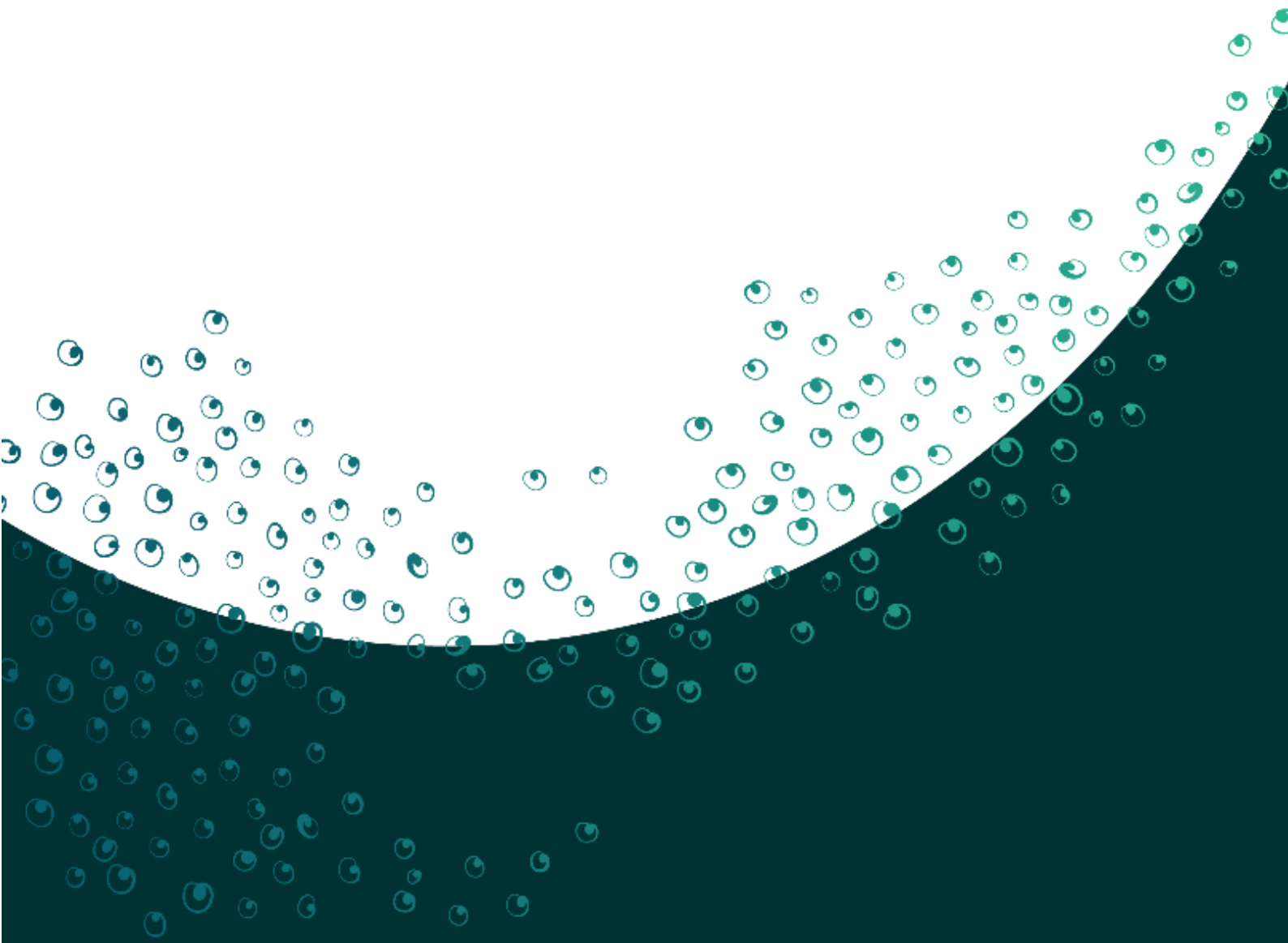

KOALA-SENSITIVE DESIGN GUIDELINE

A guide to koala-sensitive design measures for planning and development activities

Queensland Government

Prepared by: Koala Policy and Oversight Team, Department of Environment and Science

The Department of Environment and Science acknowledges Aboriginal peoples and Torres Strait Islander peoples as the Traditional Owners and custodians of the land. We recognise their connection to land, sea and community, and pay our respects to Elders past, present and emerging.

The department is committed to respecting, protecting and promoting human rights, and our obligations under the Human Rights Act 2019.

DES 2022. Koala Sensitive Design Guideline: Department of Environment and Science Government.

Acknowledgements.

Endeavour Veterinarian Ecology Pty Ltd was engaged by the department to review the guideline to ensure it reflects current best practice in koala sensitive design. The Department of Transport and Main Roads has reviewed and provided feedback on the guideline.

December 2022

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1. Overview

1.1. Purpose

The Koala-Sensitive Design Guideline (the Guideline) provides advice and information for landholders, environmental managers, land-use planners, infrastructure providers and development proponents to determine appropriate measures to avoid, minimise and mitigate the impacts of development and land-use planning on koala populations. It can be used by government and non-government organisations, developers, consultants and the community.

The Guideline provides information to support the assessment of development and facilitate compliance with the *Nature Conservation Act 1992*; State Code 25: Development in South East Queensland koala habitat areas, the State Supported Infrastructure Koala Conservation Policy (SI Policy), and the State Planning Policy (Biodiversity) (SPP).

The Guideline sets out actions that can be taken to:

- ensure koala safety and movement through enhancements to the design and layout of development
    - manage risks to koalas on-site during construction phases.

The Guideline supports adoption of Koala Sensitive Design (KSD) principles at all stages of the development process, including during planning for the site layout, the construction period and the ongoing end-use of the landscape.

Detailed information is provided in **Table 1:** Design solutions to mitigate threats to koalas and their habitat and achieve a permeable landscape at the regional and local scale.

Specific solutions to reduce risk to koalas during the operational works phase of development is provided in **Appendix 1**: Koala-sensitive operational works guidelines

Site-specific issues and scale will ultimately determine the best solutions for a particular circumstance. The Guideline sets out examples and options to solve problems and does not try to predict all possible circumstances.

Note for transport infrastructure providers:

Complimenting this Guideline is the associated Fauna Sensitive Transport Infrastructure Delivery Manual (FSTIDM) published by the Department of Transport and Main Roads. This Manual guides the planning, design, construction and maintenance of state-controlled transport infrastructure to minimise impacts and maximise benefits to wildlife, including koalas.

Details from this Guideline relevant to state-controlled transport infrastructure have been incorporated into the FSTIDM.

1.2. Koala-sensitive design (KSD) principles

Adherence to the below KSD principles will enhance the persistence and koala safe movement through human-altered landscapes. The principles aim to support healthy, viable koala populations into the future.

KSD principles include that development:

- retains, protects and improves koala habitat values in their natural state to allow koalas to feed, rest and move around safely
- achieves permeability by protecting and enhancing opportunities for the koala safe movement within and across a site
- reduces threats to resident and transient koalas

1.3. Use of the Guideline

The Guideline facilitates the persistence and safe movement of koalas by asking designers to apply the KSD principles and:

- identify threats that development activities may have on safe koala movement
- identify appropriate KSD measures to avoid and minimise those threats
- provide solutions and techniques to inform the planning, design and layout stages of development for retaining koala populations and providing for safety and movement
- provide approaches to managing and reducing impacts from operational stage of development
- provide koala-safe movement opportunities
- assist in achieving the outcomes sought in the SPP, SI Policy and State Code 25.

Figure 1: (photo Department of Environment and Science 2003)

2. Koala biology and ecology

Understanding koala behaviour, habitat use, and patterns of movement through the landscape is important to ensure that KSD measures are effective. While the measures in the Guideline are based on current best-practice methods, they are not an exclusive list of solutions. Alternative solutions can achieve KSD if developed with an understanding of koala biology and ecology.

Refer to SDAP State Code 25 and relevant guidelines for other key concepts relevant to KSD (SDAP State Code 25: Development in South East Queensland koala habitat areas).

2.1 Koala distribution

Koalas are distributed throughout Queensland and occur in a variety of eucalypt-dominated habitats (State koala mapping). Koalas are typically more abundant in the coastal regions of the state or along riparian zones where soils have higher nutrient and moisture content. Koalas can be found in remnant bushland, rural zones, suburban parks and reserves and residential areas, often in highly fragmented urban landscapes. Koalas can be permanent residents of these areas with established, stable home ranges, or transient and dispersing to alternative habitat. Koala distribution in the landscape can vary spatially and temporally in response to bushfire, drought or threat profile, for example.

2.2 Koala biology and habitat use

Koalas are predominantly arboreal animals, spending most of their time in trees. However, they also travel on the ground while moving between trees or habitat patches.

Key biological attributes to consider when using KSD principles to design or install measures are:

- koalas are suited to a predominantly arboreal life and have well-developed forelimbs and claws and excellent climbing abilities;
- an adult koala can extend their forelimbs over 90 cm from the ground and around 50 cm if reaching up and over a structure;
- koalas have the ability to jump up to 1.2 m from the ground;
- daily movements:
    - koalas are most active from dusk to dawn but often move during the day if disturbed or to seek shelter, or during the breeding season (end of June to January) when mating activity is heightened and animals are dispersing.
    - koalas will typically change trees at night, preferring to descend a tree and walk across the ground rather than move through the canopies of adjacent trees. Koalas can move a few metres per night or move a few hundred metres per night, or many kilometres overnight during times of dispersal.
    - koalas move slowly across the ground if not threatened and often with little regard to their surroundings.
- seasonal movements:
    - sub-adult koalas (prior to breeding) often disperse from their place of birth to new habitat and can move considerable distances (>10 km) before establishing a new home range. The drive to disperse is strong and koalas will manoeuvre through, over and under obstacles in their path.
    - koalas occupy home ranges that overlap with other male and female koalas, and depending on the forest structure and location, the size of a koala's home range can vary greatly from less than 1 ha to over 100 ha.
    - the home ranges of koalas can include cleared or highly fragmented areas.
    - koalas will use a variety of food and shelter trees in their home range, and a complex forest structure with mid-storey vegetation provides the best thermoregulatory opportunities for animals (which is particularly important as climate-change related impacts worsen).

3. Development planning, design and layout

3.1 Threats to koalas

Koala injury or mortality can be a direct result of anthropogenic threats associated with urbanisation and development or by indirect mechanisms such as misadventure following displacement. Specific threats to koalas from development activities should be identified and may include:

- loss or degradation of habitat
- habitat fragmentation and loss of connectivity
- vehicle strike (koala injury or death)
- domestic and wild dog attack (koala injury or death)
- drowning in pools
- increased prevalence of disease (increased susceptibility to disease due to stress caused by the above-mentioned threats)
- entrapment and injury during construction or operational-use phases of the development (see Appendix 1 for koala-sensitive operational works guidelines).

3.2 Habitat connectivity values for koala movement (permeability)

The successful movement of individual koalas through the landscape allows for genetic exchange between koala populations. This process improves genetic diversity and ultimately improves species resilience to change habitat, climate and threats at an evolutionary level. High rates of development, particularly in SEQ, are removing and fragmenting koala habitat and increasingly threatening the safe movement of koalas across the landscape. This has immediate impacts on koala survival, and negatively affects local population persistence and genetic diversity over medium to long-term timeframes.

Koala habitat quality and connectivity should be determined through environmental assessment and used in development planning, design and layout. Importantly, both existing and potential future habitat and connectivity corridors should be considered. For example, koalas may have been extirpated from an area due to historical threats, but the area may still provide valuable conservation resources which could be enhanced and protected to allow for re-establishment of koala populations in the future. Hence, the absence of koalas should not preclude the application of KSD measures in habitat or areas that otherwise are suitable for koala population re-establishment.

To determine the habitat connectivity value of the site to facilitate koala movement through the landscape, the following factors should be considered:

1. The site's location in a landscape context, with regard to:
    - areas identified as koala habitat areas (core or locally refined), or koala habitat restoration areas
    - areas identified as other remnant or regulated regrowth regional ecosystems where koalas are known to occur, or have occurred historically
    - other areas of environmental significance that need to be retained (e.g., habitat for threatened plants or ecosystems)
    - waterways and ecological corridors.

2. The local attributes of the site, including:
    - the presence, or likely presence, of koalas, or their presence historically
    - the condition and quality of the habitat
    - the presence of waterways or ecological corridors, or areas that are remnant or regulated regrowth regional ecosystems which koalas are known to use
    - edge effects and other indirect impacts of development on ecological features
    - the presence of infrastructure and services, such as roads, which present barriers for safe koala movement and dispersal
    - the presence of natural barriers, such as large waterbodies, which create barriers for koala movement and dispersal
    - temporal impacts on the quality and connectivity of habitat such as land-clearing, drought and bushfire.

- Any factors which diminish the site's habitat connectivity value for koala movement within, and adjacent to, the site and landscape, including:
- edge effects and other indirect impacts of development on ecological features
- the presence of infrastructure and services, such as roads, which present barriers for safe koala movement and dispersal
- the presence of natural barriers, such as large waterbodies, which create barriers for koala movement and dispersal
- temporal impacts on the quality and connectivity of habitat such as land-clearing, drought and bushfire.

In summary, the site's location and attributes with regards to the presence of koalas, location and condition of habitat, waterways and ecological corridors and any factors impacting on these values should be taken into consideration for planning and development.

An assessment of koala habitat connectivity values should include:

- a description of the use or potential use of the site, and areas adjacent to the site, by koalas, with consideration of spatial and temporal influences of koala distribution;
- a map of koala habitat, including bushland, groups of trees and individual trees; and
- a plan of movement corridors (connectivity), including regional and local-scale movement corridors, and existing and potential links between koala habitat within, and external to, the site.

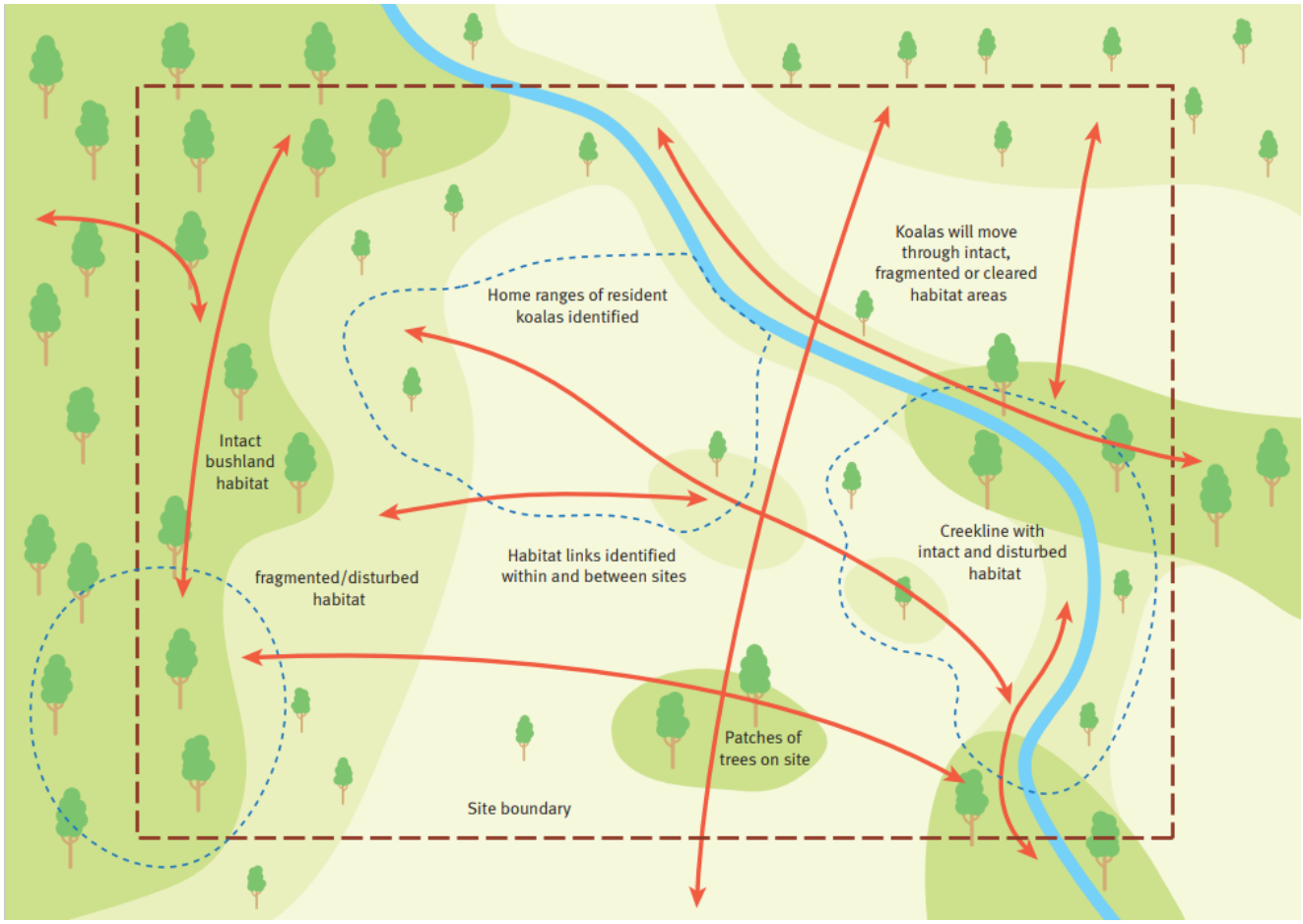

Figure 2. Example of assessment of koala habitat and connectivity value for koala movement, including on site values and broader landscape-scale connectivity for movement and genetic exchange.

3.4 Planning, design and layout for koala conservation

Following an assessment of koala habitat, connectivity values, and identification of threats; the planning, design, and layout of the development should:

1. Ensure areas of koala habitat values and habitat connectivity are protected and enhanced by:
   - creating large contiguous patches of koala habitat and habitat corridors that are at least 100 metres wide
   - retaining and enhancing vegetated stepping stones and highly connected patches (ie highly connected patches are areas less than 200 metres apart)
   - avoiding clearing non-juvenile koala habitat trees on the site, including individual, isolated trees
   - avoiding clearing of heat-refuge vegetation associated with larger habitat trees - maintaining floristic structure diversity
   - linking on-site koala habitat to koala habitat located external to the site, providing adequately spaced and sized habitat linkages - corridor establishment and enhancement
   - identifying rehabilitation areas on the site for revegetation consistent with the density, composition and distribution of native koala habitat vegetation, based on the pre-clearing regional ecosystem description
   - securing the long-term conservation of koala habitat areas using covenants or other private or public ownership arrangements.
   -
2. Locate and design the development to avoid adverse impacts on koalas, koala habitat values and habitat connectivity by:
   - selecting sites that will have least impact on koalas if developed, such as cleared land that has low koala habitat connectivity value
   - minimising the size and scale of the developable area in the development footprint and of individual buildings (e.g. higher density, multi-storey buildings may have less impact)
   - using development envelopes that are shaped and located to:
   - co-locate all associated activities, infrastructure and access strips
   - be within the least valued area of koala habitat on the lot
   - minimise the footprint of the development envelope area
   - minimise edge effects to areas external to the development envelope
   - create a buffer (road or park) between development and areas of koala habitat
   - ensuring enough area is maintained between development buildings and koala habitat trees to ensure trees will not be removed for safety (fire and falling).

3. Locate and design transport routes (bikeways, busways, roads and rail lines) to avoid fragmentation and clearing of koala habitat and to retain habitat connectivity, including:
   - avoiding transecting large contiguous areas of koala habitat or cleared land with high potential for koala habitat or connectivity corridors
   - using speed reduction devices such as speed bumps, roundabouts, chicanes, speed warning signs and painted road treatments on roads in koala-sensitive areas
   - incorporating koala crossings (over and underpasses) and using koala exclusion fencing to ensure koalas are funnelled towards koala crossings and away from busy transport routes
   - considering use of viaducts, extending bridge spans, and using tunnelling to avoid and minimise direct impacts (vegetation clearing) and indirect impacts (road trauma) on koalas.

4. Use native vegetation in landscaping and habitat restoration activities that provide food, shelter and movement opportunities for koalas.

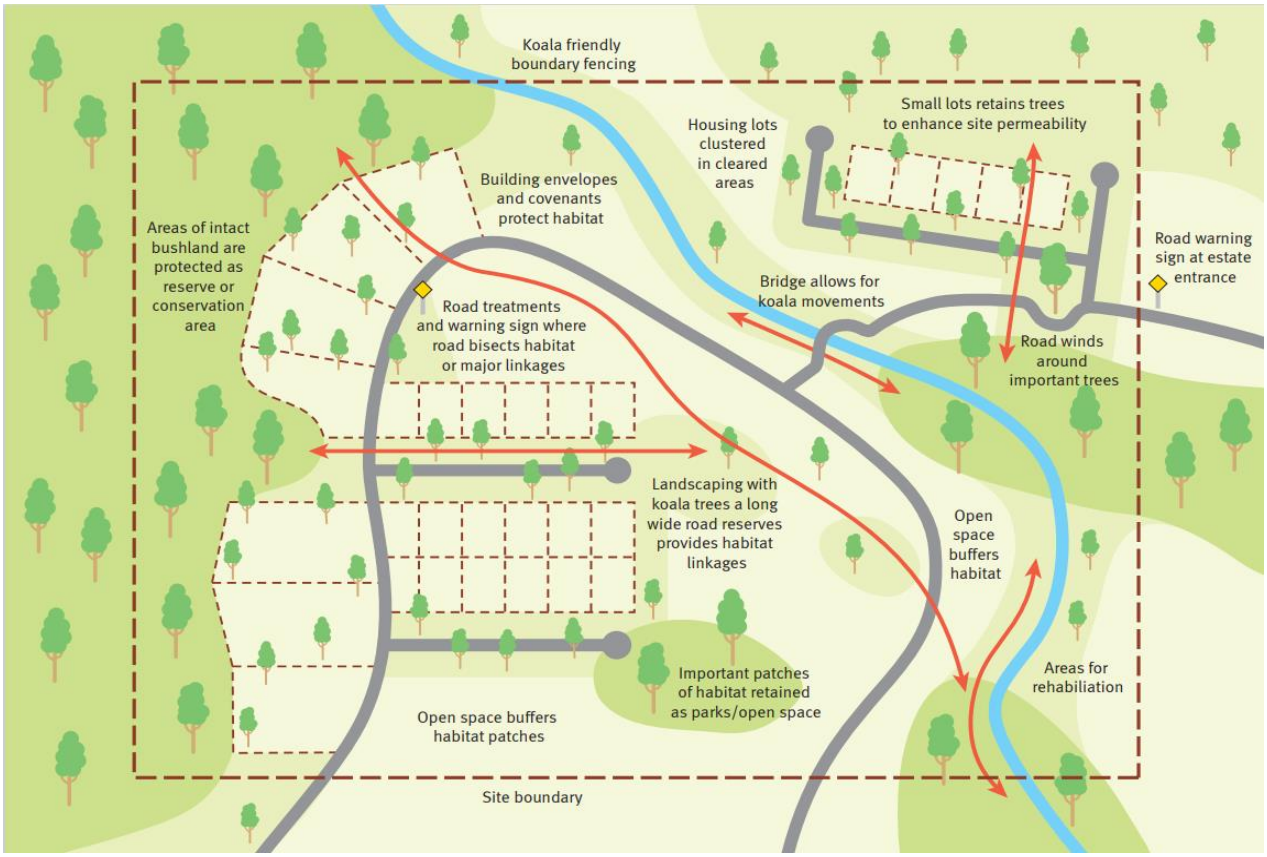

Figure 3 Example of a koala sensitive urban design - illustrates how infrastructure and development can be planned and designed to maximise retention of koala habitat and connectivity.

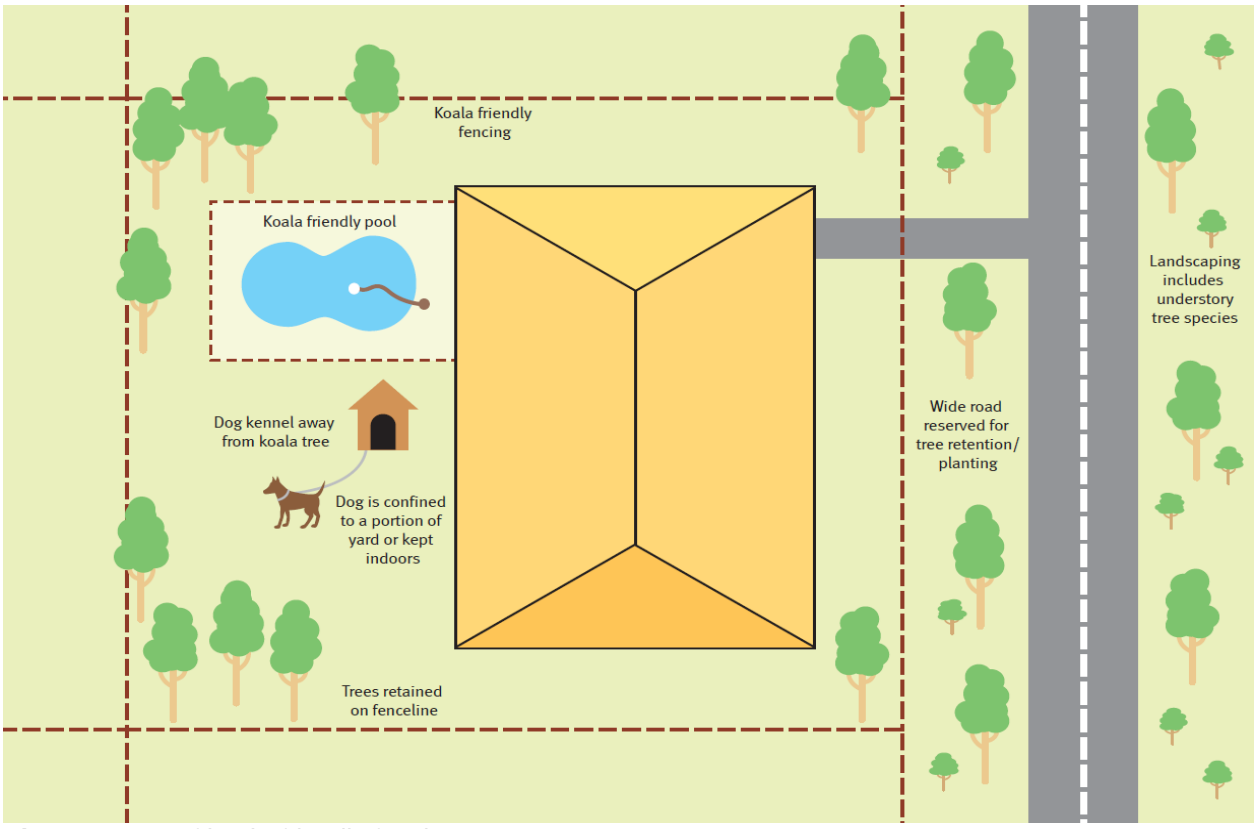

Figure 4. Use of koala-friendly fencing

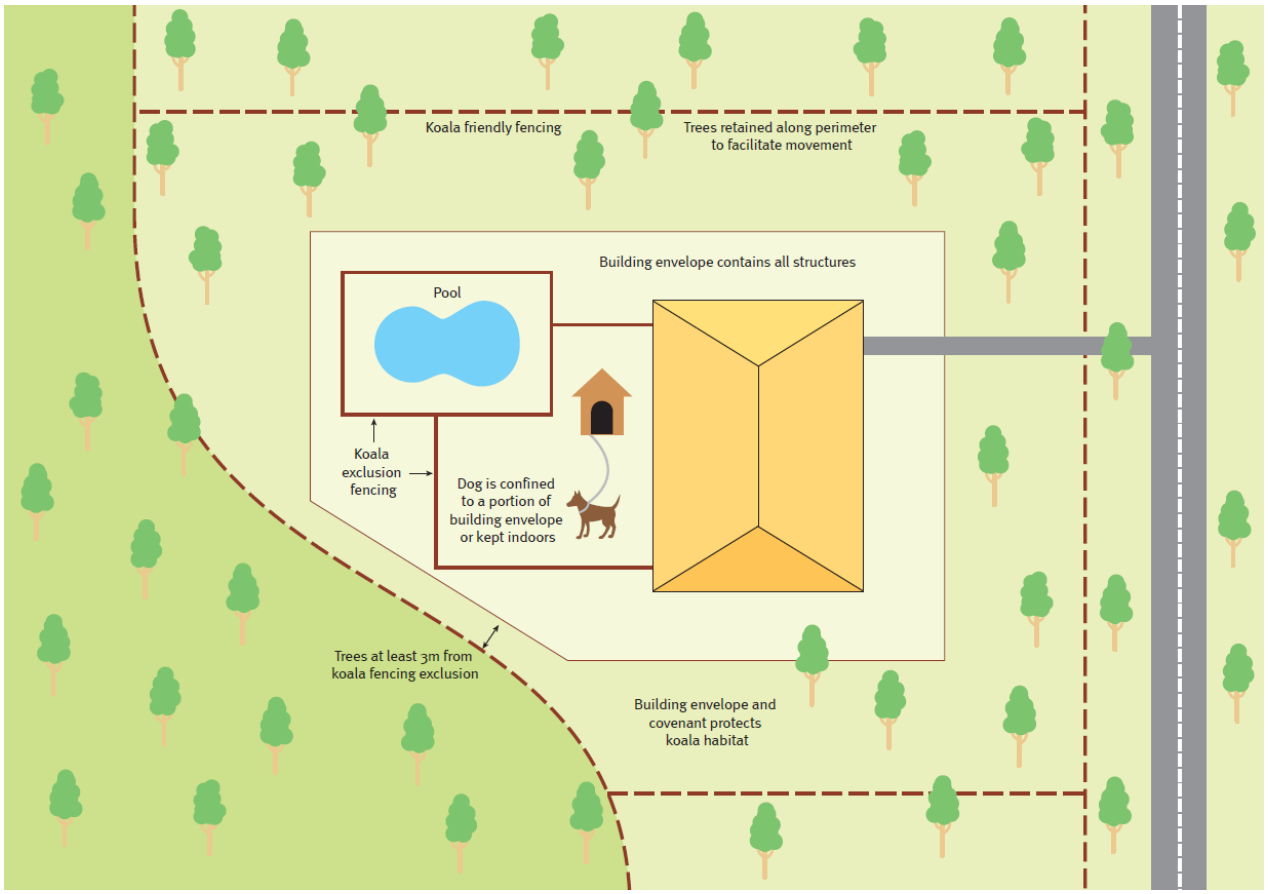

Figure 5. Use of a development envelope and koala exclusion fencing

4. Designing koala-safe movement solutions

KSD measures which can facilitate landscape permeability and safe koala movement include:

- koala-friendly (allows koala movement) and koala exclusion (prevents koala movement into unsafe areas) fencing
- koala-safe road design (including crossing structures) and placement
- mitigation of construction-related threats (including vegetation clearing)
- koala-safe pools and other water bodies
- mitigation of threats from domestic dogs and livestock
- landscaping to maintain or enhance koala habitat and connectivity
- koala detection and monitoring, and sensitive vegetation clearing practices, such as use of innovative technologies and best-practice methods
- community awareness, engagement and koala stewardship programs.

Measures chosen will be influenced by the type, size, and location of the development. It is likely that several of each type of measure will need to be used in the design and layout of the development to maximise koala safety and movement.

Table 1: Design solutions to mitigate threats to koalas and achieve a permeable landscape at the regional and local scale; provides design solutions to achieve good koala conservation outcomes including koala-exclusion and koala-permeable fencing designs, ways to navigate transport corridors, pools and dogs, koala habitat revegetation and enhancement approaches, and engaging the community to be koala aware. These design solutions can be applied to a range of development scenarios at strategic and/or site level.

For each measure, the performance outcome; the best practice solutions to achieve the desired outcome; and effective alternative solutions are provided. Supporting information, additional notes and maintenance issues are discussed.

To ensure ongoing success, all implemented measures need operational maintenance and management plans which should include responsibilities and trigger point events for checking that the installed item or fence is in its best working order (e.g., removing fallen logs from koala exclusion fencing after a fire or a storm).

Appendix 1 has been provided with this Guideline to set out how to reduce koala injury and mortality specifically from construction activities which is critical to prevent harm to koalas during construction of developments.

4.1. Note on development size and scale

The size and scale of the development will largely dictate the project budget and the capacity to implement all best practice KSD solutions. There is a strong community expectation that koala populations are conserved and managed and factored into large infrastructure project budgets so that best practice solutions are adopted. These may include:

- comprehensive telemetric monitoring and management/protection of koalas to enable the reliable location of potentially large numbers of koalas during vegetation clearing operations
- use of experienced koala spotters or fauna spotter/catchers
- the deployment and maintenance of a holistic suite of mitigation infrastructure and associated structures, and appropriate and relevant offset contributions.

However, it is often not always practical for small or single lot developments to capture and tag koalas to monitor and easily locate koalas in the area being cleared. In these instances, it may be more practical to use existing information and risk-based approaches including experienced koala spotters (fauna spotter/catchers) and arborists who will be present during vegetation clearing and ensure best practice methods are used that avoid harm to koalas and other fauna. Ensuring habitat is cleared with the utmost caution may negate the need to collar and intensively monitor koalas that may be in patches of habitat undergoing clearing.

New detection technology and methods are emerging, such as thermal-capability drone surveys, which can significantly improve koala detection prior to vegetation clearing operations and may prove to be cost effective.

Table 1: Design solutions to mitigate threats to koalas and their habitat and achieve a permeable landscape at the regional and local scale.

4.1 Koala-permeable fencing

Supporting information

Development that incorporates koala-friendly fencing assists koala movement and dispersal within and across the development site. Inappropriate fencing reduces the permeability of the landscape to koalas and can result in the funnelling of koalas to unsafe crossing points, injury, and death. Koala-friendly fencing can allow unimpeded movement of koalas between areas of habitat and can be built within properties or on lot boundaries. Koalas are skilful climbers but readily take a path of least resistance and prefer to push under or through a structure before climbing it. With this in mind, koala-friendly fencing achieves permeability by allowing koalas to climb over, under or through the fencing and ensures koalas are not entrapped by the placement and design of fencing materials (such as barbed wire or narrow palings).

Performance Outcome 1: *Allow koalas to easily climb through, over or under a fence to provide a permeable landscape.*

Design specifications

Best practice

1. Fencing raised off the ground with a minimum spacing of 300 millimetres from the ground to the fencing material, such as post and rail, provides the most permeable solution for koalas (Figure 4.1.1).
2. Incorporate existing trees into the fence to facilitate movement (Figure 4.1.2).
3. Use of push-under and push-through devices are preferred to traditional 'escape poles' constructed of treated timber poles, the effectiveness of which is not proven.
4. Fence tops must avoid barbed-wire or sharp ends (such as are used on some chain-mesh security fencing) which can entrap or snare koalas and other wildlife.

Alternative solutions

Fence design must:

- ensure gaps in the fence are large enough to allow a koala to easily pass through
- gaps are of a size (less than 60 millimetres) to allow koalas to climb over but prevent koalas climbing through and getting stuck in the fence (Figure 4.1.2 and 4.1.3)
- use rails or slats that have spaces of at least 15 mm between vertical slats and 20 millimetres between horizontal rails that koalas can climb. Alternately, use materials such as timber posts or chain wire that a koala can easily grip and climb

Figure 4.1.1 Post and rail fencing provides the most permeable fencing solution for koalas.

Figure 4.1.2. Fences incorporating trees and of slatted design provide ideal movement solutions for fence permeability to koalas.

- install a climbable timber post or log if fencing material is unclimbable. Post is a minimum 125 millimetres in diameter) leaning against the top of the fence but positioned at an angle to the fence so the log is not flush with the fence and climbable by a koala (i.e. the perpendicular space between the base of the log and the bottom of the fence is at least 400 millimetres (Figure 4.1.4).
- install a simple koala bridge (particularly suited to minimum security fences) to ensure safe movement over barbed wire using timber logs of at least 125 millimetres in diameter of the following design:
    - timber logs are positioned adjacent to and within 1 metre of each other on either side of the fence and extend above the fence. A cross piece of similar diameter to the logs connects the two vertical timber posts that are within 1-4 metres of each other on either side of the fence (Figure 4.1.5).

Maintenance

Maintenance is essential to ensure the proper functioning of the fence design. Develop maintenance plans, outlining required inspection and maintenance schedules of fencing to:

- replace parts or whole structures as per manufacture's recommendations (e.g. items that will perish over time when exposed to the elements)
- keep weeds away from key koala access points such as push-under structures and the bases of wooden poles to ensure detection and use of structures by koalas.

Notes:

1. Fencing materials must be rigid to support climbing by a koala.
2. To encourage the use of climbing poles associated with chain link or mesh fencing, fit the base of the fence with 600 millimetres skirting to ensure koalas cannot see through the fence, but instead must look up. Koalas can often be seen pacing back and forth trying to find a way through fencing to visible trees on the other side and will attempt to push under sections of unsecured fencing.
3. Consider the movements and permeability requirements of other fauna when installing koala friendly fencing.

Figure 4.1.3. Small-spaced fencing slats allow koalas to climb the fence while reducing entrapment between slats.

Figure 4.1.4. A wooden bridge over security fencing designed to facilitate the safe movement over the fence and barbed wire by koalas but effectiveness is not well established.

Figure 4.1.5. A timber post or log secured to an unclimbable fence allows entry to and exit from a property or habitat on either side of the fence.

4.2 Koala-exclusion fencing

Supporting information

The use of koala exclusion fencing may be appropriate to prevent koalas from entering an area that poses an unacceptable degree of risk, such as a road corridor, sewage sediment pond, or a construction site. Koala exclusion fencing limits landscape permeability and should only be used where there is a direct threat to koala safety and used in conjunction with associated infrastructure to provide locations of safe movement opportunities. As such, exclusion fencing has the dual purpose of guiding koalas towards koala-safe crossing points such as fauna movement underpasses or overpasses. Exclusion fencing can be temporary, or permanently installed to suit the duration of the threat.

The following situations are suitable to use koala exclusion fencing:

- domestic dog enclosures in larger properties (greater than 800 m2) to limit koala and dog interactions
- high speed/volume roads or rail lines, in association with fauna crossing structures
- swimming pools where pool design is unsafe for koalas
- construction sites where activities or works may cause harm to koalas such as vegetation clearing, digging of pits or trenches, the dewatering of ponds or dams and entrapment in site equipment. Temporary fencing that stops koala access is appropriate in this instance.

Koala exclusion fencing may not be suitable for use in the following situations:

- on roads where traffic speed is already slowed, for example, adjacent to traffic lights
- habitat linkages that would be completely severed and are important at a local or regional scale for maintaining connectivity in the population
- where the placement of driveways, local roads or other landscape features that can't be readily fenced are within close proximity to the proposed exclusion fencing, reducing the effectiveness of fencing if it were installed in areas where fencing would reduce line of sight or visibility and pose a safety risk.

Performance Outcome 2: *Exclude koalas from an area of high risk through the installation of an impermeable fence or barrier*

Design specifications

Best practice - koala-proof fencing material

- Fencing material consisting of brick, metal sheeting, Perspex or timber fencing with no gaps between palings creates a smooth unclimbable surface to koalas (Figures 4.2.1-4.2.3)
- Fencing supports and posts are located within the zone where koalas are being excluded, or they are fitted with a koala shield (Figure 4.2.4)
- Unclimbable sheeting (metal or Perspex) 600 millimetres or greater in width is retrofitted to the fencing and gates to prohibit climbing by koalas. The top of the sheeting is 1.5 metres from the ground to prohibit koalas jumping up and grabbing the fencing material above the sheeting

Figure 4.2.1. (photo D de Villiers) Koala exclusion fencing with unclimbable sheeting on the habitat side of the fence prevents koala access to the road corridor or other unsafe environments. Fencing is flush with a cement footing to prohibit koalas pushing under the fence.

Figure 4.2.2.(photo D de Villiers) Brick walls create a barrier to koala movements.

- Sheeting is fitted to fencing material at a height that is comfortable for a koala jumping from the fence to the ground. For example, 1.8 metre high fencing should fit sheeting at 0.9 m to 1.5 m off the ground, not at the top of the 1.8 metre high fence (Figure 4.2.5)
- Fencing is flush with a cement edging on the ground or retrofitted with additional wire to prohibit erosion and washouts where gaps under the fence will allow egress by koalas (Figure 4.2.1 and Figure 4.2.6)
- Particular attention needs to be paid to gates to ensure it is not a point of entry for koalas, either when left open or where the gates provide gaps (Figure 4.2.7)
- Fencing is installed with a skirt of chain mesh (permanent) or corflute (temporary) of minimum 1.0 metre width, that is fixed to the base of the fence (up to 300 millimetres) with the remainder resting on the ground, prohibiting the pushing or digging under the fence by animals. This is particularly necessary where the ground is uneven, or undulating or temporary/construction fencing is erected
- Fencing has a 90 degree return of at least 50 metres in length at the fencing boundaries to encourage koalas back into the bushland and not onto the road or other unsafe environment where the fence ends. Ideally the end of the return is angled back into the patch of habitat
- Trees and shrubs are excluded from within 3 metres of the fence and tree canopies of trees adjacent to the fence are trimmed to remove links to tree canopies on the other side of the fence (Figure 4.2.5).

Alternative solutions

Where visual amenity, cost, or other factors such as engineering considerations (wind loading) prohibit best-practice design, alternative designs can still provide some degree of effectiveness in minimising koala egress to unsafe areas and the mitigation of koala mortality. This includes the use of:

- fencing that is less than 1.5 metres high, creating a partial barrier to koalas (Figure 4.2.8)
- floppy top fencing – previously used in New South Wales (NSW Road and Maritime Services is now installing chain link with metal panel in preference to floppy-top fencing).

Trees retained within the 3 metre fence buffer can be collared with metal sheeting to prohibit access by koalas under the following conditions:

- the top of the metal sheeting needs to be a minimum of 1.5 metres from the ground
- the tree cannot have overlapping branches or canopy or with a trunk within 3metres of adjacent trees.

Maintenance:

Maintenance is essential to ensure the integrity of the koala-proof fencing. Develop maintenance plans, outlining required inspection and maintenance schedules of fencing to:

- replace parts or sections of fencing that may have sustained damage due to vandalism, storm or floods or tree falls
- remove saplings, broken branches and climbing weeds that provide climbing opportunities for koalas to navigate over the koala proof fence - a cleared buffer of approximately 3m would be appropriate

Figure 4.2.3.(photo D de Villiers) Colourbond fencing flush with the ground creates a barrier to koala movements.

Figure 4.2.4. (photo David Fleay Wildlife Park) Fencing supports fitted with a 'koala shield' prevents koalas climbing the support.

- ensure there are no wash-outs or areas of erosion leading to gaps underneath fencing that will allow animals to push under the fence.

Notes:

Koalas can climb a variety of fencing materials and structures that may seem unlikely, for example smooth metal signposts, patio supports and pool fences (Figure 4.2.9). Consider the agility and high dispersal drive of koalas in the breeding season when designing structures to exclude koalas from an area. Consider the permeability of the regional landscape and the functioning of the local site within this context and if there are alternative safe movement paths in the landscape for koalas before excluding koalas from a key habitat link or corridor.
Small gaps in fences or poorly maintained fences can significantly reduce the effectiveness of koala proof fencing, wasting resources and good intentions (Figure 4.2.10).

Figure 4.2.7.(photo D de Villiers) Poorly designed gates provide avenues for koala egress to the road corridor (gaps are shown between and under the gates).

Figure 4.2.5. (photo D de Villiers) Unclimbable metal sheeting should be fitted to fencing over 1.5 m at a height that is comfortable for a koala to jump to the ground. All vegetation within 3m of the fence has been removed.

Figure 4.2.6.(photo D de Villiers) Fencing can be retrofitted with additional wire cover gaps under koala proof fencing where the ground is undulating.

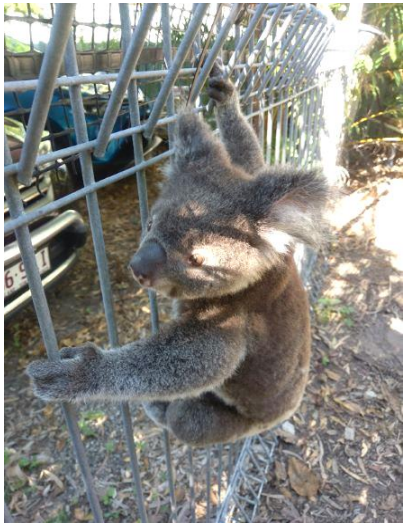

Figure 4.2.9. (photo D de Villiers) Koalas are agile and can climb a variety of structures that may seem unlikely, such as pool fencing.

Figure 4.2.8. (photo D de Villiers) Reduced fencing height creates a partial barrier to koalas and discourages koalas climbing the fence and entering the road corridor.

Figure 4.2.10. (photo D de Villiers) Even small gaps in koala proof fencing will significantly reduce the effectiveness of the fencing.

4.3(A) Koala-safe transport infrastructure - design and placement

Supporting information

Vehicle-related accidents are a key threat to koala survival. Effective road design and infrastructure placement in koala habitat areas can significantly reduce injury and premature death of koalas and benefit the long-term viability of koala populations by providing safe crossing opportunities, reducing habitat fragmentation and loss and maintaining habitat permeability and linkages. Major roads and local roads require different approaches to manage road-related impacts on koalas. Major roads have the purpose of moving large volumes of vehicles as quickly as possible in a safe and efficient manner and typically represent multi-lane highways and arterial roads. Local roads provide access to local amenities for communities and are made up of a network of suburban streets where mitigation solutions can aim to reduce speed and traffic volumes.

Performance Outcome 3A: *Design and placement of roads avoids or minimises impacts to koalas and their habitat*

Design specifications

Best practice– road design and placement

Appropriate road alignment and design mitigates threats to koalas and their movement by considering and planning for the following:

- identify the location of koala habitat and habitat linkages in the regional landscape and ensure significant habitat areas are not dissected or further fragmented
- upgrade existing roads to avoid building new roads
- minimise loss of habitat
- allow minor deviations in roads and driveways to retain important koala habitat trees.
- estimate the number of vehicles likely to use the proposed road, anticipated vehicle speeds and the likely volumes of traffic between 6 pm and 6 am (local roads)
- incorporate features that slow traffic such as narrowing roads, roundabouts, chicanes, curves or other speed reduction structures such as speed bumps (Figure 4.3.1)
- locate koala road crossing points in areas of reduced speed zones, ideally less than 40 kilometres per hour (local roads) (Figure 4.3.2)
- increase the visibility of koalas entering the road corridor by managing vegetation and landscaping within and adjacent to the road corridor
- light roads at identified or potential koala crossing points to improve the visibility of koalas when animals are most active between dusk and dawn
- incorporate trees along streets with wide verges (not wide busy streets), particularly at "go slow" points (Figure 4.3.3)
- install koala crossing warning signs and road treatments
- provide painted road treatments across lanes to mark the beginning of zones where drivers must be alert for koalas crossing roads (Figures 4.3.4 and 4.3.5)

Figure 4.3.1. (photo D de Villiers) Winding local roads with slow points helps to reduce vehicle speed and avoid collisions with koalas.

Figure 4.3.2. (photo D de Villiers) Koala crossing zone has a reduced speed limit to slow vehicles and allow the detection of koalas crossing the road between habitat patches.

- deploy Vehicle Activated Signs or Variable Message Signs/SAM (speed awareness monitors) to display interactive messages, for example, a koala smiley face or cautionary message if vehicle speed is appropriate for the zone, or a 'Slow Down' or sad face if vehicle speed conflicts with the intended speed of the conservation zone (Figure 4.3.6a-c)
- use digital signs with vehicle activated lights or messaging to engage drivers
- use temporary and mobile signage and deploy signs in road mortality hotspots in suitable places and times (Figure 4.3.7)
- use simple and unambiguous messaging and text on signs.

Alternative solutions

The full or partial adoption of best practice solutions will largely depend on the type of road, the site-specific road environment, where it sits in the broader landscape, and community acceptance of treatments. Not all solutions will be practical all the time, and there may be a spatial and temporal aspect to road treatments. For example, temporary signage may be installed at certain times of the year (the koala breeding season) or moved to areas where recent crossings or vehicle collisions have been observed. Deploy static road signs on sign posts or painted road treatments to alert drivers to koala crossing points or 'go-slow' areas (Figure 4.3.8a-d).

Maintenance

Improve the visibility of koalas entering the road corridor through vegetation management and landscaping by:

- regular mowing of grassy road edges
- trimming the lower branches of vegetation adjacent to, and within, the road corridor to improve the visibility of koalas crossing roads. vegetation near the road trimmed of lower branches and vegetation to improve the visibility of koalas entering the road corridor
- planting dense bushes and shrubs away from the edge of road or edge of the medium strip.

Maintain koala signage and road treatments for currency and messaging relevant to the location and season.

Notes:

- Static signs fixed in position have been demonstrated to be less effective at changing driver behaviours than variable messing signs or SAM signs, particularly the longer the sign is left in place.
- Driving at a reduced speed through koala habitat gives the driver a greater chance to avoid koalas on the road.
- Vehicles travelling at reduce speed and striking a koala may result in reduced injury and death of the animal.

Figure 4.3.3. (photo D de Villiers) Meandering local roads with wide road reserves and easily visible surrounds can support koala habitat and facilitate safe movements in urban areas by slowing traffic.

Figure 4.3.4. (photo D de Villiers) A painted koala road treatment is a stark visual reminder to drivers that they are entering a zone where koalas cross the road.

Figure 4.3.6. (photo D de Villiers) Vehicle activated signs displaying variable messaging depending on passing vehicle speed, with positive green koala smiley face when travelling below the speed limit (left), a cautionary message at the speed limit warning the driver to be alert to koalas crossing the road (middle), and a red unhappy face if the vehicle is travelling faster than the recommended speed in the conservation zone (right).

Figure 4.3.5.(photo D de Villiers) A painted 'koala zone' alerts drivers to the possible presence of koalas on the road.

Figure 4.3.7.(photo D de Villiers) Mobile signage can be deployed in road hotspot areas or during times when there is a risk of koala vehicle strikes.

Figure 4.3.8 a-e (left and above).(photos D de Villiers) Static signs are less effective at changing driver behaviour the longer they are in place.

4.3(B) Koala-safe transport infrastructure - koala crossing infrastructure

Supporting information

Roads can be fitted with a range of measures to reduce koala and vehicle collisions and facilitate safe and unimpeded koala movement across roads, particularly at identified or potential koala crossing points where roads intersect or fragment koala habitat and major habitat linkages. Structures should be incorporated into road design and layout and can take the form of land bridges or overpasses over roads or underpasses beneath roads, taking the form of natural crossing points under bridges, or culverts. Environmental and physical aspects relating to the landscape and topography will often influence the type, dimension and placement of road crossing structures. Budgetary considerations also heavily influence the installation of fauna solutions – fauna crossing structures are more likely to be installed on state road projects compared to the upgrade or construction of local roads.

Performance Outcome 3B: Design and placement of fauna crossing infrastructure reduces koala road mortality

Design specifications

Best practice– road crossing infrastructure

Install one or more land bridges, covered in natural substrate and vegetation, to connect habitat on either side of a road (Figure 5.3.9):

- wide bridges provide a more natural avenue for koalas to cross roads and negate the lighting and flooding issues associated with underpasses
- install escape or refuge poles on the bridge for predator avoidance while vegetation is becoming established
- bridge design conforms to road safety standards and prevents koalas and other animals from falling from the overpass into the road corridor and oncoming traffic
- land bridge is designed exclusively for wildlife movement and prohibits dual uses such as pedestrian or cyclist crossings.

Install one or more fauna overpasses/bridges to link habitat across the road (Figure 4.3.10 & Figure 4.3.10a)

- structures are as wide as possible, with a minimum width of 60 centimetres to comfortably accommodate the crossing of koalas
- build the overpass with stable, rigid materials
- rehabilitate or retain habitat at the overpass to funnel animals to the crossing structure
- design conforms to road safety standards and prevents koalas and other animals from falling from the overpass into the road corridor and oncoming traffic
- provide natural under road bridge fauna movement solutions (Figure 4.3.11)

Figure 4.3.9.(photo: google earth) A landbridge designed for use by wildlife has well established trees and ground cover to facilitate crossing.

Figure 4.3.10.(photo: google earth). A fauna overpass links habitat on either side of a main road.

- set bridge footings back from the creek edge to provide koalas with the most natural movement opportunities across unsubmerged or non-waterlogged land beneath the road bridge
- incorporate koala furniture, where warranted.

Install large 3 metre x 3 metre box culverts or pipes in strategic areas in the landscape to improve permeability and safe movements of koalas (Figure 4.3.12).

- the culvert is fauna specific and not dual purpose – as such, it may still be located in a riparian zone, however, it is adjacent to the waterway, placed higher than the typical level of the creek and is not required for drainage
- locate the culvert where the floor will remain dry except in significant rain events where the structure quickly dries out
- lengthy underpasses are avoided, for example, by using split carriageways to ensure natural light penetrates the structure
- deploy fauna furniture of post and rail design, using salvaged timber, where possible
- horizontal logs placed as high off the ground as possible to avoid predators with a minimum space of 600 mm between the top of the horizontal log and the culvert's roof
- horizontal logs are supported by vertical logs at regular intervals (approximately 2-3 m) along the underpass for koalas to ascend or descend the koala furniture as required
- logs are greater or equal to 150 millimetre in diameter, or horizontal planks are greater or equal to 150 millimetre in width
- koala furniture extends beyond the underpass into koala habitat
- retain vegetation up to the entrance of the underpass, including koala food trees and groundcover without obstructing access to the culvert
- mandatory installation of koala exclusion fencing and other associated infrastructure on all sides of the crossing structure to improve the effectiveness of the underpass or overpass and to funnel animals to the crossing point (4.3.13)
- fencing extends for a minimum of 150 metres on either side of the crossing structure.

Vegetated habitat linkages are retained or established by securing or enhancing habitat on either side of the road and crossing structure to encourage use and planting koala food tree species relevant to the local area and the regional ecosystem.

Crossing structures are installed at regular intervals along sections of road adjacent to koala habitat or habitat linkages.

- multiple culverts (approximately 100 metres apart) within a large patch of bushland will facilitate more natural ranging behaviour by the resident animals who have relatively unimpeded access to adjacent patches of habitat
- single large culverts spaced a maximum distance of one structure every 2 kilometre will allow adequate landscape scale connectivity and genetic exchange for dispersing animals.

Figure 4.3.10 a.(photo: Brisbane City Council). An overpass links habitat on either side of Boundary Road, designed for koalas and other fauna

Figure 4.3.11 (photo D de Villiers) Under-bridge crossing point for wildlife, with wide buffer to bridge footings that can accommodate fauna furniture to assist with movments and predator avoidance.

Alternative solutions

While large, fauna specific box culverts are best practice, there is a range of underpass designs and dimensions that are also suitable for use as fauna crossing structures. The number, type and positioning of fauna structures is a balance between ecological, engineering, and budgetary considerations.

Underpasses can take the form of:

- dual purpose culverts/pipes – used for vehicle or pedestrian access but are suitably placed for use by fauna.
- drainage culvert (single) – function is primarily drainage but can be used by fauna when dry.
- multiple culverts – culverts function as drainage devices but culverts are slightly elevated above the creek bank and are mostly dry to facilitate fauna movements outside major rain events.
- Box culverts of a minimum 1.5 metres x1.5 metres dimension are the minimum size for a single or dual carriageway on local roads. This size may include koala furniture.

Box culverts with dimensions as small as 900 millimetres can still be effective (Figure 4.3.14), however small culverts exclude the installation of fauna furniture, or escape poles; reduce natural light penetration and potentially reduce the use of the structure by koalas; and are only suitable for installation on single or dual carriageways less than 30metres wide.

Maintenance:

Crossing structures must be routinely inspected to ensure access points around the culvert and the culvert itself remain free from weeds or build-up of debris. The effectiveness of the crossing structure often relies on koala proof fencing to funnel or guide animals to the safe crossing points. Maintenance of fencing must include:

- a maintenance plan outlining inspection schedules and repair budgets
- management of vegetation adjacent to the structure to improve the use of culverts by koalas.

Notes:

- Natural substrate (resembling the forest floor) on the floor of the underpasses is ideal, but koalas are comfortable walking on most hard surfaces and will readily walk on concrete.
- Koalas need to be encouraged to use fauna underpasses by funnelling animals to entrances with koala exclusion fencing.
- Installing koala furniture throughout underpasses provide a means of escape for animals encountering predators in culverts. However, there is almost no evidence that koalas prefer to use furniture in culverts. Rather, almost all recorded crossings through underpasses by koalas have been on the ground.
- Koalas can incorporate underpasses and other crossing structures within their home ranges and become regular users of these structures (Figure 4.3.15).
- A lack of consistent monitoring data and robust comparative data for culverts means there is little statistical support for determining the best and most effective design to suit different environmental situations.

Figure 4.3.12. (photo D de Villiers) A 3.0 m x 3.0 m box culvert provides maximum light penetration and is large enough for fauna furniture to aid movmement and predator avoidance.

Figure 4.3.13.(photo D de Villiers) Koala exclusion fencing constructed along a rail line. Without barrier fencing, koalas will likely walk across the rail line and avoid the dedicated fauna crossing point/culvert. Fencing completed below.

Figure 4.3.14.(photo D de Villiers) Small 900 mm box culverts can still provide movement opportunities for koalas but are too small for the installation of koala furniture and will have reduced natural light penetration.

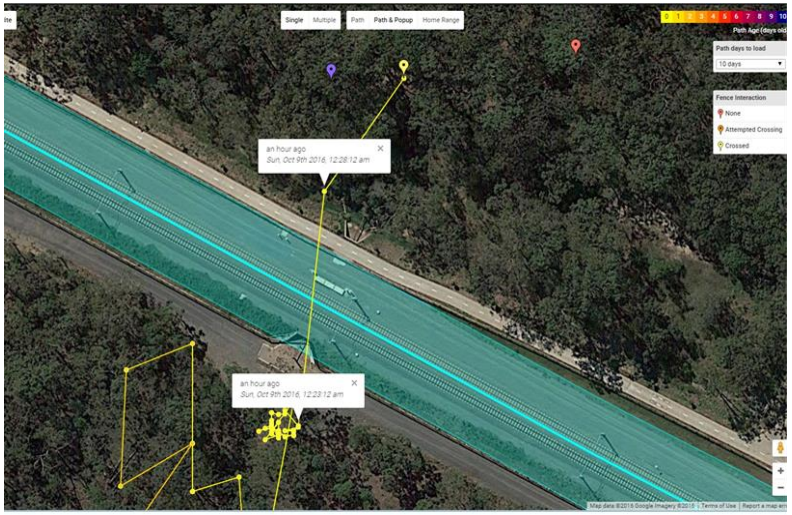

Figure 4.3.15. (photo: Endeavour Veterinary Ecology K-Tracker) Koalas will readily use culverts as part of their home range. A male koala uses one of the dedicated fauna crossing under a rail line.

4.3 Koala-safe transport infrastructure design and placement – road egress structures

Supporting information – road egress structures

Koalas often find their way onto road or rail corridors and can become trapped between road barriers and fencing and disorientated during movements through the landscape. Road egress structures provide a means for koalas to readily exit the transport corridor into the safety of adjacent habitat. These structures are used in conjunction with koala exclusion fencing and take the form of escape poles, koala gates or egress valves or other designs installed on the roadside to help koalas exit into bushland. Exclusion fencing is typically a one-way design, where sheeting prohibits koala entry from the habitat side to the road corridor. However, while the fencing on the side of the road corridor is climbable by koalas, navigating vehicle traffic and lane barriers can leave koalas disorientated and wandering on the road or along the road corridor.

Performance Outcome 3: Design and placement of road egress structures and reduces koala road mortality by allowing rapid egress from transport corridors and meet other environmental and safety requirements.

Design specifications

Best practice– road egress structures

1. Install one or more of the following road egress structures on state and local road koala mortality hotspots:
    - one-way koala escape gates, placed within the fence provide a means for koalas to manoeuvre through exclusion fencing (Figure 4.5.16).
    - install koala escape gates in areas where koalas can access the transport corridor, for example, near on/off ramps that can't be fenced adequately to exclude koalas.
    - escape gates are made of Perspex with a spring balanced/counter lever design to wield to gently pressure of a koala pushing through the gate flaps in one direction (Figure 4.3.17).
    - koala escape gates should be deployed with fencing 'wings' to maximise encounters and use of the structure. Additional fencing aims to funnel koalas to the egress structure.
2. Fencing with a minimum of a 300 mm gap from the ground to the fencing material, is fitted with a 1.0 m wide skirt made from UV stabilised netting and placed on the habitat side of the fence (Figure 4.3.18).
    - netting must be small enough to avoid the entrapment of koalas and other wildlife (mesh size <8 mm) from pushing through the netting.
    - the flexible skirting is lightweight and allows a koala to crawl underneath the netting from the road corridor but cannot easily be lifted to crawl underneath the netting from the habitat side.
3. Deploy egress structures in areas where koalas are known or likely to enter transport corridors, particularly where koala proof fencing ends or in the vicinity of on and off ramps that allow access to the road corridor.

Figure 4.3.16. (photo: Jonathan Hanger) A koala escape gate is fitted along fencing to provide one-way access out of the road corridor.

Figure 4.3.17.(photo: Jonathan Hanger) Perspex gates with a spring balanced/counter lever design will wield to gentle pressure of a koala pushing through the gate flaps in one direction but will not allow a koala to push open the gates to access the road corridor.

- deploy at least two koala gates a maximum of 250m apart on each side of the egress point onto the road corridor.
- deploy escape solutions with fencing to funnel animals to egress structures.

4. Design egress structures to meet environmental and safety constraints along state and local road networks.

Alternative solutions

Alternative designs need to carefully consider the climbing ability, natural behaviours and movements of koalas to be effective. Structures such as escape ramps have been used with limited success, however they remain a valid means of egress from the road corridor if designed correctly.

1. Escape poles, placed vertically in close proximity to koala exclusion fencing allow koalas to ascend the pole and manoeuvre over the fence and out of the transport corridor or other unsafe environment (Figure 5.3.19).
    - poles are a minimum 125 mm in diameter treated pine logs or salvaged timber.
    - poles are positioned within 300mm of the fence on the opposite site of the habitat area to ensure it is detected by a koala travelling along the fence trying to access safe habitat.
    - escape poles are paired with a pole on the other side of the fence and a horizontal cross piece of the same diameter joining the two vertical poles to allow koalas to easily manoeuvre over the fence, facilitating a more rapid exit from the transport corridor.
    - the egress pole extends a minimum of 600 mm vertically above the height of the fence allowing a koala to survey its surroundings. The ingress pole is a minimum of 300 mm above the height of the fence.
    - the horizontal pole securely connects the two vertical poles and is secured to the side of both poles or flush with the poles (see note below).
    - the habitat-side /ingress escape pole is fitted with a smooth ‘collar’ material that a koala cannot climb with the top of the collar a minimum of 1.5 m from the ground (Figure 4.3.20); or the ingress pole can be ‘floating’ at a minimum of 1.2 m to a maximum of 1.5m off the ground and out of reach of a koala or (Figure 4.3.21).
    - metal sheeting is installed vertically from the top to the bottom of the fence and with a minimum of 600mm either side of the pole to prohibit koalas climbing the fence and accessing the escape pole above the unclimbable collar (Figure 4.3.20).
    - attach 600 mm metal sheeting or other screening material to the bottom of the fence for a minimum of 10 m either side of the escape pole to encourage the koala to look up at the trees and be more likely to detect the pole.
    - deploy escape poles between and beyond koala gates to provide a variety of egress options for animals.
    - poles are spaced at regular intervals (~50 m), or more frequently in areas where koalas are likely to access the transport corridor, such as in the vicinity of on-ramps and off-ramps.

Figure 4.3.18.(photo: Jonathan Hanger) A skirt of netting allows a koala to push underneath the fence from the road corridor but cannot easily be lifted for koalas to travel in the reverse direction.

2. Escape poles are only installed on the egress/unsafe side of the fence (Figure 4.3.22).
    - the pole is within 300 millimetres of a maximum 1.5 metres high fence to allow a koala to confidently jump from the pole extending at least 600 mm beyond the height of the fence, over the fence to the ground on the habitat side of the fence; or to manoeuvre to the top of the fence and slip down the panelling into safe habitat.
    - the pole is within 300 millimetres of a fence over 1.5 metres in height, with metal sheeting fitted below the top of the fence – koalas are able to climb part way down the fence and slip/jump to the ground at the point where the sheeting is fixed to the fence.
3. Escape ramp placement, design and construction will dictate its effectiveness (Figure 4.3.23).
    - use fencing wings to funnel koalas to the ramp where road safety permits installation of additional fencing along the road corridor.
    - ensure the structure is a minimum of 1.2 metres high and is fitted with metal sheeting or other unclimbable material on and around the ramp's installation point.
    - provide a natural substrate and maintain to eliminate ground cover that will reduce detection and use by koalas
4. Escape ladders assist koalas to navigate steep natural and cement embankments (Figure 4.3.24).
    - wooden rungs of a minimum 100 millimetres diameter or width placed a maximum of 300 millimetres apart and securely fixed to the embankment allows a koala to grip and climb the structure
    - install wide structures made with climbable materials to facilitate detection and use by koalas.

Maintenance

Egress solutions with moving or pliable components will need a maintenance schedule based on manufacturer's specifications to replace worn or perishable parts of the structure (e.g. push under solutions with netting or egress valves with hinged doors). The maintenance schedule must also include weed management to keep the structures clear of vegetation that could block entry to the egress device or hinder the correct functioning of the device.

Notes:

Knowledge of the koala's preference to push through or under a fence saw the development of the koala gate. Other innovative solutions must be based on knowledge of koala movement and behaviour to achieve desired outcomes.

Escape poles can provide for resting forks for use by koalas; however, the escape pole or other structure's main purpose is to facilitate the rapid egress of the koala from an unsafe environment to safer habitat.

Trials and monitoring of structures should occur to ensure designs that 'in theory' would seem appropriate are actually used as intended by koalas. For example, determine the preferred orientation of rungs on an escape ladder might involve testing if koalas are more inclined to use a ladder with horizontal or vertical rungs (Figure 4.3.24).

Figure 4.3.19. (photo D de Villiers) A double-sided escape pole may facilitate the more rapid exit of koalas from a transport corridor. Metal sheeting on the habitat side stops koalas from climbing the fence and reaching the pole above the sheeting.

Figure 4.3.20. (photo D de Villiers) The ingress pole on the habitat side of the fence must prohibit climbing by koalas – here the pole is fitted with smooth metal sheeting and the fence adjacent to the pole is pannelled to stop koalas climbing the chain-link fencing and grabbing the pole above the metal collar.

Figure 4.3.24.(photo: google earth). A koala escape ladder is installed on a steep embankment to facilitate rapid egress by koalas from the road corridor in a known koala crossing location.

Figure 4.3.21. (photo: oreton Bay Regional Council). A 'floating' double-sided escape pole negates the need to koala-proof the inner/ingress pole.

Figure 4.3.22. (photo D de Villiers) Escape poles placed along a road corridor will allow koalas to exit the road corridor and jump over the koala exclusion fencing to the safety of adjacent habitat.

Figure 4.3.23.(photo D de Villiers) A koala escape ramp may assist to funnel koalas into secure bushland.

4.4 Mitigating construction related threats to koalas – vegetation clearing

Supporting information - vegetation clearing impacts

Development often requires the removal of koala habitat, particularly for community infrastructure, transport corridors and residential development. Construction activities, whether on a single lot or large-scale infrastructure or residential development projects, can significantly impact koalas and their habitat in the following ways:

- death and injury to koalas from vegetation clearing operations, both directly through the felling of koalas out of trees, and indirectly when the loss of habitat puts koalas in hazardous environments, such as the forced dispersal of displaced koalas across roads (Figure 4.4.1).
- the introduction of site hazards that can cause entrapment, injury and death, such as water bodies, trenches, pits, netting, wiring and fencing
- disruption to movement paths of koalas from the placement of equipment and infrastructure on site
- tree damage, loss and habitat degradation from weed incursion and spread, fire, dust and waste material and poorly defined work zones
- increased traffic movements during construction, both within the development site and on roads used to access the site
- increased noise, particularly sharp loud bursts of sound, compared to low rumbling of machinery.

The size and scale (and associated budget) of the development will guide the level of mitigation methods required and adopted during construction works, however all works regardless of the scale, must ensure koalas are not injured or killed during site works.

Performance Outcome: Manage the risk to koalas from vegetation clearing

Design specifications

Best practice

1. Robust detection/survey methods are used to locate koalas prior to the commencement of vegetation clearing operations via:
   - on-ground observational surveys by experienced koala ecologists or spotters
   - thermal imaging drone surveys
   - detection dog surveys with dogs trained to detect live animals
   - GPS and BLE near-real-time or programmable monitoring devices (Figure 4.4.2).

2. Koalas can be readily located through radio-telemetry or GPS on the development site if captured prior to vegetation clearing activities and fitted with a monitoring device.

   - mapping interfaces and ‘locate now’ features on GPS tracking units can allow the monitoring of animals remotely and in almost near real-time.

Figure 4.4.1**.(photo D de Villiers) Tree clearing operations in koala habitat areas can cause signifcant harm to koalas both directly through habitat loss and injury, and indirectly from associated site hazards.**

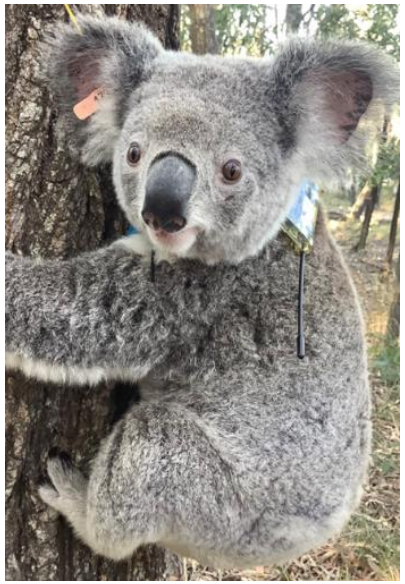

Figure 4.4.2. (photo D de Villiers) GPS collars can provide real-time location data for koalas where there is the potential for injury during site works.

- pre-clearing radio-tracking of animals in the clearing footprint will ensure koalas are located and their position identified.

3. Trees with koalas are clearly flagged with a specific colour or design of flagging tape and the on-site fauna spotter is alerted.
   •
4. Temporary fencing is installed around the perimeter of the site to minimise the haphazard emigration of fauna from the site into unsafe environments during clearing.

   - temporary fencing is fitted with a panel of unclimbable material of a minimum 600 mm width, with the top of the sheeting 1.5m from the ground (see section 5.2 Koala exclusion fencing). Temporary fencing is typically secured on footings that leaves a large unsecured gap beneath the panels that will provide unwanted movement opportunities for wildlife (Figure 4.4.3).
   - temporary fencing has a skirt of sheeting (e.g. corflute, small gauge wire) to stop the egress of animals under the panels, or fencing is of the type designed with bars that extend to the ground to keep larger fauna from pushing under the fencing (Figure 4.4.4).

5. Sequential clearing of vegetation is conducted, in the manner described in the *Nature conservation (Koala) Conservation Plan 2017*, as the most practical way of ensuring the safe exit of koalas by their own means from the clearing footprint.

   - clearing is staged (dependent on the size of the site) and timed to provide a minimum of 12 hours between clearing events.
   - appropriate habitat links, or trees retained as stepping stones, are maintained from the clearing site to adjacent habitat areas.
   - clearing is in the direction of retained habitat, adjacent habitat or local corridors to ensure koalas are not isolated in an island of vegetation.
   - trees are thinned out on the site prior to bulk clearing to encourage resident koalas to establish new home ranges.
   - no tree in which a koala is present, and no tree with a crown overlapping the tree with a koala is cleared, as per the Nature Conservation (Koala) Conservation Plan 2017.

6. Trees are felled in a controlled manner using a vertical tree grab on an excavator (Figure 4.4.5)
   •
7. Experienced koala spotters are present during tree clearing and during mulching operations (*see notes below).

Figure 4.4.3.**(photo D de Villiers) Temporary fencing is typically secured on footings with panels raised off the ground. This design allows egress of fauna into unsafe areas during clearing operations or in the construction zone.**

Figure 4.4.4**. (photo D de Villiers) Temporary fencing with bars to the ground will prohibit the movement of koalas to hazardous areas on the construction site.**

Alternative solutions

Many of the solutions listed above reflect legislative requirements and, as such, are mandatory.

It is the responsibility of the development proponent to ensure no harm or injury to koalas during habitat clearing, and any alternative solutions to habitat clearing practices need to be developed within the legislative framework. For example:

- trees approved for clearing can be ringbarked to encourage the relocation of resident koalas in the weeks prior to felling. Ringbarking of trees should be conducted in the same sequential clearing manner described above.
- areas of vegetation can be fenced with koala exclusion fencing (section 4.2 and above) to physically prohibit entry by koalas. Fencing can be expanded as koalas move into adjacent areas. However, spotters must still be present when habitat is cleared, regardless of the likely absence of koalas.

Maintenance

Fauna exclusion fencing must be maintained to ensure there are no points of egress for koalas into the construction zone. Fencing description and maintenance should form part of a wildlife management plan for the site.

Notes:

1. Koalas are cryptic and can be easily missed during surveys (Figure 4.4.6). Inexperienced observers can miss over 50% of koalas on a site. Innovative technologies using drones, Bluetooth beacons and GPS monitoring devices with near-real time data displayed on the cloud are proven effective means of monitoring the movements and wellbeing of koalas during vegetation clearing operations.
2. Thermal drone detections are optimised when conducted in the coolest part of the night and before sunrise, however there is a high possibility that the koala will change trees between the time of the detection and dawn, particularly during times of heightened activity in the breeding season. Thermal drone detections are still possible at dawn where there is less risk of the animal moving.
3. Clearing a tree housing a koala is prohibited under the Nature conservation (Koala) Conservation Plan 2017. Additionally, the capture and relocation of koalas requires a permit and approval from the state government and is only granted in very exceptional circumstances.
4. Koalas have been known to spend months in a small patch of the last remaining stand of trees on a development site where clearing has resulted in an island of vegetation. This can significantly delay clearing and prove costly for developers and significantly impact construction schedules.
5. Well-hidden young koalas can easily be missed in dense canopies.

Figure 4.4.5**.(photo: Brian Coulter**) An excavator with a tree grab can gentle lower trees to the ground, reducing the risk of broad-scale clearing and felling on fauna such as the koala.

4.4 Mitigating construction related threats to koalas – site hazards

Performance Outcome: *Manage the risk to koalas from construction-related threats from hazardous site activities*

Design specifications

Best practice

Construction activities can introduce hazards to a site and cause injury and death of koalas and degradation and loss of habitat. There are some simple measures that can reduce risk to koalas.

1. Site inductions and pre-start meetings are put in place to convey information to construction personnel and raise awareness of koalas on site and protocols relating to the protection of koalas and their habitat. For example:

    - contact list and procedures for sick or injured koalas requiring rescue are provided at induction
    - site operational works planning is in consultation with fauna spotters/ecologists at the start of the day.

2. Retained habitat is clearly demarcated with temporary fencing, tape and/or other visible markers, and access to this habitat is restricted to reduce the degradation and loss of habitat. For example:

    - restricting vehicle access and reducing risk of machinery damage
    - avoiding disturbance to the ground underneath the drip line of retained trees to avoid tree root damage
    - managing general access/use by site personnel
    - managing waste or spoil disposal to limit the spread of weeds
    - limit the use of open flames or equipment that could spark a fire and result in bushfire (Figure 4.4.7).

3. Safe movement paths between areas of habitat on site are maintained:

    - install signage on access tracks and go-slow points where koalas are known to cross the site
    - enforce speed limits
    - avoid placing equipment around vegetation used by koalas
    - fence off obstacles and structures and other site hazards that could entrap, injure, or kill a koala with koala exclusion fencing (see above and Section 4.2) including:
    - steep embankments, trenches and pits (Figure 4.4.8)
    - areas or structures that can hold water that don't have suitable egress points
    - recently dewatered dams or those currently being dewatered that can leave muddy substrates that can trap and effectively drown a koala Figure 4.4.9)

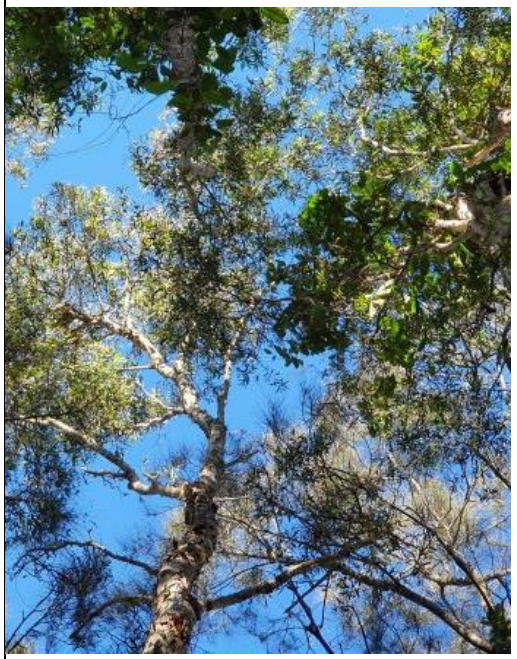

Figure 4.4.6. (photo D de Villiers) The koala in this picture was very difficult to spot, and detection rates vary widely with the level of experience of the observers and the vegetation type and cover.

Figure 4.4.7. Operational works on construction sites can introduce a range of hazards that can cause direct or indirect injury and deaths to koalas.

- equipment such as discarded fencing, mesh, wiring and other construction materials

4. Fencing encloses only those areas needed to ensure koala safety on site.
5. Domestic dogs are prohibited on site or restrained at all times.
6. Night-time vehicle movements on site and travelling to and from the site is restricted when koalas are most active between 6pm to 6am.

Maintenance

Fauna exclusion fencing must be maintained to ensure there are no points of egress for koalas into the construction zone. Fencing description and maintenance should form part of a wildlife management plan for the site.

Figure 4.4.8.(photo D de Villiers) Deep post holes for koala proof fencing along a state road upgrade entrapped a koala that could not climb out of the hole.

Figure 4.4.9. (photo D de Villiers) Dewatered of dams and sediment ponds can entrap koalas and effectively drown an animal in mud. A koala has walked over a drying surface and was entrapped and died as it sunk in wet mud at the centre of the dam.

4.5 Mitigating threats from wild and domestic dogs

Supporting information

Trauma from domestic and wild dogs continues to have an ongoing and constant impact on koala populations and is the third most common cause of koala injury and death after disease and vehicle-related trauma. Unlike

wild dogs, domestic dogs rarely attack koalas for a food source – rather, they are defending their territory (back yard) and driven by a hunting instinct to chase animals. Mortality rates from dog attacks are high - around 80% of koalas attacked by domestic dogs are killed, and almost 100% of koalas attacked by wild dogs are killed and partly or wholly consumed.

Domestic dog and wild dog control are highly emotive issues. Domestic dog control is problematic because owners are reluctant to:

- acknowledge the capacity of their dog to kill a koala
- confine or restrain dogs to the house or portion of the yard to limit koala and dog interactions.

Wild dog or dingo control is controversial and difficult as wild dogs:

- have been a part of the landscape for many thousands of years and are considered native wildlife in protected areas (Nature Conservation Act 1992) and also a declared pest species (Biosecurity Act 2014) under different legislation outside these areas. Landowners are obliged to take steps to control wild dogs on their land.
- are an apex predator and regulate ecological processes by keeping other pest animal species, such as cats and foxes, and overabundant species at sustainable levels in the environment.
- can effectively switch prey selection and within short timeframes have disproportionate impacts on native threatened species, including the koala.

Community awareness and public education campaigns can provide citizen science data on the spatial and temporal distribution of wild dog populations in the local area.

Performance Outcome 4A: *Mitigate the risk of injury and death of koalas from domestic dogs*

Best practice design specifications

1. Dog free or 'eco/green' estates entirely mitigates dog and koala interactions (Figure 4.5.1).

    - covenants support the prohibition of dogs within the residential development

2. Koalas and domestic dogs are kept apart on the property to reduce interactions that can cause injury and death to koalas.

    - dogs are confined to the house or a portion of the backyard from dusk to dawn when koalas are most active (small lot residential yards less than 800m^2) (Figure 4.5.2).
    - dogs are confined to a koala proof fenced area around the house, where property can be protected, but unfettered access to the entire property is limited (large lot residential and rural properties over 800m^2).
    - dogs undergo behavioural training to learn to avoid wildlife (e.g. The 'Leave it' program developed by Redland City Council and Griffith University) (Figure 4.5.3)
    - the property is fenced with koala-exclusion fencing to prohibit entry to the yard by koalas.

Figure 4.5.1.(photo D de Villiers) Dog-free areas effectively mitigate the threat of impacts to koalas from domestic dogs by negating interactions.

3. Development layout provides dedicated dog and koala separation areas.

    - dog off-leash areas are built away from areas of koala habitat and incorporate koala exclusion fencing (section 4.2) to keep koalas out of the enclosures.
    - reserves and areas of retained bushland are separated from residential areas by a road as a buffer to avoid yards with dogs adjacent to koala habitat (Figure 4.5.4).
    - house yards are fenced, and the remainder of the backyard is open and permeable to koalas.
    - signage that is easily interpreted outlines dog-owner's responsibilities in parks and reserves.

4. Domestic dog owners are engaged with dog expos and 'dog day out' days where koala and wildlife messaging can be delivered in a targeted approach in a relaxed atmosphere.

Performance Outcome 4B: *Mitigate the risk of injury and death of koalas from wild dogs*

Best practice design specifications

1. Determine the presence or absence of wild dogs on and adjacent to the site (Figure 4.5.5).

    - conduct surveys seasonally throughout multiple years to assess the presence, distribution and abundance of wild dogs.
    - deploy trail cameras across the site to detect wild dog activity
    - use thermal imaging drones to census the dog population
    - analyse passively collected samples (dog scats) to estimate number of genetically distinct animals in the area.

2. Enhance habitat and habitat linkages to maximise avenue of escape for koalas in the landscape where wild dogs are known to be present.
3. Install escape poles and other egress structures to facilitate rapid escape into treed habitat areas along easements, transport corridors and swathes of cleared areas where dogs roam.
4. Install refuge poles along powerline and infrastructure easements that cannot be rehabilitated to allow a refuge and means of escape for koalas crossing cleared areas.

    - poles are a minimum of 125 mm in diameter and have 1-2 resting forks that are a minimum of 3 m from the ground
    - refuge poles can be salvaged during tree clearing operations.
    - poles are placed at 10 m-20 m intervals

5. Engage local landholders to report sightings of wild dogs to track spatial and temporal distribution and abundance in the region to ensure the population is being managed at sustainable levels.

Figure 4.5.2. (photo: Helen Binstead) Domestic dogs are kennelled or confine to a portion of the yard at night when koalas are most active and dogs are unsupervised.

Figure 4.5.3.(photo: Griffith University) Dog training programs, such as "Leave it', aim to reduce dog and koala interactions.

Maintenance:

Egress solutions with moving or pliable components will need a maintenance schedule based on manufacturer's specifications to replace worn or perishable parts of the structure (e.g. push under solutions with netting or egress valves with hinged doors). The maintenance schedule must also include weed management to keep the structures clear of vegetation that could block entry to the egress device or hinder the correct functioning of the device.

Notes:

- Wild dog control is the responsibility of landowners under the *Biosecurity Act 2014*, however many urban local councils have active pest management programs to monitor and manage wild dogs in their jurisdiction.

Figure 4.5.5. (photo: Endeavour Veterinarian Ecology) An image of a wild dog caught on infra-red camera. This dog was solely responsible for the death of approximately 80 koalas in 18 months.

Figure 4.5.4. (photo: Google Earth) Suburban streets create a buffer between residential development and conservation areas in Redland City.

4.6 Koala-safe pools, ponds and other waterbodies

Supporting information

Koalas are reasonable swimmers and have been observed swimming across creeks and rivers in search of habitat or during dispersal or mating opportunities during the breeding season. However, koalas cannot swim for prolonged periods and will become waterlogged and drown. Koalas have been recovered drowned in backyard swimming pools, water treatment ponds, along beaches and in creeks.

Backyard swimming pools are a particular threat to koalas as they cannot grip the typical smooth lip of inground pools to pull themselves out of the water. Animals trapped in pools become exhausted from swimming back and forth looking for an exit and drown (Figure 4.6.1). Koalas can also succumb to shallow bodies of water, or areas that are drying out after inundation and get trapped in mud and asphyxiate or succumb to hyperthermia. Providing suitable methods of egress from waterbodies and boggy areas provides a safe and permeable environment for koalas.

Performance Outcome 6: *Mitigate the risk of injury and death of koalas from pools and other waterbodies*

Design specifications

Best practice

Install koala proof fencing to prohibit koalas' access to waterbodies (see section 4.2) or install measures to allow egress from water or areas drying after water inundation.

1. Construct and landscape pools and other bodies of water with egress points

    - shallow lagoon-style entries that are level with the ground and consist of solid substrate (Figure 4.6.2).
    - landscaping features around the pool, ponds or dams such as rocks, wooden decking or vegetation that a koala could reasonably access and climb

2. Include structures to assist a koala's egress from pools, ponds or other bodies of water

    - place a large diameter (>80 mm) marine rope with float in the water, with a length suitable to span most of the width of the body of water. Ensure some of the same length of rope is securely tied to an anchor point on the ground beyond the pool (Figure 4.6.3).
    - place a log, wooden beam or other material of width/diameter greater than 100 mm that is easily gripped by a koala into the waterbody with the end fixed securely beyond the water body at or near the ground.

Figure 4.6.1. (photo Bree Wilson) Backyard swimming pools and other waterbodies, where exit from the water is difficult, can trap and drown koalas.

- fit a floating animal escape ramp to the pool to facilitate exit from the water.

3. Install koala-exclusion fencing (section 4.2) around the perimeter of the pool, pond or water body to prohibit entry by koalas.

- perspex, glass or other material can be used to improve the aesthetics of the pool area.
- ensure fencing complies with Australian Standards and section 4.2, koala-exclusion fencing.

Alternative solutions

Devices to mitigate drowning can comprise a range of materials that a koala can grip and climb. These solutions must:

- float on the surface of the water so the structure is easily encountered by koalas
- be sturdy so that the structure does not flip over when a koala grips it, pulling the koala under the water
- be securely anchored to a point external to the pool to allow exit from the water and over the smooth lip of the pool.

Maintenance

Egress solutions with perishable components will need a maintenance schedule based on manufacturer's specifications.

Notes:

1. Pool fencing must also comply with Australian Standards and relevant state and local government requirements. See AS AS1926-2012 Fencing for swimming pools and Queensland standard QDC MP3.4.
2. Pool covers, unless held taught, can trap a koala, and drown an animal when the weight of the koala pulls the cover below the surface of the water.

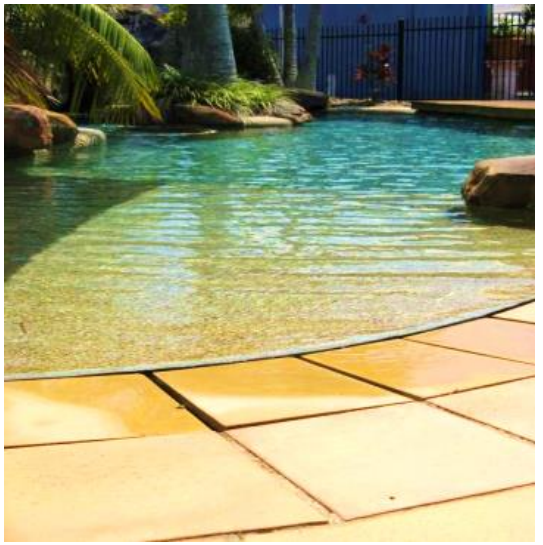

Figure 4.6.2. (photo: D de Villiers) Pools with lagoon-style exit points allow koalas to easily exit the pool.

Figure 4.6.3. (photo: D de Villiers) Large diameter marine rope securely anchored to a structure beyond the pool can provide a point of egress out of the water and be placed at opposite ends of a pool.

4.7 Koala habitat revegetation and enhancement

Supporting information

The loss, fragmentation, alteration, and degradation of koala habitat at a local level can have broader ramifications for the regional koala population. In extreme situations, habitat linkages and movement paths can be altered, areas of habitat separated, and threats introduced that limit dispersal and safe movement opportunities for koalas. Restricted genetic exchange in the population is also a long-term consequence of reduced landscape permeability. Strategic mapping of important habitat linkages and corridors can identify area for conservation, habitat restoration and targeted mitigation of threats. Appropriately designed development (section 3.3) should ensure the maximum possible retention of koala habitat values.

Habitat revegetation, enhancement and landscaping of residential estates, properties and public spaces with koala habitat trees can offset habitat loss at a local scale, provide additional habitat for urban koalas and improve habitat connectivity and permeability. Koala habitat trees grow quickly in coastal areas of South East Queensland and can provide a food and shelter resource for koalas in as little as 2-3 years (Figure 4.7.1). Revegetation with koala food tree species as a food resource and understory species to provide shelter from extremes of weather provides the complexity of habitat that koalas require and should guide koala habitat revegetation programs.

***Performance Outcome**: Restore and enhance koala habitat to improve landscape permeability*

Figure 4.7.1. photo: D de Villiers) A koala rests in a three year old tree, planted as part of a large koala habitat offset. The person on the right of the tree gives an indication of the tree height.

Design specifications

Best practice

1. Assess the site's location within the regional landscape and consider where revegetation efforts will provide the most benefit to koalas and koala habitat values in a local and regional context.

    - revegetate areas to improve habitat connectivity within and between the site and adjacent areas.
    - revegetate in bioregional corridors and locally significant habitat corridors to enhance vegetation in these priority zones.
    - revegetate in locations to enhance or buffer areas of existing vegetation, or to improve the quality of areas of degraded habitat (Figure 4.7.2).

2. Habitat is restored to reflect the site's original or endemic regional ecosystem vegetation type.

    - ecological assessment of vegetation (desktop and on-site validation) is undertaken to confirm the site's regional ecosystem and ratio of canopy and understory species.
    - seedlings grown from locally collected seed are planted to enhance revegetation efforts as they are best suited to local conditions
    - seedlings are planted at densities slightly higher than the average stem density for the regional ecosystem to account for up to 10% tree loss as the habitat matures.
    - site preparation, planting and maintenance is carried out by experienced habitat restoration teams.

Figure 4.7.2 Revegetation provides habitat and habitat linkages and permeability to other areas of koala habitat in the landscape.

- tree species are mixed, not planted in monocultures around the site, and planted in areas on the site that are better suited to that species.
- access by the public or residents is limited or prohibited while the habitat is regenerating.

Alternative solutions

1. Establish koala habitat through direct seeding or natural regeneration.

    - plants that germinate may be more resilient than tube stock, however, a large volume of seed is needed to ensure a similar level of cover to tube-stock planted revegetation areas.

2. Bias the planting to focus on preferred koala food trees and increase the ratio of preferred to non-preferred species occurring in the regional ecosystem.

3. Involve local community groups, schools, and other stakeholders to assist with revegetation efforts.

    - planting is under the supervision of an experienced bush regeneration team member to distribute species around the planting area and supervise planting techniques.

Maintenance

Maintenance of revegetation areas is essential to maximise plant establishment, growth and survival. Maintenance should include:

- watering during plant establishment, and then as required
- control of grazing by native animals or trampling by cattle during establishment using temporary fencing to keep animals out of the area
- weed control to reduce competition and smothering of trees

Notes

1. Plant to suit environmental conditions to ensure seedlings will have the best chance of establishment. Avoid planting in extremes of weather where heat waves, cold snaps or flooding can kill trees.
2. Trials are currently being conducted to determine the effectiveness of drones in the dispersal of koala habitat seeds and may be suitable for the restoration of large areas.

Definitions

Connectivity means the extent to which individual patches of koala habitat areas are functionally linked to each other in a larger network of koala habitat areas.

Connectivity can be achieved in two different ways:

1. structural connectivity which refers to physical connections between koala habitat areas which includes areas of native vegetation;

2. functional connectivity which refers to the ability for koalas to safely move between patches of koala habitat areas without increasing the risk of injury or death of a koala.

‘**Go slow’ point** is an area where koalas are expected to cross a road and features have been incorporated to reduce vehicle speed.

Koala furniture are structures that are placed within, or used in association with, road crossing structures that increase the ability of koalas to move through an

area. For example, for example, a log may be placed horizontally within a culvert to encourage koalas to pass under a road rather than across it where they may be

hit by a car.

Koala habitat means:

- an area of vegetation where koalas live; or
- a partially or completely cleared area used by koalas to cross from an area of vegetation where koalas live to another; or
- an area of vegetation where koalas do not live, if the area primarily consists of koala habitat trees and is reasonably suitable to sustain koalas.

Note: as defined under Nature Conservation (Koala) Conservation Plan 2017.

Koala habitat area means an area shown on the Koala Conservation Plan Map that the chief executive of the Nature Conservation Act 1992 has determined to be a koala habitat area due to the combination of biophysical measures and suitable vegetation of the area.

Note: as defined under *Nature Conservation (Koala) Conservation Plan 2017*.

Koala safe infrastructure means infrastructure that provides for safe movement either above or below an area that poses a risk to safe koala movement, such as a fauna overpass or underpass with koala safety fencing associated with a road.

Safe koala movement opportunity is a measure that is intended to:

- minimise threats to resident and transient koalas; or
- achieve permeability to provide for the safe movement of koalas within and across a site; or
- provide food or refuge sources for koalas.

Urban purpose means urban purpose as defined in the *Planning Regulation 2017*

Appendix 1: Koala-sensitive operational works guidelines

Background

New developments in koala habitat areas are likely to have significant adverse impacts to koalas unless koala-sensitive design guidelines are applied. In addition, the process of developing a site poses risks to koalas that inhabit, use or move through the site during operational/construction works. These risks include, but are not limited to:

1. displacement of resident koalas into dangerous areas, onto roads and into areas that do not supply their food, water and shelter needs, leading to illness, injury, starvation and death;
2. entrapment of koalas in fencing, ditches, trenches, holes and sediment collection areas, leading to death and serious injury;
3. death and serious injury of koalas caused by vegetation clearing works.

These koala-sensitive operational works guidelines will assist proponents and their construction contractors to reduce risks to koalas by applying reasonable and appropriate measures during approved operational works. They should be read in conjunction with other Codes and guidelines, including the *State Code 25: Development in South East Queensland koala habitat areas* and the *South East Queensland Koala Conservation Strategy 2020-2025;* and any conditions imposed on development approvals.

Early engagement of qualified experts in koala detection and management

Proponents should engage with koala ecology and management experts early in the planning phase to ensure that:

1. koala presence and koala habitat values in and around a proposed development site are well understood;
2. koala-sensitive design principles are considered and applied where appropriate to a proposed development;
3. requirements for active koala management are well understood prior to commencement of operational works, including engaging with DES if koala translocation is being considered;
4. management of risks to koalas during operational works is adequately planned for and appropriate measures implemented, particularly during the vegetation removal phase.

Proponents must engage a DES-approved fauna spotter/catcher and/or koala spotter well prior to the commencement of vegetation clearing and works. The fauna spotter/catcher should make a preliminary assessment of the site at least one month prior to the commencement of vegetation clearing works, to ensure adequate time is available to discuss the appropriate management of koalas on, or using, the site. This might include a need for translocation of koalas by a suitably qualified service provider, when displacement of the koalas into dangerous areas or unsuitable habitat is a likely consequence of the vegetation clearing.

Further information regarding relocation, translocation and release rules can be found here: Relocation and release of rehabilitated koalas | Environment | Department of Environment and Science, Queensland (des.qld.gov.au)

Use of innovative approaches to meeting regulatory obligations and community expectations

Prior to commencement of vegetation clearing and preferably during the planning and design phase, thorough surveys of bushland and trees on the site should be conducted to detect koala presence and/or evidence of use – such as presence of scats (faecal pellets) and characteristic scratches on smooth-barked trees.

Use of thermal drones for koala detection

New technologies, such as thermal drone surveys, can be very effective at rapidly detecting koalas in bushland. This can increase koala detection rates up to around 80-90%, significantly reducing risk of inadvertent harm during vegetation clearing works. Drone operations must abide by Civil Aviation Safety Authority (CASA) and animal ethics requirements. This approach is highly recommended to ensure that proponent and their contractors use all reasonable methods to avoid harming or killing koalas during vegetation clearing works.

Use of koala tagging and monitoring programs

For large development sites with significant numbers of koalas (or likely to be used by large numbers of koalas) should consider implementing a koala tagging and monitoring program well prior to the scheduled commencement of operational works. Such programs involve the capture and radio-telemetric tagging of koalas on a site, which can facilitate several beneficial outcomes:

1. informing the koala-sensitive design and planning by providing data on the movements and use of the site by koalas;
2. demonstrating that a proponent is applying best-practice approaches to the protection and management of koalas, thereby meeting both regulatory obligations and community expectations;
3. facilitating the rapid detection and protection of koalas during vegetation clearing works;
4. facilitating and informing community stewardship models for koala management as the development matures.

Choosing appropriate vegetation clearing methods and machinery

Choosing appropriate vegetation clearing methods and machinery can significantly reduce the risk of causing harm to, or death of, koalas during operational works. Koalas can be very difficult to see in some vegetation types, with detection rates as low as 15% in some habitat types. This means that inappropriate methods have a high likelihood of causing severe injury or death to koalas, which may expose a proponent or contractor to prosecution under several State Acts, and a stop-work order.

Suitable vegetation clearing machinery are excavators mounted with tree-grabs or grapples. These can be fixed or rotating grapples suitable for larger machines. Use of tree-grabs allows for vegetation to be 'peeled' away in layers from the standing vegetation, which significantly improves visibility for the spotter/catcher, and reduces the risk of non-detection of fauna. The use of fixed or rotating grapples also facilitates the controlled felling of fauna-containing or habitat trees and provides a means of demonstrating compliance with animal welfare and nature conservation regulatory obligations.

For larger habitat trees, both arborists' methods and use of elevated work platforms to allow for the removal of koalas and other fauna from such trees is the preferred method when this can be achieved safely and by suitably qualified personnel and as a part of an approved koala management program. A tree *must not* be felled by any means if a koala is known or reasonably suspected to be in the tree.

The use of bulldozers, mobile mulching heads, and excavators with only a bucket or ripping hook does not facilitate the controlled fell of vegetation and are not recommended. The use of inappropriate machinery leading to the death of a koala or other wildlife could expose a proponent or contractor to prosecution because of the failure to use reasonable and appropriate measures to avoid the harm.

Sequential clearing and leaving suitable wildlife escape routes

Approved vegetation clearing must be conducted in a sequential fashion and in a direction that aids displaced koala movement into remaining suitable habitat. Proponents and contractors should review the other relevant documents relating to koala protection during vegetation clearing (mentioned above).

Koala and fauna fencing

Fauna fencing can be used to either:

1. Facilitate koalas and other fauna movement across the fenced area when movement is essential for their welfare and to maintain ecological connectivity between areas that are safe for wildlife.
2. Exclude koala and other fauna from areas that are dangerous, such as roads and active construction areas.

Koala-permeable fencing

Koala permeable fencing should be used when construction or other fencing is required to allow for koala and fauna movement. Permeable fencing can be easily achieved by allowing a gap of up to 300mm under the lower rail or edge of the fencing. This is because most terrestrial wildlife and koalas, when they are moving across the ground, prefer to push under a fence, rather than climb or jump over it. Commonly used construction panel fencing

can readily be made koala-permeable by allowing for several sections where a small dug-out or depression exists or is created under the lower bar of the panel.

Koala-exclusion fencing

Koala exclusion fencing can be achieved by lining the 'safe' side of the construction panel fencing with a sheer material such as Corflute® plastic sheeting/rolls, or similar sheer sheeting of 900-1200mm in height. Design specifications for permanent koala exclusion fencing are outlined in section 5.2 Koala exclusion fencing in the *Koala-Sensitive Design Guidelines*.

Use of other measures to protect koalas during operational and construction works

Proponents should engage a koala expert to ensure that other risks that arise during operational works and construction phases are adequately mitigated. These include, but are not limited to the following hazards:

1. Trenches, pits, sediment ponds – these can fatally entrap koalas.
2. Swimming pools and other bodies of water with unclimbable sides.
3. Netting, barbed wire and other materials that can entrap or ensnare koalas.
4. Electricity poles, towers and cranes, which can be climbed by koalas and cause work stoppages and direct hazards to koalas.

In most cases, temporary or permanent fauna exclusion fencing can be used to mitigate risks by isolating the hazard area from koala ingress. More sophisticated methods using radio-telemetric tags and danger beacons can be used when combined with a koala tagging and monitoring program, to alert koala management personnel when koalas move into danger areas.