

17 OFFSETS

The assessment of impacts presented in Chapters 8, 9, 10 and 16 describe the proposal's residual impacts following avoidance, impact minimisation and rehabilitation/restoration.

This chapter documents the proposal's offset strategy to address residual impacts on environmental values relevant to both the State, as assessed by the EPA, and for MNES, as determined by the DOTE.

17.1 Definition of Offsets

Under the Commonwealth Environmental Offsets Policy (Government of Australia, 2012) the term 'environmental offsets' refers to measures that compensate for the residual adverse impacts of an action on the environment. Offsets provide environmental benefits to counterbalance the impacts that remain after avoidance and mitigation.

Under the WA Environmental Offsets Policy (Government of Western Australia, 2011) an environmental offset is an off-site action or actions that addresses significant residual environmental impacts of a development or activity.

Both State and Commonwealth policies specify that environmental offsets are not intended to make proposals with unacceptable impacts acceptable and are not a substitute for undertaking all reasonable avoidance and environmental mitigation measures.

Under both the State and Commonwealth offset policies, environmental offsets can be classified as direct or indirect. Definitions for direct and indirect offsets under these policies are discussed in Table 17.1.

Table 17.1 Definition of direct and indirect offsets

Offset category	Definition	
	State	Commonwealth
Direct	<p>Actions designed to provide for on-ground improvement, rehabilitation and conservation of habitat outside the proposal footprint.</p> <p>Direct offsets vary, depending on the specific circumstances of environmental impacts, and include acquisition, restoration, revegetation and rehabilitation of natural areas.</p>	<p>Actions that provide a measurable conservation gain for an impacted protected matter.</p> <p>A conservation gain may be achieved by improving or creating new habitat, reducing threats, or averting the loss of a protected matter or its habitat that is under threat.</p>
Indirect	<p>Actions aimed at improving scientific or community understanding and awareness of environmental values that are affected by a development or activity.</p> <p>These actions are designed to result in positive conservation outcomes and may include research to improve the management and protection of existing conservation estate or contributions to State Government initiatives, policies or strategic funds.</p>	<p>Actions that do not directly offset the impacts on the protected matter, but are anticipated to lead to benefits for the impacted protected matter, for example funding for research or educational programs. Requirements for other compensatory measures.</p>

Sources: Government of Western Australia (2011) and Government of Australia (2012).



17.2 Application of Offsets

Environmental offsets aim to counterbalance the significant residual environmental impacts or risks of a particular activity or project. Both the State and Commonwealth Governments provide advice on the application of offsets and principles for their use. The Western Australian Government endeavours to work cooperatively with the Commonwealth Government to avoid duplication of offsets, however, this is not always possible where a proposal or action is not jointly assessed under a bilateral agreement or a strategic assessment.

The State and Commonwealth Governments have formally agreed to conduct a strategic assessment in accordance with section 146 of the EPBC Act, focussing on the Perth and Peel regions of the SCP. While this proposal lies within the boundary of this strategic assessment, none of the proposed offsets are to be secured through the Strategic Assessment of the Perth Peel Region (SAPPR) process.

17.3 Offset Policies

17.3.1 State Offset Policy

The State's Environmental Offset Guidelines (Government of Western Australia, 2014) assist the EPA in the determination and application of environmental offsets on a project by project basis and ensure that decisions made on environmental offsets are consistent and accountable.

In general, significant residual impacts include those that affect rare and endangered plants and animals, areas within the formal conservation reserve system, important environmental systems and species that are protected under international agreement (e.g. Ramsar wetlands) (Government of Western Australia, 2014). A residual impact significance model has been developed to assist proponents in consistently determining the significance of residual impacts and when an offset is likely to, or may, require an offset (Government of Western Australia, 2014).

Following the determination of the level of significance for residual impacts, the type of offset should be determined in line with the EPA principles for the development of an offset package (Government of Western Australia, 2011). These are:

1. Environmental offsets will only be considered after avoidance and mitigation options have been pursued.
2. Environmental offsets are not appropriate for all projects.
3. Environmental offsets will be cost-effective, as well as relevant and proportionate to the significance of the environmental value being impacted.
4. Environmental offsets will be based on sound environmental information and knowledge.
5. Environmental offsets will be applied within a framework of adaptive management.
6. Environmental offsets will be focussed on longer term strategic outcomes.

17.3.2 Commonwealth Offset Policy

The Commonwealth's Offset Assessment Guide (DSEWPAC, 2012a) provides a framework to determine the suitability (i.e. appropriateness and adequacy) of proposed offsets for protected matters, including an impact and offset calculator. The Commonwealth outlines that (Government of Australia, 2012):

- Suitable offsets must deliver an overall conservation outcome that improves or maintains the viability of the protected matter.
- Suitable offsets must be built around direct offsets, but may include other compensatory measures.

- Suitable offsets must be in proportion to the level of statutory protection that applies to the protected matter.
- Suitable offsets must be of a size and scale proportionate to the residual impacts on the protected matter.
- Suitable offsets must effectively account for and manage the risks of the offset not succeeding.
- Suitable offsets must be additional to what is already required, determined by law or planning regulations or agreed to under other schemes and programs.
- Suitable offsets must be efficient, effective, timely, transparent, scientifically robust and reliable.
- Suitable offsets must have transparent governance arrangements including being able to be readily measured, monitored, audited and enforced.

17.4 Rationale

The offset strategy for this proposal has been developed in consideration of various field assessments and supporting studies and consultations with the EPA, DOTE, DPAW and the Department of the Premier and Cabinet. The objective for this offset strategy is to achieve a net environmental benefit once the proposal has been implemented. To achieve this objective, a suite of offsets are proposed to address the various residual impacts and formulate the offset package for this proposal.

The following specific principles have been adopted when assessing the suitability of the proposed offsets:

- The offset represents a lasting environmental benefit.
- Preference is given to offsets that are relevant to the values being impacted by the proposal, including the conservation of:
 - Existing Black Cockatoo foraging, breeding and roosting habitat.
 - State listed TECs.
 - CCWs.
 - Conservation areas.


17.5 Summary of Significant Residual Impacts

A summary of significant residual impacts that are likely to require offsetting, as identified in Chapters 8, 9, 10, 15 and 16 and the relevant offset proposal under which they are addressed, is provided in Table 17.2.

Table 17.2 Summary of significant residual impacts requiring offset

Significant environmental value	Residual impact	Extent of residual impact ¹	Total extent of residual impact outside SAPPR boundary	Relevant offset proposal ²
Black Cockatoo habitat ¹	Removal of Carnaby's Cockatoo foraging habitat, inclusive of breeding habitat, potential breeding trees and roosting habitat ³ .	201.8 ha foraging habitat, including: <ul style="list-style-type: none"> • 120.1 ha breeding habitat • 763 potential breeding trees; and • 58.6 ha roosting habitat³. 	5.15 ha of foraging, roosting and breeding habitat and 107 potential breeding trees.	1
Forest Red-tailed Black Cockatoo habitat	Removal of Forest Red-tailed Black Cockatoo foraging habitat, inclusive of breeding habitat and potential breeding trees and roosting habitat ³ .	120.1 ha foraging habitat, including: <ul style="list-style-type: none"> • 120.1 ha breeding habitat • 763 potential breeding trees; and • 58.6 ha roosting habitat³. 	5.15 ha of foraging, roosting and breeding habitat and 107 potential breeding trees.	1 and 4
Conservation areas	Excision of Class A Nature Reserve.	8 ha	Not applicable.	1
	Excision of 106 ha of State Forest.	Removal of 106 ha of State Forest	Not applicable.	1
	Removal of intact native vegetation across nine Bush Forever sites (partial and complete removal).	171.5 ha ⁴	Not applicable.	1
TECs	Removal of SCP02 (Southern wet shrublands).	0.4 ha	Not applicable.	3
	Removal of SCP20a (<i>Banksia attenuata</i> woodlands over species rich dense shrublands).	4.0 ha	Not applicable.	1
CCWs	Partial or complete filling of five CCWs and other indirect impacts.	16.0 ha	Not applicable.	2
Threatened Flora	Removal of critical habitat for <i>Caladenia huegelii</i> .	39.2 ha	Not applicable.	1

1. Total extent of residual impact, both inside and outside the SAPPR boundary. None of the proposed offsets are to be secured through the SAPPR process.
2. For details relating to each of the offset proposals, see Sections 17.6, 17.7, 17.8 and 17.9.
3. These figures represent the area to be impacted on both State and Commonwealth lands.
4. Inclusive of 31.5 ha of State Forest and Class A Nature Reserve.



17.6 Offset Proposal 1 – Ioppolo Rd, Chittering

17.6.1 Commitment

MRWA will vest 673.5 ha of land with the Conservation Commission, and subsequent management by the DPAW for conservation purposes.

17.6.2 Description of Offset

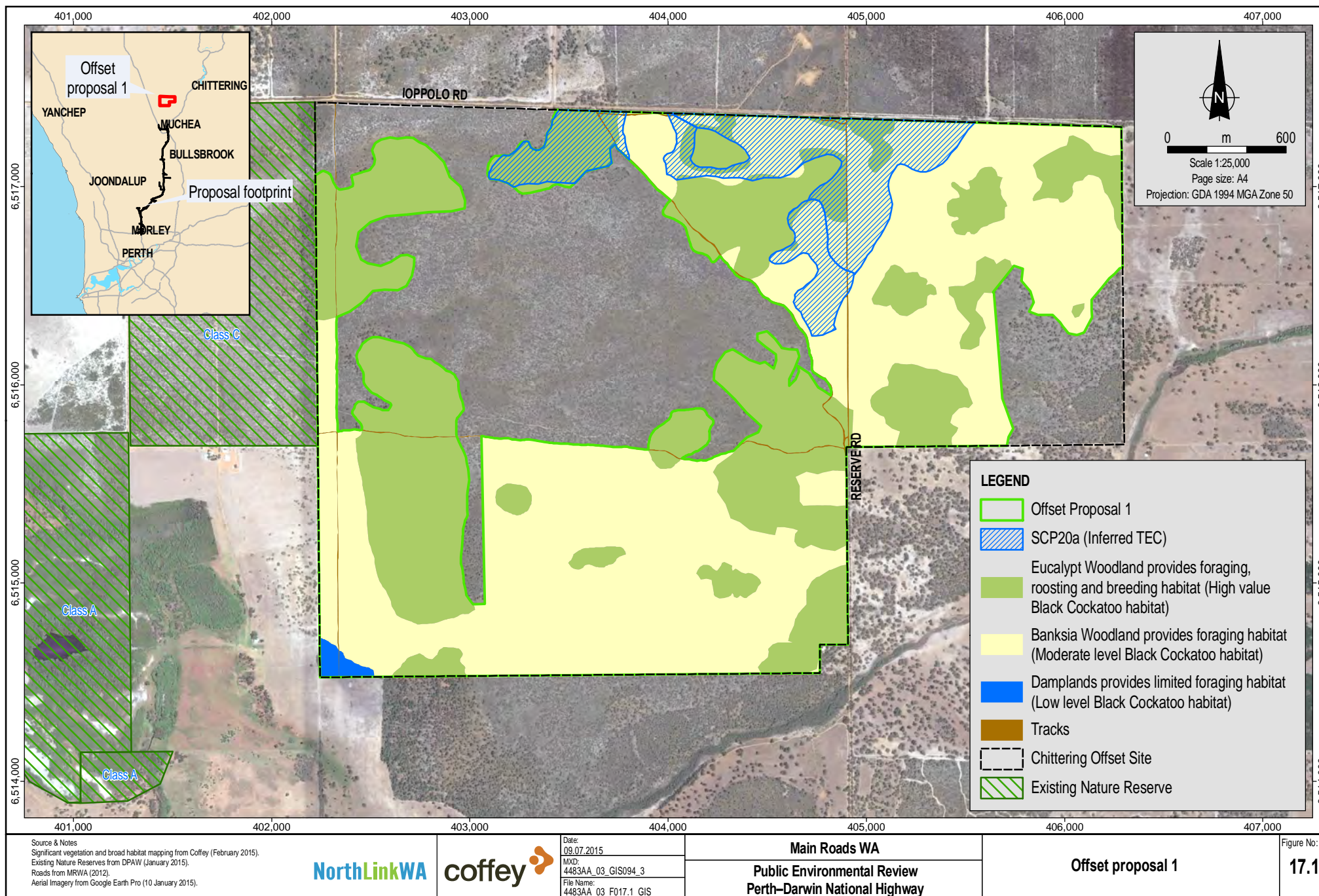
The proposed 673.5 ha offset area occurs within a larger 983 ha block of land located on Ioppolo Road, Chittering (herein referred to as Ioppolo Road). Ioppolo Road is surrounded by private land, with the exception of an existing C Class Nature Reserve managed by the DPAW to the west (Figure 17.1). It is currently zoned 'Agriculture Resource' under the Shire of Chittering Town Planning Scheme No. 6. MRWA has purchased Ioppolo Road for the purpose of offsetting impacts of the wider NorthLink WA Project (including this proposal and the Tonkin Grade Separations project).


A field survey was undertaken to determine the existing environmental values within Ioppolo Road (Coffey, 2015f) (Appendix V). The environmental assessment included a Level 1 flora and vegetation survey and a Level 1 fauna survey and Black Cockatoo habitat assessment. The assessment identified the following key values:

- The majority (84%) of the vegetation was in excellent condition due to the intact vegetation structure, minimal anthropogenic disturbances and minimal signs of disturbance as a result of pathogens, diseases and overgrazing from native and non-native fauna.
- Approximately 981 ha of Carnaby's Cockatoo foraging habitat, 315 ha of Forest Red-tailed Black Cockatoo foraging habitat, both of which include 315 ha of Black Cockatoo breeding and roosting habitat.
- Two inferred Threatened Ecological Communities (SCP20a and SCP20b), one known TEC (SCP20c), and three inferred PECs (Banksia yellow-orange sands, SCP23b and SCP21c)
- One Threatened and one Priority flora species were recorded, another five Priority listed plant taxa (including one P4 taxa known to occur in the proposal footprint) are known to occur and a further 25 conservation significant plant taxa have the potential to occur.
- The Western Brush Wallaby (*Macropus irma*), listed as Priority 4 under DPAW's Priority listing, was recorded and a further 10 conservation significant fauna species are considered to have the potential to occur within this study area.

The Carnaby's Cockatoo foraging habitat is associated with Eucalypt Woodland and Banksia Woodland and contains 17 species of foraging resources, including the following dominant species: *Eucalyptus marginata*, *E. tottiana*, *Corymbia calophylla*, *Allocasuarina humilis*, *Banksia menziesii* and *B. attenuata*. The 315 ha of Forest Red-tailed Black Cockatoo habitat is associated with Eucalypt Woodland that contains *Eucalyptus marginata* and *Corymbia calophylla*, both of which are the main constituents of this species' diet.

Within the Ioppolo Road site, 315 ha of Eucalypt Woodland habitat (specifically the stands of tall *Eucalyptus marginata*, *E. tottiana* and *Corymbia calophylla*) also represents Black Cockatoo breeding and roosting habitat. An estimated 6,300 potential breeding trees are present within the Eucalypt Woodland habitat, based on an average tree density of 20 trees per hectare. Given that tree age is sufficient to produce large hollows and as the region is known to have breeding records (Johnstone and Kirkby, 2011b), Ioppolo Road is classified as having current breeding potential for Carnaby's Cockatoos.





The threatened taxa *Chamelaucium* sp. Gingin (N.G. Marchant 6) occurs in the northwest of Ippolo Road. *Chamelaucium* sp. Gingin (N.G. Marchant 6) is considered to be a Threatened taxon under the WC Act with a classification of Vulnerable under the Act. In addition to the listing under the WC Act, it is listed as Endangered under the EPBC Act. *Chamelaucium* sp. Gingin (N.G. Marchant 6) is endemic to WA and is apparently confined to the Gingin/Chittering area, where it is known from a range of only 3 km and six populations (Stack and English, 2003). The six priority flora known to occur include *Acacia cummingiana* (P3), *Caustis* sp. Gigas (A.S. George 9318) (P2), *Hypolaena robusta* (P4), *Schoenus griffinianus* (P3), *Verticordia rutilastra* (P3) and *Verticordia serrata* var. *linearis* (P3). MRWA will conduct further surveys in spring 2015 to confirm the extent of the inferred occurrence of TEC SCP20a.

The Ippolo Road site is currently outside (approximately 10 km north) the known distribution for the Forest Red-tailed Black Cockatoo. Given recent expansion of this species' distribution west from the edge of the Darling Scarp and onto the SCP (Johnstone et al., 2013), a review of current and historic information and a field survey is to be conducted to verify the suitability of this site as an offset for Forest Red-tailed Black Cockatoos. If the Ippolo Road site is found unsuitable, MRWA commits to providing an appropriate offset for this species.

Based upon vegetation mapping a total of 39.2 ha of critical habitat for *Caladenia huegelii* will be removed as part of the proposal. Surveys for suitable habitat at the Ippolo Road offset site will be conducted during spring 2015. If surveys show that the Ippolo Road site does not comprise suitable habitat, then MRWA commits to offsetting the amount of critical habitat impacted by the proposal through a package that may comprise protection of habitat through acquisition or covenant, and contributions to the recovery plan such as a cultivation and translocation program.

17.6.3 Purpose of Offset

The purpose of Offset Proposal 1 is to offset the proposal's significant residual impacts on Black Cockatoo habitat, conservation areas of Nature Reserve, State Forest and Bush Forever, TEC SCP20a and threatened flora. A summary of Offset Proposal 1 is provided in Table 17.3 and is depicted in Figures 17.1 and 17.2.

Offset 1 provides the following values and net conservation benefits:

- Vesting with the Conservation Commission for long-term conservation management as a conservation reserve.
- Vegetation in better condition (Excellent) than the majority of the vegetation to be cleared.
- Additional numbers of rare and priority listed flora and conservation significant fauna to be protected.
- Is adjacent to a Class C conservation reserve and forms part of the catchment protecting Chandala wetlands a significant conservation area.
- Provides conservation management of an important ecological linkage for Black Cockatoos and is part of an ecological linkage between conservation areas.
- Management of Ippolo Road as part of the conservation estate will include management of threatening processes such as dieback.

Management of the Ippolo Road site will be undertaken by DPAW and will include control of third party access and reducing the risk of the introduction and/or spread of dieback and weeds and existing weeds and dieback.

Table 17.3 Summary of Offset Proposal 1

Significant environmental value	Extent of residual impact	Regulatory agency requiring offset	Offset area required	Indicative values provided in Offset Proposal 1 ¹
Carnaby's Cockatoo habitat	Removal of 201.8 ha foraging habitat, inclusive of 120.1 ha breeding habitat (and 763 potential breeding trees) and 58.6 ha roosting habitat ² .	EPA/DOE	673.5 ha ³	Formal protection of 673.5 ha of foraging habitat, including 279 ha of potential breeding habitat and approximately 5,580 trees.
Forest Red-tailed Black Cockatoo habitat	Removal of 120.1 ha foraging habitat, inclusive of 120.1 ha breeding habitat (and 763 potential breeding trees) and 58.6 ha roosting habitat ² .	EPA/DOE	339 ha ³	Formal protection of 279 ha of foraging and potential breeding habitat including approximately 5,580 trees.
<i>Caladenia huegelii</i> critical habitat	Removal of 39.2 ha of critical habitat for <i>Caladenia huegelii</i> .	DOE	39.2 ha	Formal protection of suitable habitat to equivalent area of impacts.
Conservation areas	Excision of 8 ha of Class A Nature Reserve, 106 ha of State Forest and 171.5 ha of intact native vegetation within Bush Forever sites ⁴ .	EPA	253 ha ⁵	673.5 ha vested in Conservation Commission to be managed as a Nature Reserve.
SCP20a TEC	Removal of 4.0 ha of SCP20a (<i>Banksia attenuata</i> woodlands over species rich dense shrublands).	EPA	8 ha	Formal protection of 78 ha of inferred SCP20a.

1. As illustrated in Figures 17.1 and 17.2.

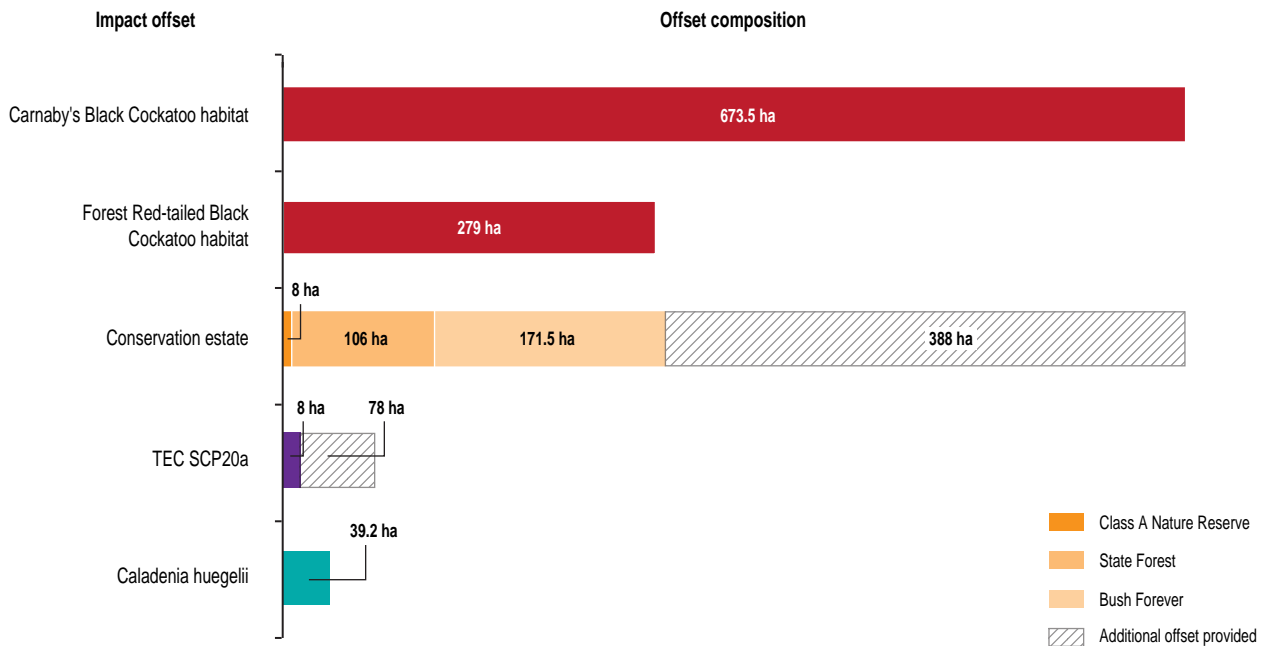
2. These figures represent the area to be impacted on both State and Commonwealth lands.

3. Based on the Commonwealth offset assessment guide (see Appendix V). Includes 673.5 ha of foraging habitat and 279 ha of potential breeding habitat (including 5,580 potential breeding trees).

4. Includes the 31.5 ha of Bush Forever site that is also recognised as State Forest/Class A Nature Reserve.

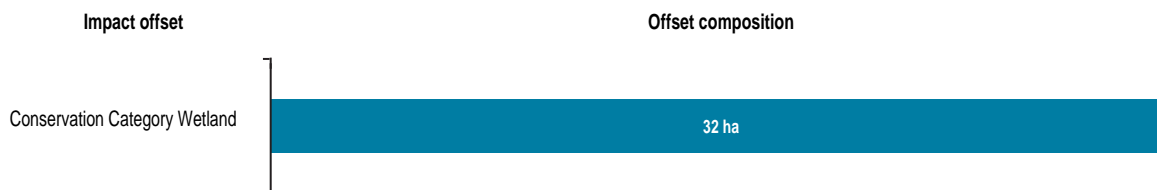
5. Total impact on conservation areas based on 8 ha of Class A Nature Reserve, 106 ha of State Forest and 139 ha of Bush Forever (excluding the 31.5 ha of Bush Forever also recognised as State Forest/Class A Nature Reserve).

OFFSET PROPOSAL ONE

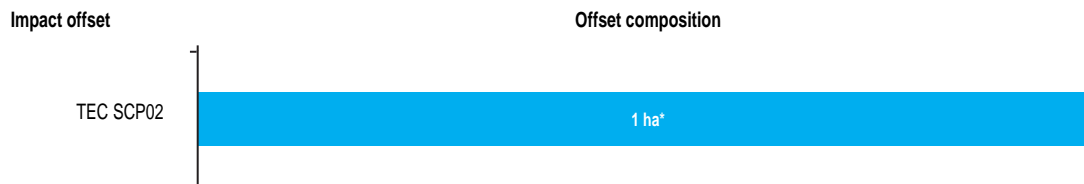


* Excluding the 31.5ha of Bush Forever recognised as State Forest/Class A Nature Reserve.

OFFSET PROPOSAL TWO



OFFSET PROPOSAL THREE*



* Only required where TEC SCP02 is confirmed to be present within the proposal footprint.

OFFSET PROPOSAL FOUR





17.7 Offset Proposal 2 – Conservation of Land Comprising CCWs

17.7.1 Commitment

MRWA will fund the acquisition or covenanting of a property or properties to be managed for conservation, or for improved management or rehabilitation to offset the loss of CCW. The properties will contain at least 32 ha of CCW (Figure 17.2).

17.7.2 Purpose of Offset

The purpose of the Offset Proposal 2 is to offset the loss of 16 ha of CCW comprised of direct impacts to 14.8 ha from 6 CCWs and the indirect impacts to CCW 15260 of 1.2 ha. The acquisition of 32 ha of CCW, when implemented, will provide a ratio of 2:1 for the area of protected wetland for each hectare of impacted CCW. This will achieve a net gain of more than 16 ha of CCW to be protected and managed and improved (if necessary), for conservation.

17.8 Offset Proposal 3 – Conservation of TEC

17.8.1 Commitment

MRWA will undertake further surveys of the site that potentially represents TEC SCP02 Southern Wet Shrublands. These surveys will be conducted in spring 2015. If the TEC is confirmed, MRWA will commit to acquire or covenant the location of one ha of land representative of this TEC or a TEC of similar or greater threat (see Figure 17.2).

17.8.2 Purpose of Offset

As an Endangered TEC at the State level, effective management of remaining sites contributes to the long term conservation of this community that is readily invaded by weeds and affected by hydrological changes. The purpose of this offset proposal, if the community is confirmed, is to increase the conservation management of the known locations of the TEC by providing funding for the acquisition or covenanting and protection of at least one ha of SCP02, based on an offset ratio of 2:1. This will achieve an additional hectare of an endangered TEC to be protected and managed for conservation.

17.9 Offset Proposal 4 – Conservation of Forest Red-tailed Black Cockatoo Habitat

17.9.1 Commitment


MRWA will fund the acquisition or covenanting of a property or properties to be managed for conservation or for improved management or rehabilitation to offset the loss of Forest Red-tailed Black Cockatoo habitat in addition to the offset area proposed in Offset Proposal 1. Offset Proposal 1 does not contain sufficient Forest Red-tailed Black Cockatoo habitat to offset the impacts of the proposal and an additional 60 ha of habitat in similar condition to Offset Proposal 1 is required (see Figure 17.2).

17.9.2 Purpose of Offset

As the Ippolo Road site in Offset Proposal 1 does not contain sufficient habitat to completely offset impacts to Forest Red-tailed Black Cockatoo, a supplementary offset is required. The purpose of Offset Proposal 4 is to offset the loss of Forest Red-tailed Black Cockatoo habitat through the protection of at least 60 ha of suitable habitat to meet the total of 339 ha.

17.10 Offset Summary

To offset effectively the significant residual impacts of the proposal (see Figure 17.2) MRWA will provide:

- 
- Offset Proposal 1: Purchase and transfer of 673.5 ha of freehold land to conservation estate, which includes intact native vegetation, Threatened flora, Threatened Ecological Communities and Black Cockatoo habitat.
 - Offset Proposal 2: Provision of funding to acquire or covenant wetlands comprising at least 32 ha of CCW.
 - Offset Proposal 3: Provision of funding to acquire or covenant 1 ha of TEC SCP02, subject to the confirmation of the presence of TEC SCP02 within the proposal footprint following further surveys.
 - Offset Proposal 4: Provision of funding to acquire or covenant 60 ha of Forest Red-tailed Black Cockatoo habitat.

The majority of the significant residual impacts are offset by Offset Proposal 1. Additional offsets are required to address the CCW areas, the potential TEC SCP02 and further Forest Red-tailed Black Cockatoo habitat. The degree to which each of these offsets addresses significant residual impacts of the proposal is represented in Figure 17.2.

A summary of all four offset proposals using the Western Australian offsets template is provided in Table 17.4.



This page is intentionally blank.

Table 17.4 Quantification of offset proposals

Existing environment and impact	Mitigation			Significant residual impact	Offset calculation methodology				
	Avoid and minimise	Rehabilitation type	Likely rehab. success		Type	Risk	Likely offset success	Time lag	Offset quantification
Carnaby's Cockatoo habitat Removal of 201.8 ha foraging habitat, inclusive of 120.1 ha breeding habitat (and 763 potential breeding trees) and 58.6 ha roosting habitat.	The proposal alignment predominantly (approximately 77.5%) follows existing infrastructure, cleared areas or secondary habitats, which reduces impacts to existing fauna habitats. Through design efficiencies the proposal footprint has been reduced from 1,028.4 ha to about 746 ha in size and reduced impacts to fauna habitats by a total of 49.6 ha across the alignment (Table 9.5). To avoid an area containing a high concentration of Black Cockatoo breeding trees, the width of the proposal footprint was reduced between Baal Street and Ngangara Road (see Figure 4.3), reducing the number of breeding trees cleared from 410 to 342.	Onsite rehabilitation opportunities will be limited to temporary construction areas. Furthermore the use of Banksia and other Black Cockatoo foraging resources will be limited as part of revegetation activities within 10 m of the road, as this increases the risk of bird strike. As MRWA will work to minimise its footprint, temporary areas of disturbance greater than 10 m from the road are anticipated to be limited.	N/A	<p>Extent: Significant residual impact remains as 201.8 ha foraging habitat, inclusive of 120.1 ha breeding habitat (and 763 potential breeding trees) and 58.6 ha roosting habitat as potential area of suitable rehabilitation unknown at this stage.</p> <p>Quality: In accordance with the How to Use the DOTE's Offset Assessment Guide (DSEWPAC, 2012a), the assessment of a threatened species' habitat must consider the site's condition, the site's context and the species' stocking rate. A Quality Score of 6 has been applied to this species habitat within the proposal footprint (see Appendix V).</p> <p>Conservation significance: Endangered species.</p> <p>Land tenure: The following habitat features are located in conservation reserve:</p> <ul style="list-style-type: none"> State Forest: 2.5 ha of breeding and roosting habitat and 30.5 ha foraging habitat. Nature Reserve: 0.4 ha of foraging habitat. Bush Forever Site: 95.9 ha of breeding habitat, 32.6 ha of roosting habitat and 155.2 ha of foraging habitat. <p>Timescale: Permanent.</p>	Offset Proposal 1	Low – land to be acquired and transferred conservation estate.	This is not applicable for land acquisition – see risk comments.	No time lag. The proposed offset site has already been acquired and is in the process of being ceded to the Conservation Commission.	In accordance with the DOTE's Offset Assessment Guide (see Appendix V): 673.5 ha of foraging habitat, inclusive of 279 ha of Eucalyptus Woodland (which contains approximately 6,300 breeding/roosting trees).

Existing environment and impact	Mitigation			Significant residual impact	Offset calculation methodology				
	Avoid and minimise	Rehabilitation type	Likely rehab. success		Type	Risk	Likely offset success	Time lag	Offset quantification
Forest Red-tailed Black Cockatoo habitat Removal of 120.1 ha foraging habitat, inclusive of 120.1 ha of breeding habitat (and 763 potential breeding trees) and 58.6 ha roosting habitat.	The proposal alignment predominantly (approximately 77.5%) follows existing infrastructure, cleared areas or secondary habitats, which reduces impacts to existing fauna habitats. Through design efficiencies the proposal footprint has been reduced from 1,028.4 ha to about 741 ha in size and reduced impacts to fauna habitats by a total of 49.6 ha across the alignment (Table 9.5). To avoid an area containing a high concentration of Black Cockatoo breeding trees, the width of the proposal footprint was reduced between Baal Street and Gngara Road (see Figure 4.3), reducing the number of breeding trees cleared from 410 to 342.	Onsite rehabilitation opportunities will be limited to temporary construction areas. Furthermore the use of Black Cockatoo foraging resources will be limited as part of revegetation activities within 10 m of the road, as this increases the risk of bird strike. As MRWA will work to minimise its footprint, temporary areas of disturbance greater than 10 m from the road are anticipated to be limited.	N/A	Extent: Significant residual impact remains as 120.1 ha foraging habitat, inclusive of 120.1 ha breeding habitat (and 763 potential breeding trees) and 58.6 ha roosting habitat as potential area of suitable rehabilitation unknown at this stage. Quality: In accordance with the How to Use the DOTE's Offset Assessment Guide (DSEWPAC, 2012a), the assessment of a threatened species' habitat must consider the site's condition, the site's context and the species' stocking rate. A Quality Score of 6 has been applied to this species habitat within the proposal footprint (see Appendix V). Conservation significance: Vulnerable species. Land tenure: The following habitat features are located in conservation reserve: <ul style="list-style-type: none"> State Forest: 2.5 ha of breeding, roosting and foraging habitat. Bush Forever Site: 95.9 ha breeding and foraging habitat and 32.6 ha of roosting habitat. Timescale: Permanent.	Offset and 4 Proposals 1	Low – land to be acquired and transferred to conservation estate.	This is not applicable for land acquisition – see risk comments.	No time lag for Offset proposal 1. The proposed offset site has already been acquired and is in the process of being ceded to the Conservation Commission. Time lag anticipated for Offset Proposal 4.	In accordance with the DOTE's Offset Assessment Guide (see Appendix V): 279 ha of foraging habitat (Eucalyptus Woodland, which contains approximately 5,580 breeding/roosting trees).

Existing environment and impact	Mitigation			Significant residual impact	Offset calculation methodology				
	Avoid and minimise	Rehabilitation type	Likely rehab. success		Type	Risk	Likely offset success	Time lag	Offset quantification
Conservation areas <ul style="list-style-type: none"> Excision of 8 ha of Class A Nature Reserve. Excision of 106 ha of State Forest. Removal of 171.5 ha of intact native vegetation across nine Bush Forever sites (Inclusive of 31.5 ha of State Forest and Class A Nature Reserve). 	Through design efficiencies the proposal footprint has been refined to reduce the impact to 14 ha of State Forest, 2 ha of Nature Reserve and 58 ha of Bush Forever.	<p>Onsite rehabilitation opportunities will be limited to temporary construction areas. Total area to be rehabilitated unknown at this stage-will be dependent on final design.</p> <p>Revegetation will focus on using native provenance vegetation that is suited to the surrounding landscape characteristics and land use.</p> <p>However, the use of Banksia and other Black Cockatoo foraging resources will be limited as part of revegetation activities within 10 m of the road, as this increases the risk of bird strike.</p>	N/A	<p>Extent: Significant residual impact remains as:</p> <ul style="list-style-type: none"> Excision of 8 ha of Class A Nature Reserve. Excision of 106 ha of State Forest. Removal of 171.5 ha of intact native vegetation across nine Bush Forever sites (Inclusive of 31.5 ha of State Forest and Class A Nature Reserve). <p>Quality: All native vegetation with condition rated degraded or above.</p> <p>Conservation significance:</p> <ul style="list-style-type: none"> 3 individuals <i>Millotia tenuifolia</i> var. <i>laevis</i> (P2). 1 individual <i>Hypolaena robusta</i> (P4). 1 individual <i>Anigozanthos humilis</i> subsp. <i>chrysanthus</i> (P4). 1 individual <i>Meeboldina decipiens</i> subsp. <i>decipiens</i> ms (P3). 98.6 ha of high value Black Cockatoo habitat and 28 ha of moderate value. 3.8 ha of TEC SCP20a. <p>Land tenure: Class A Nature Reserve/ State Forest. 31.5 ha impacted Bush Forever Sites overlap/within the abovementioned State Forest and Nature Reserve.</p> <p>Timescale: Permanent.</p>	Offset Proposal 1	Low – land to be acquired and transferred to conservation estate.	This is not applicable for land acquisition – see risk comments.	No time lag. The proposed offset site has already been acquired and is in the process of being ceded to the Conservation Commission.	Acquisition and ceding of 673.5 ha to Conservation Commissions with the intention that the land will become a conservation reserve and be managed by the DPAW in the long term.
TECs <p>Removal of 0.4 ha of inferred SCP02 (Southern wet shrublands).</p> <p>The existence of this TEC will be confirmed during spring 2015 surveys and the information will be provided to OEPA during the response to submissions period.</p>	Through design efficiencies the proposal footprint has also been refined to reduce the impact to inferred SCP02 from 1.1 ha to 0.4 ha.	No rehabilitation possible. MRWA will work to minimise its footprint, and will locate any temporary construction areas (i.e. laydown areas) outside of this TEC.	N/A	<p>Extent: 0.4 ha of inferred SCP02.</p> <p>Quality: Very Good condition.</p> <p>Conservation significance: State listed TEC.</p> <p>Land Tenure: N/A.</p> <p>Timescale: Permanent.</p>	Offset Proposal 3	Low – land to be acquired and transferred to conservation estate or covenanted and managed in perpetuity	This is not applicable for land acquisition – see risk comments.	–	MRWA will fund the acquisition or covenanting of 1 ha of TEC SCP02, subject to the confirmation of the presence of TEC SCP02 within the proposal footprint following further surveys.

Existing environment and impact	Mitigation			Significant residual impact	Offset calculation methodology				
	Avoid and minimise	Rehabilitation type	Likely rehab. success		Type	Risk	Likely offset success	Time lag	Offset quantification
TECs Removal of 4.0 ha of inferred SCP20a (<i>Banksia attenuata</i> woodlands over species rich dense shrublands). The extent of this TEC will be confirmed during spring 2015 surveys and the information will be provided to OEPA during the response to submissions period.	A location of inferred SCP20a along Reid Highway, east of the Reid Tonkin interchange, has been avoided. Through design efficiencies the proposal footprint has been refined to reduce the impact to inferred SCP20a from 4.3 ha to 4.0 ha.	No rehabilitation possible. MRWA will work to minimise its footprint, and will locate any temporary construction areas (i.e. laydown areas) outside of any known locations of this TEC.	N/A	Extent: 4.0 ha of inferred SCP20a. Quality: Mostly in Excellent condition. Conservation significance: State listed TEC. Land tenure: N/A. Timescale: Permanent.	Offset Proposal 1	Low – land to be acquired and transferred to conservation estate.	This is not applicable for land acquisition – see risk comments.	No time lag. The proposed offset site has already been acquired and is in the process of being vested with the Conservation Commission.	Acquisition and ceding of 673.5 ha to Conservation Commission with the intention that the land will become a conservation reserve and be managed by the DPAW in the long term. This site provides 78 ha of inferred TEC SCP20a.
CCWs Partial or complete filling of seven CCWs totalling 14.8 ha. Loss of ecosystem function in a portion of one CCW isolated by the proposal (1.2 ha).	Design changes have been employed to avoid impacts to one CCW (UFI 8914) and an additional 17.8 ha of CCW within the development envelope.	No rehabilitation possible. MRWA will work to minimise its footprint, and will locate any temporary construction areas (i.e. laydown areas) outside of any known CCW locations.	N/A	Extent: Complete loss of one CCW (0.9 ha) and partial loss of an additional six CCWs (13.9 ha). Indirect loss of 1.2 ha of CCW. Quality: Varying condition. Conservation significance: Conservation Category wetland. Land tenure: N/A. Timescale: Permanent.	Land acquisition and/or covenant.	Low – land is expected to be either vested with the Conservation Commission, or covenanted with the intention that the land will be managed for conservation in the long term.	This is not applicable for land acquisition – see risk comments.	–	MRWA will fund the acquisition or covenanting of a property or properties to be managed for conservation or for improved management or rehabilitation to offset the loss of CCWs. The properties acquired/ covenanted will collectively contain at least 32 ha of CCWs.



18 CONCLUSION

MRWA is proposing to construct a new 38 km section of the PDNH between Malaga and Muchea, Western Australia. The proposal has been driven by traffic congestion, increased travel times and reduced amenity on the existing PDNH along the Great Northern Highway. Construction is scheduled to commence in 2016 or 2017 and will proceed in stages.

This PER has presented the EPA's preliminary key environmental factors for the proposal as well as other environmental and integrating factors requiring consideration. MRWA believes that the proposal can meet the EPA's objective for each of the environmental and integrating factors addressed, as well as requirements under the EPBC Act.

The proposal will result in the loss of 205 ha of native vegetation, impacts to two state-listed TECs and five state-listed PECs. Five Priority flora species are located in the proposal footprint, though no threatened flora will be cleared. Approximately 128 ha of native vegetation within Bush Forever Sites will be cleared. With the appropriate mitigation measures and offsets for Threatened and Priority flora, TECs and native vegetation, the proposal is likely to meet the EPA's objectives.


Clearing will result in the loss of 159 ha of natural fauna habitats. Fauna habitat will become more fragmented and susceptible to edge effects; however, the provision of fauna underpasses in key locations will help to maintain ecological connectivity.

Black Cockatoo habitat expected to be cleared includes foraging habitat (201.8 ha for Carnaby's Cockatoo and 120.1 ha for Red-tailed Black Cockatoo), 58.6 ha of roosting habitat, 120.1 ha of potential breeding habitat and 737 suitable breeding trees. Acceptable mitigation measures and offset strategies to manage the potential impacts on Black Cockatoo species to meet the EPA objectives, will be implemented.

Conservation significant species for which habitat is expected to be lost include Great Egret (15.5 ha), Cattle Egret (271.2 ha), Rainbow Bee-eater (367.5 ha), Jewelled Sandplain Ctenotus (81.7 ha), Black Striped-snake (124.8 ha), Western Carpet Python (124.8 ha), Western Brush Wallaby (124.8 ha) and Southern Brown Bandicoot (19.0 ha).

The proposal will result in the loss of one conservation category wetland (0.9 ha), direct impacts to another six conservation category wetlands (13.9 ha) and indirect impacts to one further wetland (1.2 ha). Four resource enhancement wetlands will also be partially lost (14.0 ha). Hydrological and hydrogeological impacts are otherwise expected to be limited to minor localised alterations to surface water flows and groundwater levels. The existing surface water flow regime will be maintained as much as possible by the incorporation of retention basins and drainage culverts into the design. The proposal will result in benefits to the Lexia wetlands as public access will be restricted and associated rubbish dumping activities being curtailed by the presence of the highway. The proposal will be managed to ensure that surrounding hydrological regimes and ecosystem function is maintained and so it is considered that the proposal is likely to meet the EPA's objectives for hydrological processes and inland waters environmental quality.

Revegetation of areas disturbed only during construction will ensure stability of roadside soils. In the long term, revegetation will enhance the ecological function of adjacent native vegetation, assisting in the conservation of local biodiversity values and contributing towards amenity and aesthetics. Implementation of the revegetation strategy and associated management measures will meet the EPA's objective to ensure that the proposal footprint is rehabilitated in an ecologically sustainable manner, consistent with agreed outcomes and land uses, and without unacceptable liability to the State.



The proposal will impact four registered Aboriginal heritage places. The temporary disturbance of Ellen Brook and other watercourses is not considered to have a significant effect on Aboriginal heritage values. The registered Aboriginal Site DAA Place ID 20058 is not extant, having been destroyed in the 1990s, and construction will have no additional impact. Lightning Swamp (DAA Place ID 21393), adjacent to Reid Highway, will be impacted through construction of the proposal. However, the impact was not described by Aboriginal representatives as significant.

Four European heritage sites will also be impacted during construction. The European heritage in the proposal footprint is of limited archaeological or cultural value and is not included on any Commonwealth or State statutory heritage lists. The demolition/clearing of these places is not likely to adversely affect any historical or cultural associations. As such, the proposal is considered likely to meet the EPA's objectives for heritage. An application under Section 18 of the AH Act will be submitted to the DAA to obtain approval to disturb these sites within the proposal footprint.

Traffic noise from the operation of the proposal will be managed in accordance with the provisions of SPP5.4. For areas between Reid Highway and Hepburn Avenue the noise limit of 60 dB L_{Aeq} can be achieved through the construction of noise walls. For areas between Hepburn Avenue and Ellenbrook, the noise target of 55 dB L_{Aeq} will be achievable. Noise wall heights will be capped at a maximum height of 5m to reduce visual and amenity impacts. The noise limit of 60 dB L_{Aeq} will not be exceeded at any noise sensitive receptors along this section of the proposal. It is expected that the daytime noise target of 55 dB L_{Aeq} will not be achieved at eight rural residential properties north of Ellenbrook due to limitations on noise wall locations. All reasonably practical management measures will be implemented to meet the EPA's objectives in respect of noise north of Ellenbrook.


The proposal will result in the loss of land on which recreational infrastructure had been planned in Dick Perry Reserve. Construction of the proposal will result in a reduction in the size of the proposed reserve and the potential for its use as community open space. Amenity to users of Whiteman Park is expected to be largely unaffected, as none of the facilities used by the community will be disturbed by the proposal. Vegetation clearance, habitat fragmentation and fauna mortalities from vehicle interactions are the principal impacts to Whiteman Park and have been addressed under the relevant environmental factors.

The proposal will impact a number of conservation areas, including requiring the excision of 8 ha of Class A Nature Reserve (46919 and 46920), 106 ha of Gngangara–Moore River State Forest (No. 65) and the clearing 128 ha of intact native vegetation across nine Bush Forever sites (including sites 97, 100, 192, 198, 300, 304, 307, 399 and 480). The area to be excised through the State excision process has been minimised as far as practicable, whilst ensuring a suitably sized development envelope to accommodate a safe and efficient highway in these areas and so is likely to meet the EPA's objective, even before consideration of the proposed offsets.

Matters of National Environmental Significance under the EPBC Act will be directly affected by the proposal. The proposal will not impact on any known TECs or any Threatened flora species. Five fauna species listed under the EPBC Act will be impacted by the proposal, including the Carnaby's Black Cockatoo, Forest Red-tailed Black Cockatoo, Great Egret, Cattle Egret and Rainbow Bee-eater. Impacts to these species comprise the habitat loss and degradation described above.

A 4.05 km section of Commonwealth land, managed by the DOD, will be impacted by the proposal. Impacts to this land include the loss of conservation category wetlands (0.4 ha of CCW 8773 and 40 m² of CCW 8909), 26 suitable breeding trees for Black Cockatoos, water bores, remnant portions of land and local road access.

As the residual impacts to flora and vegetation, conservation significant fauna and wetlands are likely to be significant, the proposal will include measures to offset the remaining impacts for these environmental factors. To offset the loss of Black Cockatoo habitat under both Western Australian and Commonwealth



legislation, removal of conservation areas, the TEC SCP20a and native vegetation, the proposal will provide for the vesting of a 674 ha portion of land in Chittering as a Class A Nature Reserve. Offsets for remaining impacts to wetlands are in development and will be subject to the approval of the EPA. Once implemented, MRWA expects that the offsets will enable the proposal to meet the EPA's objectives for flora and vegetation, terrestrial fauna, hydrological processes and inland waters environmental quality.

When the offsets described in Chapter 17 are implemented, MRWA believes that all of the EPA's objectives for environmental and integrating factors will be met.



This page is intentionally blank.


19 GLOSSARY

19.1 Abbreviations


Term	Definition
AAQ NEPM	National Environment Protection (Ambient Air Quality) Measure
ACMA	Australian Communications and Media Authority
AH Act	<i>Aboriginal Heritage Act 1972</i>
AHD	Australian Height Datum
AHIS	Aboriginal Heritage Inquiry System
ASA	Airservices Australia
ASS	acid sulfate soils
BAM Act	<i>Biosecurity and Agricultural Management Act 2007</i>
BOM	Bureau of Meteorology
Bonn Convention	Convention on migratory species that aims to conserve terrestrial, aquatic and avian migratory species throughout their range
CALM Act	<i>Conservation and Land Management Act 1984</i>
CAMBA	China-Australia Migratory Bird Agreement
CAR	comprehensive, adequate and representative
CCTV	closed-circuit television
CCW	Conservation Category Wetland
CO	carbon monoxide
CR	Critically Endangered
CS Act	<i>Contaminated Sites Act 2003</i>
DAA	Department of Aboriginal Affairs
DBH	diameter at breast height
DEC	Department of Environment and Conservation
DER	Department of Environment Regulation
DFES	Department of Fire and Emergency Services
DMP	Department of Mines and Petroleum
DOD	Department of Defence
DOP	Department of Planning
DOE	Department of the Environment



Term	Definition
DOW	Department of Water
DPAW	Department of Parks and Wildlife
EAG	Environmental Assessment Guideline
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
EMS	Environmental Management System
EN	Endangered
EP Act	<i>Environmental Protection Act 1986</i>
EPA	Environment Protection Authority
EPBC Act	<i>Environment Protection and Biodiversity Conservation Act 1999</i>
EPP Lakes	<i>Environmental Protection (Swan Coastal Plain Lakes) Policy 1992</i>
ESD	Environmental Scoping Document
EWNSR	East Wanneroo North-South Route
EWR	ecological water requirements
FCT	floristic community type
FPC	Forest Products Commission
GDEs	groundwater dependent ecosystems
GHPDP	Government Heritage Property Disposal Process
GNH	Great Northern Highway
GSS	Gnangara Sustainability Strategy
IBRA	Interim Biogeographic Regionalisation of Australia
ISCA	Infrastructure Sustainability Council of Australia
ISO 14001	AS/NZS ISO 14001:2004 Environmental management systems—Requirements with guidance for use
IUCN	International Union for the Conservation of Nature
IWSS	Integrated Water Supply Scheme
JAMBA	Japan-Australia Migratory Bird Agreement
LA Act	<i>Land Administration Act 1997</i>
M	Migratory
MNES	Matters of National Environmental Significance
MRS	Metropolitan Region Scheme
MRWA	Main Roads Western Australia




Term	Definition
MUW	Multiple Use Wetland
OEPA	Office of Environmental Protection Authority
P1	Priority 1
P2	Priority 2
P3	Priority 3
P4	Priority 4
P5	Priority 5
PASS	pyrite acid sulfate soils
PBP	Perth Biodiversity Project
PDNH	Perth–Darwin National Highway
PEC	Priority Ecological Community
PER	Public Environmental Review
PMST	Protected Matters Search Tool
PMR	Perth Metropolitan Region
PSP	Principal Shared Path
REW	Resource Enhancement Wetland
RIWI Act	<i>Rights in Water and Irrigation Act 1914</i>
RMP	Rehabilitation Management Plan
ROKAMBA	Republic of Korea-Australia Migratory Bird Agreement
RTAA	road train assembly area
S1	Schedule 1
S2	Schedule 2
S3	Schedule 3
S4	Schedule 4
SAPPR	Strategic Assessment of Perth-Peel Region
SCP	Swan Coastal Plain
SCOTI	Standing Council on Transport and Infrastructure
SKM	Sinclair Knight Merz
SPP 2	Statement of Planning Policy No. 2: Environment and Natural Resources Policy
SPP 2.8	State Planning Policy No. 2.8: Bushland Policy for the Perth Metropolitan Region
SRE	short-range endemic
SWALSC	South-West Aboriginal Land and Sea Council



Term	Definition
SWA02	Perth subregion 2
TEC	Threatened Ecological Community
TGS	Tonkin Grade Separations
TSS	total suspended solids
UFI	unique feature identifier
UPDC	Ultimate Planning Design Concept
UWPCA	Underground Water Pollution Control Area
VU	Vulnerable
WA	Western Australia
WAH	Western Australian Herbarium
WALGA	Western Australian Local Government Association
WAPC	Western Australia Planning Commission
WC Act	<i>Wildlife Conservation Act 1950</i>
WHPZ	Wellhead Protection Zone
WONS	weeds of national significance
WPP	weed prioritisation process

19.2 Units and Symbols

°	degrees
%	percentage
°C	degrees Celsius
dB	decibel
ha	hectare
km	kilometre
kg	kilogram
L_{Aeq}	average noise energy
$L_{A10,18\text{ hour}}$	the average of the hourly L_{a10} (noise level exceeded for 10% of the measuring period) levels between 6.00 a.m. and midnight
$L_{Aeq\text{ (Day)}}$	the average of the hourly L_{aeq} levels between 6.00 a.m. and 10.00 p.m.
$L_{Aeq\text{ (Night)}}$	the average of the hourly L_{aeq} levels between 10.00 p.m. and 6.00 a.m.
m	metre
m^2	square metre
mm	millimetre



NO ₂	nitrogen dioxide
O ₃	Ozone
Pb	Lead
SO ₂	sulfur dioxide
µm	micron <i>or</i> micrometre

19.3 Definitions

A

Amenity *n.* features, facilities, or services of a house, estate, district, etc., which make for a comfortable and pleasant life.

B

Bilateral agreement *adj.* a bilateral agreement is an agreement between the Commonwealth and a state or self-governing territory, which either accredits certain environmental impact assessment processes of that state or territory (an assessment bilateral) or delegates to a state or self-governing territory the authority to decide whether to approve an action. Under an assessment bilateral agreement, the Australian Government Minister for the Environment remains responsible for deciding whether an action requires assessment and whether to approve an action.

Bonn Convention *n.* a convention on migratory species that aims to conserve terrestrial, aquatic and avian migratory species throughout their range.

Bush Forever sites *n.* a plan designed to identify, protect and manage regionally significant bushland in metropolitan Perth.

C

Carriageway *n.* each of the two sides of a dual carriageway or motorway, each of which usually have two or more lanes.

Controlled action *adj.* a proposed action that is likely to have a significant impact on: a matter of national environmental significance; the environment of Commonwealth land (even if taken outside Commonwealth land); or the environment anywhere in the world (if the action is undertaken by the Commonwealth).


Congestion *adj.* condition on road networks that occurs as use increases, and is characterized by slower speeds, longer trip times, and increased vehicular queueing. The most common example is the physical use of roads by vehicles.

Constrained area *n.* an area where there is an expectation that development will be able to proceed, this may include urban, urban deferred or industrial zoned land or land with existing development approvals.

Cosmopolitan distribution *n.* a wide ranging species found across all or most of the world in appropriate habitats.

D

Dampland *n.* a type of vegetation characterised by occasional *Eucalyptus rudis* trees over *Melaleuca preissiana* and/or *Melaleuca raphiophylla* low woodland over occasional heath scrub dominated by *Pericalymma spp.*, *Astartea spp.* and *Melaleuca spp.* over sedges and rushes. This habitat type is an area where moisture collects and during the winter months becomes seasonally waterlogged.



Dieback *n.* a condition of plants observed to start at the outer leaf tips causing gradual yellowing, loss of leaves and progressive lifelessness; may be caused by a variety of agents including salinity, drought, insect damage or plant pathogens such as the fungus *Phytophthora cinnamomi*.

Development envelope *n.* the area for which Main Roads WA is seeking approval to implement the proposal within.

E

Edge effect *n.* refers to the changes in population or community structures that occur at the boundary of two habitats.

Ephemeral creek *adj.* a creek or portion of a creek which flows briefly in direct response to precipitation in the immediate vicinity and whose channel is at all times above the ground water reservoir.

Environmental offset *n.* is an offsite action or actions to address significant residual environmental impacts of a development or activity.

Eutrophication *n.* a form of water pollution involving an excess of mineral nutrients such as nitrates and phosphorus leaching from soils; often the result of pollution from sewage effluent, soil fertilisers.

F

Facultative *v.* the capacity to live under more than one specific set of environmental conditions, does not rely on groundwater in order to survive (opposed to obligate).

Flyovers *n.* a high-level overpass, built above main overpass lanes, or a bridge built over what had been an at-grade separation.

Foraging *n.* the seeking or obtaining of food.

G

Grade separation *n.* is the method of aligning a junction of two or more surface transport axes at different heights (grades) so that they will not disrupt the traffic flow on other transit routes when they cross each other.

H

Habitat fragmentation *n.* is the process by which habitat loss results in the division of large, continuous habitats into smaller, more isolated remnants.

I

Intergenerational equity *n.* the concept of fairness or justice owed by each generation or age group to the others; especially significant in considerations of what environment future generations will inherit.

L

LIDAR *n.* a detection system which works on the principle of radar, but uses light from a laser.


O

Obligate *v.* require access to groundwater to meet all or some water requirements in order to survive (opposed to facultative).

P

Pinch point *n.* a point where two areas meet creating a bottleneck for native flora and fauna.

Precautionary principle *n.* an ethical and political principle, applying particularly in the environmental context, which states that if there is the risk of serious or irreversible harm occurring to people or to the



environment, lack of full scientific certainty about the existence of the risk should not be used as a reason for failing to take or for postponing measures to prevent it.

Predation *n.* the killing of an individual of another species as a habitual source of food.

Proposal footprint *n.* the area required to be disturbed based on the proposal's current design.

R

Rehabilitation *adj.* is the repair of ecosystem processes and includes the management of weeds, disease or feral animals.

S

Salinisation *n.* the gradual increase in salinity of soil such as the introduction of brackish water.

Short-range endemic *n.* species of animal (predominantly Invertebrates) that have a restricted distribution, less than 10,000 km².

Study area *n.* is the survey area identified in the initial design footprint and will differ depending on the specialist study.

T

Topographical *adj.* relating to the arrangement or accurate representation of the physical features of an area.

V

Vadose zone *adj.* of, relating to, or resulting from water found above the watertable.

Vegetation association *n.* a concept that covers two or more plant communities with similar structure and dominant species. May vary significantly in associated species but all stands referred to it will have some visual similarity.

Vegetation complex *n.* a concept that covers a range of structural types that occur in a related pattern with borders defined by major geomorphological units with some subdivision on floristics between southern and northern parts of the geomorphological units.

W

Wetland *n.* an area in which the soil is frequently or permanently saturated with or under water, as a swamp, marsh.



This page is intentionally blank.




20 REFERENCES

Publications


- 360 Environmental. 2013. Black Cockatoo Assessment – Tonkin Highway. December. Report prepared for Main Roads Western Australia by 360 Environmental Pty Ltd.
- 360 Environmental. 2014a. Swan Valley Bypass, Perth–Darwin National Highway: Level 2 Flora and Vegetation Survey. February. Draft report prepared for Main Roads Western Australia by 360 Environmental Pty Ltd.
- 360 Environmental. 2014b. General Stratigraphy, Wetland Hydrology and Wetland Vegetation – Swan Valley Bypass NorthLink WA. July. Prepared for Main Roads Western Australia by 360 Environmental Pty Ltd.
- 360 Environmental. 2014c. Tonkin Grade Separations: Flora, Vegetation and Fauna Survey. February. Report prepared for Main Roads Western Australia by 360 Environmental Pty Ltd.
- Amergin. 2014. Report of an Aboriginal Heritage Desktop Assessment of the NorthLink WA Project (Perth–Darwin National Highway). December. Prepared for Main Roads Western Australia by Amergin Consulting (Australia) Pty Ltd.
- Amergin. 2015. Report of an Ethnographic Aboriginal Heritage Survey of the Proposed NorthLink WA Project. Part 2: Perth–Darwin National Highway. May. Report prepared for Main Roads Western Australia on behalf of Coffey Environments Pty Ltd and BG&E Pty Ltd by Amergin Consulting (Australia) Pty Ltd.
- Bamford. 2011. Roads and Wildlife. A Review of Purpose-Built Fauna Underpasses. July. Report prepared by M.J. and A.J. Bamford Consulting Ecologist for City of Armadale.
- Barrett, G., Silcocks, A., Barry, S., Cunningham, R. and Poulter, R. 2003. The New Atlas of Australian Birds. Royal Australasian Ornithologists Union, Melbourne, Victoria.
- Beard, J. S. 1990. Plant Life of Western Australia. Kangaroo Press, Kenthurst, New South Wales.
- Beer, J. and Fox, M. 1997. Conserving vegetation in fragmented rural landscapes: edge effects and eucalypt forest remnants. In Conservation Outside Nature Reserves. Edited by Hale, P. and Lamb, D. Centre for Conservation Biology, The University of Queensland.
- BG&E. 2015. Drainage Strategy. NorthLink WA Perth–Darwin National Highway. May. Report prepared for NorthLink WA by BG&E Pty Ltd.
- Brown, P. H., Davis, R. A., Sonneman, T. and Kinloch, J. 2009. Ecological Linkages proposed for the Gngangara Groundwater System. May. Report prepared on behalf of the Department of Environment and Conservation for the Gngangara Sustainability Taskforce, Department of Water, Perth, Western Australia.
- Burbidge, A. A., Kuchling, G., Olejnik, C. and Mutter, L. 2010. Western Swamp Tortoise (*Pseudemydura umbrina*) Recovery Plan. Wildlife Management Program No. 50. Department of Environment and Conservation, Western Australia.
- Burnham, Q., Barrett, G., Blythman, M. and Scott, R. 2010. Carnaby's Cockatoo (*Calyptrorhynchus latirostris*) identification of nocturnal roost sites and the 2010 Great Cocky Count. August. Report prepared for the Department of Environment and Conservation, Western Australia.


- 
- Bush, B., Maryan, B., Browne-Cooper, R. and Robinson, D. 2007. Reptiles and Frogs in the Bush: Southwestern Australia. UWA Press, Nedlands, Western Australia.
- Bush, B., Maryan, B., Browne-Cooper, R. and Robinson, D. 2010. Field Guide to Reptiles and Frogs of the Perth Region. 2nd ed. Western Australian Museum, Welshpool, Western Australia.
- Cale, B. 2003. Carnaby's Black-Cockatoo (*Calyptrorhynchus latirostris*) Recovery Plan. Report prepared by Department of Conservation and Land Management, Wanneroo, Western Australia.
- CALM et al. Undated. Gnangara Park Concept Plan. Prepared by a Technical Working Group consisting of: Department of Conservation & Land Management, Water & Rivers Commission, Water Corporation, Ministry for Planning, Department of Environmental Protection.
- CALM. 2004. Recreation Master Plan (3 year): Dick Perry Reserve. October. Department of Conservation and Land Management, Western Australia.
- CALM. 2006. Community of Tumulus (organic mound) springs of the Swan Coastal Plain Interim Recovery Plan No. 198. Department of Conservation and Land Management, Perth, Western Australia.
- Chapman, T. 2007. Forest Black Cockatoo (Baudin's Cockatoo *Calyptrorhynchus baudinii* and Forest Red-tailed Black Cockatoo *Calyptrorhynchus banksii naso*) Recovery Plan 2007–2016. January. Report prepared for the Forest Black Cockatoo Recovery Team by Department of Environment and Conservation, Western Australia.
- Coffey. 2014. Environmental values of the Neaves Road, Bullsbrook Wetlands, NorthLink WA Perth–Darwin National Highway. Memorandum. 27 October 2014.
- Coffey. 2015a. Level 2 Spring Flora and Vegetation Assessment: NorthLink WA Perth–Darwin National Highway. May. Report prepared for NorthLink WA by Coffey Environments Australia Pty Ltd, Burswood, Western Australia.
- Coffey. 2015b. Level 2 Targeted Fauna Assessment: NorthLink WA Perth–Darwin National Highway. March. Report prepared for NorthLink WA by Coffey Environments Australia Pty Ltd, Burswood, Western Australia.
- Coffey. 2015c. Perth–Darwin National Highway Level 1 fauna assessment of local roads and additional areas. Memorandum. Coffey Environments Australia, Burswood, Western Australia.
- Coffey. 2015d. Wetland Assessment. NorthLink WA Perth–Darwin National Highway. March. Prepared for NorthLink WA by Coffey Environments Australia Pty Ltd, Burswood, Western Australia.
- Coffey. 2015e. Preliminary Acid Sulfate Investigation. NorthLink WA Perth–Darwin National Highway. January. Report prepared for NorthLink WA by Coffey Environments Australia Pty Ltd, Burswood, Western Australia.
- Coffey. 2015f. Flora, Vegetation and Fauna Assessment. 570 Ippolo Road, Chittering. NorthLink WA Perth–Darwin National Highway. March. Draft report prepared for NorthLink WA by Coffey Environments Australia Pty Ltd, Burswood, Western Australia.
- DEC. 2009. Grand Spider Orchid (*Caladenia huegelii*) Recovery Plan. Department of Environment and Conservation, Kensington, Western Australia.
- DEC. 2011. Acid Sulfate Soils Guideline Series: Treatment and management of soils and water in acid sulfate soil landscapes. July. Prepared by Contaminated Sites Branch Environmental Regulation Division Department of Environment and Conservation.
- DEC. 2012a. A guide to managing and restoring wetlands in Western Australia. Department of Environment and Conservation, Perth, Western Australia.


- 
- DEC. 2012b. Fauna profiles: Carpet Python *Morelia spilota*. Fauna profiles. February. Department of Environment and Conservation.
- DEC. 2013a. Acid Sulfate Soils Guideline Series: Identification and Investigation of Acid Sulfate Soils and Acidic Landscapes. March. Prepared by Contaminated Sites Branch Environmental Regulation Division Department of Environment and Conservation, Perth, Western Australia.
- DEC. 2013b. Identification and investigation of acid sulfate soils and acidic landscapes. March. Report prepared by Contaminated Sites Branch, Department of Environment and Conservation, Western Australia.
- DEWHA. 2010. Survey guidelines for Australia's threatened birds. Department of the Environment, Water, Heritage and the Arts.
- DOE. 2013. Matters of National Environmental Significance. Significant Impact guidelines 1.1. Department of the Environment, Canberra, Australian Capital Territory.
- DOE. 2014a. Client Service Charter: New Alignment of the Perth–Darwin National Highway (Swan Valley Section), Western Australia (EPBC 2013/7042). February. Department of the Environment.
- DOE. 2014b. Australia's Bioregions (IBRA). A WWW publication accessed in July at <http://www.environment.gov.au/topics/land/national-reserve-system/science-maps-and-data/australias-bioregions-ibra>. Department of the Environment.
- DOE. 2014c. EPBC Act Protected Matters Report. A custom report generated on 14 November 2014 using the Protected Matters Search Tool at <http://www.environment.gov.au/webgis-framework/apps/pmst/pmst.jsf>. Department of the Environment.
- DOE. 2014d. *Ardea modesta* – Eastern Great Egret. Species Profile and Threats Database. A WWW publication accessed on 1 December 2014 at http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=82410. Department of the Environment, Canberra, Australian Capital Territory.
- DOE. 2014e. *Calyptorhynchus banksii naso* – Forest Red-tailed Black-Cockatoo, Karrak. Species Profile and Threats Database. A WWW publication accessed on 1 December 2014 at http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=67034. Department of the Environment, Canberra, Australian Capital Territory.
- DOE. 2014f. EPBC Act Protected Matters Report. A custom report generated on 3 July 2014 using the Protected Matters Search Tool at <http://www.environment.gov.au/webgis-framework/apps/pmst/pmst.jsf>. Department of the Environment.
- DOE. 2014g. *Pseudemydura umbrina* – Western Swamp Tortoise. Species Profile and Threats Database. A WWW publication accessed on 1 December 2014 at http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=1760. Department of the Environment, Canberra, Australian Capital Territory.
- DOE. 2015. *Calyptorhynchus latirostris* — Carnaby's Black Cockatoo, Short-billed Black Cockatoo. A WWW publication accessed on 23 January 2015 at http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=59523. Department of the Environment, Canberra, Australian Capital Territory.
- DOW. 2004. Stormwater Management Manual. February. Department of Water, Perth, Western Australia.
- DOW. 2006a. Roads near sensitive water resources. Water Quality Protection Note 44. October. Department of Water, Perth, Western Australia.

- 
- DOW. 2006b. Vegetation buffers to sensitive water resources. Water Quality Protection Note 6. February. Department of Water, Perth, Western Australia.
- DOW. 2006c. Land use planning in Public Drinking Water Source Areas. Water Quality Protection Note 76. March. Department of Water, Perth, Western Australia.
- DOW. 2009a. Gnamptarra groundwater areas allocation plan. Water resource allocation and planning series. No. 30. November. Department of Water, Perth, Western Australia.
- DOW. 2009b. Protecting public drinking water source areas. Water Quality Protection Note 36. February. Department of Water, Perth, Western Australia.
- DOW. 2009c. Decision process for stormwater management in WA. August. Department of Water, Perth, Western Australia.
- DPAW. 2013a. Carnaby's Cockatoo (*Calyptorhynchus latirostris*) Recovery Plan. October. Department of Parks and Wildlife, Western Australia.
- DPAW. 2013b. 2013 Statewide Vegetation Statistics incorporating the CAR Reserve Analysis (Full Report). Current as of June 2013. A WWW publication available at <https://www2.landgate.wa.gov.au/web/guest/downloader>. Department of Parks and Wildlife, Perth, Western Australia.
- DPAW. 2013c. Weed Prioritisation Process for DPAW (formerly DEC) - An integrated approach to Weed Management on DPAW-managed lands in WA. November. Department of Parks and Wildlife, Western Australia.
- DPAW. 2013d. A methodology for the evaluation of specific wetland types on the Swan Coastal Plain, Western Australia. August. Draft report prepared by Department of Parks and Wildlife, Bentley, Western Australia.
- DPAW. 2014a. Threatened and Priority Flora Information. Custom report 11-0714FL generated on 7 July 2014 by Department of Parks and Wildlife, Kensington, Western Australia.
- DPAW. 2014b. FloraBase custom search. A WWW publication at <https://florabase.dpaw.wa.gov.au/>. Department of Parks and Wildlife.
- DPAW. 2014c. Threatened and Priority Fauna Database. Custom report No. 4849 generated on 11 July 2014 by Department of Parks and Wildlife, Kensington, Western Australia.
- DPAW. 2014d. NatureMap Species Report. A custom report generated on 3 July 2014 using the Species By Area tool at <http://naturemap.dpaw.wa.gov.au/default.aspx>. Department of Parks and Wildlife.
- DPAW. 2015. Threatened and Priority Ecological Community Database Searches. Custom report 10-0714EC generated on 19 February 2015 by Department of Parks and Wildlife, Kensington, Western Australia.
- DSEWPAC. 2011. Survey guidelines for Australia's threatened reptiles. Department of Sustainability, Environment, Water, Population and Communities.
- DSEWPAC. 2012a. Offsets Assessment Guide. A WWW publication accessed at <http://www.environment.gov.au/epbc/publications/epbc-act-environmental-offsets-policy>. Department of Sustainability, Environment, Water, Population and Communities.
- DSEWPAC. 2012b. How to Use the Offsets Assessment Guide. A WWW publication accessed on 2 February 2015 at <http://www.environment.gov.au/system/files/resources/12630bb4-2c10-4c8e-815f-2d7862bf87e7/files/offsets-how-use.pdf>. Department of Sustainability, Environment, Water, Population and Communities.


- 
- DSEWPAC. 2012c. EPBC Act referral guidelines for three threatened black cockatoo species. Department of Sustainability, Environment, Water, Population and Communities.
- DSEWPAC. 2013. Actions on, or impacting upon, Commonwealth land, and actions by Commonwealth agencies. Significant impact guidelines 1.2. Department of Sustainability, Environment, Water, Population and Communities. Canberra, Australian Capital Territory.
- English, V. and Blyth, J. 2000. *Corymbia calophylla* - *Xanthorrhoea preissii* woodlands and shrublands (Swan Coastal Plain Community type 3c - Gibson et al. 1994) Interim Recovery Plan 2000-2003. No. 60. January. Western Australian Threatened Species and Communities Unit, Department of Conservation and Land Management, Wanneroo, Western Australia.
- Environment Australia. 2001. National Objectives and Targets for Biodiversity Conservation 2001 - 2005. Report prepared by Environment Australia for the Department of Environment and Heritage. Canberra, Australian Capital Territory.
- EPA and DEC. 2010. Technical Guide – Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment. September. Environmental Protection Authority and Department of Environment and Conservation, Perth, Western Australia.
- EPA. 2000. Position Statement No. 2: Environmental Protection of Native Vegetation in Western Australia. December. Environmental Protection Authority.
- EPA. 2002a. Guidance for the Assessment of Environmental Factors – Guidance Statement for Minimising Greenhouse Gas Emissions No. 12. October. Environmental Protection Authority, Western Australia.
- EPA. 2002b. Position Statement No. 3: Terrestrial Biological Surveys as an Element of Biodiversity Protection. March. Environmental Protection Authority.
- EPA. 2003. Guidance for the Assessment of Environmental Factors – Implementing Best Practice in proposals submitted to the Environmental Impact Assessment process. No. 55. December. Environmental Protection Authority, Western Australia.
- EPA. 2004a. Guidance for the Assessment of Environmental Factors – Assessment of Aboriginal Heritage No. 41. April. Environmental Protection Authority, Perth, Western Australia.
- EPA. 2004b. Guidance for the Assessment of Environmental Factors – Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia No. 51. June. Environmental Protection Authority, Western Australia.
- EPA. 2004c. Guidance for the Assessment of Environmental Factors – Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia No. 56. June. Environmental Protection Authority, Western Australia.
- EPA. 2004d. Position Statement No. 4: Environmental Protection of Wetlands. November. Environmental Protection Authority.
- EPA. 2004e. Position Statement No. 7: Principles of Environmental Protection. August. Environmental Protection Authority.
- EPA. 2006a. Guidance for the Assessment of Environmental Factors. No. 6. Rehabilitation of Terrestrial Ecosystems. June. Environmental Protection Authority.
- EPA. 2006b. Guidance for the Assessment of Environmental factors – Level of Assessment for Proposal Affecting Natural Areas within the System 6 Region and Swan Coastal Plain Portion of the System 1 Region No. 10. June. Environmental Protection Authority, Perth, Western Australia.


- 
- EPA. 2006c. Guidance for the Assessment of Environmental Factors – Protection of the Western Swamp Tortoise Habitat, Upper Swan/Bullsbrook. No. 7. June. Environmental Protection Authority, Western Australia.
- EPA. 2007. State of the Environment Report: Western Australia 2007. Department of Environment and Conservation, Perth, Western Australia.
- EPA. 2008. Environmental Guidance for Planning and Development. Guidance Statement No. 33. May. Environmental Protection Authority, Western Australia.
- EPA. 2009. Guidance for the Assessment of Environmental Factors – Sampling of Short Range Endemic Invertebrate Fauna for Environmental Impact Assessment in Western Australia No. 20. May. Environmental Protection Authority, Perth, Western Australia.
- EPA. 2012. Environmental Assessment Guideline for Defining the Key Characteristics of a Proposal. EAG 1. May. Environmental Protection Authority, Western Australia.
- EPA. 2013a. Environmental Assessment Guideline for Recommending environmental conditions. September. EAG 11. Environmental Protection Authority, Western Australia.
- EPA. 2013b. Protection of naturally vegetated areas through planning and development. Environmental Protection Bulletin No. 20. December. Environmental Protection Authority, East Perth, Western Australia.
- EPA. 2014a. Environmental Scoping Document. March. Perth, Western Australia.
- EPA. 2014b. Environmental Assessment Guideline for Consideration of environmental impacts from noise. EAG 13. September. Environmental Protection Authority, Western Australia.
- EPA. 2014c. Environmental Offsets. Environmental Protection Bulletin No. 1. August. Environmental Protection Authority, Western Australia.
- EPA. 2015a. Environmental Assessment Guideline for Environmental principles, factors and objectives. EAG 8. January. Environmental Protection Authority, Western Australia.
- EPA. 2015b. Environmental Assessment Guideline for Application of a significance framework in the environmental impact assessment process. EAG 9. January. Environmental Protection Authority, Western Australia.
- Estill. 2014. Community and Stakeholder Engagement Plan. NorthLink WA Perth–Darwin National Highway. December. Final draft report prepared for NorthLink WA by Estill & Associates.
- Garnett, S. T., Szabo, J. K. and Dutson, G. 2011. The Action Plan for Australian Birds 2010. CSIRO Publishing, Collingwood, Victoria.
- GHD. 2008a. Brief Hydrogeological Review: Threatened Ecological Community – Gaston Road Spring, Bullsbrook, Western Australia. July. Report prepared for MRWA.
- GHD. 2008b. Report for Perth Darwin National Highway Alignment Selection, Raphael Rd Conservation Category Wetland Assessment. August. Report prepared by GHD Pty Ltd for Main Roads Western Australia, Perth, Western Australia.
- GHD. 2009. Wetlands assessment along Raphael Road and Stock Road - PDNH alignment. Memorandum. GHD Pty Ltd, Perth, Western Australia.
- GHD. 2010. Report for Perth - Darwin National Highway, Southern section: Maralla Road, Ellenbrook to Muchea, Alignment Definition Report. February. Report prepared for Main Roads Western Australia by GHD Pty Ltd, Perth, Western Australia.


- 
- GHD. 2012. New Perth Bunbury Highway: Groundwater and Wetland Monitoring. April. Report prepared for Main Roads Western Australia by GHD Pty Ltd.
- GHD. 2013a. Perth Darwin National Highway Alignment Definition Study. Maralla Road, Bullsbrook to Northern Highway, Muchea. Environmental Impact Assessment and Environmental Management Plan. March. Report prepared for Main Roads Western Australia by GHD Pty Ltd, Perth, Western Australia.
- GHD. 2013b. Perth–Darwin National Highway – Tonkin Highway Link Alignment Definition Study: Environmental Impact Assessment and Biological Survey. October. Report prepared for Main Roads Western Australia, by GHD Pty Ltd.
- GHD. 2013c. Mitchell Freeway extension. Flora and fauna assessment report. November. Prepared for Main Roads Western Australia by GHD Pty Ltd.
- Gibson, N., Keighery, B. J., Keighery, G. J., Burbidge, A. H. and Lyons, M. N. 1994. A Floristic Survey of the southern Swan Coastal Plain. Unpublished report for the Australian Heritage Commission prepared by Department of Conservation and Land Management and the Conservation Council of Western Australia (Inc).
- Golder. 2014. Geotechnical, Hydrogeological and Pavement Desk Study. NorthLink WA Perth–Darwin National Highway. July. Report prepared for NorthLink WA by Golder Associates Pty Ltd.
- Golder. 2015. Design Groundwater Level for Northern Section of NorthLink WA Road Alignment. NorthLink WA Perth–Darwin National Highway. April. Report prepared for NorthLink WA by Golder Associates.
- Government of Australia. 2012. Environment Protection and Biodiversity Conservation Act 1999 Environmental Offsets Policy. October. Department of Sustainability, Environment, Water, Population and Communities, Canberra, Australian Capital Territory.
- Government of Western Australia. 2000a. State Planning Policy 1: State Planning Framework Policy. May. Prepared under Section 5AA of the Town Planning and Development Act 1928 by Western Australia Planning Commission, Perth, Western Australia.
- Government of Western Australia. 2000b. Keeping the Bush in the City: Bush Forever. Department of Environmental Protection, Perth, Western Australia.
- Government of Western Australia. 2003. Statement of Planning Policy No. 2. Environment and Natural Resources Policy. June. Western Australian Planning Commission.
- Government of Western Australia. 2005. Statement of Planning Policy 2.2. Gnamptoglossa Groundwater Protection. August. Western Australian Planning Commission.
- Government of Western Australia. 2006. State Planning Policy 2.9: State Planning Framework Policy. December. Prepared under Section 26 of the Planning and Development Act 2005 by Western Australia Planning Commission, Perth, Western Australia.
- Government of Western Australia. 2009. State Planning Policy 5.4: Road and Rail Transport Noise and Freight Considerations in Land Use Planning. September. Prepared under Section 26 of the Planning and Development Act 2005 by Western Australia Planning Commission, Perth, Western Australia.
- Government of Western Australia. 2010. State Planning Policy 2.8. Bushland Policy for the Perth Metropolitan Region. June. Western Australian Planning Commission.
- Government of Western Australia. 2011. WA Environmental Offsets Policy. September. Environmental Protection Authority, Western Australia.
- Government of Western Australia. 2014. WA Environmental Offsets Guidelines. August. Environmental Protection Authority, Western Australia.

- 
- Groom, P. K., Froend, R. H., and Mattiske, E. M. 2000. Impact of groundwater abstraction on a Banksia woodland, Swan Coastal Plain, Western Australia. *Ecological Management and Restoration* 1(2): 117–124.
- Groom, C. 2011. Plants used by Carnaby's Black Cockatoo. April. Department of Environment and Conservation.
- Harvey, M. S. 2002. Short-range endemism amongst the Australian fauna: some examples from non-marine environments. *Invertebrate Systematics* 16(4): 555–570.
- Hedde, E. M., Loneragan, O. W., and Havel, J. J. 1980. Vegetation Complexes of the Darling System. In: *Atlas of Natural Resources, Darling System, Western Australia*. Department of Conservation and Land Management.
- Hill, A. L., Semeniuk, C. A., Semeniuk, V. and Del Marco, A. 1996. Wetlands of the Swan Coastal Plain. Vol. 2b. Wetland Mapping, Classification and Evaluation, Wetland Atlas. Water and Rivers Commission and Department of Environment Protection, Western Australia.
- How, R. A. and Dell, J. 2000. Ground vertebrate fauna of Perth's vegetation remnants: impact of 170 years of urbanization. *Pacific Conservation Biology* 6: 198–217.
- Johnston, T. 2013. Food resource availability for Carnaby's cockatoo *Calyptorhynchus latirostris* on the Swan coastal plain. School of Natural Sciences, Edith Cowan University.
- Johnstone, R. E. and Kirkby, T. 2011. Black Cockatoos on the Swan Coastal Plain. Carnaby's Cockatoo (*Calyptorhynchus latirostris*), Baudin's Cockatoo (*Calyptorhynchus baudinii*) and the Forest Red-tailed Black Cockatoo (*Calyptorhynchus banksii naso*) on the Swan Coastal Plain (Lancelin–Dunsborough), Western Australia. Studies on distribution, status, breeding, food, movements and historical changes. Report prepared for Department of Planning, Western Australia.
- Johnstone, R. E., and Storr, G. M. 1998. Handbook of Western Australian Birds. Vol 1 - Non-Passerines (Emu to Dollarbird). Western Australian Museum, Perth, Western Australia.
- Johnstone, R. E., Johnstone, C. and Kirkby, T. 2008. Carnaby's Cockatoo (*Calyptorhynchus latirostris*) on the northern Swan Coastal Plain (Lancelin-Perth). Report prepared for the Department of the Environment, Water, Heritage and the Arts.
- Johnstone, R. E., Kirkby, T and Sarti, K. 2013. The breeding biology of the Forest Red-tailed Black Cockatoo *Calyptorhynchus banksii naso* Gould in south-western Australia. I. Characteristics of nest trees and nest hollows. *Pacific Conservation Biology* 19:121–142.
- Keighery, B. J. Keighery, G. J. Longman, V. M. and Clarke, K. A. 2012. Native and Weed Flora of the Southern Swan Coastal Plain: 2005 Dataset. Department of Environment and Conservation, Kensington, Western Australia.
- Keighery, B. 1994. Bushland plant survey: A Guide to plant community survey for the community. Wildflower Society of Western Australia, Nedlands, Western Australia.
- Lloyd George Acoustics. 2015a. Pre-Construction Ambient Noise Monitoring. NorthLink WA: Perth–Darwin National Highway. January. Report prepared for NorthLink WA by Lloyd George Acoustics Pty Ltd, Hillarys, Western Australia.
- Lloyd George Acoustics. 2015b. Transportation Noise Assessment. NorthLink WA: Perth–Darwin National Highway Project. June. Draft. Report prepared for NorthLink WA by Lloyd George Acoustics Pty Ltd, Hillarys, Western Australia.

- 
- Mitchell, D., Williams, K. and Desmond, A. 2002. Swan Coastal Plain 2 (SWA2 – Swan Coastal Plain subregion). In A biodiversity audit of Western Australia's 53 Biogeographical Subregions. January. Department of Conservation and Land Management.
- MRWA. 2004. Environmental Guideline: Revegetation Planning and Techniques. Document No. 6707/031. May. Prepared by Main Roads Western Australia.
- MRWA. 2008. Community Engagement Policy. Main Roads Western Australia.
- MRWA. 2009. Perth Darwin National Highway, Maralla Road, Bullsbrook to Brand Highway, Muchea, Department of Defence Land Impact Proposed Resolution Strategy. December. Draft report prepared by Main Roads Western Australia.
- MRWA. 2010. Design of Fauna Underpasses. A WWW publication accessed on 23 January 2015 at https://www.mainroads.wa.gov.au/BuildingRoads/StandardsTechnical/RoadandTrafficEngineering/Roadsideltems/Pages/Design_of_Fauna_Underpasses.aspx. Main Roads Western Australia, East Perth, Western Australia.
- MRWA. 2012a. Perth–Darwin National Highway, Bullsbrook to Bindoon: Planning Summary Report. June. Report prepared by Planning and Technical Services Directorate Road Planning Branch. Perth, Western Australia.
- MRWA. 2012b. Perth Darwin Nation Highway; Strategic Network Review, PDNH – Tonkin Link. March. Main Roads Western Australia, Perth, Western Australia.
- MRWA. 2013a. Perth Darwin National Highway: Tonkin Highway to Muchea (Swan Valley Bypass). Revised Template 1–6 (Section 4). January. Main Roads Western Australia, Perth, Western Australia.
- MRWA. 2013b. Environmental Guideline: Vegetation Placement within the Road Reserve. Document No. 6707/022. November. Prepared by Main Roads Western Australia.
- MRWA. 2013c. Environmental Guideline: Revegetation – Topsoil Management. Document No. 6707/053. August. Prepared by Main Roads Western Australia.
- Murchia, C. 1995. Edge effects in fragmented forests: implications for conservation. *Tree* 10 (2): 58–62.
- NorthLink. 2015a. Tonkin Highway Grade Separation. Business Case. March. Draft report prepared for NorthLink WA.
- NorthLink. 2015b. Twin Swamps Hydrology. NorthLink WA Perth–Darwin National Highway. Position Paper. 30 June 2015.
- NorthLink. 2015c. Hydrogeological PER Considerations – Groundwater Level Impact from Construction Dewatering and Groundwater Abstraction. Position Paper. 30 June 2015.
- NorthLink. 2015d. Road Embankment Assessment (Groundwater). NorthLink WA Perth–Darwin National Highway. Position Paper. 13 July 2015.
- NorthLink. 2015e. Ellenbrook Nature Reserve. NorthLink WA Perth–Darwin National Highway. Position Paper. 30 June 2015.
- OEPA. 2012. Guidelines for Preparing a Public Review. November. Office of the Environmental Protection Authority, Perth, Western Australia.
- Pearson, D., Shine, R. and Williams, A. 2005. Spatial ecology of a threatened python (*Morelia spilota imbricata*) and the effects of anthropogenic habitat change. *Austral Ecology* 30:261–274.

- 
- Phillimore, R. and English, V. 2000. Narrow Curved-leaf Grevillea (*Grevillea curviloba* subsp. *Incurva*) Interim Recovery Plan No. 67, 2000–2003. June. Department of Conservation and Land Management, Wanneroo, Western Australia.
- Pizzey, G. and Knight, F. 2007. A Field Guide to the Birds of Australia. HarperCollins Publishers, Sydney, New South Wales.
- QDMR. 2000. Fauna Sensitive Road Design. Queensland Department of Main Roads, Planning, Design and Environment Division, Brisbane, Queensland.
- Richardson, S., Irvine, E., Froend, R., Boon, P. and Barber, S. 2011. Australian groundwater-dependent ecosystems toolbox part 1: assessment framework. Waterlines report. December. Prepared for National Water Commission, Canberra, Australian Capital Territory.
- Saunders, D. A., Mawson, P. and Dawson, R. 2011. The impact of two extreme weather events and other causes of death on Carnaby's Black Cockatoo: a promise of things to come for a threatened species? *Pacific Conservation Biology* 17:141–148.
- SCOTI. 2012. National Land Freight Strategy. Standing Council on Transport and Infrastructure. Department of Infrastructure and Transport, Canberra Australian Capital Territory.
- SKM. 2000. Perth Darwin National Highway, Alignment Selection Study Area. December. Report prepared for Main Roads Western Australia. Perth, Western Australia.
- Snappy Gum. 2015a. A Report on the Archaeological Assessment of the NorthLink WA Project (Perth–Darwin National Highway). February. Prepared for Main Roads Western Australia on behalf of Amergin Consulting (Australia) Pty Ltd, Coffey Environments Pty Ltd and BG&E Pty Ltd by Snappy Gum Heritage Services Pty Ltd, Success, Western Australia.
- Snappy Gum. 2015b. A Report on the Archaeological Assessment of the Forestry Department's Divisional Headquarters. February. Prepared for Main Roads Western Australia on behalf of Amergin Consulting (Australia), TBP: Town Planning, Urban Design and Heritage Pty Ltd, Coffey Environments Pty Ltd and BG&E Pty Ltd by Snappy Gum Heritage Services Pty Ltd, Success, Western Australia.
- SRT. 2009a. Local Water Quality Improvement Plan Ellen Brook Catchment. September. Swan River Trust, Western Australia.
- SRT. 2009b. Swan Canning Water Quality Improvement Plan. December. Swan River Trust, East Perth, Western Australia.
- SRT. 2011a. Local Water Quality Improvement Plan Bennett Brook Catchment. March. Swan River Trust, Western Australia.
- SRT. 2011b. Local Water Quality Improvement Plan Saint Leonards Creek Catchment. March. Swan River Trust, Western Australia.
- Stack, G. and English, V. 2003. Interim Recovery Plan No. 140: Gingin Wax (*Chamelaucium* sp. *Gingin*) 2003–2008. March. Report prepared by Department of Conservation and Land Management, Wanneroo, Western Australia.
- Storr, G. M., Smith, L. A. and Johnstone, R. E. 1999. Lizards of Western Australia. Vol. I. Skinks. 2nd ed. Western Australian Museum, Perth, Western Australia.
- Swarts, N. D., Sinclair, E. A., Siegfried, L. K. and Dixon, K. W. 2009. Genetic diversity in fragmented populations of the critically endangered spider orchid *Caladenia huegelii*: implications for conservation. *Conservation Genetics* 10(5): 1199–1208.

- 
- Syrinx. 2011. Roe Extension Project: Wetland Ecology Investigations. Part 2: Results and Impact Identification. January. Prepared for South Metro Connect by Syrinx Environmental Pty Ltd and V and C Semeniuk Research Group.
- Terratree. 2014. Phytophthora Dieback Linear Assessment. Perth Darwin National Highway Project Corridor. Report prepared for Coffey Environments Australia Pty Ltd by Terratree Pty Ltd, Fremantle, Western Australia.
- Thackway, R. and Cresswell, I. D. 1995. An interim biogeographic regionalisation for Australia: a framework for setting priorities in the National Reserves System Cooperative Program. Version 4.0. Australian Nature Conservation Agency, Canberra, Australian Capital Territory.
- TPG. 2015a. NorthLink WA European Heritage Desktop Report. January. Report prepared by Town Planning Urban Design and Heritage for Main Roads Western Australia, Perth, Western Australia.
- TPG. 2015b. Historic Heritage Report: Forestry Department's Divisional Headquarters. March. Report prepared by Town Planning Urban Design and Heritage for Main Roads Western Australia, Perth, Western Australia.
- TSSC. 2012. Approved Conservation Advice for Clay Pans of the Swan Coastal Plain. A WWW publication accessed at <http://www.environment.gov.au/biodiversity/threatened/communities/pubs/121-conservation-advice.pdf>. Threatened Species Scientific Community, Department of the Environment. Canberra, Australian Capital Territory.
- Van Etten, E. J. 2014. Assessment of edge effects and other indirect impacts of the proposed Keane Road Strategic Link. March. Report prepared for Enviroworks and City of Armadale.
- WALGA. 2004. Local Government Biodiversity Planning Guidelines for the Perth Metropolitan Region. 1st ed. June. Western Australian Local Government Association, West Perth, Western Australia.
- WALGA. 2013. 2013 Native Vegetation extent by Vegetation complexes on the Swan Coastal Plain south of Moore River (Local Biodiversity Program, 2013). A WWW publication at <http://pbp.walga.asn.au/Publications.aspx>. Western Australian Local Government Association.
- WAPC and WRC. 2001a. Gnangara Land Use and Water Management Strategy. Final report. January. Prepared by Western Australian Planning Commission. In conjunction with Waters and Rivers Commission, Perth, Western Australia.
- WAPC and WRC. 2001b. Gnangara – Land Use and Water Management Strategy. Final Report. January. Report prepared by Western Australian Planning Commission in conjunction with Water and Rivers Commission, Perth, Western Australia.
- WAPC. 2012. Metropolitan Region Scheme Amendment 1222/41, Perth–Darwin National Highway, Maralla Road Bullsbrook to Northern MRS Boundary Muchea. Amendment Report. July. Report prepared for City of Swan by Western Australian Planning Commission, Perth, Western Australia.
- Whiteman Park. 2015. Whiteman Park. A WWW site accessed on 6 February 2015 at <http://www.whitemanpark.com.au>. Whiteman, Western Australia.
- Wills, R. T. and Keighery, G. J. 1994. The ecological impact of plant disease on plant communities. *Journal of Royal Society of Western Australia* 77:127–132.
- Wilson, B. A. and Valentine, L. E. 2009. Biodiversity Values and Threatening Processes of the Gnangara Groundwater System. September. Prepared by Department of Environment and Conservation for the Gnangara Sustainability Strategy Taskforce, Department of Water, Perth, Western Australia.

- 
- Woinarski, J. C. Z., Burbidge, A. A. and Harrison, P. L. 2014. The Action Plan for Australian Mammals 2012. CSIRO Publishing, Collingwood, Victoria.
- WRC. 2002. Hydrogeological Information for Management Planning in the Ellen Brook Catchment. Salinity and Land Use Impacts Series. September. Waters and Rivers Commission, East Perth, Western Australia.
- Ziembicki, M. 2010. Australian Bustard. Australian natural history series. CSIRO Publishing, Collingwood, Victoria.

Personal Communications

- Chambers, B. Research Fellow, School of Animal Biology, University of Western Australia. Telephone conversation. Late 2014.

BG&E NorthLinkWA
GPO Box 2776
Cloisters Square
Perth WA 6850



Australian Government



mainroads
WESTERN AUSTRALIA



NorthLinkWA