply. The rehabilitation and maintenance of road reserve vegetation, and the maintenance of effective underpasses, may be required to allow species such as the Quenda to be able to continue to move through this area.

References

- Bamford, M.J. and Bamford, A.R. (1999). A study of the Brush or Black-gloved Wallaby *Macropus irma* (Jourdan 1837) in Whiteman Park. Whiteman Park Technical Report Series No. 1. Western Australian Planning Commission, Perth.
- Bamford, M.J. and Everard, C. (2015). Report on East Lexia Frog Monitoring; 2003 to 2014. Unpubl. report to Water and Rivers Commission, Perth.
- Bamford, M.J. and Huang, N (2009). The Occurrence and Status of Frogs in the Gnangara Sustainability Strategy Study Area. Report prepared on behalf of the Department of Environment and Conservation for the Gnangara Sustainability Strategy, Perth.

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