Department of Agriculture and Food

GOVERNMENT OF WESTERN AUSTRALIA

Potential ecological footprint of the proposed Esperance extension to the State Barrier Fence on wildlife

Report prepared by the
Department of Agriculture and Food, Western Australia

Important disclaimer

Contents

Background

The State Barrier Fence (SBF) is the primary tool for management of emus, wild dogs and kangaroos moving from rangelands into the grain producing agricultural lands of the southwest land division in Western Australia (WA). The SBF has become increasingly important for the management of wild dogs in the agricultural region of WA, particularly since the installation of lapwire to the entire SBF was completed in February 2013. Lapwire, attached under tension to the bottom of the fence, prevents wild dogs from digging underneath the fence.

The SBF currently runs for 1190km starting north of Kalbarri on the coast at Zuytdorp Cliffs to 25km east of Ravensthorpe. In late 2014, 170km of new SBF was constructed to fill a 50-year gap in the fence (the 'Yilgarn Gap') located between Southern Cross and Hyden.

Construction of the original SBF commenced in 1901 to stop rabbits invading from South Australia and extended from the coast at Jerdacuttup, near Ravensthorpe 1822km to 80-Mile Beach north of Port Hedland. Several additional versions and variations to the SBF were constructed over the next 100 years with the expansion of agriculture, to assist with rabbit, emu and wild dog control (Figure 1). There is now one consolidated SBF in WA currently maintained by State Government (Figure 2). While unsuccessful in preventing the spread of rabbits, the SBF has proved successful in limiting the impact of emus, wild dogs and kangaroos on agricultural enterprises.

Barrier fences have been used extensively as a tool in mitigating human-wildlife conflict associated with predation of livestock (Treves and Karanth, 2003) and in conservation (Somers and Hayward, 2011). For example, in 2015 the Australian Wildlife Conservancy constructed a 43km long, 1.8m high, electric fence enclosing 7800 hectares at Mt Gibson, WA (near the Eastern Wheatbelt) for exclusion of feral cats and foxes (Australian Wildlife Conservancy 2016).

An extension of the SBF is proposed around the Esperance agricultural area (Figure 2) to offer the same level of protection to the south-east agricultural area from wild dogs, emus and kangaroos that the rest of the agricultural land in WA receives. A detailed map of the proposed Esperance Extension (EE) alignment is shown at Appendix A.

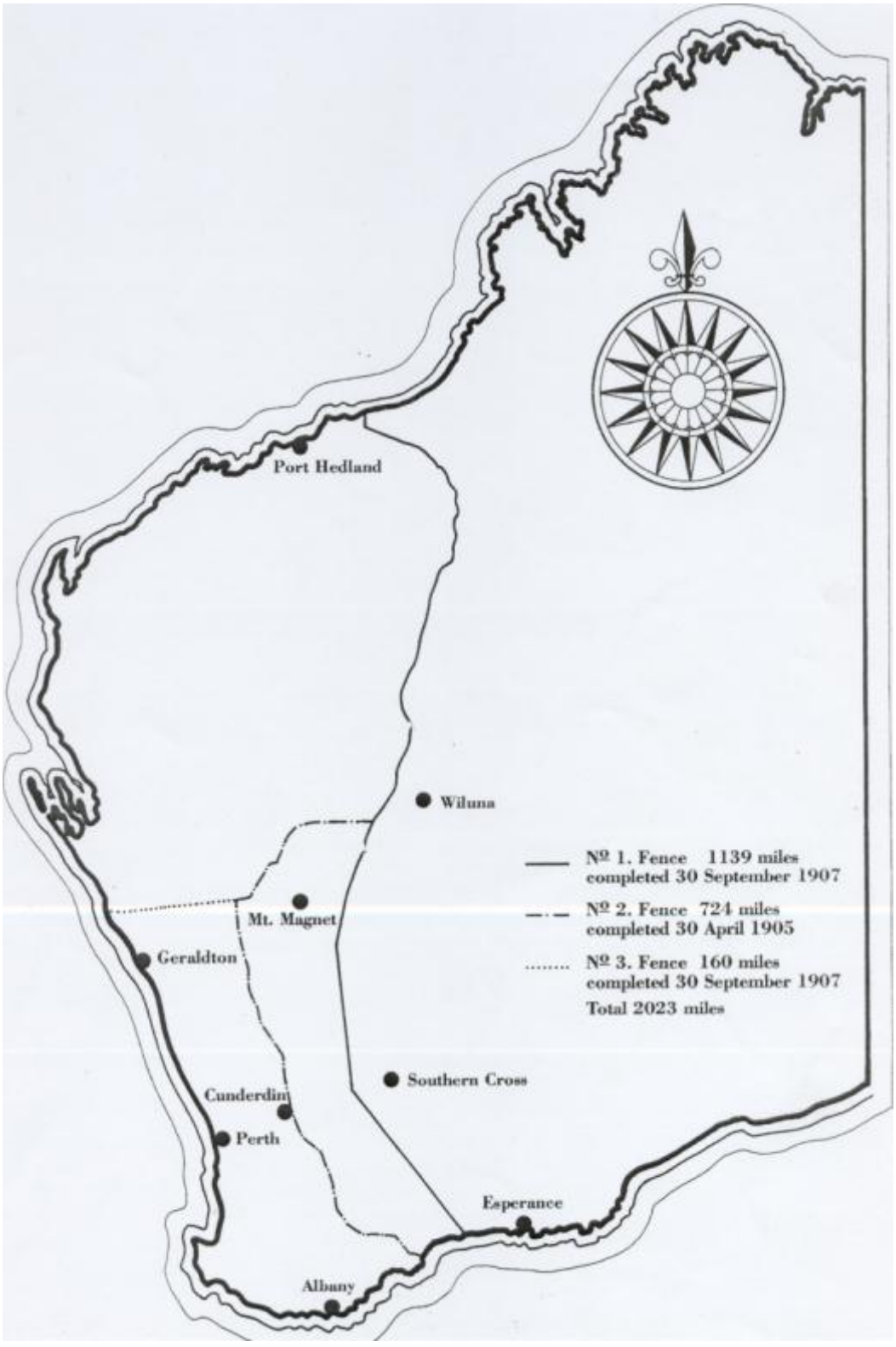


Figure 1 Previous major versions of the SBF (National Library of Australia 2016)

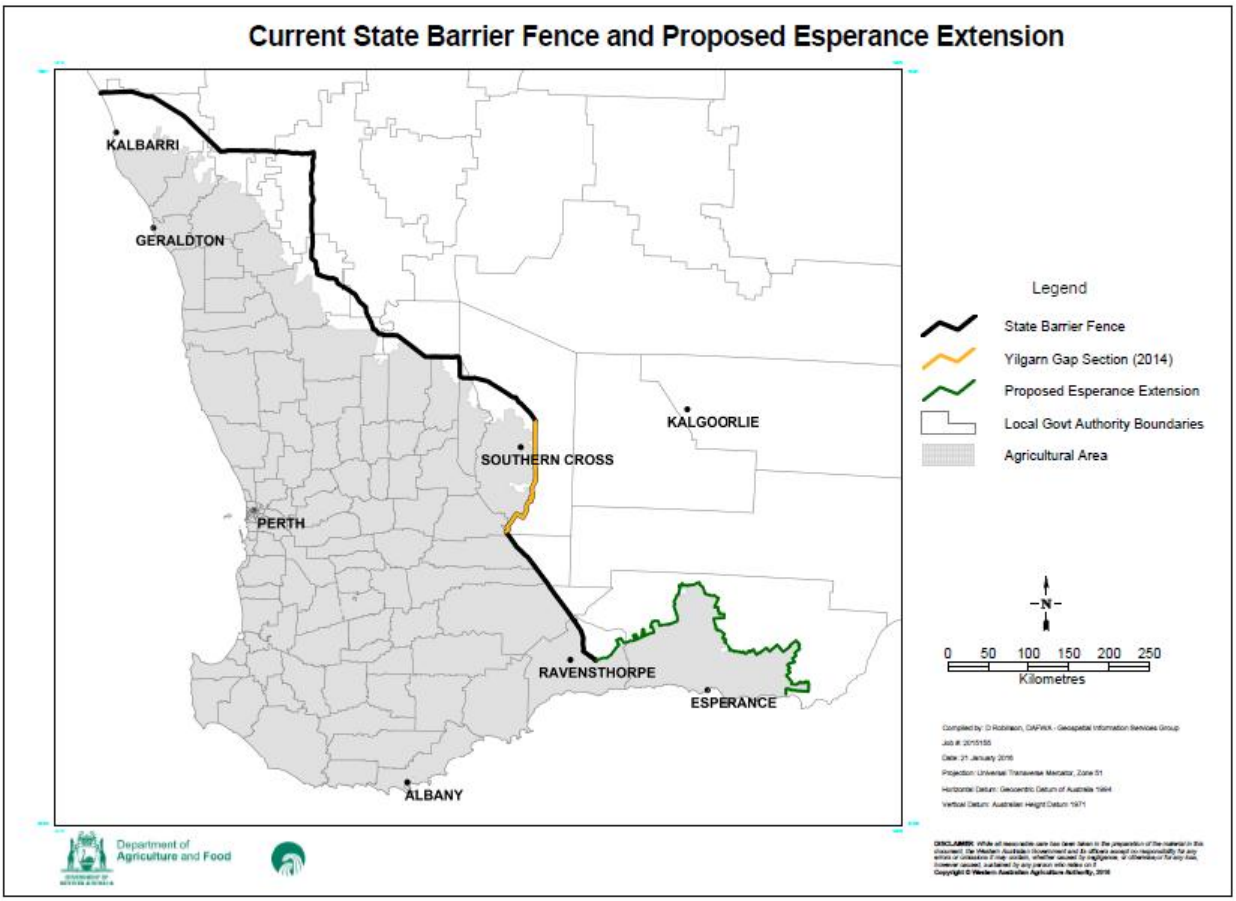


Figure 2 Current SBF and proposed Esperance extension

Specifications for construction of the proposed 660km EE fence are the same as that for the recently constructed 'Yilgarn Gap' barrier fence (Figure 3) and summarised below.

- The fence is constructed of ten-line fabricated wire netting with a height of approximately 1.35m. A single strand of 2.8mm high tensile plain wire is on top of the fabricated netting.
- Star pickets with a height of 1.8m are placed every 7m with 1.3m high visibility fluorescent orange droppers attached to the fence 7m apart (in-between the star pickets). The fabricated wire netting mesh size has a minimum size of 152mm x 102mm increasing to 152mm x 152mm at the top of the fence.
- Lap wire extends 400mm from the base of the fence along the ground under tension to prevent wild dogs and macropods burrowing under the fence.

Figure 3 The Yilgarn Gap SBF which was constructed during 2013 and 2014

Where located on unallocated Crown land, the EE would be constructed down the middle of a 6m wide track cleared of vegetation to provide vehicle access to both sides of the fence for maintenance. The remaining vegetation either side of the track out to a total width of 15–20m would be chained and potentially mulched (where cost effective) close to ground level to reduce impacts from wildfires on the fence and adjacent areas, and to provide a suitable distance for animals to avoid colliding with the fence. Where located on private land (113km) the EE would replace an existing farm fence and no new additional clearing would be undertaken, only trimming of overhanging branches where necessary.

The sectional distances of the EE and clearing footprints across the various land types is provided at Appendix B. A map illustrating the existing chained/cleared, unchained and private land sections of the proposed EE alignment is provided at Appendix C. A photo of a typical existing chained area where approximately 65% of the fence would be aligned is shown at Figure 4.

Figure 4 Typical chained fire break and fire access tracks next to agricultural paddocks, Esperance. Approximately 66% of the proposed fence would be aligned in similar, existing disturbed conditions to this, 17% on private cleared farmland, 7% next to graded tracks and 10% through uncleared bush

Approximately 320km of the proposed EE alignment was re-chained/cleared for firebreaks during the November 2015 emergency fires surrounding Esperance. Ongoing fire management/clearing of vegetation in this area will continue to occur to protect human life and property regardless of the EE. Additional fire mitigation works are proposed by Department of Parks and Wildlife prior to 30 June 2016 in the same area as the proposed fence alignment. Aligning the fence in this chained area where possible will result in the least environmental impact and minimise duplication of clearing.

Significant planning and biological studies have been undertaken to avoid or mitigate potential ecological impacts of the EE, compared with alternative alignments. The proposed EE alignment is more complicated and costly than the existing SBF, and initially proposed EE alignments. The final alignment has been purposefully designed to minimise fragmentation of the woodlands and any new clearing footprint (and hence maintain ecological values). This is at considerable additional cost compared to a straight line alignment. A different, lower cost, straighter alignment would have a substantially higher ecological footprint.

This document provides an overview of the potential ecological risks and benefits to native wildlife of the EE and identifies measures taken to mitigate potential negative impacts. Further species-specific detail can be found in the *State Barrier Fence Biological Surveys* Fauna Survey Results and Discussions sections prepared by Ecoscape Australia Pty Ltd (2015).

Potential wildlife impacts

The intention of the EE is to protect agricultural enterprises from the impact of emus, wild dogs and kangaroos coming from the rangelands and adjacent woodlands. The proposed extension is in response to socio-economic impacts on industry and communities in the region from periodic emu ‘migrations’, kangaroo damage to crops and pasture and the impact of wild dogs in limiting livestock enterprises. It is important to note that the EE is not an impermeable barrier to wildlife but is permeable to most species. All birds (with the exception of the targeted emus) can fly over it. All reptiles, small mammals and their young and invertebrates can disperse through it. The proposed EE alignment also has three major waterways that will not be fenced and a three kilometre wide unfenced coastal corridor near Cape Arid National Park. These are the most significant landscape corridors for wildlife. There will be baiting targeted at wild dogs but all other native species can pass undeterred along these four corridors.

The objective of creating a barrier to the movement of pest animals carries with it identified risks associated with conservation and animal welfare, as well as some potential benefits to native wildlife. Risks to wildlife as a result of landscape-scale fences and the actions taken to mitigate these risks follow.

Collision and entrapment

The Department of Agriculture and Food, Western Australia (DAFWA) has monitored thousands of kilometres of the existing SBF over many decades and considers that

mortality of birds (other than emus), bats, reptiles or small mammals to be highly unlikely events. The very low mortality levels recorded for the SBF would be expected to have negligible impacts on wildlife populations or broader ecosystem effects. Data collected by DAFWA staff on SBF wildlife entanglement numbers between 2007 and 2015 are presented in Appendix 12 of *State Barrier Fence Biological Surveys* by Ecoscape Australia Pty Ltd (2015). The data records only 40 kangaroo and emu entrapments (with one goat) over an eight year period and these occur at very low frequency along the existing SBF (average of 0.0043 animals per km per year). The number of kangaroos and emus killed by the SBF is very low in comparison to road-kills. For example, during 2009 one insurance company in WA (SGIO Insurance) reported 1320 claims for vehicle crashes with kangaroos and 40 claims for crashes with emus (Quotesonline 2016).

Between August 2014 and September 2015, DAFWA has also had passive motion detecting camera traps in position at key points along the existing SBF as part of a project examining the effects of the SBF upgrades on the passage of movement of wild dogs through the fence. At any one time there were between eight and 24 cameras deployed over a 14-month period. The cameras were deployed between Lake Moore, south of Payne's Find and the Great Northern Highway near Kalbarri National Park with a minimum of five kilometres between camera sites. The cameras are capable of detecting movement throughout the day and night and have approximately a 1.27sec response time once movement is detected. The cameras are set to detect small-medium sized animals and are capable of detecting birds the size of dusky wood swallows and bronzewings (which periodically alight on the fence or the ground in front of the camera). Cameras have been directly focusing on the fence at gates, grids and known holes at ground level. The field of view of the camera traps at the fence is approximately 7m. To date the cameras have been in place for 2311 "camera trap days" (number of cameras multiplied by number of 24 days deployed) or 6.33 camera trap years. No impact of any animals with the fence was recorded over this period.

Figure 5 Motion detecting camera photo at undercut in existing State Barrier Fence

A range of species including large mammals and emus, but also including other birds (some nocturnal species), bats, reptiles and smaller mammals can be affected by collisions and entanglement with fences resulting in mortality (Caughley et al., 1987; van der Ree, 1999; Long and Robley, 2004). In a review of feral animal exclusion fences for conservation purposes across Australia by Long and Robley (2004), 20 fence managers were surveyed about native animals that had been injured or killed in exclusion fences. Most fence managers indicated that native animals had been injured or killed in their exclusion fence, but in all cases this occurred infrequently and was not considered to constitute a serious impact on resident fauna populations. The fences in this review were also generally much taller, electrified, barbed and/or had significantly smaller mesh size than that of the proposed EE. Recommendations made in Long and Robley (2004) to mitigate entanglement or collisions of wildlife with the fence included larger mesh size, plain wire as opposed to barbed wire, lower fence heights, high visibility materials attached to the fence and regular inspections, all of which are incorporated into the EE.

Within the EE area, taxa most susceptible to collision and entanglement include macropods, predominantly Western Grey Kangaroos (*Macropus fuliginosus*) and emus (*Dromaius novaehollandiae*). These collisions are very rare unless animals are put under stress (e.g. by hunting in vehicles), which is why access along the SBF is legally prohibited unless a permit is issued by DAFWA.

Collision and entrapment: mitigation strategies

The choice of construction materials and the physical structure of the proposed EE fence have been designed to reduce collisions and entanglement.

- Fence specifications have been modified from the original SBF design to include fluorescent orange droppers every 7m to increase the visibility of the fence in a colour spectrum that is more visually obvious than conventional fencing. The number of florescent orange fence droppers would also be doubled along approximately 85km of fence near (two kilometres from) known Western ground parrot habitat at Cape Arid National Park where dispersing juvenile ground parrots could conceivably encounter or cross the fence if they expand from their known range. Two florescent orange droppers would be installed in-between each 7m solid star picket about 2.3m apart to further minimise collision potential in this area.
- The fence mesh dimensions are also large enough (minimum 152mm x 102mm increasing to 152mm x 152mm at the top of the fence) to allow the majority of fauna species including snakes, lizards and small to mid-sized (or juvenile) mammals to pass through.
- No barbed wire is used to reduce entanglement or injury potential.
- A relatively low fence height of 1.35m will reduce collision potential with bats or birds.

- Electrical wires will not be used as they can cause mortality of smaller native species (e.g. some reptiles and echidnas) which can become entrapped against electrical wires (Long and Robley, 2004).

Regular inspections of the EE will be conducted by DAFWA staff and contractors during construction and particularly during the first year of operation while wildlife gets used to the new fence. In the unexpected occurrence of entrapped animals, they would be cared for, released, or euthanised.

Prevention of dispersal and access to resources

The intended aim of the EE is to significantly reduce the movement of wild dogs, emus and kangaroos from the rangelands and adjacent woodlands into the agricultural land.

'Migrations' of large numbers of emus occur when years of good rainfall lead to increases in the emu population, which are followed by the failure of rains over consecutive seasons (Davies, 1977). These emu migrations are not natural but they occur because of artificially heightened emu numbers as a result of enhanced water supplies in pastoral areas (Davies, 1977). For example, in 2015 there were approximately 14 400 artificial watering points plus approximately 1300 dams in the southern pastoral area of Western Australia (DAFWA GIS data, 2015). The emus mostly follow rain-bearing clouds and head south east (i.e. not all into agricultural areas) in search of better environmental conditions and most are expected to die as a result of the migration, irrespective of a SBF. Migrations occur on average approximately every 7–11 years. If large numbers of emus enter the agricultural region during these migrations they can cause significant damage by trampling crops.

The proposed EE will intercept the movement of emus during large scale migration events, limiting emu access to the south east agricultural region. Where the proposed EE intersects the direction of emu movement there is a potential for build-up of emu numbers. Under some weather conditions, emus may return to the rangelands, however some may perish.

Along the interface of the rangelands and the agricultural region, the SBF has provided an effective, non-lethal means of emu control during migrations. During periods where there is not a migration occurring densities of emus inside the agricultural region can exceed those in the rangelands. In the Esperance agricultural area emu densities have been estimated to be <0.1km^2 outside the proposed fenced area and approximately 0.3km^2 in the neighbouring agricultural areas (Caughley and Grice, 1982). Even with the completion of the EE there will be emus in agricultural areas, with quite a high population moving east-west along the coast.

To a much lesser extent, temporary aggregations of Western grey kangaroos may also occur alongside the fence, as has been documented for macropods against the Dingo Barrier Fence in eastern Australia (Caughley et al., 1987; Hayward and Kerley, 2009). These temporary aggregations of macropods alongside the fence are likely to have little negative ecological impact.

None of the wildlife species in the proposed area which are likely to be susceptible to the impacts of the fence are truly migratory. Therefore an issue of interruption of migratory patterns is not a concern.

Medium to large-sized wildlife species may have access to resources (water, habitat) limited as a result of the fence and associated cleared areas, and smaller species may perceive a cleared area by the fenceline as a substantial barrier (Goosem, 2001 and 2002). These effects are likely to be localised and for the majority of the fence would have already occurred to a large extent because most agricultural land has been cleared for 30–40 years inside the proposed EE. Cleared fire breaks and associated fire tracks surround most agricultural land in the Esperance Shire with farm fences of varying permeability already in place along the majority of the proposed EE. Any new effects from the EE would therefore be limited, though larger wildlife (macropods, emus and wild dogs) will be restricted from entering agricultural land from the woodlands to access artificial water points (e.g. dams and windmills), crops and pastures.

Prevention of dispersal and access to resources: mitigation strategies

Three main rivers systems, the Oldfield, Young and Lort Rivers will not be fenced as part of the EE for environmental and cultural reasons. Gaps in the fence at the Oldfield River (about 1km wide) the Young River (about 400m wide) and the Lort River (about 2km wide) will leave these waterways and riparian areas open to animal movement on the western side of the alignment. On the eastern side of the EE a 3.2km wide gap in the fence from the agricultural land to the coast adjacent to Cape Arid National Park will allow fauna movement to continue through this coastal corridor. Additional wild dog control management will be required at these gaps in the fence.

Proposed clearing activity for the EE has been modified from the historical SBF practice of bulldozing and grading the entire 20m wide area, to only bulldozing and grading a 6m wide track. The remaining area adjacent to the track will be chained and potentially mulched (instead of bare earth cleared) to reduce erosion potential, maintain the seed bank, and to provide some ground habitat and cover for smaller animals. A reduced clearing width to 15m from the original 20m proposal is also proposed for most of the alignment, except in the high fire risk (previously uncleared) land to the north of Salmon Gums. Clearing will primarily be undertaken through existing impacted/chained firebreak areas, adjacent to private properties and existing cleared fire tracks will be used for the fence track wherever possible. This is expected to significantly reduce any new impacts on smaller species which may perceive a cleared area by the fenceline as a substantial barrier. Further, 113km of the proposed fence is proposed on private land to minimise environmental and cultural impacts. No new additional clearing will be undertaken in these private sections other than trimming of any overhanging branches where necessary.

DAFWA has gained experience from emu migrations along existing sections of the SBF. The most critical strategy for risk mitigation during migrations is to keep human activity along the fence to a minimum. This is required to prevent unlawful culling of emus and to prevent emus being forced along the fence. Work instructions for emu

migrations have been developed for DAFWA staff. These focus on ensuring that areas of fence subject to pressure from large numbers of emus are avoided. Emus suffering from exhaustion are humanely euthanised. Traffic along the SBF is kept to a minimum by control of access permits and penalties apply to those who access the fence without a permit. The EE has also been aligned to reduce the number of bottlenecks/acute angles that emus may aggregate in while also minimising the isolation of large sections of woodlands by predominantly following the cleared agricultural/woodland interface.

Separation and isolation of populations

The agricultural area south of the proposed EE is relatively large (about 18000km^2) and broadly follows the separation of unallocated Crown land and agricultural land. This is a large area and so is likely to support viable populations of most common wildlife species. The high fecundity of emus and kangaroos combined with permanent, artificial water points and high value food sources on agricultural land inside the EE will sustain populations of these species inside the fence where suitable habitat remains. Populations of kangaroos and emus have been sustained inside the SBF throughout the rest of WA for over 100 years, despite two former versions of the SBF extending to WA's south coast for approximately 50–70 years before coming obsolete (National Library of Australia 2016).

There is one rarer species (Western brush wallaby (*M. irma;* a Priority 4 species) for which the EE may partition its distribution because it is less likely to pass through or over the fence. A separate risk assessment was prepared for this species by independent experts for the WA Environmental Protection Authority and Commonwealth environmental referrals (Bamford Consulting Ecologists 2016). Noting that on one side of the fence is typically cleared agricultural crop land and on the other side is native vegetation, there are relatively few places where there is currently continuous, unfenced native vegetation across the trajectory of the proposed fence. Further, existing farm boundary fences are located within approximately 100m of the proposed EE for 552km of its 660km length (Appendix D). The EE would therefore represent a hardening of a barrier to gene flow rather than a new barrier along most of its length.

Separation and isolation of populations: mitigation strategies

The three main river systems on the west of the alignment and the coastal corridor to the east of the alignment will be left open allowing some fauna movement. The low height of the fence will allow some kangaroos to jump over and Mallee fowls could fly over the fence or pass through as juveniles. Barrier fences are rarely impenetrable and some animals will pass under washouts caused by flooding, through gates if they aren't closed and across stock grids at public road crossings.

The EE alignment has been significantly modified to reduce isolation of large sections of the Great Western Woodlands compared to the original scoping studies preferred alignment (GHD, 2012). While this has increased the fence length and costs significantly, it has been adopted to improve environmental and cultural outcomes. The alignment has also been modified (in agreement with the

landholders) onto private property for approximately 113km where high environmental and cultural concerns were identified. This will be achieved in various sections by replacing existing farm fences with a barrier fence and no new clearing would be undertaken. Vegetation clearing has also been avoided in all A-Class Nature Reserves and Cape Arid National Park.

Changes to faunal communities within the fence

Landscape-scale fences can affect the fauna community on the inside of the fence. Reduction in wild dog numbers on the inside of the Dingo Barrier Fence in eastern Australia is recognised as contributing to increases in macropod and emu numbers (Caughley et al.,1987; Pople et al., 2000; Newsome et al., 2001). Decreases in numbers among smaller species (both native species and introduced rabbits) with release of mesopredators (foxes and cats) in the absence of an apex predator have also been documented on the inside of the Dingo Barrier Fence on the east coast (Lentic and Koch, 2010). However, wild dogs are unlikely to have been at sufficient density in the Esperance region to regulate emus, kangaroos, cats or foxes in the Esperance agricultural area for some time due to sustained wild dog management in the area. Despite these management efforts, the vast adjacent woodlands provide a continued source of new dogs to the agricultural area that needs to be addressed for small livestock enterprises to remain viable. Emus and kangaroos are already effectively living in the absence of predators in the Esperance agricultural area. Further decline of threatened species or a change in mesopredator pressure is unlikely to alter the fauna community in response to reduced wild dog density following the erection of the EE due to the minimal densities of wild dogs there now.

The ecological benefits from kangaroos and emus will be retained in the agricultural area. A fence would prevent periodic irruption of emu numbers into the agricultural area but would be unlikely to decrease numbers within the agricultural area during ‘normal years’. There is no intent to remove these taxa from within the fenced area. Densities of emus in the agricultural area can exceed that in the rangelands (Caughley and Grice, 1982) so the ecological benefits of these taxa will likely remain, as they have for the rest of the agricultural area in WA that has existed inside a SBF for over 100 years.

Other potential negative impacts

Other potential negative impacts which have been proposed in other reviews of fence impacts, but about which it is difficult to be definitive include:

- Potential for alteration of predator behaviour such as preferential predation along fence lines, thus increasing predation on native species (van Dyk and Slotow, 2003). Existing fence lines and fire management tracks along most of the proposed EE would already allow for this to occur, so little change is likely to result.
- Long term loss of anti-predator behaviour in prey species (Hayward and Kerley, 2009). Wild dogs have not been at sufficient density to provide a regulatory role in the Esperance agricultural area for some time due to sustained wild dog management so little new impact is expected.

- Potential for increases in invasive species number, abundance and distribution as the fence and attendant road allow greater access to bushland. This is unlikely given that most of the fence is proposed in existing cleared areas and existing fire tracks adjacent to agricultural land for which there is currently very limited access management. Public access to travel along the EE fence reserve would be prohibited without a permit. Significant penalties apply for non-compliance and a legitimate need is required to obtain a permit.
- Restriction of animal movement in fires (Hayward and Kerley, 2009) for macropods, emus and wild dogs. The EE will predominantly be constructed within an existing fire buffer area from 80–100m wide that helps protect human life, property and agricultural land from fires that start in the adjacent woodlands. Vegetation within the 15–20m wide cleared area the fence sits in will be regularly maintained and cleared of any larger/flammable vegetation to protect the fence from wildfire. Improved access for firefighting should reduce the impact of fires on native vegetation and wildlife, although animals may not escape fire irrespective of the EE as this risk is already present due to existing farm fences along the proposed EE alignment. Kangaroos could jump the 1.35m high fence if scared (e.g. an approaching fire or being chased).

Potential benefits to native wildlife

Potential benefits to native wildlife that may result from the proposed EE include:

Wild dogs are recognised as a threat to several threatened species including several medium-sized macropods (e.g. Bridled Nailtail Wallaby (*Onychogalea fraenata*) and rock-wallabies (*Petrogale* spp.) (Augusteyn, 2010; Allen and Fleming, 2012). Sustained protection from wild dog predation on the southern side of the EE may benefit some wildlife species including the Western Brush Wallaby and potentially other medium-sized fauna. The EE also provides a barrier against which to work fox control on the inside of the fence. Continued baiting will occur on either side of the EE to control both foxes and wild dogs.

The wild dogs in the proposed fenced area and immediately to the north have a relatively high degree of dingo purity (Stephens, 2011). Where conservation of pure dingoes is a management goal, the greatest threat to the existence of dingoes as a separate taxon to domestic dogs is introgression of genes from domestic dogs (Stephens et al. 2015). Further, it has been proposed that maintenance of intact dingo pack structure within some areas of the Great Western Woodlands would have conservation benefits (Duncan et al., 2006). A fence preventing movement of dingos/wild dogs into and out of the agricultural area could facilitate conflicting management approaches (wild dog control and dingo conservation) and help preserve the genetic integrity of the dingo in the Great Western Woodlands.

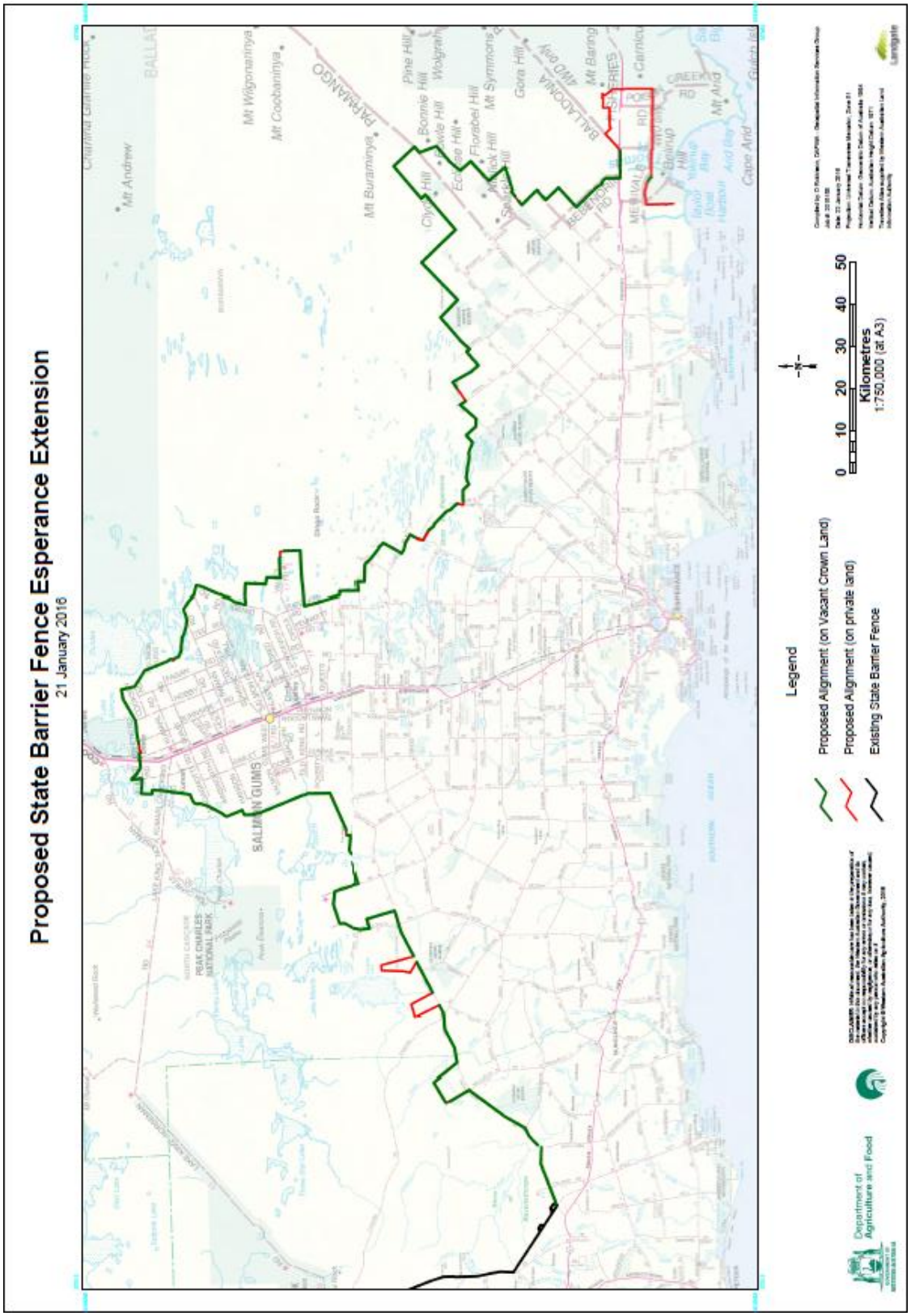
Provision of access to firefighting was proposed as a benefit by McLeod (McLeod, 2008). While most of the EE has been aligned along existing, chained fire breaks and associated tracks, more regular vegetation maintenance and monitoring along the barrier fence reserve than currently occurs should assist future access for firefighting and maintenance of the agricultural/woodland fire protection buffer zones. Improved

access for firefighting should reduce the impact of fires on native vegetation and wildlife.

Conclusions

- The proposed EE will provide significant benefits to agriculture and have other associated positive impacts for the region (URS, 2007; Economic Resource Associates, 2009). These benefits have been endorsed by the agricultural industry in the Esperance community and the WA Government.
- The proposed EE will have some initial impacts on wildlife associated primarily with collisions and restriction of movement of larger animals. However the effects are likely to primarily affect the target species (wild dogs, emus and kangaroos) with the fence being permeable to most other species. There may be some positive impacts which include protection of susceptible species from wild dog impacts.
- Potential impacts on wildlife and the broader ecosystem have been mitigated by the choice of fence design, modified clearing practices and the final chosen alignment. Specifically:
    - The design of the fence has reduced the potential for collision and entanglement with a suite of species through careful choice of construction materials and structure (e.g. large wire mesh size to allow most native species to pass through the fence, use of plain wire in the upper strand, low fence height and brightly coloured construction materials).
    - Further design improvements include positioning tracks and existing cleared areas near the fence where possible to increase visibility for wildlife; reducing the clearing footprint to 15m width from 20m along most of the EE; modifying the clearing practices within the fence reserve so some ground cover remains; placing the fence on private land and not clearing any additional land where environmental or cultural concerns were high.
    - The alignment has minimised the use of acute angles to address the potential for aggregations of large animals from the woodlands/rangelands and limited the isolation of large sections of woodlands by predominantly following the existing cleared agricultural/woodland interface.
    - The alignment has provided for connectivity of larger animals with the adjacent woodlands by leaving the three main river systems in the west and the coastal corridor in the east open to animal movement. Some connectivity will always remain due to imperfect fence maintenance, the ability of animals to jump or fly over the fence and where fence grids cross roads.

Appendix A The proposed Esperance Extension to the SBF



Appendix B Calculated EE maximum clearing footprints

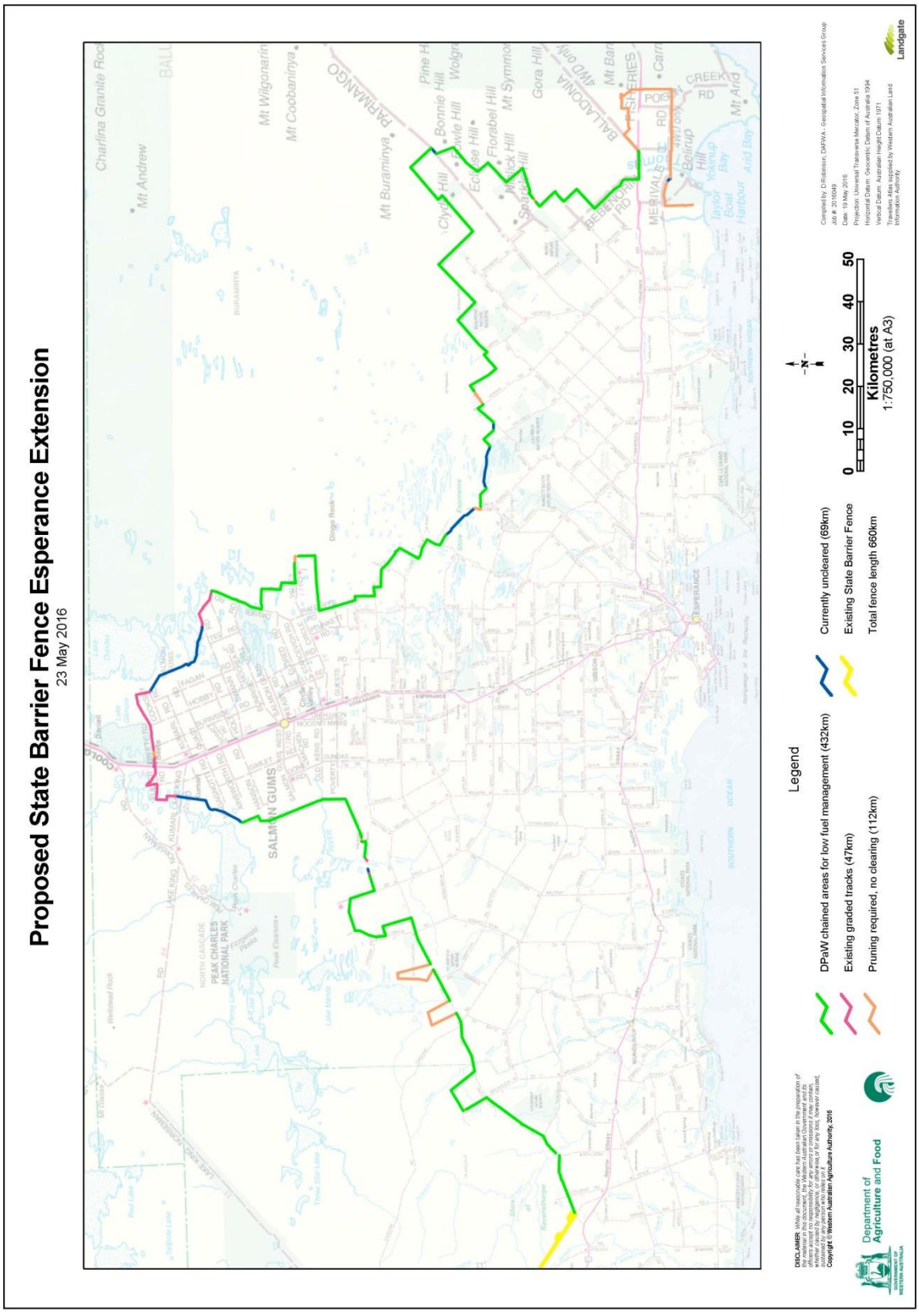
Table B1 Sectional distances by land type and maximum clearing footprints

Fence sections	Fence distance (km)	% of total fence	Clearing footprint/area (ha)
Un-cleared	68	10	120
Previously cleared (chained)	432	66	648
Graded (6m wide existing track)	47	7	65
Private property farm land	113	17	3
Water turnouts	-	-	6
Total	660	100	843

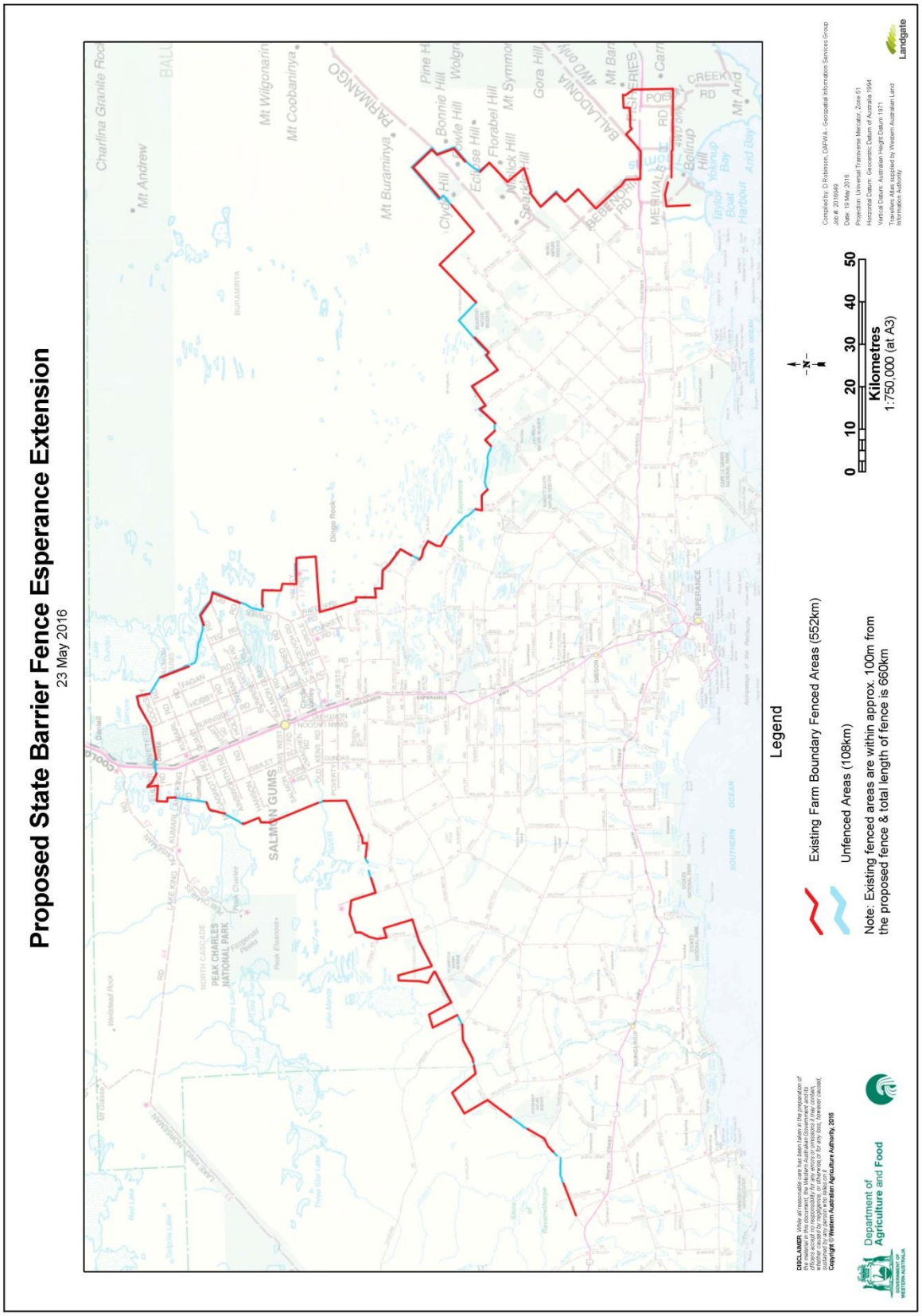
Information used to calculate sectional distances of fence:

- 20m wide clearing required for previously unchained sections north of Salmon Gums, 15m wide clearing in chained sections.
- 10m x 2.5m wide water turnout required every 200m alternating from the edge of the 6m wide track where necessary for erosion control resulting in 7.5m^2 clearing per turnout for 20m wide cleared area and 13.75m^2 for 15m wide cleared sections.

Appendix C Sectional distances of the EE project area



Appendix D Existing farm boundary fences within 100m of proposed EE



References

Allen, B. L. & Fleming, P. J. S. (2012) Reintroducing the dingo: the risk of dingo predation to threatened vertebrates of western New South Wales. Wildlife Research 39, 35-50.

Augusteyn, J. (2010) Determining the effectiveness of canine control at Taunton National Park (Scientific) and its impact on the population of bridled nailtail wallabies in Proceedings of the Queensland Pest Animal Symposium.

Australian Wildlife Conservancy 2016, *Mt Gibson Endangered Wildlife Restoration Project*, Australian Wildlife Conservancy, viewed 10 February 2016. australianwildlife.org/sanctuaries/mt-gibson-sanctuary/mt-gibson-endangered-wildlife-restoration-project.aspx

Caughley, G and Grice, D (1982). A correction factor for counting emus from the air, and its application to counts in Western Australia. Australian Wildlife Research 9, 253–259.

Caughley, G., Shepherd, N. & Short, J. (1987) Kangaroos: Their ecology and management in the sheep rangelands of Australia. Cambridge University Press, Melbourne, Vic, Australia.

Davies, S. J. J. F. (1977). Man's activities and bird's distribution in the Arid Zone. *Emu* 77, 169–172.

Duncan, S., Traill, B. J. & Watson, C. (2006) Vertebrate fauna of the Honman Ridge-Bremer Range district, Great Western Woodlands, Western Australia. Report prepared for The Wilderness Society, West Perth.

Economic Resource Associates (2009). Economic evaluation of the proposed upgrading and extension of the State Barrier Fence. A report prepared for the Department of Agriculture and Food. Perth, WA, Australia. p36.

Ecoscape Australia Pty Ltd (2015). State Barrier Fence Biological Surveys prepared for the Department of Agriculture and Food WA.

GHD Pty Ltd (2012). Report for State Barrier Fence Esperance Extension" Scoping Study September 2012 prepared by GHD for DAFWA.

Goosem, M. (2001) Effects of tropical rainforest roads on small mammals: inhibition of crossing movements. Wildlife Research 28, 351-364.

Goosem, M. (2002) Effects of tropical rainforest roads on small mammals: fragmentation, edge effects and traffic disturbance. Wildlife Research 29, 277-289.

Hayward, M. W. & Kerley, G. I. H. (2009) Fencing for conservation: Restriction of evolutionary potential or a riposte to threatening processes? Biological Conservation 142, 1-13.

Letnic, M. & Koch, F. (2010) Are dingoes a trophic regulator in arid Australia? A comparison of mammal communities on either side of the dingo fence. Austral Ecology 35, 167-175.

Long, K. & Robley, A. (2004) Cost effective feral animal exclusion fencing for areas of high conservation value in Australia. Arthur Rylah Institute for Environmental Research, Department of Sustainability and Environment, Victoria, Melbourne, Australia. pp61.

McLeod, P. (2008) Economic evaluation of the proposed upgrading and extension of the State Barrier Fence. Report prepared by Economic Resource Associates for the Department of Agriculture and Food. Perth, Western Australia. pp36.

National Library of Australia 2016. *The State Barrier Fence of Western Australia* viewed 10 February 2016, pandora.nla.gov.au/pan/43156/20040709-0000/agspsrv34.agric.wa.gov.au/programs/app/barrier/content.htm

Newsome, A. E., Catling, P. C., Cooke, B. D. & Smyth, R. (2001) Two ecological universes separated by the dingo barrier fence in semi-arid Australia: Interactions between landscapes, herbivory and carnivory, with and without dingoes. Rangelands Journal 23, 71-98.

Pople, A. R., Grigg, G. C., Cairns, S. C., Beard, L. A. & Alexander, P. (2000) Trends in the number of red kangaroos and emus on either side of the South Australian dingo fence: evidence for predator regulation? Wildlife Research 27, 269-276.

Quotesonline. *Insurance data reveals high rate of roo collisions in Western Australia* viewed 10 February 2016, quotesonline.com.au/insurance-data-reveals-high-rate-of-roo-collisions-in-western-australia

Somers, M.J., Hayward, M., (2011). Fencing for conservation: Restriction of evolutionary potential or a riposte to threatening processes? Springer Science & Business Media.

Stephens, D (2011). The molecular ecology of Australian wild dogs: hybridisation, gene flow and genetic strucutres at multiple grographic scales PhD thesis, University of Western Australia. pp121.

Stephens D., Wilton A.N., Fleming P.J.S, and Berry O. (2015). Death by sex in an Australian icon: a continent-wide survey reveals extensive hybridisation between dingoes and domestic dogs. Molecular Ecology.

Treves, A. and Karanth, K.U., (2003). Human-carnivore conflict and perspectives on carnivore management worldwide. Conservation Biology 17, 1491-1499.

URS Australia (2007). Benefit-cost analysis of the State Barrier Fence. Prepared for the Department of Agriculture and Food WA. Perth, Western Australia, Australia. pp74.

van der Ree, R. (1999) Barbed wire fencing as a hazard for wildlife. The Victorian Naturalist 116, 210-216.

van Dyk, G. & Slotow, R. (2003) The effects of fences and lions on the ecology of African wild dogs reintroduced to Pilanesberg National Park, South Africa. African Zoology 38, 79-94.