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Santos GLNG Offset Plan and Acquittal Summary - EPBC 2008/4096

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GLNG is a Santos PETRONAS Total KOGAS project.

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Abbreviations

Acronym	Description
ATP	Authority to Prospect
DAWE	Department of Agriculture, Water and the Environment
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Cth)
CSG	Coal Seam Gas
GLNG	Gladstone Liquefied Natural Gas
GTP	Gas Transmission Pipeline
ha	Hectare
km	Kilometre
MNES	Matters of National Environmental Significance
m	Metre
PL	Petroleum Lease
SLATS	Statewide Landcover and Trees Study
TEC	Threatened Ecological Community
SEVT	Semi-evergreen vine thickets of the Brigalow Belt (North and South) and Nandewar Bioregions
SSMP	Significant Species Management Plan
VM Act	*Vegetation Management Act 1999* (Qld)

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1.0 Introduction

1.1 Background

The Santos Gladstone Liquefied Natural Gas (GLNG) Project involves the development of Coal Seam Gas (CSG) resources in the Surat and Bowen Basins in Queensland, to supply gas via a 430 kilometre (km) gas transmission pipeline (GTP) to the LNG Facility located on Curtis Island.

Throughout the development of the Santos GLNG Project and in accordance with Santos GLNG Project approvals, potentially impacted environmental values are systematically identified and assessed and in order of preference are avoided, minimised or mitigated. For a project the size and scale of the Santos GLNG Project, not all potential impacts to identified values can be avoided and/or mitigated, resulting in significant residual adverse impacts to environmental values. Santos is committed to providing environmental offsets to compensate for significant residual impacts on matters of national environmental significance (MNES).

The Santos GLNG Project requires environmental offsets for significant residual impacts on MNES under five separate approvals under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act):

- EPBC 2008/4057 which relates to the LNG facility and associated onshore facilities
- EPBC 2008/4058 which relates to the marine facilities for the LNG facility
- EPBC 2008/4059 which relates to the CSG fields
- EPBC 2008/4096 which relates to the GTP
- EPBC 2012/6615 which relates to the expansion of the CSG fields (the Santos GLNG Gas Field Development Project).

1.2 Purpose

This document has been prepared to demonstrate how Santos will acquit MNES offset obligations associated with the development of the GTP under EPBC 2008/4096, specifically all offset obligations required under EPBC 2008/4096 (Conditions 15-22) and the Gas Transmission Pipeline Significant Species Management Plan (GTP SSMP; 3380-GLNG-4-1.3-0104).

1.3 Scope

This document includes:

- offset conditions of EPBC 2008/4096 and where each condition is addressed in this document (Section 2.0)
- summary of the MNES offset requirements based on conditions of EPBC 2008/4096 and the GTP SSMP addressed as part of this document (Section 3.0)
- brief overview of the offset properties selected to acquit the MNES offset requirements of EPBC 2008/4096 and the GTP SSMP, namely, Bottle Tree (Lot 7 TR39), Kentucky (Lot 1 WT37) and the Monte Christo offset (Section 4.0)
- demonstration of how each MNES offset requirement is acquit (Section 5.0)
- offset area management plans for the Bottle Tree and Kentucky offset areas (Appendix A and B).

2.0 Approval conditions

Table 2-1 provides a summary of the conditions related to offsets under EPBC 2008/4096 and the GTP SSMP offset obligations and how they have been addressed within this document.

Table 2-1: EPBC Act Approval Conditions and how they are met

Condition Number	Condition	How the conditions are met
EPBC Act approval 2008/4096		
8	If a listed threatened species or migratory species or their habitat, or a listed ecological community is encountered during the surveys undertaken as required by condition 5 and is not specified in the Table 1 or 2 at condition 11 and 12, the proponent must submit a separate management plan for each species or ecological community to manage the unexpected impacts of clearing. In relation to each listed species or ecological community, each plan must address: a) the relevant characteristics describing each ecological community b) a map of the location of species, species' habitat, or ecological community in proximity to the ROW; c) measures that will be employed to avoid impact on the species, species' habitat, or ecological community; d) a quantification of the unavoidable impact (in hectares and/or individual specimens); e) where impacts are unavoidable and a disturbance limit is not specified for the listed species or ecological community under condition 11, propose offsets to compensate for the impact on the population of the species' habitat, or the ecological community; f) current legal status (under the EPBC Act); g) known distribution.	The Gas Transmission Pipeline Significant Species Management Plan (SSMP) has been developed to address all aspects of this condition including (e) the proposal of offsets to compensate for the impact on the population of the species' habitat, or the ecological community. This Offset Plan demonstrates how Santos will acquit the offset requirements for significant, residual, adverse impacts to MNES subject to EPBC 2008/4096 based on the offset ratios presented in the approved GTP SSMP. This Offset Plan complements previous offset plans and proposals submitted to the Commonwealth Government and has been prepared to address the offset commitments outlined in the GTP SSMP.
Offset for Semi-evergreen vine thickets of the Brigalow Belt (North and South) and Nandewar Bioregions (SEVT)		
15	Within 12 months of the commencement of pipeline development the proponent must prepare an Offset Plan to provide an offset area for the approved disturbance limits relating to Semi-evergreen vine thickets of the Brigalow Belt (North and South) and Nandewar Bioregions within the project area. The offset area to be secured must be an area of private land which includes at least 19.2 ha of Semi-evergreen vine thickets of the Brigalow Belt (North and South) and Nandewar Bioregions. Note: Offsetting requirements for this approval can be accommodated as part of a single offset plan addressing the requirements of this approval and those required by EPBC 2008/4059.	The first offset plan for the GTP Project was submitted on 22 April 2011. This plan included properties that would be suitable to meet the offset requirement for Semi-evergreen vine thickets of the Brigalow Belt (North and South) and Nandewar Bioregions (SEVT). A number of revisions have occurred since then; however, this current offset plan supersedes all previously submitted plans. A summary of the offset acquittal for SEVT is detailed in Section 5.0. This offset plan addresses offset obligations under EPBC 2008/4096 and has been prepared to complement the offset plan addressing offset requirements under EPBC 2008/4059 approved by the Department of Agriculture, Water and the Environment (DAWE) on 23 March 2021.
16	The Offset Plan must include details of the offset area including: the timing and arrangements for property acquisition, maps and site description, environmental values relevant to MNES, connectivity with other habitats and biodiversity corridors, a rehabilitation program, and mechanisms for long-term protection, conservation and management.	Offset obligations for SEVT are proposed to be acquit on the Kentucky offset area, as summarised in Section 4.0. Further detail on the Kentucky offset area is provided in the attached offset area management plan (Appendix B). Current title documents demonstrating Santos' ownership of the Kentucky property have been provided to the Commonwealth Government previously and can be provided again upon request.
17	The Offset Plan must be submitted for the approval of the Minister within 12 months of the commencement of gas field development. The approved Offset Plan must be implemented within 30 business days of approval.	The first Offset Plan for the GTP Project was submitted on 22 April 2011. This plan included properties that would be suitable to meet the offset requirement for SEVT. A number of revisions have occurred since then; however, this current Offset Plan supersedes all previously submitted plans. Once approved, this plan will be implemented.
18	If the approved Offset Plan cannot be implemented because of failure of arrangements to secure the necessary area of private land then the proponent must submit for the Minister's approval an alternative Offset Plan. The alternative Offset Plan must provide at least an equivalent environmental outcome to those specified under condition 15. The approved alternative Offset Plan must be implemented.	This offset plan addresses offset obligations under EPBC 2008/4096 and includes details of the necessary areas of private land required to meet these obligations. Once approved, this plan will be implemented.

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Condition Number	Condition	How the conditions are met
19	If the proponent proposes any action within a proposed offset area, other than actions related to managing that area as an offset property, approval must be obtained, in writing from the Department. In seeking Departmental approval the proponent must provide a detailed assessment of the proposed action including a map identifying where the action is proposed to take place and an assessment of all associated adverse impacts on MNES. If the Department agrees to the action within the proposed offset site, the area identified for the action must be excised from the proposed offset and alternative offsets secured of equal or greater environmental value in relation to the impacted MNES.	Currently there are no actions proposed within any offset areas subject to this offset plan.
20	The proponent must secure the offset within 2 years of commencement.	Current title documents demonstrating Santos' ownership of the Kentucky property have been provided to the Commonwealth Government previously and can be provided again upon request.
SEVT Offset Area Management		
21	Within 12 months of securing the offset area required under the approved Offset Plan, the proponent must develop an Offset Area Management Plan which must specify measures to improve the environmental values of the offset area in relation to MNES, including; a) the documentation and mapping of current environmental values relevant to MNES of the area; b) measures to address threats to MNES including but not limited to grazing pressure and damage by livestock and adverse impacts from feral animals and weeds; c) measures to provide fire management regimes appropriate for the MNES; d) measures to manage the offset area to improve the condition of the SEVT ecological community within the offset area and to increase the areal extent of SEVT ecological community within the offset area as objectives of the program. e) monitoring, including the undertaking of ecological surveys to assess the success of the management measures against identified milestones and objectives; performance measures and reporting requirements against identified objectives, including trigger levels for corrective actions and the actions to be taken to ensure performance measures and objectives are met.	Offset obligations for SEVT are proposed to be acquit on the Kentucky offset area, as summarised in Section 4.0. An offset area management plan for the Kentucky offset area is provided in Appendix B. This plan specifies measures to improve the environmental values of the offset area in relation to the relevant MNES.
22	Within 12 months of securing the offset area the Offset Area Management Plan must be submitted for the approval of the Minister. The approved Offset Area Management Plan must be implemented.	Offset obligations for SEVT are proposed to be acquit on the Kentucky offset area, as summarised in Section 4.0. The Kentucky offset area management plan supersedes previous management plans submitted to the Commonwealth Government to satisfy this condition. The OAMP will be implemented following approval.

3.0 Offset requirements

Santos GLNG will provide offsets to compensate for significant residual impacts to MNES in accordance with the following:

- conditions 15 to 22 of EPBC 2008/4096 (Conditions 15-22)
- the GTP SSMP (3380-GLNG-4-1.3-0104).

Table 3-2 presents the impacts to MNES associated with EPBC 2008/4096 and the GTP SSMP addressed as part of this document.

3.1 EPBC Act Offset framework

At the time of the Project's approval under the EPBC Act the magnitude of an offset package and specific offset ratios to compensate for the impacts of development were determined on a case-by-case basis with consideration of the principles discussed in the EPBC Act draft Environmental Offsets Policy 2007 and the Queensland Government offset policies in place at the time (Table 3-1).

Table 3-1: Ratios used to determine offset requirements as per the GTP SSMP

MNES matter	Offset ratio
Endangered ecological community	8:1
Endangered flora	6:1
World heritage values	5:1
Migratory birds	8:1
Vulnerable reptiles	8:1
Vulnerable birds	8:1
Endangered birds	8:1
Vulnerable mammals	8:1
Endangered mammals	8:1

On the 16 July 2015, the Commonwealth Government accepted Santos' approach to determining significant residual, adverse impacts to MNES which is consistent with the EPBC Act Environmental Offsets Policy.

The approved GTP SSMP details the proposed impacts on MNES subject to EPBC 2008/4096 required to be offset including the offset ratios used to determine the quantum of the proposed offset areas subject to this Offset Plan, as summarised in Table 3-2.

Table 3-2: Summary of the disturbance in which offsets will be provided for under EPBC 2008/4059 as presented in the approved GTP SSMP

MNES	Disturbance area (ha)	Offset ratio	Offset area (ha)/number of species
Endangered ecological communities			
Brigalow (*Acacia harpophylla* dominant and co-dominant)	11.23	8	89.84
Semi-evergreen vine thickets of the Brigalow Belt (North and South) and Nandewar Bioregions	2.4	8	19.2
Endangered fauna species			
Australasian bittern (*Botaurus poiciloptilus*)	0.8	8	6.4
Northern quoll (*Dasyurus hallucatus*)	1.53	8	12.24
Australian painted snipe (*Rostratula australis*)	4.79	8	38.32
Vulnerable fauna species			
Black-breasted button-quail (Turnix melanogaster)	2.61	8	20.88
Collared delma (*Delma torquata*)	86.22	8	689.76
Dunmall's snake (*Furina dunmalli*)	79.78	8	638.24
Fitzroy river turtle (*Rheodytes leukops*)	1.05	8	8.4
Large-eared pied bat (*Chalinolobus dwyeri*)	44.11	8	352.88
Ornamental snake (*Denisonia maculata*)	25.46	8	203.68
Red goshawk (*Erythrotriorchis radiatus*)	68.91	8	551.28
South-Eastern long-eared bat (*Nyctophilus corbeni*)	142.91	8	1143.28
Squatter pigeon (Geophaps *scripta scripta*)	225.15	8	1801.2
Water mouse (*Xeromys myoides*)	0.01	8	0.08
Yakka skink (*Egernia rugosa*)	63.11	8	504.88
Migratory birds			
Cattle egret (*Ardea ibis*)	1.67	8	13.36
Eastern osprey (*Pandion haliaetus*)	1.4	8	11.2
Great egret (*Ardea modesta*)	3.83	8	30.64
Rainbow bee-eater (*Merops ornatus*)	225.39	8	1803.12
White-bellied sea-eagle (*Haliaeetus leucogaster*)	25.09	8	200.72
Migratory woodland bird species			
Black-faced monarch (*Monarcha melanopsis*)	14.68	8	117.44
Spectacled monarch (*Monarcha trivirgatus*)			
Satin flycatcher (*Myiagra cyanoleuca*)			
Rufous fantail (*Rhipidura rufifrons*)			
Oriental cuckoo (*Cuculus saturatus*)			
Migratory marine bird species			

MNES	Disturbance area (ha)	Offset ratio	Offset area (ha)/number of species
Bar-tailed godwit (*Limosa lapponica*)	0.8	8	6.4
Black-tailed godwit (*Limosa limosa*)	0.8	8	6.4
Broad-billed sandpiper (*Limicola falcinellus*)	0.8	8	6.4
Common greenshank (*Tringa nebularia*)	0.8	8	6.4
Common sandpiper (*Actitis hypoleucos*)	0.8	8	6.4
Curlew sandpiper (*Calidris ferruginea*)	0.8	8	6.4
Double-banded plover (*Charadrius bicinctus*)	0.8	8	6.4
Eastern reef egret (*Egretta sacra*)	0.8	8	6.4
Far eastern curlew (*Numenius madagascariensis*)	0.8	8	6.4
Great knot (*Calidris tenuirostris*)	0.8	8	6.4
Greater sand plover (*Charadrius leschenaultii*)	0.8	8	6.4
Grey plover (*Pluvialis squatarola*)	0.8	8	6.4
Grey-tailed tattler (*Tringa brevipes*)	0.8	8	6.4
Latham's snipe (*Gallinago hardwickii*)	0.8	8	6.4
Lesser sand plover (*Charadrius mongolus*)	0.8	8	6.4
Little curlew (*Numenius minutus*)	0.8	8	6.4
Marsh sandpiper (*Tringa stagnatilis*)	0.8	8	6.4
Pacific golden plover (*Pluvialis fulva*)	0.8	8	6.4
Red knot (*Calidris canutus*)	0.8	8	6.4
Red-necked stint (*Calidris ruficollis*)	0.8	8	6.4
Ruddy turnstone (*Arenaria interpres*)	0.8	8	6.4
Sanderling (*Calidris alba*)	0.8	8	6.4
Sharp-tailed sandpiper (*Calidris acuminata*)	0.8	8	6.4
Terek sandpiper (*Xenus cinereus*)	0.8	8	6.4
Whimbrel (*Numenius phaeopus*)	0.8	8	6.4
Migratory tern bird species			
Caspian tern (*Sterna caspia*)	0.05	8	0.4
Little tern (*Sternula albifrons*)	0.05	8	0.4
Endangered flora species			
Ooline (*Cadellia pentastylis*)	36 individuals	6:1	216
Xerothamnella herbacea	42 individuals	6:1	252
Philotheca sporadica	0	6:1	0

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MNES	Disturbance area (ha)	Offset ratio	Offset area (ha)/number of species
Large-fruited zamia (*Cycas megacarpa*)	1,100 individuals	No ratio	3,990[a]

a Offset requirements are in accordance with EPBC approval 2008/4096 Condition 23 (a) and have been addressed as part of the approved GLNG Gas Transmission Pipeline *Cycas megacarpa* Translocation and Management Plan (3380-GLNG-4-1.3-0013).

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4.0 Offset approach

Santos will acquit the offset obligations under EPBC 2008/4096 (conditions 15-22) and the GTP SSMP through the following offset options:

- Bottle Tree, Kentucky and Monte Christo offset areas (Figure 1)
- threatened flora translocation programs
- nest protection program for the Fitzroy River Turtle.

The following sections provide an overview of each offset option, and how the offset is secured for each of the required matters is shown in Table 4-1.

Table 4-1: How and where the offset obligations under EPBC 2008/4096 are secured

MNES	Offset area to be secured (ha)			How/where the offset is secured
	Bottle Tree	Kentucky	Monte Christo	
Endangered ecological communities				
Brigalow (*Acacia harpophylla* dominant and co-dominant)	1,019.47	-	-	Bottle Tree
Semi-evergreen vine thickets of the Brigalow Belt (North and South) and Nandewar Bioregions	-	19.79	-	Kentucky
Endangered fauna species				
Australasian bittern (*Botaurus poiciloptilus*)	-	-	6.4	Monte Christo
Northern quoll (*Dasyurus hallucatus*)	678.44	-	-	Bottle Tree
Australian painted snipe (*Rostratula australis*)	-	-	38.32	Monte Christo
Vulnerable fauna species				
Black-breasted button-quail (*Turnix melanogaster*)	2.33	19.79	-	Bottle Tree and Kentucky
Collared delma (*Delma torquata*)	1,140.89	-	-	Bottle Tree
Dunmall's snake (*Furina dunmalli*)	1,140.89	-	-	Bottle Tree
Fitzroy river turtle (*Rheodytes leukops*)	Offset obligation satisfied through nest protection program (see Section 4.4).			Nest Protection Program
Large-eared pied bat (*Chalinolobus dwyeri*)	678.44	-	-	Bottle Tree

MNES	Offset area to be secured (ha)			How/where the offset is secured
	Bottle Tree	Kentucky	Monte Christo	
Ornamental snake (*Denisonia maculata*)	1,143.63	-	-	Bottle Tree
Red goshawk (*Erythrotriorchis radiatus*)	1,143.63	-	-	Bottle Tree
South-Eastern long-eared bat (*Nyctophilus corbeni*)	1,143.63	-	-	Bottle Tree
Squatter pigeon (Geophaps *scripta scripta*)	1,141.31	-	659.89	Bottle Tree and Monte Christo
Water mouse (*Xeromys myoides*)	-	-	0.08	Monte Christo
Yakka skink (*Egernia rugosa*)	1,140.89	-	-	Bottle Tree
Migratory birds				
Cattle egret (*Ardea ibis*)	-	-	13.36	Monte Christo
Eastern osprey (*Pandion haliaetus*)	-	-	11.2	Monte Christo
Great egret (*Ardea modesta*)	-	-	30.64	Monte Christo
Rainbow bee-eater (*Merops ornatus*)	-	-	1,803.12	Monte Christo
White-bellied sea-eagle (*Haliaeetus leucogaster*)	-	-	200.72	Monte Christo
Migratory woodland bird species				
Black-faced monarch (*Monarcha melanopsis*)	-	-	117.44	Monte Christo
Spectacled monarch (*Monarcha trivirgatus*)				
Satin flycatcher (*Myiagra cyanoleuca*)				
Rufous fantail (*Rhipidura rufifrons*)				
Oriental cuckoo (*Cuculus saturatus*)				
Migratory marine bird species				

MNES	Offset area to be secured (ha)			How/where the offset is secured
	Bottle Tree	Kentucky	Monte Christo	
Bar-tailed godwit (*Limosa lapponica*)	-	-	6.4	Monte Christo
Black-tailed godwit (*Limosa limosa*)				
Broad-billed sandpiper (*Limicola falcinellus*)				
Common greenshank (*Tringa nebularia*)				
Common sandpiper (*Actitis hypoleucos*)				
Curlew sandpiper (*Calidris ferruginea*)				
Double-banded plover (*Charadrius bicinctus*)				
Eastern reef egret (*Egretta sacra*)				
Far eastern curlew (*Numenius madagascariensis*)				
Great knot (*Calidris tenuirostris*)				
Greater sand plover (*Charadrius leschenaultii*)				
Grey plover (*Pluvialis squatarola*)				
Grey-tailed tattler (*Tringa brevipes*)				
Latham's snipe (*Gallinago hardwickii*)				
Lesser sand plover (*Charadrius mongolus*)				
Little curlew (*Numenius minutus*)				
Marsh sandpiper (*Tringa stagnatilis*)				
Pacific golden plover (*Pluvialis fulva*)				

MNES	Offset area to be secured (ha)			How/where the offset is secured
	Bottle Tree	Kentucky	Monte Christo	
Red knot (*Calidris canutus*)				
Red-necked stint (*Calidris ruficollis*)				
Ruddy turnstone (*Arenaria interpres*)				
Sanderling (*Calidris alba*)				
Sharp-tailed sandpiper (*Calidris acuminata*)				
Terek sandpiper (*Xenus cinereus*)				
Whimbrel (*Numenius phaeopus*)				
Migratory tern bird species				
Caspian tern (*Sterna caspia*)	-	-	0.4	Monte Christo
Little tern (*Sternula albifrons*)	-	-	0.4	Monte Christo
Endangered flora species				
Ooline (*Cadellia pentastylis*)	4.5	-	-	Bottle Tree
Xerothamnella herbacea	2.4	-	-	Bottle Tree
Philotheca sporadica	-	-	-	None required
Large-fruited zamia (*Cycas megacarpa*)	See approved *GLNG Gas Transmission Pipeline Cycas megacarpa Translocation and Management Plan* (3380-GLNG-4-1.3-0013).			Red Shirt

4.1 Bottle Tree

Bottle Tree (Lot 7 TR39) is a 3,853 hectare (ha) property located in the Brigalow Belt South Bioregion, approximately 75 km north-northeast of Injune in south central Queensland. The Bottle Tree property was acquired by Santos on 12 December 2012 primarily based on the presence of suitable environmental values to provide offsets for the Santos GLNG project.

Bottle Tree is located entirely within the Brown River catchment, part of the Fitzroy River basin, with the major watercourse being Arcadia Creek. Several minor watercourses are present on the eastern side of the property. The topography is varied and is comprised of alluvial plains, undulating plains, low hills and a steep scarp of Precipice Sandstone. Elevation ranges between approximately 300 and 346 metres (m) on the lower lying areas and reaches a maximum of about 630 m at the crest of the Expedition Range. The eastern end of the property adjoins Expedition (Limited Depth) National Park (NP).

The Bottle Tree offset area was approved by DAWE on 23 March 2021 to acquit MNES offset requirements under EPBC 2008/4059, including surplus areas of suitable MNES habitat for Santos to drawdown on for future project offset acquittal. Table 4-2 provides a summary of the area secured to acquit EPBC 2008/4059 offset obligations and the area of surplus offsets available as presented in the approved Santos GLNG Offset Plan and Acquittal Summary (Document Number: 0007-650-EMP-0009) with some areas subsequently refined based on MNES habitat associations used as part of the GTP Adverse Impact Assessment Methodology (approved by the Commonwealth government on 16 July 2015).

The Bottle Tree offset area will continue to be managed by Santos to enhance and improve the condition of the environmental values on the property in accordance with the Bottle Tree offset area management plan in Appendix A.

Table 4-2: Summary of offset area secured on Bottle Tree to acquit offset obligations under EPBC 2008/4059 and area of surplus habitat

MNES	Status under EPBC Act	Bottle Tree offset area	
		Offset area required to be secured under offsets assessment guide for EPBC 2008/4059 (ha)	Surplus area available using species assumptions from the GTP SSMP for EPBC 2008/4096 (ha)
Listed threatened ecological communities			
Brigalow (*Acacia harpophylla* dominant and co-dominant)	E	73.00	1,202.44
Semi-evergreen vine thickets of the Brigalow Belt (North and South) and Nandewar Bioregions	E	7.00	-
Listed threatened species			
South-eastern long-eared bat (*Nyctophilus corbeni*)	V	647.47	1,327.05
Collared delma (*Delma torquata*)	V	579.82	1,323.82
Yakka skink (*Egernia rugosa*	V	480.12	1,323.82
Northern quoll (*Dasyurus hallucatus*)	E	411.30	678.44*
Large-eared pied bat (*Chalinolobus dwyeri*)	V	411.30	678.44*

MNES	Status under EPBC Act	Bottle Tree offset area	
		Offset area required to be secured under offsets assessment guide for EPBC 2008/4059 (ha)	Surplus area available using species assumptions from the GTP SSMP for EPBC 2008/4096 (ha)
Red goshawk (*Erythrotriorchis radiatus*)	V	647.47	1,327.05
Black-breasted button-quail (*Turnix melanogaster*)	V	12.00	2.33
Dunmall's snake (*Furina dunmalli*)	V	480.12	1,323.82
Squatter pigeon (southern) (*Geophaps scripta scripta*)	V	290.74	1,324.24
Ornamental snake (*Denisonia maculata*)	V	19.00	1,327.05
Australian painted snipe (*Rostratula australis)*	E	-	-

* Note this figure has been amended from the approved Santos GLNG Offset Plan and Acquittal Summary (Document Number: 0007-650-EMP-0009) to account for total area of surplus available.

4.2 Kentucky

Kentucky (Lot 1 WT37) is a 4,468 ha property located in the Brigalow Belt south Bioregion, approximately 50 km east-northeast of Injune, south central Queensland. The Kentucky property was acquired by Santos GLNG on 13 February 2012 primarily based on the presence of suitable environmental values to provide offsets for the Santos GLNG project.

Kentucky lies within rugged terrain and contains large vegetation remnants that are contiguous with Expedition (Limited Depth) National Park to the east and Lonesome Holding (proposed national park) to the north. The property is located entirely within the Dawson River catchment, part of the Fitzroy River basin, with the major watercourses being the Dawson River and Baffle Creek. The topography is varied and is comprised mainly of hills, ridges, plateaux and steep scarps, with sandstone of the Precipice and Evergreen Formations forming the underlying geology. Small alluvial flats occur beside the Dawson River. Baffle Creek and its associated tributaries have associated deep gorges which provide a visually spectacular landscape.

The Kentucky offset area was approved by DAWE on 23 March 2021 to acquit MNES offset requirements under EPBC 2008/4059, including surplus areas of suitable MNES habitat for Santos to drawdown on for future project offset acquittal. Table 4-3 provides a summary of the area secured to acquit EPBC 2008/4059 offset obligations and the area of surplus offsets available as presented in the Santos GLNG Offset Plan and Acquittal Summary (Document Number: 0007-650-EMP-0009).

Kentucky will continue to be managed by Santos to enhance and improve the condition of the environmental values on the property in accordance with the Kentucky offset area management plan in Appendix B.

Table 4-3: Summary of offset area secured on Kentucky to acquit offset obligations under EPBC 2008/4059 and area of surplus habitat

MNES	Status under EPBC Act	Kentucky offset area: Offset area required to be secured under offsets assessment guide for EPBC 2008/4059 (ha)	Kentucky offset area: Surplus area available using species assumptions from the GTP SSMP for EPBC 2008/4096 (ha)
Listed threatened ecological communities			
Brigalow (*Acacia harpophylla* dominant and co-dominant)	E	-	-
Semi-evergreen vine thickets of the Brigalow Belt (North and South) and Nandewar Bioregions	E	-	19.79
Listed threatened species			
South-eastern long-eared bat (*Nyctophilus corbeni*)	V	2,310.00	1,463.65
Collared delma (*Delma torquata*)	V	2,330.00	1,392.18
Yakka skink (*Egernia rugosa*) -essential	V	2,020.00	-
Yakka skink (*Egernia rugosa*) -general	V	400.00	1,443.85
Northern quoll (*Dasyurus hallucatus*)	E	145.00	1,463.65
Large-eared pied bat (*Chalinolobus dwyeri*)	V	860.00	1,463.65
Red goshawk (*Erythrotriorchis radiatus*)	V	1,600.00	1,463.65
Black-breasted button-quail (*Turnix melanogaster*)	V	-	19.79
Dunmall's snake (*Furina dunmalli*)	V	2,370.00	1,463.65
Squatter pigeon (southern) (*Geophaps scripta scripta*)	V	1,955.00	1,392.18
Ornamental snake (*Denisonia maculata*)	V	-	-
Australian painted snipe (*Rostratula australis)*	E	-	-

4.3 Monte Christo

The Monte Christo Offset Area is located on Curtis Island, north of Gladstone in central Queensland. The joint LNG proponents (QCLNG, Santos GLNG and Australia Pacific LNG) collaboratively delivered the Monte Christo Offset to acquit the collective environmental offset requirements for the:

- LNG plants and marine facilities on Curtis Island for each of the LNG proponents
- respective GTP right-of-ways on Curtis Island
- the GTP marine crossings of the Kangaroo Island Wetlands
- the Narrows crossing for each GTP of the LNG proponents.

The Monte Christo Offset Proposal Document (3301-GLNG-4-1.3-0049; the Proposal) was prepared to demonstrate acquittal of the collective offset requirements described above and approved by the Commonwealth Government on 27 September 2013 and the Queensland Coordinator-General on 15 April 2014.

In addition to acquitting the collective environmental offset requirements mentioned above, the proposal document also identified capacity to address additional offset requirements for the LNG proponents. Specifically, Section 9.2 states:

> '*The Monte Christo Offset proposal contains sufficient capacity to address additional offset requirements for the LNG proponents, particularly those relating to the mainland gas transmission pipelines; however, this will be subject to further consultation and approval from both Queensland and Australian Governments*'.

The Proposal states that where positive offset balances are noted for environmental values, the proponents propose to draw down on these to acquit future offset requirements.

Table 17 of the Proposal provides a summary of offset requirements that can be acquitted by the Proposal and identifies the positive offset balances that are the surplus offset values to be distributed between the joint LNG proponents for future acquittal. A summary of the surplus MNES offset values for all proponents is provided in Table 4-4.

Santos proposes to draw down on the surplus values allocated to GLNG to acquit MNES offset obligations where they are not present or have sufficient area available on the Bottle Tree or Kentucky offset areas, including Australasian bittern, Australian painted snipe, squatter pigeon, water mouse, and migratory marine species bird species generally associated with the more northern sections of the GTP.

Table 4-4: Surplus MNES offset values distributed between the joint LNG proponents following the Proposal

Environmental value	Surplus / Advanced Offset Secured (ha)			
	TOTAL*	GLNG	Australia Pacific LNG	QCLNG
World Heritage	21,774.40	7,312.42	7,343.44	7,118.54
Water mouse *(Xeromys myoides)*	9,729.50	3,255.45	3,220.77	3,253.29
Shorebirds including: - Beach stone curlew *(Esacus magnirostris)* - Sooty oystercatcher *(Haematopus fuliginosus)* - Eastern curlew *(Numenius madagascariensis)*	6,170.04	2,075.77	2,022.05	2,072.21
Koala *(Phascolarctos cinereus)*	3,877.48	1,299.03	1,283.11	1,295.33
Black-breasted button- quail *(Turnix melanogaster)*	19,493.17	6,497.72	6,497.72	6,497.72
Red goshawk *(Erythrotriorchis radiatus)*	22,119.06	7,324.86	7,397.10	7,397.10
Rainbow bee-eater *(Merops ornatus)*	25,286.35	8,219.66	8,533.34	8,533.34
White-bellied sea-eagle *(Haliaeetus leucogaster)*	5,980.38	1,975.91	2,002.23	2,002.23
Little tern (*Sternula albifrons)*	2,812.69	937.30	937.70	937.70
Caspian tern *(Sterna caspia)*	2,812.69	937.30	937.70	937.70
Squatter pigeon *(Geohaps scripta scritpa)*	22,585.83	7,394.53	7,595.65	7,595.65

Environmental value	Surplus / Advanced Offset Secured (ha)			
	TOTAL*	GLNG	Australia Pacific LNG	QCLNG
Cattle egret *(Ardea ibis)*	6,005.98	2,001.51	2,002.23	2,002.23
Great egret *(Ardea modesta)*	5,974.46	1,969.99	2,002.23	2,002.23
Migratory woodland species: - Black-faced monarch *(Monarcha melanopsis)* - Spectacled monarch *(Monarcha trivirgatus)* - Satin flycatcher *(Myiagra cyanoleuca)* - Rufous fantail *(Rhipidura rufifrons)* - Oriental cuckoo *(Cuculus optatus)* - Dollarbird *(Eurystomus orientalis)*	22,687.83	7,496.53	7,595.65	7,595.65
Eastern osprey *(Pandion haliaetus)*	3,192.90	1,063.82	1,064.54	1,064.54
Australian painted snipe *(Rostratula australis)*	6,005.98	2,001.51	2,002.23	2,002.23
Coastal vine thicket TEC	104.65	34.88	34.88	34.88

* The total surplus values are taken from Monte Christo Offset Proposal (Table 17: Summary of offset requirements that can be acquitted by the Monte Christo Offset Proposal), 18 December 2013.

4.4 Fitzroy River turtle

Santos GLNG proposes to offset residual adverse impacts to Fitzroy River turtle habitat by conducting a nest protection program. Both the Commonwealth Conservation Advice and State Government species profiles for the Fitzroy River turtle identify the disturbance of nesting sites and predation of eggs as one of the most significant threats to the Fitzroy River turtle. Due to the high rate of nest predation, numbers of juveniles recruiting into the population is very low. The routine survey and protection of new nests each nesting season has been found to be one of the most successful conservation strategies employed with the Fitzroy River turtle.

The details of the nest protection program have been provided to the Commonwealth Government in a separate document titled 'Santos GLNG Mainland Gas Transmission Pipeline Fitzroy River Turtle Offset Plan' (document number: 0007-650-PLA-0001). The final version of this plan was approved by the Department on 16 May 2016.

On 4 April 2017, Santos wrote the Department to discuss the completion of Fitzroy River Turtle Offset Program and provide a report prepared by the Fitzroy Basin Association describing the results of the nest protection program conducted during the summer of 2016/2017.

On 8 June 2017 Santos received a letter from the department confirming the completion of the Fitzroy River Turtle Offset Program. The letter states:

'The report demonstrates that the goals of the Fitzroy River Turtle Offset Plan have been achieved. The Department also recognises that each of the outcome targets specified in the Offset Plan were not only achieved, but exceeded, providing superior outcomes for the turtles, Rheodytes leukops'.

'The Department recognises that the target for Rheodytes leukops has been successfully achieved and considers that the offset for the project's assessed potential] pacts to the species has been successfully acquitted'.

4.5 Threatened flora species

Santos proposes to acquit offset obligations for threatened flora species, Ooline (*Cadellia pentastylis*) and *Xerothamnella herbacea* through species specific propagation and translocation programs. A summary on the progress of these offsets is provided below.

4.5.1 Ooline (*Cadellia pentastylis*)

Santos has legally secured a 4.5 ha offset area through a Voluntary Declaration under the *Vegetation Management Act 1999* (VM Act; Qld) on the south-western boundary of the Bottle Tree property as a dedicated planting site containing existing stands of Ooline (Figure 2 of Appendix A).

The offset area management objectives are to plant approximately 350 Ooline (C*adellia pentastylis)* seedlings and maintain them until they become a self-sustaining population. Management actions will enable the seedlings to mature by minimising immediate competition species (weeds and pasture grasses); controlling entry of browsing fauna to the offset area, ensuring water is available during extended dry periods and maintaining adequate fire protection. At least 220 of the 350 planted seedlings are required to survive through to maturity to meet regulatory and third-party requirements.

The offset area is currently fenced to exclude livestock grazing and is being managed, monitored and reported on in accordance with a dedicated management plan for the sites, attached to the approved and certified Voluntary Declaration.

4.5.2 *Xerothamnella herbacea*

Santos has legally secured a 2.4 ha offset area through a Voluntary Declaration under the VM Act in the south of the Bottle Tree property to support translocation of *Xerothamnella herbacea* propagated individuals (Figure 2 of Appendix A).

The offset area management objectives are to plant approximately 300 *Xerothamnella herbacea* seedlings and maintain them until they become a self-sustaining population. Management actions will enable the seedlings to mature by minimising immediate competition species (weeds and pasture grasses); controlling entry of browsing fauna to the offset area, ensuring water is available during extended dry periods and maintaining adequate fire protection. At least 252 of the 300 planted seedlings are required to survive through to maturity to meet regulatory and third-party requirements.

The offset area is current fenced to exclude livestock grazing and is being managed, monitored and reported on in accordance with a dedicated management plan for the sites, attached to the approved and certified Voluntary Declaration.

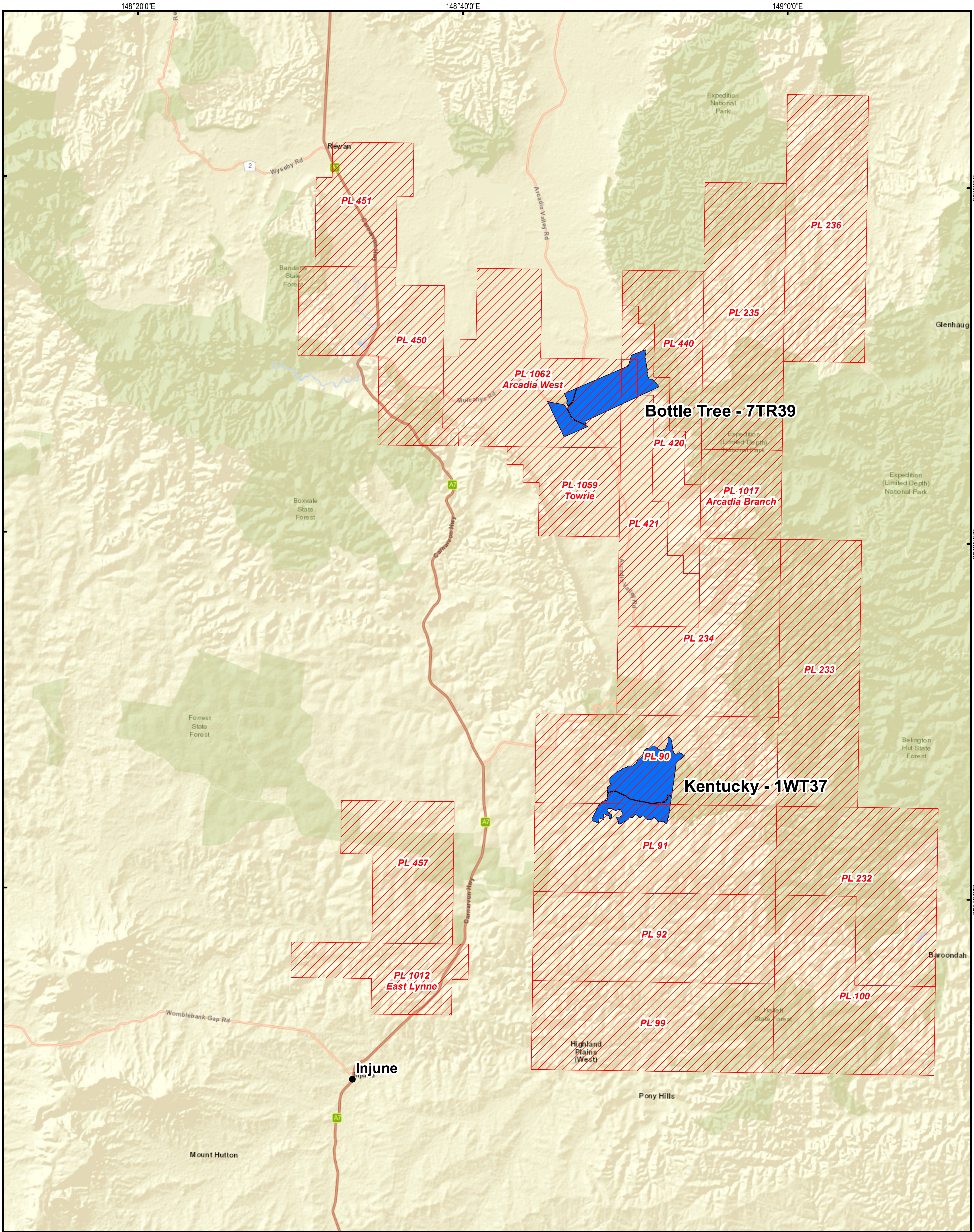

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Figure 1
EPBC 2008/4096
offset properties

Santos Petroleum Lease

Offset properties

DATA SOURCE:
The following datasets are © State of Qld:
- Cadastral data
- Petroleum leases

Date: 7/30/2021 Coordinate System: GDA 1994 MGA Zone 55 Projection: Transverse Mercator Datum: GDA 1994 Scale: 1:350,000@A3

0 2.5 5 7.5 10
Kilometres

N

CO2 Australia

Location diagram

Path: P:\GISData\Projects\Santos\ENV_20_0041\9.GTP_Offset_Maps\Acquittal Document\Figure 1 - Project context.mxd

5.0 Offset acquittal

Table 5-1 presents a summary of the offset areas to be secured to acquit offset requirements under EPBC 2008/4096 (conditions 15-22) and the GTP SSMP on Bottle Tree, Kentucky and Monte Christo as well the area of surplus offset values remaining within each of the offset areas. For MNES where a surplus is noted, Santos proposes to draw down on these to acquit future offset requirements.

The results of the detailed field assessments including the ground-truthed Regional Ecosystem mapping and fauna habitat associations were used to inform the suitability and location of the offset areas on each of the properties and are discussed in detail as part of the Bottle Tree and Kentucky offset area management plans (see Appendix A and B) and the approved Monte Christo Offset Proposal.

Table 5-1: Offset acquittal under EPBC 2008/4096

MNES	Disturbance area (ha)	Offset ratio	Offset area (ha)/number of species required to be secured	Bottle Tree			Kentucky			Monte Christo			Total offset area to be secured
				Available area (ha)	Offset area to be secured (ha)	Remaining surplus (ha)	Available area (ha)	Offset area to be secured (ha)	Remaining surplus (ha)	Available area (ha)	Offset area to be secured (ha)	Remaining surplus (ha)	
Endangered ecological communities													
Brigalow (*Acacia harpophylla* dominant and co-dominant)	11.23	8	89.84	1,202.44	1,019.47	182.93	-	-	-	-	-	-	1,019.47
Semi-evergreen vine thickets of the Brigalow Belt (North and South) and Nandewar Bioregions	2.4	8	19.20	-	-	-	19.79	19.79	-	-	-	-	19.79
Endangered fauna species													
Australasian bittern (*Botaurus poiciloptilus*)	0.8	8	6.40	-	-	-	-	-	-	811.04	6.40	804.64	6.40
Northern quoll (*Dasyurus hallucatus*)	1.53	8	12.24	678.44	678.44	-	1,463.65	-	1,443.85	-	-	-	686.84
Australian painted snipe (*Rostratula australis*)	4.79	8	38.32	-	-	-	-	-	-	2,001.51	38.32	1,963.19	38.32
Vulnerable fauna species													
Black-breasted button-quail (*Turnix melanogaster*)	2.61	8	20.88	2.33	2.33	-	19.79	19.79	-	6,497.72	-	6,497.72	22.12
Collared delma (*Delma torquata*)	86.22	8	689.76	1,323.82	1,140.89	182.93	1,392.18	-	1,392.18	808.40	-	808.40	1,140.89
Dunmall's snake (*Furina dunmalli*)	79.78	8	638.24	1,323.82	1,140.89	182.93	1,463.65	-	1,443.85	799.92	-	799.92	1,140.89
Fitzroy river turtle (*Rheodytes leukops*)	1.05	8	8.40	Offset obligation satisfied through nest protection program (see Section 4.4)									
Large-eared pied bat (*Chalinolobus dwyeri*)	44.11	8	352.88	678.44	678.44	-	1,463.65	-	1,443.85	-	-	-	686.84
Ornamental snake (*Denisonia maculata*)	25.46	8	203.68	1,327.05	1,143.63	183.42	-	-		-	-	-	1,143.63
Red goshawk (*Erythrotriorchis radiatus*)	68.91	8	551.28	1,327.05	1,143.63	183.42	1,463.65	-	1,443.85	7,324.86	-	7,324.86	1,143.63
South-Eastern long-eared bat (*Nyctophilus corbeni*)	142.91	8	1143.28	1,327.05	1,143.63	183.42	1,463.65	-	1,443.85	6,659.01	-	6,659.01	1,143.63
Squatter pigeon (Geophaps *scripta scripta*)	225.15	8	1801.20	1,324.24	1,141.31	182.93	1,392.18	-	1,392.18	7,394.53	659.89	6,734.64	1,801.20
Water mouse (*Xeromys myoides*)	0.01	8	0.08	-	-	-	-	-		3,255.45	0.08	3,255.37	0.08
Yakka skink (*Egernia rugosa*)	63.11	8	504.88	1,323.82	1,140.89	182.93	1,443.85	-	1,443.85	758.96	-	758.96	1,140.89
Migratory birds													
Cattle egret (*Ardea ibis*)	1.67	8	13.36	-	-	-	-	-	-	2,001.51	13.36	1,988.15	13.36
Eastern osprey (*Pandion haliaetus*)	1.4	8	11.20	-	-	-	-	-	-	1,063.82	11.20	1,052.62	11.20
Great egret (*Ardea modesta*)	3.83	8	30.64	-	-	-	-	-	-	1,969.99	30.64	1,939.35	30.64
Rainbow bee-eater (*Merops ornatus*)	225.39	8	1803.12	-	-	-	-	-	-	8,219.66	1,803.12	6,416.54	1,803.12
White-bellied sea-eagle (*Haliaeetus leucogaster*)	25.09	8	200.72	-	-	-	-	-	-	1,975.91	200.72	1,775.19	200.72
Migratory woodland bird species													
Black-faced monarch (*Monarcha melanopsis*)	14.68	8	117.44	-	-	-	-	-	-	7,496.53	117.44	7,379.09	117.44
Spectacled monarch (*Monarcha trivirgatus*)													
Satin flycatcher (*Myiagra cyanoleuca*)													

MNES	Disturbance area (ha)	Offset ratio	Offset area (ha)/number of species required to be secured	Bottle Tree			Kentucky			Monte Christo			Total offset area to be secured
				Available area (ha)	Offset area to be secured (ha)	Remaining surplus (ha)	Available area (ha)	Offset area to be secured (ha)	Remaining surplus (ha)	Available area (ha)	Offset area to be secured (ha)	Remaining surplus (ha)	
Rufous fantail (*Rhipidura rufifrons*)													
Oriental cuckoo (*Cuculus saturatus*)													
Migratory marine bird species													
Bar-tailed godwit (*Limosa lapponica*)	0.8	8	6.40	-	-	-	-	-	-	2,075.77	6.40	2,069.37	6.40
Black-tailed godwit (*Limosa limosa*)	0.8	8	6.40										
Broad-billed sandpiper (*Limicola falcinellus*)	0.8	8	6.40										
Common greenshank (*Tringa nebularia*)	0.8	8	6.40										
Common sandpiper (*Actitis hypoleucos*)	0.8	8	6.40										
Curlew sandpiper (*Calidris ferruginea*)	0.8	8	6.40										
Double-banded plover (*Charadrius bicinctus*)	0.8	8	6.40										
Eastern reef egret (*Egretta sacra*)	0.8	8	6.40										
Far eastern curlew (*Numenius madagascariensis*)	0.8	8	6.40										
Great knot (*Calidris tenuirostris*)	0.8	8	6.40										
Greater sand plover (*Charadrius leschenaultii*)	0.8	8	6.40										
Grey plover (*Pluvialis squatarola*)	0.8	8	6.40										
Grey-tailed tattler (*Tringa brevipes*)	0.8	8	6.40										
Latham's snipe (*Gallinago hardwickii*)	0.8	8	6.40										
Lesser sand plover (*Charadrius mongolus*)	0.8	8	6.40										
Little curlew (*Numenius minutus*)	0.8	8	6.40										
Marsh sandpiper (*Tringa stagnatilis*)	0.8	8	6.40										
Pacific golden plover (*Pluvialis fulva*)	0.8	8	6.40										
Red knot (*Calidris canutus*)	0.8	8	6.40										
Red-necked stint (*Calidris ruficollis*)	0.8	8	6.40										
Ruddy turnstone (*Arenaria interpres*)	0.8	8	6.40										
Sanderling (*Calidris alba*)	0.8	8	6.40										
Sharp-tailed sandpiper (*Calidris acuminata*)	0.8	8	6.40										
Terek sandpiper (*Xenus cinereus*)	0.8	8	6.40										
Whimbrel (*Numenius phaeopus*)	0.8	8	6.40										
Migratory tern bird species													
Caspian tern (*Sterna caspia*)	0.05	8	0.40	-	-	-	-	-	-	937.30	0.40	936.90	0.40
Little tern (*Sternula albifrons*)	0.05	8	0.40	-	-	-	-	-	-	937.30	0.40	936.90	0.40
Endangered flora species													
Ooline (*Cadellia pentastylis*)	36 individuals	6:1	216	-	4.5	-	-	-	-	-	-	-	4.5

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MNES	Disturbance area (ha)	Offset ratio	Offset area (ha)/number of species required to be secured	Bottle Tree			Kentucky			Monte Christo			Total offset area to be secured
				Available area (ha)	Offset area to be secured (ha)	Remaining surplus (ha)	Available area (ha)	Offset area to be secured (ha)	Remaining surplus (ha)	Available area (ha)	Offset area to be secured (ha)	Remaining surplus (ha)	
Xerothamnella herbacea	42 individuals	6:1	252	-	2.4	-	-	-	-	-	-	-	2.4
Philotheca sporadica	0	6:1	0	-	-	-	-	-	-	-	-	-	-
Large-fruited zamia (*Cycas megacarpa*)	1,100 individuals	No ratio	3,990[a]	See approved GLNG Gas Transmission Pipeline *Cycas megacarpa* Translocation and Management Plan (3380-GLNG-4-1.3-0013).									

6.0 Future management of Bottle Tree and Kentucky

6.1 Petroleum development excluded

Bottle Tree and Kentucky properties are located over petroleum tenures owned by Santos which contain prospective areas of gas resources. From 2015 to 2019 Santos GLNG proposed the following two different gas field development scenarios for the Bottle Tree and Kentucky properties to allow for gas field development and the provision of offsets:

- a flexible offset concept where a certain percentage of offset area was excised from the total property area and development would proceed anywhere within the property up to the percentage excised.
- infrastructure would be located throughout the offset as per the usual practice and then the disturbed areas would be excised from the offset area. The remaining areas of vegetation between the infrastructure would then be secured as offsets.

When presented with this proposal, the Commonwealth advised that such a development within the offset areas on both properties was unacceptable. The two uses were considered incompatible due to the potential for adverse impacts on the offset areas, including edge effects, habitat alteration and increased pest animal activity.

Based on the above, in early 2020, Santos made the decision to exclude petroleum activities from the proposed offset areas on Kentucky and Bottle Tree properties. Both properties were scheduled for future gas development as soon as 2021:

- Bottle Tree is located across two Petroleum Leases (PL) 420 and PL 421 as well as Authority to Prospect ATP 1191 and are all operated by Santos. Santos' long-term supply plan for the Bottle Tree property included the Arcadia Valley Phase 2 project and conversion of ATP1191 to a PL for future production. The Arcadia Phase 2 project over the Bottle Tree property was scheduled to commence in mid-2021. The project was to include 14 wells located within the proposed offset area at a well spacing of approximately 1000 metres with an associated network of gas and water flowlines and access tracks. An estimated 14 petajoules of gas would have been realised for an estimated value exceeding $2M.
- Kentucky is wholly located across two Petroleum Leases (PL) operated by Santos (PL 90 and PL 91) and occupies approximately 12% of the land surface of PL 90. Santos' long term supply plan included an appraisal program on Kentucky planned for 2021, to support a broader production program to follow. The Kentucky subproject would develop and realise an estimated 30 petajoules for an estimated value exceeding $4M. Gas value would be realised by a well spacing of approximately 1000 metres with an associated network of gas flowlines and access tracks. Steep topography across this property would result in larger than average disturbances to support safe and stable infrastructure.

The decision not to proceed with development comes at a cost to Santos, and without the legal security of these vegetated areas afforded through an approved offset plan and a Voluntary Declaration under the VM Act, development would proceed, leading to a direct loss of existing and potential MNES values and a decreased level of condition across areas remaining. Research in central Queensland has shown vegetation within 1 km of an edge was degraded as a result of edge effects and habitat fragmentation associated with linear infrastructure (Neldner et al. 2017). Therefore, approval of this Offset Plan will result in avoidance of significant impacts to MNES values consistent with first step of the mitigation hierarchy.

6.2 Clearing for grazing excluded

Arcadia Valley contains very productive soils and almost all vegetation in the Valley has been extensively cleared since the 1950s for pasture and cropping. The Statewide Landcover and Trees Study (SLATS) is a vegetation monitoring initiative of the Queensland Government, undertaken by the Remote Sensing Centre in the Department of Environment and Science. The primary objective of the study is to map the location and extent of woody vegetation clearing across Queensland and report annualised rates of clearing. SLATS data shows that over the last 10 years the area of Arcadia sub-Bioregion has reduced that has been replaced by pasture or cropping was 15,183 ha.

The Bottle Tree property is currently grazed by DOCE Pty Ltd, a wholly owned subsidiary of Santos. If the offset area on Bottle Tree was not approved the area would be subject to unrestricted grazing and the maximum return for grazing would be sought by DOCE Pty Ltd. Maximum grazing return would target the valuable areas comprising immature woody regrowth on Bottle Tree. These areas are not protected from clearing under the Queensland VM Act.

Eyre et al. (2009) identified the significant changes that grazing can cause in Brigalow Belt ecosystems. As these areas are now being used as offsets, grazing will only be used strategically and on a limited basis to manage fuel loads and control exotic weeds and pasture grasses – consequently, through the management of strategic grazing potential impacts on MNES, particularly those comprising regrowth communities, will be avoided.

Accordingly, the above changes to the future management of Bottle Tree and Kentucky have informed preparation of the respective offset area management plans (Appendix A and B).

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7.0 References

Eyre, T.J., Maron, M., Mathieson, M.T. and Haseler, M. (2009). *Impacts of grazing, selective logging and hyper-aggressors on diurnal bird fauna in intact forest landscapes of the Brigalow Belt, Queensland*. Austral Ecology, 34: 705-716. doi:10.1111/j.1442-9993.2009.01979.x

V.J. Neldner, M.J. Laidlaw, K.R. McDonald, M.T. Mathieson, R.I. Melzer, R. Seaton, W.J. F. McDonald, R. Hobson, and C.J. Limpus (2017). *Scientific review of the impacts of land clearing on threatened species in Queensland*. Queensland Government, Brisbane.

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APPENDIX A

Bottle Tree Offset Area Management Plan

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Bottle Tree Offset Area Management Plan – EPBC 2008/4096

Document Number: 0007-650-EMP-0018

Date	Rev	Reason For Issue	Reviewed	Endorsed	Approved
30 July 2021	0	For DAWE submission	MB	MB	JC/ED
23 September 2021	1	Updated based on DAWE review	MB	MB	ED

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Abbreviations

Acronym	Description
BPA	Biodiversity Planning Assessment
CSG	Coal Seam Gas
°C	Degrees Celsius
DAF	Department of Agriculture and Forestry (Qld)
DAWE	Department of Agriculture, Water and the Environment; formerly Department of the Environment and Energy (DEE)
DES	Department of Environment and Science; formerly Department of Environment and Heritage Protection (DEHP)
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Cth)
GIS	Geographical Information System
GLNG	Gladstone Liquefied Natural Gas
GTDTHQ	Guide to Determining Terrestrial Habitat Quality
GTP	Gas Transmission Pipeline
ha	Hectare
km	Kilometre
MNES	Matters of National Environmental Significance
m	Metre
mm	Millimetre
NP	National Park
OAMP	Offset Area Management Plan
PMAV	Property Map of Assessable Vegetation
RE	Regional Ecosystem
REDD	Reginal Ecosystem Description Database
SEVT	Semi-evergreen vine thickets of the Brigalow Belt (North and South) and Nandewar Bioregions
SSMP	Significant Species Management Plan

Acronym	Description
spp	species
TEC	Threatened Ecological Community
TSSC	Threatened Species Scientific Committee
VM Act	*Vegetation Management Act 1999* (Qld)

Executive summary

This offset area management plan (OAMP) has been prepared to address the requirements of the Santos Gladstone Liquefied Natural Gas (GLNG) Project approval EPBC 2008/4096 to provide suitable offsets for matters of national environmental significance (MNES) to compensate for direct and indirect adverse impacts on MNES.

Santos will secure a 2,769 hectare (ha) offset area on the Bottle Tree property (Lot 7 TR39). The Bottle Tree offset area was approved by the Department of Agriculture, Water and the Environment (DAWE) on 23 March 2021 to acquit MNES offset requirements under EPBC 2008/4059, including surplus areas of suitable MNES habitat for Santos to drawdown on for future project offset acquittal. The Bottle Tree offset area includes (Table ES 1):

- 1,143.6 ha to acquit offset requirements under EPBC 2008/4096 (conditions 15-22) and the Gas Transmission Pipeline Significant Species Management Plan (GTP SSMP; 3380-GLNG-4-1.3-0104 Rev W).
- 1,422.6 ha to acquit offset requirements under EPBC 2008/4059 (approved by DAWE 23 March 2021) including 494.9 ha of future habitat area that will support threatened species in the future following appropriate management as part of this OAMP (approved by DAWE 23 March 2021; however, was provided in addition to acquitting MNES offset obligations under EPBC 2008/4059 to support the overall conservation gain of the offset area).
- 183.4 ha of the remaining surplus offset value comprising moderate quality habitat for MNES and will be used by Santos to acquit future project offset requirements.
- 18.8 ha of non-remnant vegetation or existing infrastructure with no offset value. This area was included to maintain useful land management practices such as existing fence lines.

For MNES where a surplus is noted, Santos proposes to draw down on these to acquit future offset requirements under related approvals. The remaining obligations under EPBC 2008/4096 and the GTP SSMP will be satisfied elsewhere.

The Bottle Tree property is located within the Santos GLNG Project tenements approximately 75 kilometres north-east of Injune and adjacent to the Expedition (Limited Depth) National Park. The property is mapped within a state conservation corridor. Desktop and field surveys of the Bottle Tree property have been completed to confirm the presence of offset values and suitability to satisfy the Project's offset obligations as follows:

- 2011
  - Preliminary desktop assessment of biodiversity offset values
  - Detailed field assessment to ground truth vegetation and confirm presence of environmental values
- 2015
  - Further refine ground-truthed and potential Regional Ecosystem (RE) types and their extent as well as confirming location of potential areas to support biodiversity offsets
- 2020
  - Update fine-scale RE mapping and BioCondition assessments
  - Targeted flora and fauna surveys and habitat assessments

- 2021
  - BioCondition assessments
  - Targeted flora and fauna surveys and habitat assessments

The outcome of this OAMP is to acquit the offset obligations under EPBC 2008/4096 (conditions 15-22) and the GTP SSMP. The Bottle Tree offset area will be managed and monitored, based on an adaptive management framework, to achieve the interim performance targets and completion criteria presented in Table ES 2.

The key management actions to be implemented include:

- restricting access to the offset area
- management and restoration of regrowth Threatened Ecological Community (TEC)
- maintenance and upgrades of existing access tracks, fencing and firebreaks
- fire management through strategic grazing and fuel hazard reduction burns
- weed management
- pest animal management.

Ongoing monitoring events will be undertaken to assess the effectiveness of the management actions and progress of the offset area in achieving the interim performance targets and completion criteria, including:

- biannual offset area inspections
- biomass monitoring
- fuel load monitoring
- weed monitoring
- pest animal monitoring
- rapid monitoring events
- habitat quality assessments
- brigalow stem counts
- photo monitoring.

Annual reports will be prepared to detail progress of the offset area in achieving the interim performance targets and completion criteria for each management year including the results of management and monitoring activities completed.

Santos will apply to have the offset area protected via a Voluntary Declaration under section 19E and 19F of the *Queensland Vegetation Management Act 1999* (including surplus areas identified in Table ES 1). In accordance with previous OAMPs over the Bottle Tree property, Santos will lodge the Voluntary Declaration application by 23 March 2022 and the Voluntary Declaration will remain in place for the life of EPBC 2008/4096 and 2008/4059. In addition, once areas of regrowth Brigalow (*Acacia harpophylla* dominant and co-dominant) TEC and Semi-evergreen vine thickets of the Brigalow Belt (North and South) and Nandewar Bioregions TEC have reached the requirements to achieve remnant status Santos will apply to have these areas reclassified as remnant vegetation in accordance with the relevant Queensland legislation.

Table ES 1: Summary of the Bottle Tree offset area and acquittal for EPBC 2008/4096

MNES	Disturbance area (ha)	Offset ratio	Offset area (ha)/number of species	Bottle Tree offset area approved under EPBC 2008/4059**		Bottle Tree offset area to be secured under EPBC 2008/4096		Surplus area remaining on Bottle Tree following acquittal of EPBC 2008/4059 and 2008/4096 (ha)
				Offset area to be secured (ha)	Available surplus area (ha)	Offset area to be secured (ha)	Offset requirement satisfied on Bottle Tree?	
Endangered ecological communities								
Brigalow (*Acacia harpophylla* dominant and co-dominant)	11.23	8	89.84	344.8	1,202.44	1,019.47	Yes	182.93
Semi-evergreen vine thickets of the Brigalow Belt (North and South) and Nandewar Bioregions	2.4	8	19.2	15.4	-	-	No	-
Endangered fauna species								
Australasian bittern (*Botaurus poiciloptilus*)	0.8	8	6.4	-	-	-	No	-
Northern quoll (*Dasyurus hallucatus*)	1.53	8	12.24	411.3	678.44*	678.44	Yes	-
Australian painted snipe (*Rostratula australis*)	4.79	8	38.32	-	-	-	No	-
Vulnerable fauna species								
Black-breasted button-quail (Turnix melanogaster)	2.61	8	20.88	12.0	2.33	2.33	No	-
Collared delma (*Delma torquata*)	86.22	8	689.76	579.8	1,323.82	1,140.89	Yes	182.93
Dunmall's snake (*Furina dunmalli*)	79.78	8	638.24	480.1	1,323.82	1,140.89	Yes	182.93
Fitzroy river turtle (*Rheodytes leukops*)	1.05	8	8.4	Offset obligation satisfied through approved nest protection program				
Large-eared pied bat (*Chalinolobus dwyeri*)	44.11	8	352.88	411.3	678.44*	678.44	Yes	-
Ornamental snake (*Denisonia maculata*)	25.46	8	203.68	19.0	1,327.05#	1,143.63	Yes	183.42
Red goshawk (*Erythrotriorchis radiatus*)	68.91	8	551.28	647.5	1,327.05	1,143.63	Yes	183.42
South-Eastern long-eared bat (*Nyctophilus corbeni*)	142.91	8	1143.28	647.5	1,327.05	1,143.63	Yes	183.42
Squatter pigeon (Geophaps *scripta scripta*)	225.15	8	1801.2	290.7	1,324.24#	1,141.31	No	182.93
Water mouse (*Xeromys myoides*)	0.01	8	0.08	-	-	-	No	-
Yakka skink (*Egernia rugosa*)	63.11	8	504.88	480.1	1,323.82	1,140.89	Yes	182.93
Migratory birds								
Cattle egret (*Ardea ibis*)	1.67	8	13.36	-	-	-		-
Eastern osprey (*Pandion haliaetus*)	1.4	8	11.2	-	-	-		-
Great egret (*Ardea modesta*)	3.83	8	30.64	-	-	-	No	-
Rainbow bee-eater (*Merops ornatus*)	225.39	8	1803.12	-	-	-		-
White-bellied sea-eagle (*Haliaeetus leucogaster*)	25.09	8	200.72	-	-	-		-

MNES	Disturbance area (ha)	Offset ratio	Offset area (ha)/number of species	Bottle Tree offset area approved under EPBC 2008/4059**		Bottle Tree offset area to be secured under EPBC 2008/4096		Surplus area remaining on Bottle Tree following acquittal of EPBC 2008/4059 and 2008/4096 (ha)
				Offset area to be secured (ha)	Available surplus area (ha)	Offset area to be secured (ha)	Offset requirement satisfied on Bottle Tree?	
Migratory woodland bird species								
Black-faced monarch (*Monarcha melanopsis*)	14.68	8	117.44	-	-	-	No	-
Spectacled monarch (*Monarcha trivirgatus*)								
Satin flycatcher (*Myiagra cyanoleuca*)								
Rufous fantail (*Rhipidura rufifrons*)								
Oriental cuckoo (*Cuculus saturatus*)								
Migratory marine bird species								
Bar-tailed godwit (*Limosa lapponica*)	0.8	8	6.4	-	-	-	No	-
Black-tailed godwit (*Limosa limosa*)	0.8	8	6.4	-	-	-		-
Broad-billed sandpiper (*Limicola falcinellus*)	0.8	8	6.4	-	-	-		-
Common greenshank (*Tringa nebularia*)	0.8	8	6.4	-	-	-		-
Common sandpiper (*Actitis hypoleucos*)	0.8	8	6.4	-	-	-		-
Curlew sandpiper (*Calidris ferruginea*)	0.8	8	6.4	-	-	-		-
Double-banded plover (*Charadrius bicinctus*)	0.8	8	6.4	-	-	-		-
Eastern reef egret (*Egretta sacra*)	0.8	8	6.4	-	-	-		-
Far eastern curlew (*Numenius madagascariensis*)	0.8	8	6.4	-	-	-		-
Great knot (*Calidris tenuirostris*)	0.8	8	6.4	-	-	-		-
Greater sand plover (*Charadrius leschenaultii*)	0.8	8	6.4	-	-	-		-
Grey plover (*Pluvialis squatarola*)	0.8	8	6.4	-	-	-		-
Grey-tailed tattler (*Tringa brevipes*)	0.8	8	6.4	-	-	-		-
Latham's snipe (*Gallinago hardwickii*)	0.8	8	6.4	-	-	-		-
Lesser sand plover (*Charadrius mongolus*)	0.8	8	6.4	-	-	-		-
Little curlew (*Numenius minutus*)	0.8	8	6.4	-	-	-		-
Marsh sandpiper (*Tringa stagnatilis*)	0.8	8	6.4	-	-	-		-
Pacific golden plover (*Pluvialis fulva*)	0.8	8	6.4	-	-	-		-
Red knot (*Calidris canutus*)	0.8	8	6.4	-	-	-		-

MNES	Disturbance area (ha)	Offset ratio	Offset area (ha)/number of species	Bottle Tree offset area approved under EPBC 2008/4059**		Bottle Tree offset area to be secured under EPBC 2008/4096		Surplus area remaining on Bottle Tree following acquittal of EPBC 2008/4059 and 2008/4096 (ha)
				Offset area to be secured (ha)	Available surplus area (ha)	Offset area to be secured (ha)	Offset requirement satisfied on Bottle Tree?	
Red-necked stint (*Calidris ruficollis*)	0.8	8	6.4	-	-	-		-
Ruddy turnstone (*Arenaria interpres*)	0.8	8	6.4	-	-	-		-
Sanderling (*Calidris alba*)	0.8	8	6.4	-	-	-		-
Sharp-tailed sandpiper (*Calidris acuminata*)	0.8	8	6.4	-	-	-		-
Terek sandpiper (*Xenus cinereus*)	0.8	8	6.4	-	-	-		-
Whimbrel (*Numenius phaeopus*)	0.8	8	6.4	-	-	-		-
Migratory tern bird species								
Caspian tern (*Sterna caspia*)	0.05	8	0.4	-	-	-	No	-
Little tern (*Sternula albifrons*)	0.05	8	0.4	-	-	-		-
Endangered flora species								
Ooline (*Cadelia pentasyli*)	36 individuals	6:1	216	Existing 4.5 ha offset area legally secured on Bottle Tree property				
Xerothamnella herbacea	42 individuals	6:1	252	Existing 2.4 ha offset area legally secured on Bottle Tree property				
Philotheca sporadica	0	6:1	0	-	-	-	-	-
Large-fruited zamia (*Cycas megacarpa*)	1,100 individuals	No ratio	3,990[a]	See approved GLNG Gas Transmission Pipeline *Cycas megacarpa* Translocation and Management Plan (3380-GLNG-4-1.3-0013).				

* Note this figure has been updated from the approved Santos GLNG Offset Plan and Acquittal Summary (Document Number: 0007-650-EMP-0009) to account for total area of surplus available.

\# Surplus area available takes into account MNES habitat associations used as part of the GTP Adverse Impact Assessment Methodology (approved by the Commonwealth government on 16 July 2015).

**Plus an additional 494.9 ha of future habitat area has been committed to in addition to offset obligations under EPBC 2008/4059.

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Table ES 2: Interim performance targets and completion criteria for the EPBC 20058/4096 Bottle Tree offset area

MNES	Baseline	Interim performance targets			Completion criteria
		Year 5	Year 10	Year 15	Year 20
South-eastern long-eared bat	4	Increase in the habitat quality score from baseline score of 4	Increase in the habitat quality score from year 5	Increase in the habitat quality score from year 10	Improve the quality of habitat to achieve a score of at least 6
Collared delma	3	Increase in the habitat quality score from baseline score of 3	Increase in the habitat quality score from year 5	Increase in the habitat quality score from year 10	Improve the quality of habitat to achieve a score of at least 5
Yakka skink	3	Increase in the habitat quality score from baseline score of 3	Increase in the habitat quality score from year 5	Increase in the habitat quality score from year 10	Improve the quality of habitat to achieve a score of at least 5
Northern quoll	4	Increase in the habitat quality score from baseline score of 4	Increase in the habitat quality score from year 5	Increase in the habitat quality score from year 10	Improve the quality of habitat to achieve a score of at least 6
Large-eared pied bat	4	Increase in the habitat quality score from baseline score of 4	Increase in the habitat quality score from year 5	Increase in the habitat quality score from year 10	Improve the quality of habitat to achieve a score of at least 6
Red goshawk	4	Increase in the habitat quality score from baseline score of 4	Increase in the habitat quality score from year 5	Increase in the habitat quality score from year 10	Improve the quality of habitat to achieve a score of at least 6
Black-breasted button-quail	4	Increase in the habitat quality score from baseline score of 4	Increase in the habitat quality score from year 5	Increase in the habitat quality score from year 10	Improve the quality of habitat to achieve a score of at least 6
Dunmall's snake	4	Increase in the habitat quality score from baseline score of 4	Increase in the habitat quality score from year 5	Increase in the habitat quality score from year 10	Improve the quality of habitat to achieve a score of at least 6
Squatter pigeon	4	Increase in the habitat quality score from baseline score of 4	Increase in the habitat quality score from year 5	Increase in the habitat quality score from year 10	Improve the quality of habitat to achieve a score of at least 6
Ornamental snake	4	Increase in the habitat quality score from baseline score of 4	Increase in the habitat quality score from year 5	Increase in the habitat quality score from year 10	Improve the quality of habitat to achieve a score of at least 6
Brigalow TEC	4	Increase in the habitat quality score from baseline score of 4	Increase in the habitat quality score from year 5	Increase in the habitat quality score from year 10	Improve the quality of habitat to achieve a score of at least 6

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1.0 Introduction

The Santos Gladstone Liquefied Natural Gas (GLNG) Project involves the development of Coal Seam Gas (CSG) resources in the Surat and Bowen Basins in Queensland, to supply gas via a 430 kilometre (km) gas transmission pipeline (GTP) to the liquified natural gas (LNG) facility located on Curtis Island. Throughout the development of the Santos GLNG Project and in accordance with Santos GLNG Project approvals, potentially impacted environmental values are systematically identified and assessed and in order of preference are avoided, minimised or mitigated.

The Santos GLNG Project is required to provide environmental offsets for significant residual impacts on matters of national environmental significance (MNES) in accordance with approvals granted under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

The Bottle Tree offset area was approved by the Department of Agriculture, Water and the Environment (DAWE) on 23 March 2021 to acquit MNES offset requirements under EPBC 2008/4059, including surplus areas of suitable MNES habitat for Santos to drawdown on for future project offset acquittal.

This offset area management plan (OAMP) has been prepared to address the acquittal of the MNES offset obligations under the GLNG Project approval EPBC 2008/4096, specifically offset obligations required under EPBC 2008/4096 (Conditions 15-22) and the Gas Transmission Pipeline Significant Species Management Plan (GTP SSMP; 3380-GLNG-4-1.3-0104 Rev W), outlined in Table 1, and will draw down on the approved surplus areas within the Bottle Tree offset area (Figure 1; Figure 2; Section 2.7).

Table 1: Summary of the disturbance in which offsets will be provided for under EPBC 2008/4096 as presented in the approved GTP SSMP

MNES	Disturbance area (ha)	Offset ratio	Offset area (ha)/number of species
Endangered ecological communities			
Brigalow (*Acacia harpophylla* dominant and co-dominant)	11.23	8	89.84
Semi-evergreen vine thickets of the Brigalow Belt (North and South) and Nandewar Bioregions	2.4	8	19.2
Endangered fauna species			
Australasian bittern (*Botaurus poiciloptilus*)	0.8	8	6.4
Northern quoll (*Dasyurus hallucatus*)	1.53	8	12.24
Australian painted snipe (*Rostratula australis*)	4.79	8	38.32
Vulnerable fauna species			
Black-breasted button-quail (Turnix melanogaster)	2.61	8	20.88
Collared delma (*Delma torquata*)	86.22	8	689.76

MNES	Disturbance area (ha)	Offset ratio	Offset area (ha)/number of species
Dunmall's snake (*Furina dunmalli*)	79.78	8	638.24
Fitzroy river turtle (*Rheodytes leukops*)	1.05	8	8.4
Large-eared pied bat (*Chalinolobus dwyeri*)	44.11	8	352.88
Ornamental snake (*Denisonia maculata*)	25.46	8	203.68
Red goshawk (*Erythrotriorchis radiatus*)	68.91	8	551.28
South-Eastern long-eared bat (*Nyctophilus corben*i)	142.91	8	1143.28
Squatter pigeon (Geophaps *scripta scripta*)	225.15	8	1801.2
Water mouse (*Xeromys myoides*)	0.01	8	0.08
Yakka skink (*Egernia rugosa*)	63.11	8	504.88
Migratory birds			
Cattle egret (*Ardea ibis*)	1.67	8	13.36
Eastern osprey (*Pandion haliaetus*)	1.4	8	11.2
Great egret (*Ardea modest*a)	3.83	8	30.64
Rainbow bee-eater (*Merops ornatus*)	225.39	8	1803.12
White-bellied sea-eagle (*Haliaeetus leucogaster*)	25.09	8	200.72
Migratory woodland bird species			
Black-faced monarch (*Monarcha melanopsis*)	14.68	8	117.44
Spectacled monarch (*Monarcha trivirgatus*)			
Satin flycatcher (*Myiagra cyanoleuca*)			
Rufous fantail (*Rhipidura rufifrons*)			
Oriental cuckoo (*Cuculus saturatus*)			
Migratory marine bird species			
Bar-tailed godwit (*Limosa lapponica*)	0.8	8	6.4
Black-tailed godwit (*Limosa limosa*)	0.8	8	6.4
Broad-billed sandpiper (*Limicola falcinellus*)	0.8	8	6.4

MNES	Disturbance area (ha)	Offset ratio	Offset area (ha)/number of species
Common greenshank (*Tringa nebularia*)	0.8	8	6.4
Common sandpiper (*Actitis hypoleucos*)	0.8	8	6.4
Curlew sandpiper (*Calidris ferruginea*)	0.8	8	6.4
Double-banded plover (*Charadrius bicinctus*)	0.8	8	6.4
Eastern reef egret (*Egretta sacra*)	0.8	8	6.4
Far eastern curlew (*Numenius madagascariensis*)	0.8	8	6.4
Great knot (*Calidris tenuirostris*)	0.8	8	6.4
Greater sand plover (*Charadrius leschenaultii*)	0.8	8	6.4
Grey plover (*Pluvialis squatarola*)	0.8	8	6.4
Grey-tailed tattler (*Tringa brevipes*)	0.8	8	6.4
Latham's snipe (*Gallinago hardwickii*)	0.8	8	6.4
Lesser sand plover (*Charadrius mongolus*)	0.8	8	6.4
Little curlew (*Numenius minutus*)	0.8	8	6.4
Marsh sandpiper (*Tringa stagnatilis*)	0.8	8	6.4
Pacific golden plover (*Pluvialis fulva*)	0.8	8	6.4
Red knot (*Calidris canutus*)	0.8	8	6.4
Red-necked stint (*Calidris ruficollis*)	0.8	8	6.4
Ruddy turnstone (*Arenaria interpres*)	0.8	8	6.4
Sanderling (*Calidris alba*)	0.8	8	6.4
Sharp-tailed sandpiper (*Calidris acuminata*)	0.8	8	6.4
Terek sandpiper (*Xenus cinereus*)	0.8	8	6.4
Whimbrel (*Numenius phaeopus*)	0.8	8	6.4
Migratory tern bird species			
Caspian tern (*Sterna caspia*)	0.05	8	0.4
Little tern (*Sternula albifrons*)	0.05	8	0.4

MNES	Disturbance area (ha)	Offset ratio	Offset area (ha)/number of species
Endangered flora species			
Ooline (*Cadellia pentastylis*)	36 individuals	6:1	216
Xerothamnella herbacea	42 individuals	6:1	252
Philotheca sporadica	0	6:1	0
Large-fruited zamia (*Cycas megacarpa*)	1,100 individuals	No ratio	3,990[a]

1.1 Purpose

This OAMP provides a detailed management and monitoring framework for the Bottle Tree offset area in accordance with the requirements of EPBC 2008/4096 as presented in Table 2 below.

Table 2: How EPBC Act approval 2008/4096 are satisfied

Condition Number	Condition	How the conditions are met
EPBC Act approval 2008/4096		
8	If a listed threatened species or migratory species or their habitat, or a listed ecological community is encountered during the surveys undertaken as required by condition 5 and is not specified in the Table 1 or 2 at condition 11 and 12, the proponent must submit a separate management plan for each species or ecological community to manage the unexpected impacts of clearing. In relation to each listed species or ecological community, each plan must address: a) the relevant characteristics describing each ecological community b) a map of the location of species, species' habitat, or ecological community in proximity to the ROW; c) measures that will be employed to avoid impact on the species, species' habitat, or ecological community; d) a quantification of the unavoidable impact (in hectares and/or individual specimens); e) where impacts are unavoidable and a disturbance limit is not specified for the listed species or ecological community under condition 11, propose offsets to compensate for the impact on the population of the species' habitat, or the ecological community; f) current legal status (under the EPBC Act); known distribution.	The Gas Transmission Pipeline Significant Species Management Plan (SSMP) has been developed to address all aspects of this condition including (e) the proposal of offsets to compensate for the impact on the population of the species' habitat, or the ecological community. An Offset Plan has been prepared to demonstrate how Santos will acquit the offset requirements for significant, residual, adverse impacts to MNES subject to EPBC 2008/4096 based on the offset ratios presented in the approved GTP SSMP. The Offset Plan complements previous offset plans and proposals submitted to the Commonwealth Government and has been prepared to address the offset commitments outlined in the GTP SSMP. This OAMP includes a detailed management and monitoring program to improve the quality of MNES offset values within the Bottle Tree offset area. This OAMP is based on an adaptive management framework which involves flexible decision making based on the outcomes of ongoing management and monitoring to ensure the environmental outcomes of the OAMP are achieved. This OAMP for the Bottle Tree offset area supersedes previous management plans submitted to the Department to satisfy this condition. This OAMP will be implemented following approval.
Offset for Semi-evergreen vine thickets of the Brigalow Belt (North and South) and Nandewar Bioregions (SEVT)		
15	Within 12 months of the commencement of pipeline development the proponent must prepare an Offset Plan to provide an offset area for the approved disturbance limits relating to Semi-evergreen vine thickets of the Brigalow Belt (North and South) and Nandewar Bioregions within the project area. The offset area to be secured must be an area of private land which includes at least 19.2 ha of Semi-evergreen vine thickets of the Brigalow Belt (North and South) and Nandewar Bioregions. Note: Offsetting requirements for this approval can be accommodated as part of a single offset plan addressing the requirements of this approval and those required by EPBC 2008/4059.	The first offset plan for the GTP Project was submitted on 22 April 2011. This plan included properties that would be suitable to meet the offset requirement for Semi-evergreen vine thickets of the Brigalow Belt (North and South) and Nandewar Bioregions (SEVT). A number of revisions have occurred since then; however, the current offset plan supersedes all previously submitted plans. The offset requirement for SEVT is proposed to be acquit on another offset property as detailed in the offset plan. The offset plan addresses offset obligations under EPBC 2008/4096 and has been prepared to complement the offset plan addressing offset requirements under EPBC 2008/4059 approved by DAWE on 23 March 2021.
16	The Offset Plan must include details of the offset area including: the timing and arrangements for property acquisition, maps and site description, environmental values relevant to MNES, connectivity with other habitats and biodiversity corridors, a rehabilitation program, and mechanisms for long-term protection, conservation and management.	The offset requirement for SEVT is proposed to be acquit on another offset property as detailed in the offset plan. Further detail on the proposed offset property is provided in a separate offset area management plan (Appendix B of the offset plan).
17	The Offset Plan must be submitted for the approval of the Minister within 12 months of the commencement of gas field development. The approved Offset Plan must be implemented within 30 business days of approval.	The first offset plan for the GTP Project was submitted on 22 April 2011. This plan included properties that would be suitable to meet the offset requirement for SEVT. A number of revisions have occurred since then; however, the current offset plan supersedes all previously submitted plans. Once approved, the offset plan will be implemented.
18	If the approved Offset Plan cannot be implemented because of failure of arrangements to secure the necessary area of private land then the proponent must submit for the Minister's approval an alternative Offset Plan. The alternative Offset Plan must provide at least an equivalent environmental outcome to those specified under condition 15. The approved alternative Offset Plan must be implemented.	An offset plan has been prepared to address offset obligations under EPBC 2008/4096 and includes details of the necessary areas of private land required to meet these obligations. Once approved, the offset plan will be implemented.

Condition Number	Condition	How the conditions are met
19	If the proponent proposes any action within a proposed offset area, other than actions related to managing that area as an offset property, approval must be obtained, in writing from the Department. In seeking Departmental approval the proponent must provide a detailed assessment of the proposed action including a map identifying where the action is proposed to take place and an assessment of all associated adverse impacts on MNES. If the Department agrees to the action within the proposed offset site, the area identified for the action must be excised from the proposed offset and alternative offsets secured of equal or greater environmental value in relation to the impacted MNES.	Currently there are no actions proposed within the Bottle Tree offset area or any other offset areas subject to the offset plan.
20	The proponent must secure the offset within 2 years of commencement.	An offset plan addresses offset obligations under EPBC 2008/4096 and includes details of the necessary areas of private land required to meet these obligations. The offset requirement for SEVT is proposed to be acquit on another offset property as detailed in the offset plan. Current title documents demonstrating Santos' ownership of the property have been provided to the Commonwealth Government previously and can be provided again upon request.
SEVT Offset Area Management		
21	Within 12 months of securing the offset area required under the approved Offset Plan, the proponent must develop an Offset Area Management Plan which must specify measures to improve the environmental values of the offset area in relation to MNES, including; a) the documentation and mapping of current environmental values relevant to MNES of the area; b) measures to address threats to MNES including but not limited to grazing pressure and damage by livestock and adverse impacts from feral animals and weeds; c) measures to provide fire management regimes appropriate for the MNES; d) measures to manage the offset area to improve the condition of the SEVT ecological community within the offset area and to increase the areal extent of SEVT ecological community within the offset area as objectives of the program. e) monitoring, including the undertaking of ecological surveys to assess the success of the management measures against identified milestones and objectives; performance measures and reporting requirements against identified objectives, including trigger levels for corrective actions and the actions to be taken to ensure performance measures and objectives are met.	The offset requirement for SEVT is proposed to be acquit on another offset property as detailed in the offset plan. An offset area management plan for the proposed property to acquit SEVT offset obligations is provided in Appendix B of the offset plan. This plan specifies measures to improve the environmental values of the offset area in relation to the relevant MNES.
22	Within 12 months of securing the offset area the Offset Area Management Plan must be submitted for the approval of the Minister. The approved Offset Area Management Plan must be implemented.	The offset area management plan for the SEVT offset (Appendix B of the offset plan) supersedes previous management plans submitted to the Commonwealth Government to satisfy this condition. The OAMP will be implemented following approval.

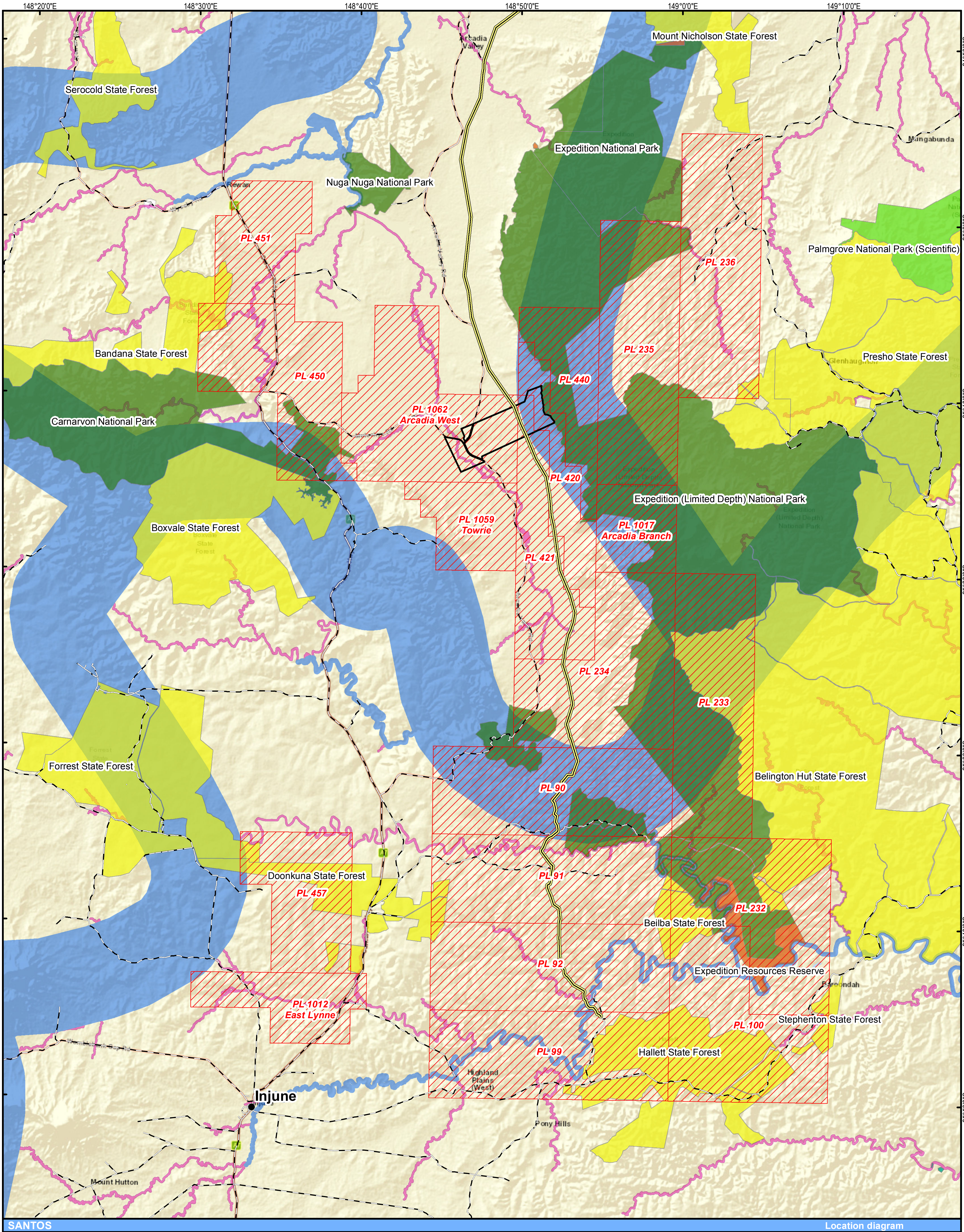

Figure 1
Project context

Bottle Tree - 7TR39
GTP - petroleum pipeline (PPL 166)
Santos Petroleum Lease
Roads/tracks

Protected Area
National Park
National Park (Scientific)
State Forest
Conservation Park
Resources Reserve
Nature Refuge

Statewide Corridors v1.4
State
Regional

0 2.5 5 7.5 10
Kilometres

CO2 Australia

DATA SOURCE:
The following datasets are © State of Qld:
- Cadastral data
- Petroleum leases
- Protected areas
- Statewide corridors

Date: 6/11/2021 Coordinate System: GDA 1994 MGA Zone 55 Projection: Transverse Mercator Datum: GDA 1994 Scale: 1:350,000@A3

2.0 Bottle Tree property

2.1 Property overview

Bottle Tree (Lot 7 TR39) is a 3,853 ha property located approximately 75 km north-northeast of Injune in south central Queensland (Figure 1). The property is owned by Santos and was acquired primarily for its potential environmental offset values for the Santos GLNG Project. Bottle Tree is situated within Subregion 20 (Arcadia) of the Brigalow Belt South bioregion (Sattler and Williams 1999) within the jurisdiction of the Central Highlands Regional Council. Access to the property is via the Arcadia Valley Road, east of the Carnarvon Developmental Road between Injune and Rolleston. Current land uses on the property include cattle grazing, activities associated with coal seam gas exploration and production as well as areas dedicated to environmental offsets.

The property is located entirely within the Brown River catchment, part of the Fitzroy River basin, with the major watercourse being Arcadia Creek. Several other minor watercourses are present on the property. The topography is varied and is comprised of alluvial plains, undulating plains, low hills and a steep scarp of Precipice Sandstone. Elevation ranges between approximately 300 and 346 metres (m) on the lower lying areas of the property and reaches a maximum of about 630 m at the crest of the Expedition Range.

Table 3 summarises Bottle Tree landholder and property details.

Table 3: Bottle Tree landholder and property details

Landholder and Property Details	
Registered Owner/s on Title:	Santos GLNG Pty Ltd (JV representative) Total GNG Australia PAPL (Downstream) Pty Ltd KGLNG Liquefaction Pty Ltd
ABN/ACN:	ABN 12 131 271 648 (Santos GLNG Pty Ltd)
Postal Address:	PO Box 329, Roma Queensland 4455
Lot on plan(s):	Lot 7 TR39
Address:	5744 Arcadia Valley Road, Arcadia Valley Queensland
Tenure:	Freehold
Area:	3,853 ha
Primary Local Government Area:	Central Highlands Regional Council
Permits	
Coal Exploration Permit:	EPC 1772 Tri-Star Coal Company
Petroleum and gas exploration permit	ATP1191 SANTOS QNT Pty Ltd.

Petroleum and gas production permit	PL1062 SANTOS QNT Pty. Ltd (application) PL420 and PL421 Santos Toga Pty Ltd
Infrastructure permit	PPL166 Santos GLNG Pty ltd

2.2 Connectivity

The Bottle Tree property is mapped within a state conservation corridor (Figure 1). Conservation corridors have been mapped as part of the Queensland Government's Biodiversity Planning Assessments (BPA) which assess the biodiversity significance of land in a bioregion. The mapping of corridors within the Brigalow Belt Bioregion, in which the Bottle Tree property is located, has focussed on those corridors that link adjacent bioregions or connect wildlife refugia. Corridors identified as of state significance are considered of the greatest importance at the bioregional scale. As illustrated in Figure 1 the state conservation corridor runs along the eastern portion of the property as part of the contiguous tract of remnant vegetation including Expedition (Limited Depth) National Park (NP).

More detail on BPAs can be found at https://www.qld.gov.au/environment/plants-animals/biodiversity/planning.

2.3 Existing threatened flora offsets

Santos has satisfied offset obligations for Ooline (*Cadellia pentastylis*) and *Xerothamnella herbacea* under EPBC 2008/4096 through the propagation and translocation of individuals on two planting sites (existing offset area) on the Bottle Tree offset area (see Figure 2).

Two individual offset areas for Ooline and *Xerothamnella herbacea,* respectively, have been legally secured through a Voluntary Declaration under the Queensland *Vegetation Management Act 1999* (VM Act). These offset areas are currently being managed, monitored and reported on in accordance with dedicated management plans for the sites, also attached to the Voluntary Declarations.

The offset area to be secured as part of this OAMP exclude areas already legally secured for the Ooline and *Xerothamnella herbacea.* This OAMP has been prepared to align with the management actions detailed in the individual management plans for the Ooline and *Xerothamnella herbacea* offset areas and will be implemented concurrently.

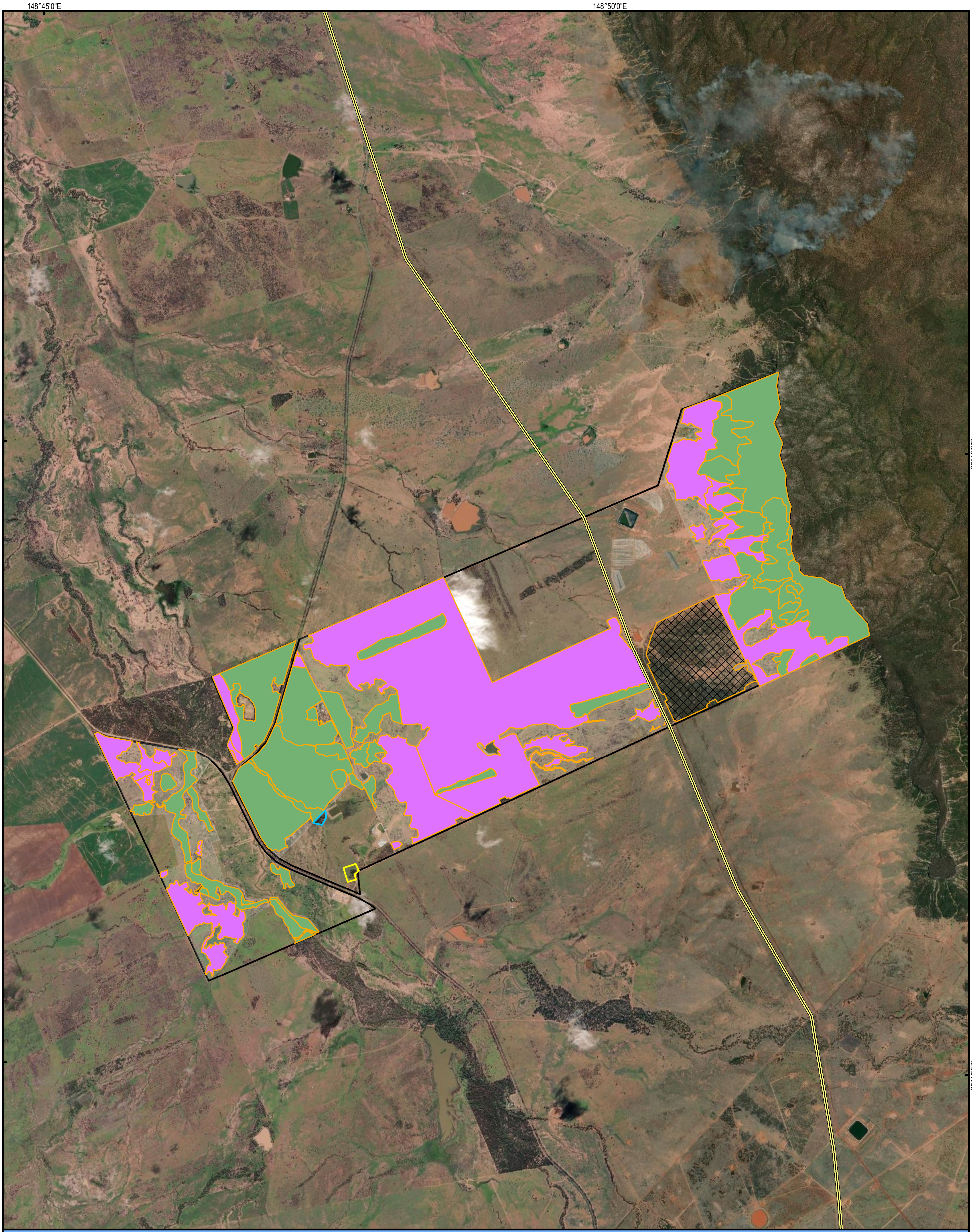

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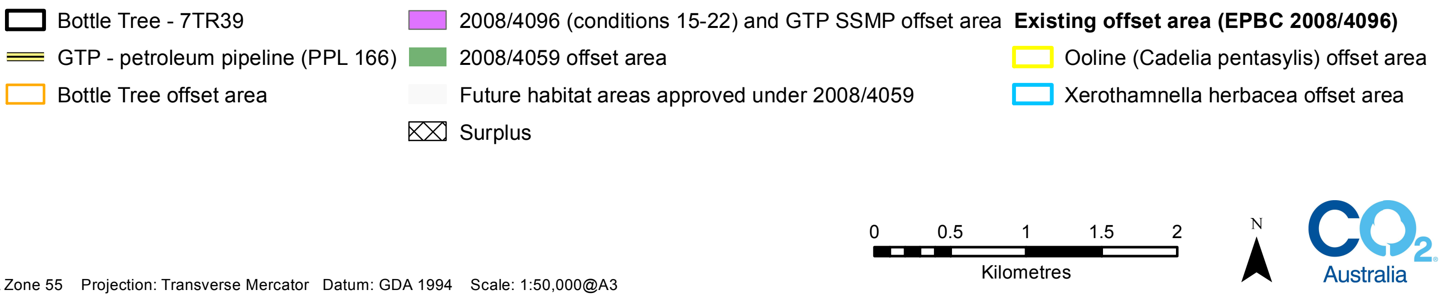
Figure 2
Property overview



Location diagram

DATA SOURCE:
The following datasets are © State of Qld:
- Cadastral data
- Petroleum pipeline
- Existing offset area (PMAV 2016/006243, PMAV 2018/004187)
Bottle Tree offset area provided by SANTOS

Date: 6/11/2021 Coordinate System: GDA 1994 MGA Zone 55 Projection: Transverse Mercator Datum: GDA 1994 Scale: 1:50,000@A3

CO2 Australia

Path: P:\GISData\Projects\Santos\ENV_20_004\9.GTP_Offset_Maps\Bottle Tree\BottleTree_Figure 2_Property overview.mxd

2.4 Climate

The Bottle Tree property is characterised by a hotter wet season (typically November to March) and a cooler dry season (typically April to October) (see Figure 3). Weather records from the Injune weather station (#43015), approximately 75 km south-west of Bottle Tree, show the mean monthly rainfall for the period 1961-1990 ranges from 24.9 millimetres (mm) (September) to 94.6 mm (January). Mean monthly maximum temperatures range from 19.6 degrees Celsius (°C) (July) to 33.7°C (January) and mean monthly minimum temperatures range from 3°C (July) to 19.2°C (January).

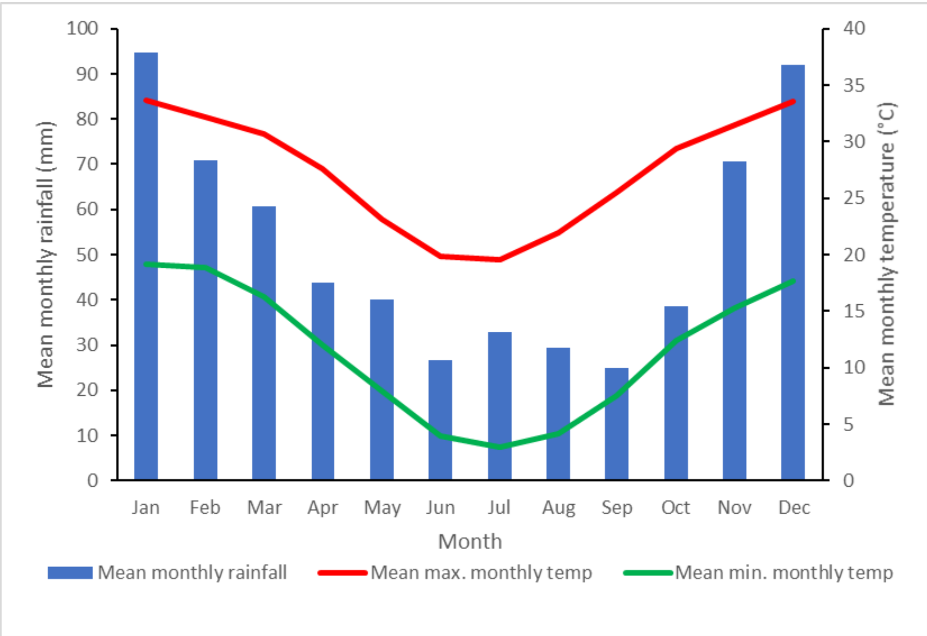


Figure 3: Mean monthly temperature and rainfall records from Injune Post Office weather station (ID: 43015) 1961-1990 (Bureau of Meteorology 2021)

2.5 On-ground property assessments

Santos has dedicated 2,769 ha for environmental offsets within the Bottle Tree property (herein referred to as the offset area). This area excludes existing legally secured offsets for Ooline and *Xerothamnella herbacea* (Figure 2).

A combination of desktop and detailed on-ground assessments of the offset area have been undertaken to confirm the suitability of the area to satisfy the Project's offset obligations. The key desktop and field surveys of the offset area completed to date are summarised below:

- 2011
  - Preliminary desktop assessment of biodiversity offset values (Ecofund 2011).
  - Detailed field assessment undertaken by Boobook to ground truth vegetation and confirm presence of environmental values (Boobook 2011).

- 2015
  - Further refine ground-truthed and potential Regional Ecosystem (RE) types and their extent as well as confirming location of potential areas to support biodiversity offsets based on examination of high-resolution aerial photography provided for the property by Santos (Boobook 2015).
- 2020
  - Update large-scale RE mapping across the offset area (Terrestria 2020).
  - BioCondition assessments within the Bottle Tree offset area in accordance with the BioCondition methodology (Eyre et al. 2015). The number of assessments sites per unit was guided by the Guide to Determining Terrestrial Habitat quality (version 1.2, Department of Environment and Heritage Protection [DEHP] 2017). The condition of each site was compared to the benchmark data provided for each RE. Benchmarks were obtained from either Santos' internal BioCondition results (Boobook 2015) or from the DEHP website at http://www.qld.gov.au/environment/plants-animals/biodiversity/benchmarks/#benchmarks. Photo monitoring sites were established at all BioCondition assessment sites.
  - Targeted flora surveys and habitat assessments, including unbounded meander flora surveys were conducted in line with the timed meander survey methodology contained within the DEHP Flora Survey Guidelines (2016).
  - Targeted fauna surveys using the following methods to assess fauna species richness for the endangered and vulnerable species also listed below within the Bottle Tree offset area:
    - Northern quoll
    - Large-eared pied bat
    - Black-breasted button-quail
    - Red goshawk
    - Australian painted snipe
    - Collared delma
    - Ornamental snake
    - Squatter pigeon (Southern)
    - Yakka skink
    - Dunmall's snake
    - Eastern long-eared bat
    - Australasian bittern
    - Koala
    - Southern greater glider
    - Powerful owl
    - Survey methods:
      - Camera traps focused on bait stations;
      - Elliott B trapping;
      - funnel trapping;
      - Ultrasonic bat call detection;
      - Active daytime habitat searching;
      - Spotlighting habitat searches; and
      - Active koala searches and scat analysis.

- Unbounded fauna surveys were conducted to assess the presence and abundance of native and pest fauna and threatening processes. General assessments were carried out across the entirety of the offset area including passive recording techniques such as sightings, recognition of characteristic vocalisations, and/or identification of animal signs.
- Fauna surveys were conducted from 06 – 11 January 2020. Weather conditions were very hot and very dry, with only 71 mm of rainfall in the 6 months preceding. The average maximum daily temperature for the preceding 3 months was 35°C. Subsequent active searches and camera trapping was employed between 24th March and 3rd April 2020. A total of 254 mm of rainfall had fallen between the 11 January and 10 March 2020 and conditions for reptiles had improved markedly. However insufficient time had passed in order for population numbers to have recovered. Never-the-less the chances of finding threatened reptiles had increased for those individuals that had survived the drought. It is expected that reptile activity and diversity on the site will increase during improved seasonal conditions and as the offset habitats mature.

- 2021
    - BioCondition assessments within the Bottle Tree offset area in accordance with the BioCondition methodology (Eyre et al. 2015).
    - Targeted flora surveys and habitat assessments, including unbounded meander flora surveys were conducted in line with the timed meander survey methodology contained within the DEHP Flora Survey Guidelines (2016).
    - Targeted fauna surveys for the endangered and vulnerable species listed above to assess ongoing fauna species richness within the Bottle Tree offset area.

2.6 Ground-truthed vegetation and habitat mapping

Based on the results of detailed ecological field assessments ground-truthed vegetation within the offset area has been classified into four categories remnant, advanced regrowth, young regrowth and future offset commitment (Boobook 2015; Terrestria 2020).

- Remnant: woody vegetation that has not been cleared or vegetation that has been cleared but where the dominant canopy has greater than 70% of the height and greater than 50% of the cover relative to the undisturbed height and cover of that stratum and is dominated by species characteristic of the vegetation's undisturbed canopy (Neldner et al. 2012).
- Advanced regrowth: areas previously cleared or disturbed (e.g. by wildfire) and containing well advanced woody vegetation floristically and structurally consistent with the RE but typically <70% of the height and <50% density of the RE. Such regrowth with appropriate management will likely achieve remnant status (potentially <30 years).
- Young regrowth: areas previously cleared or disturbed (e.g. by wildfire) and containing varying densities of woody vegetation floristically consistent with the RE type. Such regrowth lacks structural elements typical of the RE but with appropriate management may eventually achieve remnant status (likely >30 years).
- Future Offset Commitment (future habitat): areas previously cleared or otherwise significantly disturbed which have little woody vegetation present and are currently unsuitable as biodiversity offsets. It is envisioned that as natural regeneration occurs within these areas native shrub and canopy layers will develop to the point where they can be designated as viable habitat offset areas.

The results of detailed field assessments were subsequently used to confirm the suitability of the mapped ground-truthed RE on the offset area to support habitat for the Project's MNES offset requirements also taking into account MNES habitat associations used as part of the GTP Adverse Impact Assessment Methodology (approved by the Commonwealth government on 16 July 2015) as well as the habitat mapping rules for the Santos GLNG Project area outlined in the *Predictive Habitat Mapping Rules for Selected MNES Fauna Species within the Roma, Fairview and Arcadia Gas Fields* report (Boobook 2020).

Known habitat requirements for each conservation significant species were assessed against on-ground microhabitat observations within each vegetation type of the offset area. The assessments were used to map the extent of habitat for MNES within the offset area defined as habitat containing potentially suitable vegetation and microhabitat features and/or that may currently be occupied by or utilised by the species on a seasonal/opportunistic basis.

2.6.1 Vegetation description

Table 4 provides a summary of the ground-truthed RE mapped on the Bottle Tree offset area.

The offset area is bookended by well-connected, good quality remnant vegetation, to the west by riparian woodlands associated with Brown's Creek and to the east by woodland and open forest of brigalow (*Acacia harpophylla*), Gum-top ironbark (*Eucalyptus decorticans*) and SEVT associated with the base of the Expedition Range escarpment. These communities are in relatively good condition and little impacted by ecosystem altering weeds. The contrasting substrates of the alluvial creek system and the rocky rudosols of the Expedition Range provide a broad range of habitat types that can potentially support a wide range of threatened flora and fauna species.

The middle of the offset area is dominated by relatively flat clay plains derived from fine-grained sandstones that support regenerating woodlands and open forest dominated by brigalow. These communities are regenerating on lands previously cleared for cattle grazing and consequently much of this land supports relatively young low canopies with low species diversity, lacking fallen woody material and supporting exotic pasture grasses within the ground layer. These communities are developing and will, over time, develop taller canopies with mature shrub layers that will shade out exotic pasture grasses and produce litter layers.

Non-remnant grassland across the offset area have been identified as future commitment offset areas. These areas are often dominated by introduced pasture grasses, including buffel grass. In the lower areas this habitat appears to be subject to regeneration with immature woodland shrubs and trees occurring in varying densities. With limited structural and floristic diversity, non-remnant grassland habitats support limited fauna diversity in comparison to the other habitats present. These areas were very dry at the time of survey providing very little feeding resources for granivores or herbivores. The potential for these areas to support threatened fauna species will increase over time as these areas will be managed to increase native flora diversity and reduce the prevalence of exotic pasture grasses.

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Table 4: Ground-truthed RE mapped within the Bottle Tree offset area

RE	Description	Type	Bottle Tree offset area (ha)			
			EPBC 2008/4059 offset area	EPBC 2008/4096 offset area	Surplus offset	Total Area
11.3.2	*Eucalyptus populnea* woodland on alluvial plains	Remnant	6.77	-	-	6.77
		Regrowth (advanced)	2.49	-	-	2.49
		Regrowth (young)	-	-	-	-
11.3.17	*Eucalyptus populnea* woodland with *Acacia harpophylla* and/or *Casuarina cristata* on alluvial plains	Regrowth (advanced)	17.89	-	-	17.89
		Regrowth (young)	-	121.43	-	121.43
11.3.25	*Eucalyptus tereticornis* or *E. camaldulensis* woodland fringing drainage lines	Remnant	54.36	-	-	54.36
		Regrowth (advanced)	0.90	-	-	0.90
		Regrowth (young)	-	2.74	-	2.74
11.3.27	Freshwater wetlands	Remnant	12.40	-	-	12.40
		Regrowth (young)	-	-	0.49	0.49
11.9.4	Semi-evergreen vine thicket or *Acacia harpophylla* with a semi-evergreen vine thicket understorey on fine-grained sedimentary rocks	Remnant	61.72	-	-	61.72
		Regrowth (advanced)	37.98	-	-	37.98
		Regrowth (young)	8.40	-	-	8.40

RE	Description	Type	Bottle Tree offset area (ha)			
			EPBC 2008/4059 offset area	EPBC 2008/4096 offset area	Surplus offset	Total Area
11.9.5	*Acacia harpophylla* and/or *Casuarina cristata* open forest on fine-grained sedimentary rocks	Remnant	2.60	-	-	2.60
		Regrowth (advanced)	154.33	-	-	154.33
		Regrowth (young)	271.85	1,017.14	182.93	1,471.91
11.9.5a		Remnant	79.89	-	-	79.89
		Regrowth (advanced)	7.82	-	-	7.82
		Regrowth (young)	-	2.33	-	2.33
11.10.3	*Acacia catenulata* or *A. shirleyi* open forest on coarse-grained sedimentary rocks. Crests and scarps	Remnant	0.22	-	-	0.22
11.10.4	*Eucalyptus decorticans, Lysicarpus angustifolius* +/- *Eucalyptus* spp., *Corymbia* spp., *Acacia* spp. woodland on coarse-grained sedimentary rocks	Remnant	205.10	-	-	205.10
11.10.7	*Eucalyptus crebra* woodland on coarse-grained sedimentary rocks	Remnant	3.01	-	-	3.01
-	Future habitat areas	Non-remnant	494.9	-	-	494.9
-	Non-remnant vegetation or existing infrastructure with no offset value	Non-remnant	-	-	-	18.8
	Total		**1,422.6**	**1,143.6**	**183.4**	**2,768.5**

2.6.2 Habitat description

Following the results of detailed field assessments known habitat requirements for each fauna species surveyed for were assessed against on-ground microhabitat observations within each habitat type to categorise the quality of habitat present into good quality habitat, lesser quality habitat and future habitat (Terrestria 2020). This assessment also considered the habitat mapping rules for the Santos GLNG Project area outlined in the *Predictive Habitat Mapping Rules for Selected MNES Fauna Species within the Roma, Fairview and Arcadia Gas Fields* report (Boobook 2020) and has been subsequently refined based on MNES habitat associations used as part of the GTP Adverse Impact Assessment Methodology (approved by the Commonwealth government on 16 July 2015).

- High quality habitat is defined as habitat containing sufficient suitable microhabitat features to be occupied or utilised by a threatened species. These habitat types are generally found within remnant vegetation and advanced regrowth.
- Moderate quality habitat is defined as habitat containing some areas of suitable microhabitat features that provide patches that threatened species could periodically occupy on a seasonal or opportunistic basis and is progressing toward good quality habitat. These areas are generally found within young regrowth.
- Future habitat includes those areas known to previously support habitat for threatened species and may potentially support threatened species in the future following appropriate management.

Table 5 provides a summary of the extent of suitable habitat available on the Bottle Tree offset area for the Project's MNES offset requirements based on the results of detailed field assessments and subsequent analysis based on habitat associations (Terrestria 2020). An additional description of the offset area for each MNES is provided in Section 3.0.

Table 5: Extent of suitable habitat available on the Bottle Tree offset area for MNES subject to EPBC 2008/4096

Species	Potentially Suitable REs	Habitat Mapping Rules	Moderate Quality Habitat (ha)*
Collared delma	11.3.2, 11.3.17, 11.9.4, 11.9.5, 11.9.5a, 11.10.3,11.10.4, 11.10.7	*High Quality Habitat* includes all areas of remnant and mature regrowth of all REs except wetlands and watercourses (RE 11.3.27 and RE 11.3.25). *Moderate Quality Habitat* includes all immature regrowth of suitable REs.	1,323.82
Yakka skink	11.3.2, 11.3.17, 11.9.5, 11.9.5a, 11.10.3, 11.10.4, 11.10.7	*High Quality Habitat* includes all remnant vegetation and mature regrowth except wetlands, watercourses and SEVT (RE 11.3.27, RE 11.3.25 and RE 11.9.4). *Moderate Quality Habitat* includes all immature regrowth of suitable REs.	1,323.82
Dunmall's snake	11.3.2, 11.3.17, 11.9.5, 11.9.5a, 11.10.3, 11.10.4, 11.10.7	*High Quality Habitat* includes all areas of remnant vegetation and mature regrowth that may be suitable for foraging or shelter except wetlands, watercourses and SEVT (RE 11.3.27, RE 11.3.25 and RE 11.9.4). *Moderate Quality Habitat* includes all immature regrowth of suitable REs.	1,323.82
Squatter pigeon	11.3.2, 11.3.25, 11.3.17, 11.9.5, 11.10.3, 11.10.4. 11.10.7	*High Quality Habitat* includes remnant and regrowth of the nominated REs and excludes wetland, grassland, and vine thicket REs. Moderate *Quality Habitat* includes all immature regrowth of suitable REs.	1,324.24
Large-eared pied bat	11.3.2, 11.3.17, 11.3.25, 11.3.27, 11.9.4, 11.9.5, 11.9.5a, 11.10.3, 11.10.4, 11.10.7	*High Quality Habitat* includes all areas of remnant vegetation and mature regrowth that are ≤5 km from potentially suitable shelter habitat. *Moderate Quality Habitat* includes all immature regrowth of suitable REs that are ≤5 km from potentially suitable shelter habitat.	678.44
South-eastern long-eared bat	11.3.2, 11.3.17, 11.3.25, 11.3.27, 11.9.4, 11.9.5, 11.9.5a, 11.10.3, 11.10.4, 11.10.7	*High Quality Habitat* includes all areas of remnant vegetation and mature regrowth that may be suitable for foraging or shelter of all Res. *Moderate Quality Habitat* includes all immature regrowth of suitable REs.	1,327.05
Ornamental snake	11.3.2, 11.3.17, 11.3.25, 11.3.27, 11.9.5, 11.9.5a	*High Quality Habitat* includes all low-lying areas with clay substrates and especially containing gilgais, depressions, swamps and watercourses/drainage features; this includes remnant and mature regrowth vegetation. *Moderate Quality Habitat* includes all immature regrowth of suitable REs.	1,327.05
Northern quoll	11.3.2, 11.3.17, 11.3.25, 11.3.27, 11.9.4, 11.9.5, 11.9.5a, 11.10.3, 11.10.4, 11.10.7	High Quality Habitat includes all remnant and mature regrowth vegetation within ≤5 km of potentially suitable den sites or (these are currently within the Expedition Range only). *Moderate Quality Habitat* includes all immature regrowth of suitable REs within ≤5 km of potentially suitable den sites.	678.44
Black-breasted button-quail	11.9.4, 11.9.5a	*High Quality Habitat* includes all remnant and mature regrowth RE 11.9.4 and 11.9.5a. *Moderate Quality Habitat* includes all immature regrowth of suitable Res.	2.33
Australian painted snipe	11.3.27	*High Quality Habitat* includes all remnant and regrowth wetlands RE 11.3.27.	0.49
Red goshawk	11.3.2, 11.3.17, 11.3.25, 11.3.27, 11.9.4, 11.9.5, 11.9.5a, 11.10.3, 11.10.4, 11.10.7	*High Quality Habitat* includes all woody vegetation (remnant, mature regrowth) This species may also forage within non-remnant vegetation. *Moderate Quality Habitat* includes all immature regrowth of suitable Res.	1,327.05
Australasian bittern	11.3.27	*High Quality Habitat* includes all remnant and regrowth wetlands RE 11.3.27.	0.49

* Note, only moderate quality habitat available to acquit offset requirements under EPBC 2008/4096 following acquittal of offsets requirements for EPBC 2008/4059.

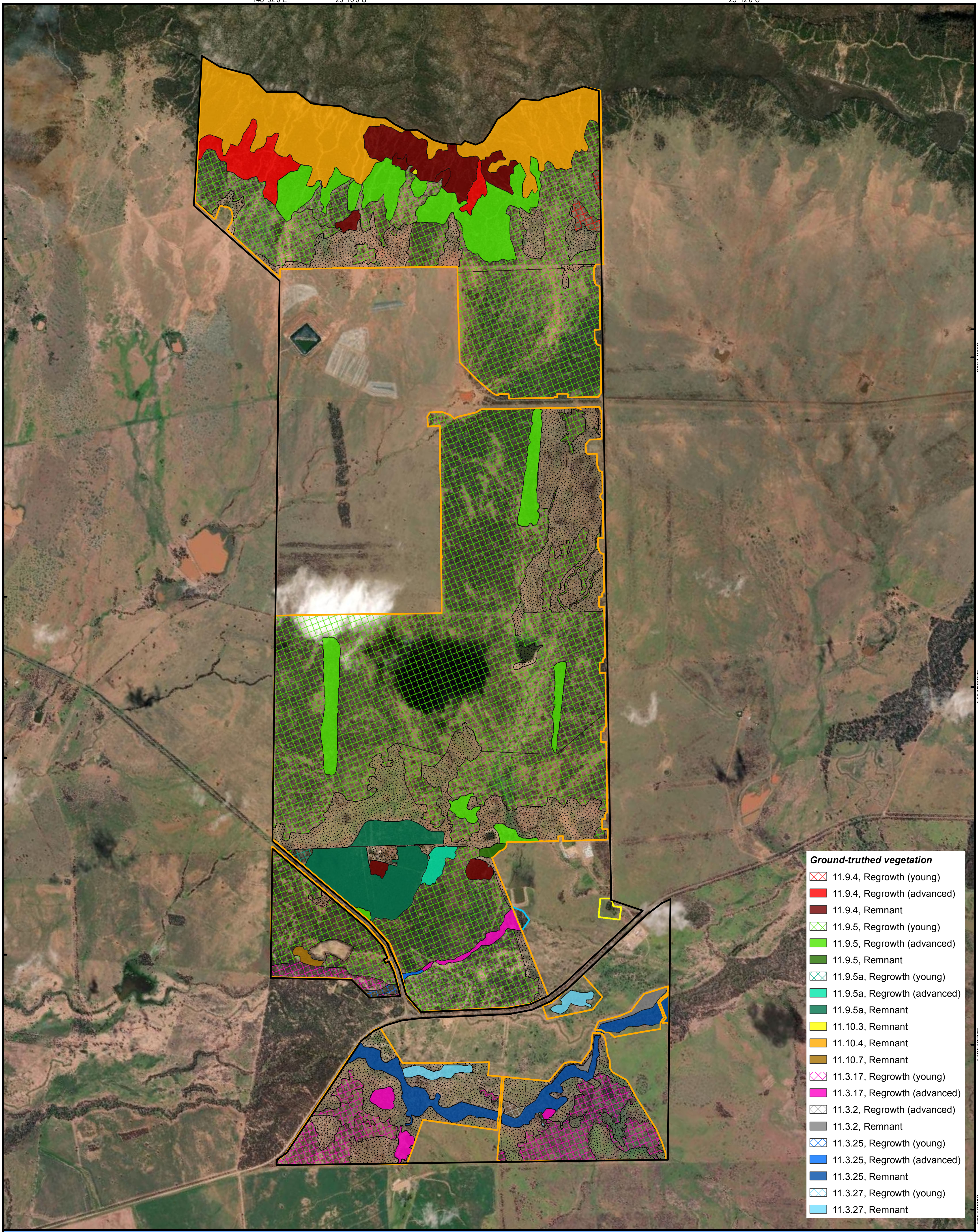

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Figure 4
Bottle Tree vegetation and offset area

Bottle Tree - 7TR39
Bottle Tree offset area
Future habitat areas

Existing offset area (EPBC 2008/4096)
Ooline (Cadelia pentasylis) offset area
Xerothamnella herbacea offset area

Location diagram

DATA SOURCE:
The following datasets are © State of Qld:
- Existing offset area (PMAV 2016/006243, PMAV 2018/004187)
Bottle Tree offset area provided by SANTOS

Date: 6/11/2021 Coordinate System: GDA 1994 MGA Zone 55 Projection: Transverse Mercator Datum: GDA 1994 Scale: 1:35,000@A3

0 0.5 1 1.5 2
Kilometres

CO2 Australia

Path: P:\GISData\Projects\Santos\ENV_20_00419 GTP_Offset_Maps\Bottle Tree\Figure 4 - Vegetation and offset area.mxd

2.7 Offset area

The offset area is 2,769 ha and located across most of the Bottle Tree property, as illustrated in Figure 4. The offset area includes:

- 1,143.6 ha to acquit offset requirements under EPBC 2008/4096 (conditions 15-22) and the GTP SSMP.
- 1,422.6 ha to acquit offset requirements under EPBC 2008/4059 (approved by DAWE 23 March 2021) including 494.9 ha of future habitat area that will support threatened species in the future following appropriate management as part of this OAMP (approved by DAWE 23 March 2021; however, was provided in addition to acquitting MNES offset obligations under EPBC 2008/4059 to support the overall conservation gain of the offset area).
- 183.4 ha of the remaining surplus offset value comprising moderate quality habitat for MNES and will be used by Santos to acquit future project offset requirements.
- 18.8 ha of non-remnant vegetation or existing infrastructure with no offset value. This area was included to maintain useful land management practices such as existing fence lines.

Table 6 provides a summary the Bottle Tree offset area including the offset area allocated to acquit the MNES offset requirements under EPBC 2008/4096, EPBC 2008/4059 and the remaining area of surplus offset values available within the Bottle Tree offset area. For MNES where a surplus is noted, Santos proposes to draw down on these to acquit future offset requirements under related approvals.

The results of the detailed field assessments including the ground-truthed RE mapping and fauna habitat associations discussed in Section 2.6, were used to inform the suitability and location of the offset area on the Bottle Tree property.

The quantum of offset area required to be secured for each MNES under EPBC 2008/4096 is based on the significant residual impacts and offset ratios specified in the approved GTP SSMP as well as Table 1 of this OAMP.

A baseline habitat quality score for each MNES offset value was determined generally in accordance with the GTDTHQ (version 1.2; DEHP 2017) based on the results of the detailed field assessments (Section 2.5). The baseline habitat quality score will be used as a measure to assess the success of the OAMP through the interim performance targets and completion criteria outlined in Section 4.0. A detailed summary of the baseline habitat quality scores for each MNES is provided in Appendix B.

Table 6: Summary of the Bottle Tree offset area and acquittal for EPBC 2008/4096

MNES	Disturbance area (ha)	Offset ratio	Offset area (ha)/number of species	Bottle Tree offset area approved under EPBC 2008/4059**		Bottle Tree offset area to be secured under EPBC 2008/4096		Surplus area remaining on Bottle Tree following acquittal of EPBC 2008/4059 and 2008/4096 (ha)
				Offset area to be secured (ha)	Available surplus area (ha)	Offset area to be secured (ha)	Offset requirement satisfied on Bottle Tree?	
Endangered ecological communities								
Brigalow (*Acacia harpophylla* dominant and co-dominant)	11.23	8	89.84	344.8	1,202.44	1,019.47	Yes	182.93
Semi-evergreen vine thickets of the Brigalow Belt (North and South) and Nandewar Bioregions	2.4	8	19.2	15.4	-	-	No	-
Endangered fauna species								
Australasian bittern (*Botaurus poiciloptilus*)	0.8	8	6.4	-	-	-	No	-
Northern quoll (*Dasyurus hallucatus*)	1.53	8	12.24	411.3	678.44*	678.44	Yes	-
Australian painted snipe (*Rostratula australis*)	4.79	8	38.32	-	-	-	No	-
Vulnerable fauna species								
Black-breasted button-quail (Turnix melanogaster)	2.61	8	20.88	12.0	2.33	2.33	Partially	-
Collared delma (*Delma torquata*)	86.22	8	689.76	579.8	1,323.82	1,140.89	Yes	182.93
Dunmall's snake (*Furina dunmalli*)	79.78	8	638.24	480.1	1,323.82	1,140.89	Yes	182.93
Fitzroy river turtle (*Rheodytes leukops*)	1.05	8	8.4	Offset obligation satisfied through approved nest protection program				
Large-eared pied bat (*Chalinolobus dwyeri*)	44.11	8	352.88	411.3	678.44*	686.84	Yes	-
Ornamental snake (*Denisonia maculata*)	25.46	8	203.68	19.0	1,327.05[#]	1,143.63	Yes	183.42
Red goshawk (*Erythrotriorchis radiatus*)	68.91	8	551.28	647.5	1,327.05	1,143.63	Yes	183.42
South-eastern long-eared bat (*Nyctophilus corb*eni)	142.91	8	1143.28	647.5	1,327.05	1,143.63	Yes	183.42
Squatter pigeon (Geophaps *scripta scripta*)	225.15	8	1801.2	290.7	1,324.24[#]	1,141.31	Partially	182.93
Water mouse (*Xeromys myoides*)	0.01	8	0.08	-	-	-	No	-
Yakka skink (*Egernia rugosa*)	63.11	8	504.88	480.1	1,323.82	1,140.89	Yes	182.93
Migratory birds								
Cattle egret (*Ardea ibis*)	1.67	8	13.36	-	-	-		-
Eastern osprey (*Pandion haliaetus*)	1.4	8	11.2	-	-	-		-
Great egret (*Ardea modesta*)	3.83	8	30.64	-	-	-	No	-
Rainbow bee-eater (*Merops ornatus*)	225.39	8	1803.12	-	-	-		-
White-bellied sea-eagle (*Haliaeetus leucogaster*)	25.09	8	200.72	-	-	-		-

MNES	Disturbance area (ha)	Offset ratio	Offset area (ha)/number of species	Bottle Tree offset area approved under EPBC 2008/4059**		Bottle Tree offset area to be secured under EPBC 2008/4096		Surplus area remaining on Bottle Tree following acquittal of EPBC 2008/4059 and 2008/4096 (ha)
				Offset area to be secured (ha)	Available surplus area (ha)	Offset area to be secured (ha)	Offset requirement satisfied on Bottle Tree?	
Migratory woodland bird species								
Black-faced monarch (*Monarcha melanopsis*) Spectacled monarch (*Monarcha trivirgatus*) Satin flycatcher (*Myiagra cyanoleuca*) Rufous fantail (*Rhipidura rufifrons*) Oriental cuckoo (*Cuculus saturatus*)	14.68	8	117.44	-	-	-	No	-
Migratory marine bird species								
Bar-tailed godwit (*Limosa lapponica*)	0.8	8	6.4	-	-	-	No	-
Black-tailed godwit (*Limosa limosa*)	0.8	8	6.4	-	-	-		-
Broad-billed sandpiper (*Limicola falcinellus*)	0.8	8	6.4	-	-	-		-
Common greenshank (*Tringa nebularia*)	0.8	8	6.4	-	-	-		-
Common sandpiper (*Actitis hypoleucos*)	0.8	8	6.4	-	-	-		-
Curlew sandpiper (*Calidris ferruginea*)	0.8	8	6.4	-	-	-		-
Double-banded plover (*Charadrius bicinctus*)	0.8	8	6.4	-	-	-		-
Eastern reef egret (*Egretta sacra*)	0.8	8	6.4	-	-	-		-
Far eastern curlew (*Numenius madagascariensis*)	0.8	8	6.4	-	-	-		-
Great knot (*Calidris tenuirostris*)	0.8	8	6.4	-	-	-		-
Greater sand plover (*Charadrius leschenaultii*)	0.8	8	6.4	-	-	-		-
Grey plover (*Pluvialis squatarola*)	0.8	8	6.4	-	-	-		-
Grey-tailed tattler (*Tringa brevipes*)	0.8	8	6.4	-	-	-		-
Latham's snipe (*Gallinago hardwickii*)	0.8	8	6.4	-	-	-		-
Lesser sand plover (*Charadrius mongolus*)	0.8	8	6.4	-	-	-		-
Little curlew (*Numenius minutus*)	0.8	8	6.4	-	-	-		-
Marsh sandpiper (*Tringa stagnatilis*)	0.8	8	6.4	-	-	-		-
Pacific golden plover (*Pluvialis fulva*)	0.8	8	6.4	-	-	-		-
Red knot (*Calidris canutus*)	0.8	8	6.4	-	-	-		-

MNES	Disturbance area (ha)	Offset ratio	Offset area (ha)/number of species	Bottle Tree offset area approved under EPBC 2008/4059**		Bottle Tree offset area to be secured under EPBC 2008/4096		Surplus area remaining on Bottle Tree following acquittal of EPBC 2008/4059 and 2008/4096 (ha)
				Offset area to be secured (ha)	Available surplus area (ha)	Offset area to be secured (ha)	Offset requirement satisfied on Bottle Tree?	
Red-necked stint (*Calidris ruficollis*)	0.8	8	6.4	-	-	-		-
Ruddy turnstone (*Arenaria interpres*)	0.8	8	6.4	-	-	-		-
Sanderling (*Calidris alba*)	0.8	8	6.4	-	-	-		-
Sharp-tailed sandpiper (*Calidris acuminata*)	0.8	8	6.4	-	-	-		-
Terek sandpiper (*Xenus cinereus*)	0.8	8	6.4	-	-	-		-
Whimbrel (*Numenius phaeopus*)	0.8	8	6.4	-	-	-		-
Migratory tern bird species								
Caspian tern (*Sterna caspia*)	0.05	8	0.4	-	-	-	No	-
Little tern (*Sternula albifrons*)	0.05	8	0.4	-	-	-		-
Endangered flora species								
Ooline (*Cadelia pentasyli*)	36 individuals	6:1	216	Existing 4.5 ha offset area legally secured on Bottle Tree property				
Xerothamnella herbacea	42 individuals	6:1	252	Existing 2.4 ha offset area legally secured on Bottle Tree property				
Philotheca sporadica	0	6:1	0	-	-	-	-	-
Large-fruited zamia (*Cycas megacarpa*)	1,100 individuals	No ratio	3,990[a]	See approved GLNG Gas Transmission Pipeline *Cycas megacarpa* Translocation and Management Plan (3380-GLNG-4-1.3-0013).				

* Note this figure has been amended from the approved Santos GLNG Offset Plan and Acquittal Summary (Document Number: 0007-650-EMP-0009) to account for total area of surplus available.

Surplus area available takes into account MNES habitat associations used as part of the GTP Adverse Impact Assessment Methodology (approved by the Commonwealth government on 16 July 2015).

**Plus an additional 494.9 ha of future habitat area has been committed to in addition to offset obligations under EPBC 2008/4059.

2.8 Development

Santos has comitted to excluding any development for the Project from the Bottle Tree offset area.

The areas on the Bottle Tree property outside of the offset area may be utilised for petroleum and/or farming infrastructure and facilities; however, no infrastructure will be located within the offset area or impact the offset area's ability to achieve the completion criteria outlined in this OAMP.

Prior to being acquired by Santos, the Bottle Tree property was formerly utilised for grazing purposes. The following ancillary infrastructure is still present on the property and will be maintained ongoing without impact to the offset area:

- Cattle Yards; and
- Bottle Tree house and workshop.

2.9 Offset protection

The 2,769 ha Bottle Tree offset area (including surplus areas identified in Table 6) will be protected via a Voluntary Declaration under section 19E and 19F of the VM Act and will be declared as an area of high nature conservation value. Santos will apply for the offset area to be secured under a Voluntary Declaration by 23 March 2022. The Voluntary Declaration will be registered on the property title and will be binding on current and future landowners.

A Voluntary Declaration under the VM Act is an authorised legally binding mechanism and is considered appropriate to legally secure MNES values and protect the area from vegetation clearing. The offset area will be mapped as a Category A area on the Property Map of Assessable Vegetation (PMAV). A Category A area on a PMAV is described as an "Area subject to compliance notices, offsets and voluntary declarations".

The Voluntary Declaration will remain in place for the life of EPBC 2008/4059 and 2008/4096. The Voluntary Declaration may only be removed in accordance with the provisions of the VM Act or if the chief executive the Queensland Department of Natural Resources, Mines and Energy considers it necessary.

Offset area coordinates for the proposed declared area for the Voluntary Declaration are given in Appendix C.

In addition, once areas of regrowth vegetation on the Bottle Tree property have reached the requirements to achieve remnant status Santos will apply to these areas reclassified as remnant vegetation in accordance with the relevant Queensland legislation. Santos will notify the Commonwealth Government within 30 business days of the reclassification occurring.

2.10 EPBC Act Environmental Offset Policy

Table 7 outlines how the GLNG Project offset obligations acquit on the Bottle Tree offset area meet the requirements of the EPBC Act Environmental Offsets Policy.

Santos

Table 7: Assessment against Principles of the Offset Policy

Principle	How the principle is met in this offset proposal
1. deliver an overall conservation outcome that improves or maintains the viability of the aspect of the environment that is protected by national environment law and affected by the proposed action	The Bottle Tree offset area partially acquits MNES offset requirements under EPBC 2008/4096 as outlined in Table 6. The remaining will be acquit elsewhere. The Bottle Tree offset area will be managed and monitored to improve the quality of Brigalow TEC, SEVT TEC and viability of habitat for threatened fauna species. This will include the management of regrowth vegetation to become self-sustaining functional remnant vegetation communities. This OAMP sets out specific management objectives with interim performance targets and completion criteria. Management actions are outlined with accompanying adaptive management triggers and corrective actions in the event that monitoring identifies that interim performance targets are not attained or completion criteria are not attained and/or maintained. The offset area will be managed and monitored from approval of the OAMP for a minimum of 20 years. It is anticipated that the completion criteria will be achieved within a 20 year period.
2. be built around direct offsets but may include other compensatory measures	MNES offset obligations under EPBC 2008/4096 (conditions 15-22) and the GTP SSMP will be acquit through the delivery of direct land-based offsets on the Bottle Tree offset area and additional land based offset areas to be secured by Santos.
3. be in proportion to the level of statutory protection that applies to the protected matter 4. be of a size and scale proportionate to the residual impacts on the protected matter	At the time of the Project's approval under the EPBC Act the magnitude of an offset package and specific offset ratios to compensate for the impacts of development were determined on a case by case basis with consideration of the principles discussed in the EPBC Act draft Environmental Offsets Policy 2007 and the Queensland Government offset policies in place at the time (see Table 1). The Commonwealth government has since introduced the EPBC Act Environmental Offsets Policy (DSEWPaC 2012) which outlines the government's requirements for the provision of environmental offsets under the EPBC Act to compensate for residual adverse impacts on MNES. On the 16 July 2015, the Commonwealth Government accepted Santos' approach to determining significant residual, adverse impacts to MNES which is consistent with the EPBC Act Environmental Offsets Policy. The approved GTP SSMP details the proposed impacts on MNES subject to EPBC 2008/4096 required to be offset including the offset ratios used to determine the quantum of the proposed offset areas.
5. effectively account for and manage the risks of the offset not succeeding	This OAMP has been developed in consideration of known and identified threats to the offset values to manage the risk of failing to the achieve the completion criteria and overall environmental outcomes for the offset area. Threats to the offset site are managed by through the implementation of the management measures discussed in Section 6.0, including: • Fire prevention and management • Weed monitoring and control • Clearing protection • Management of grazing • Restricted access

Principle	How the principle is met in this offset proposal
	The relevant risks were identified based on a review of current literature (i.e. conservation advices, recovery plans etc) and identification of potential site-specific risks based on the results of field surveys and discussions with the landholder. The results of the risk assessment, presented in Appendix D, have informed the adaptive management process including the identification of threats to offset values, management objectives, performance criteria, management actions, monitoring programs, adaptive management triggers and corrective actions. If the offset cannot attain and maintain the completion criteria then additional offsets will be provided to compensate for the impact and the failed offset (see Section 5.2.4).
6. be additional to what is already required, determined by law or planning regulations or agreed to under other schemes or programs (this does not preclude the recognition of state or territory offsets that may be suitable as offsets under the EPBC Act for the same action)	The environmental outcomes proposed to be achieved through the implementation of this OAMP are based on additional management and monitoring measures conducted as part of business as usual on the Bottle Tree property. For example under the *Biosecurity Act 2014* a person has a general biosecurity obligation to: take all reasonable and practical steps to prevent or minimise each biosecurity risk. The steps proposed in this OAMP are above reasonable and practical steps required to control feral animals and weeds in central Queensland. Once the Voluntary Declaration has been secured over the offset area, environmental laws prevent other land uses inconsistent with this OAMP being approved over this part of the property.
7. be efficient, effective, timely, transparent, scientifically robust and reasonable	The Bottle Tree offset area has been identified to be suitable using an evidence based and scientifically robust approach. The environmental outcomes to be achieved through this OAMP will be delivered progressively over 20 years. The offset area will be legally secured through a Voluntary Declaration under the VM Act, therefore any vegetation clearing contravention of this OAMP is not permissible without specific Queensland government approval. The preparation and implementation of this OAMP supports the efficient, effective, timely, transparent and scientifically robust approach to providing offsets.
8. have transparent governance arrangements including being able to be readily measured, monitored, audited and enforced.	This OAMP includes a detailed monitoring program which will assess the effectiveness of the management actions undertaken and the progress of the offset area in achieving the environmental outcomes. The results of all management and monitoring programs will be included in annual reports (Section 8.0). An implementation schedule for monitoring and management is provided in Section 9.0 which will be reviewed at least annually to ensure the timely implementation of this OAMP.

3.0 Offset values

The following sections provide a description of the offset area and potential threats that will be managed as part of this OAMP for each MNES offset value. Figure 5 and Figure 6 presents the MNES offset areas on Bottle Tree.

3.1 Brigalow TEC

3.1.1 Offset area

Brigalow TEC within the offset area comprises areas of remnant and mature regrowth RE 11.9.5 and 11.9.5a.

Extensive tracts of Brigalow-dominated open forest occur across most of the centre of the offset area. Significant patches of mature brigalow occur within the central north of the offset area with some significant patches of brigalow with bottle trees and SEVT. Areas of remnant and mature regrowth are in relatively good condition and meet the requirements for Brigalow TEC (as listed under the EPBC Act). Canopy cover is relatively closed, weed cover is negligible and abundant fallen timber is generally present. There are scattered shrubs, often of SEVT species. This habitat provides suitable foraging values for a variety of forest bird species that prefer a closed canopy. There is abundant shelter for ground fauna (particularly reptiles) in the form of fallen logs and low shrubs. Peeling bark is common in this habitat providing refuge for arboreal reptiles. The balance of brigalow communities across much of the centre of the offset area are characterised by immature brigalow regrowth. These communities have low disjunct canopies ranging from dense to very sparse, little to no shrub layer development and ground layers devoid of fallen woody material and litter being dominated by exotic grasses and bare earth. These areas currently provide little in the way of habitat for threatened species, with the possible exception of the ornamental snake in areas of cracking clays and gilgais and yakka skink where concentrated patches of fallen woody material may provide sufficient habitat for a colony to persist. The mature regrowth patches offer increased habitat values in comparison to the immature regrowth areas (Terrestria 2020).

3.1.2 Threats

The following key threats to Brigalow TEC identified on the property will be addressed through the implementation of this OAMP (DAWE 2020a):

- clearing of regrowth vegetation
- inappropriate fire regimes and management
- pest plant infestation
- potential knowledge gaps
- increased grazing by livestock.

3.2 SEVT TEC

3.2.1 Offset area

The SEVT TEC within the offset area comprises areas of remnant and mature regrowth RE 11.9.4.

RE 11.9.4 is generally restricted to the foot slopes of Expedition range escarpment in the east of the offset area. These areas include the presence of large rocks with extensive areas of rocky crevice habitat. The canopy is relatively low and tended to be sparse in some areas. The shrub and ground layer is patchy but dense in some areas. Where a suitable shrub/low tree layer occurs there is a thick leaf litter layer. Fallen timber is generally abundant. This habitat provides significant value in the form of potential shelter sites for several target threatened species including northern quoll, large-eared pied bat and collared delma and yakka skink (Terrestria 2020).

A number of larger fauna on the site will use this habitat as daytime shelter areas including a range of macropods such as Herbert's rock-wallaby and wallaroo (*Macropus robustus*). This habitat also provides suitable foraging values for a variety of smaller forest bird species that prefer a closed canopy and dense low vegetation such as white-browed scrubwren, fantails and fairywrens. Fan-tailed cuckoo (*Cacomantis flabelliformis*) and eastern yellow robin were only recorded in this habitat. There is abundant shelter for ground fauna (particularly reptiles) in the form of rock crevices and low shrubs, particularly reptiles but also small mammals such as dasyurids and rodents (Terrestria 2020).

3.2.2 Threats

The following key threats to SEVT TEC identified on the property will addressed through the implementation of this OAMP (DAWE 2020b):

- clearing of regrowth vegetation
- inappropriate fire regimes
- invasion by introduced pasture species
- increased grazing by livestock
- disturbance by pest animals.

3.3 Australian painted snipe & Australasian bittern

3.3.1 Offset area

Habitat for Australian painted snipe and Australasian bittern within the offset area comprises areas of remnant and regrowth RE 11.3.27.

The large areas of semipermanent palustrine wetland areas associated with the alluvial plains flanking Brown's creek provide suitable habitat for both the Australasian bittern and Australian painted snipe, in particular RE 11.3.27. These communities are fringed by large mature eucalypts and are characterized by large swaths of spike rush beds and open water. Both species are able to forage and nest around ephemeral and permanent wetlands. Grazing within these areas will be minimised to the extent needed to reduce fuel load only. In time, it is planned that maturing native vegetation will shade out exotic pasture grasses and fuel load reduction grazing of this area will no longer be needed. The primary threat for these species is the loss and alteration of wetland habitat, therefore the active management of the riparian area on Bottle Tree is considered to represent the best way of enhancing the general habitat for both species.

3.3.2 Threats

The following key threats to Australian painted snipe and Australasian bittern identified on the property will addressed through the implementation of this OAMP (DAWE 2020c; DAWE 2020d):

- degradation of wetland habitat
- grazing and associated trampling of habitat
- weed incursion into habitat.

3.4 Northern quoll

3.4.1 Offset area

Habitat for northern quoll within the offset area comprises areas of RE 11.3.2, 11.3.17, 11.3.25, 11.3.27, 11.9.4, 11.9.5, 11.9.5a, 11.10.3, 11.10.4, 11.10.7.

High quality habitat for the species is generally located in the eastern section of the offset area within ≤5 km of potentially suitable den sites which are currently within the Expedition Range only. This species is dependent on the presence of suitable shelter habitat in the form of caves and deep crevices in extensive rock formations (commonly sandstone) and forages in associated woodland and forest habitat (DAWE 2020e). The foot slopes of the Expedition range escarpment include areas of large rocks with extensive areas of rocky crevice habitat. Patches of Brigalow TEC and SEVT TEC along the escarpments provides significant value in the form of potential den and shelter habitat suitable den sites (these are currently within the Expedition Range only). The base of the Expedition range escarpment is connected to remnant woodlands along the eastern boundary of the offset area providing important connectivity to den, shelter and foraging habitat for northern quoll.

The offset area is located within the species historical range, although recent records for the species are lacking (DAWE 2020e).

3.4.2 Threats

The following key threats to northern quoll were identified on the property will addressed through the implementation of this OAMP (DAWE 2020e):

inappropriate fire regimes

- overgrazing by stock
- predation by feral species
- weed invasion.

3.5 Black-breasted button-quail

3.5.1 Offset area

Habitat for black-breasted button quail within the offset area comprises RE 11.9.4 and 11.9.5a.

SEVT (RE 11.9.4) and Brigalow (RE 11.9.5a) communities along the base of Expedition range escarpment provide suitable habitat for black-breasted button-quail, known to support the species in the Brigalow Belt South bioregion (DAWE 2020f). Black-breasted button-quail is known to prefer SEVT communities and other closed forest types with dense leaf litter and low shrubs (DAWE 2020f). Within areas of SEVT vegetation where a suitable shrub/low tree layer occurs there is a thick leaf litter layer. Within areas of remnant Brigalow vegetation areas of scattered shrubs are present, often of SEVT species. The managed recovery of regrowth vegetation (particularly SEVT) to remnant status over time is considered one of the best ways to provide habitat for this species. Areas of remnant and advanced and young regrowth 11.9.4 and 11.9.5a which are currently distant from the Expedition Range; however, also considered to provide suitable habitat for the species.

The closest records to the property are at Palmgrove National Park to the north of the Expedition Range to which the offset area is connected. The continuity of the SEVT habitats with the larger habitats of the Expedition range present an opportunity for the presence of black-breasted button-quail.

3.5.2 Threats

The following key threats to black-breasted button-quail were identified on the property will addressed through the implementation of this OAMP (DAWE 2020f):

- habitat loss through clearing
- habitat degradation by overgrazing by stock and pest animals (e.g. feral pigs)
- fire regimes that remove understorey, course woody debris and ground litter.

3.6 Collared delma

3.6.1 Offset area

Habitat for collared delma within the offset area comprises areas of RE 11.3.2, 11.3.17, 11.9.4, 11.9.5, 11.9.5a, 11.10.3,11.10.4, and 11.10.7

Collared delma is known to occur in REs on land zones 3, 9 and 10 including 11.3.2, 11.9.10, 11.10.1 and 11.10.4 all of which identified in the offset area (DAWE 2020h). The species appears to require rocks, timber, bark or other surface debris for shelter (DAWE 2020h). Riparian vegetation communities flanking Brown’s creek were confirmed to be in good condition including the presence of fallen woody material and leaf litter providing suitable foraging and shelter habitat for the species. The patches of Brigalow and SEVT understorey along the escarpments also provides significant value in the form of potential shelter sites including areas comparing abundant fallen timber and thick leaf litter layer in addition to presence of large rocks and extensive rock crevice habitat.

3.6.2 Threats

The following key threats to collared delma were identified on the property will addressed through the implementation of this OAMP (Boobook 2015):

- habitat loss through clearing

- habitat degradation by overgrazing by stock
- fire regimes that remove course woody debris and ground litter.

3.7 Dunmall's snake

3.7.1 Offset area

Habitat for Dunmall's snake within the offset area comprises RE 11.3.2, 11.3.17, 11.9.5, 11.9.5a, 11.10.3, 11.10.4, and 11.10.7.

The species occurs in a variety of habitats including forests to woodlands (including *Eucalyptus*, *Acacia Callitris* spp.) on sandy soils, cracking clay soils with Brigalow scrub, and dry vine scrub (Terrestria 2020). Areas of remnant and mature regrowth REs on land zones 3, 9 and 10 are considered suitable foraging and shelter. Areas comprising abundant fallen timber, large rocks and extensive rock crevice habitat are located along the riparian vegetation communities flanking Brown's creek, and patches of Brigalow understorey along the Expedition range escarpment. These areas are all considered to provide significant foraging and shelter habitat for Dunmall's snake.

3.7.2 Threats

The following known and potential threats to Dunmall's snake will addressed through the implementation of this OAMP (Boobook 2015):

- habitat loss through clearing
- habitat degradation by overgrazing by stock.
- fire regimes that remove course woody debris and ground litter.

3.8 Large-eared pied bat

3.8.1 Offset area

Habitat for large eared pied bat within the offset area comprise RE 11.3.2, 11.3.17, 11.3.25, 11.3.27, 11.9.4, 11.9.5, 11.9.5a, 11.10.3, 11.10.4, 11.10.7.

Large-eared pied bat was recorded by Anabat close to the base of the Expedition range which is a known strong hold for the species. The species is likely to be primarily utilising suitable roosting and shelter sites on the larger rocky outcrops along the eastern margin of the offset area and adjoining lands. Suitable foraging habitat for the species occurs across much of the offset area within areas of adjacent remnant and mature regrowth vegetation. The species requires a combination of sandstone cliffs/escarpments to provide roosting habitat that is adjacent to fertile woodlands preferably box gum or river/rainforest corridors for foraging (Threatened Species Scientific Committee [TSSC] 2012).

3.8.2 Threats

The following known and potential threats to large eared pied bat will be addressed through the implementation of this OAMP (Boobook 2015):

- damage to and abandonment of nursery sites and roosting hollows,
- clearing of habitat
- predation by foxes.

3.9 Ornamental snake

3.9.1 Offset area

Habitat for ornamental snake within the offset area comprises RE 11.3.2, 11.3.17, 11.3.25, 11.3.27, 11.9.5 and 11.9.5a[1].

Ornamental snake is known to occur in woodland and grassland with cracking clay soils, usually in close proximity to at least seasonally wet areas e.g. billabongs, gilgais, floodplains, riparian corridors. The species shelters in logs and under coarse woody debris, ground litter and soil cracks (DAWE 2020i).

Suitable habitat for the species has been identified within all low-lying areas with clay substrates and especially containing gilgais, depressions, swamps and watercourses/drainage features; including areas comprising non-remnant vegetation mapped as RE 11.3.2, 11.3.17, 11.3.25, 11.3.27. The offset area is within the known distribution of the species (DAWE 2020i); however, on the southern extent of its expected range.

3.9.2 Threats

The following known and potential threats to ornamental snake will be addressed through the implementation of this OAMP (Boobook 2015):

- habitat loss through clearing
- overgrazing by stock
- predation by feral species.

3.10 Red goshawk

3.10.1 Offset area

Habitat for red goshawk within the offset area comprise RE 11.3.2, 11.3.17, 11.3.25, 11.3.27, 11.9.4, 11.9.5, 11.9.5a ,11.10.4, 11.10.3 and 11.10.7.

Suitable habitat for red goshawk includes vegetation along and adjacent to the steep cliffs of the Expedition range combined with tall open forests of Brown’s Creek and tall ironbark woodlands at the base of the escarpment. Red goshawk is a highly mobile species with a large home range. Breeding habitat is in intact tall forest associated with major drainage lines; however, the species may often forage much further away from these areas (DAWE 2020g).

3.10.2 Threats

The following known and potential threats to ornamental snake will be addressed through the implementation of this OAMP (Boobook 2015; DAWE 2020g):

- habitat loss through clearing
- overgrazing, or other changes in land management could reduce prey availability
- fire, and changed burning regimes have the potential to impact breeding sites and reduce prey availability.

[1] RE 11.9.5 and 11.9.5a are included as part of the habitat associations for ornamental snake used as part of the GTP Adverse Impact Assessment Methodology (approved by the Commonwealth government on 16 July 2015). This included impact areas associated with the GTP on the Bottle Tree property.

3.11 Squatter pigeon

3.11.1 Offset area

Habitat for squatter pigeon within the offset area comprises *Eucalyptus populnea* woodland on alluvial plains (RE 11.3.2) and *Eucalyptus tereticornis* or *E. camaldulensis* woodland fringing drainage lines (RE 11.3.25). Other RE considered to provide suitable habitat for the species include RE 11.3.17, 11.10.3, 11.10.4, 11.10.7 and 11.9.5[2]. The squatter pigeon favours open-forests to sparse, open-woodlands and scrub that are close to water bodies or watercourses. Permanent water associated with the large permanent dam provides habitat opportunities for this species. In better conditions Browns Creek would also provide a reliable source of water. Much of the site offers habitat for this species and this species has been recorded nearby in the Arcadia Valley (Terrestria 2020). This species may potentially forage elsewhere on the property; however, grassy woodlands with ground layer dominated by native grasses and in close proximity to water are confined to the western end of the offset area.

3.11.2 Threats

The following key threats to squatter pigeon will be addressed through the implementation of this OAMP (TSSC 2015a):

- ongoing vegetation clearance and fragmentation
- degradation of habitat by overgrazing livestock
- trampling of nests by livestock
- weed invasion
- habitat degradation by rabbits
- predation by feral cats and foxes
- inappropriate fire regimes
- thickening of understorey vegetation.

3.12 Yakka skink

3.12.1 Offset area

Habitat for yakka skink within the Bottle Tree offset area consists of REs 11.3.2, 11.3.17, 11.9.5, 11.9.5a, 11.10.3, 11.10.4, 11.10.7 and extends across the majority of the property where Brigalow and Belah woodland and scrub vegetation is present.

The species is commonly found under partly buried rocks and logs or in abandoned animal burrows. The large well-connected expanses of remnant and mature regrowth vegetation along Brown's Creek and at the base of the Expedition Range provide good habitat. Older growth communities contain good structure in the form of developed shrub and ground layers and fallen timber and deep leaf litter. Fallen timber is abundant along Brown's Creek and fallen timber and rock crevices are abundant along the base of the expedition range, providing potential shelter (Terrestria 2020).

[2] RE 11.9.5 included in the habitat associations for squatter pigeon used as part of the GTP Adverse Impact Assessment Methodology (approved by the Commonwealth government on 16 July 2015). This included impact areas associated with the GTP on the Bottle Tree property.

Discrete patches of Gum-top ironbark (*Eucalyptus decorticans*) woodland occur on the lower slopes of the Expedition range escarpment in the west of the offset area. These communities are in relatively good condition with large individual canopy trees with small hollows and some exfoliating bark (Terrestria 2020). Fallen woody material is common in this community and large boulders providing potential shelter opportunities.

3.12.2 Threats

The following key threats to yakka skink will be addressed through the implementation of this OAMP (DAWE 2020j):

- clearing of habitat
- overgrazing of habitat by livestock
- loss of fallen timber and ground litter through inappropriate fire regimes
- invasion of habitat by predatory animals and introduced weeds.

3.13 South-eastern long-eared bat

3.13.1 Offset area

Habitat on the Bottle Tree offset area for south-eastern long-eared bat includes RE 11.3.2, 11.3.17, 11.3.25, 11.3.27, 11.9.4, 11.9.5, 11.9.5a, 11.10.3, 11.10.4, 11.10.7.

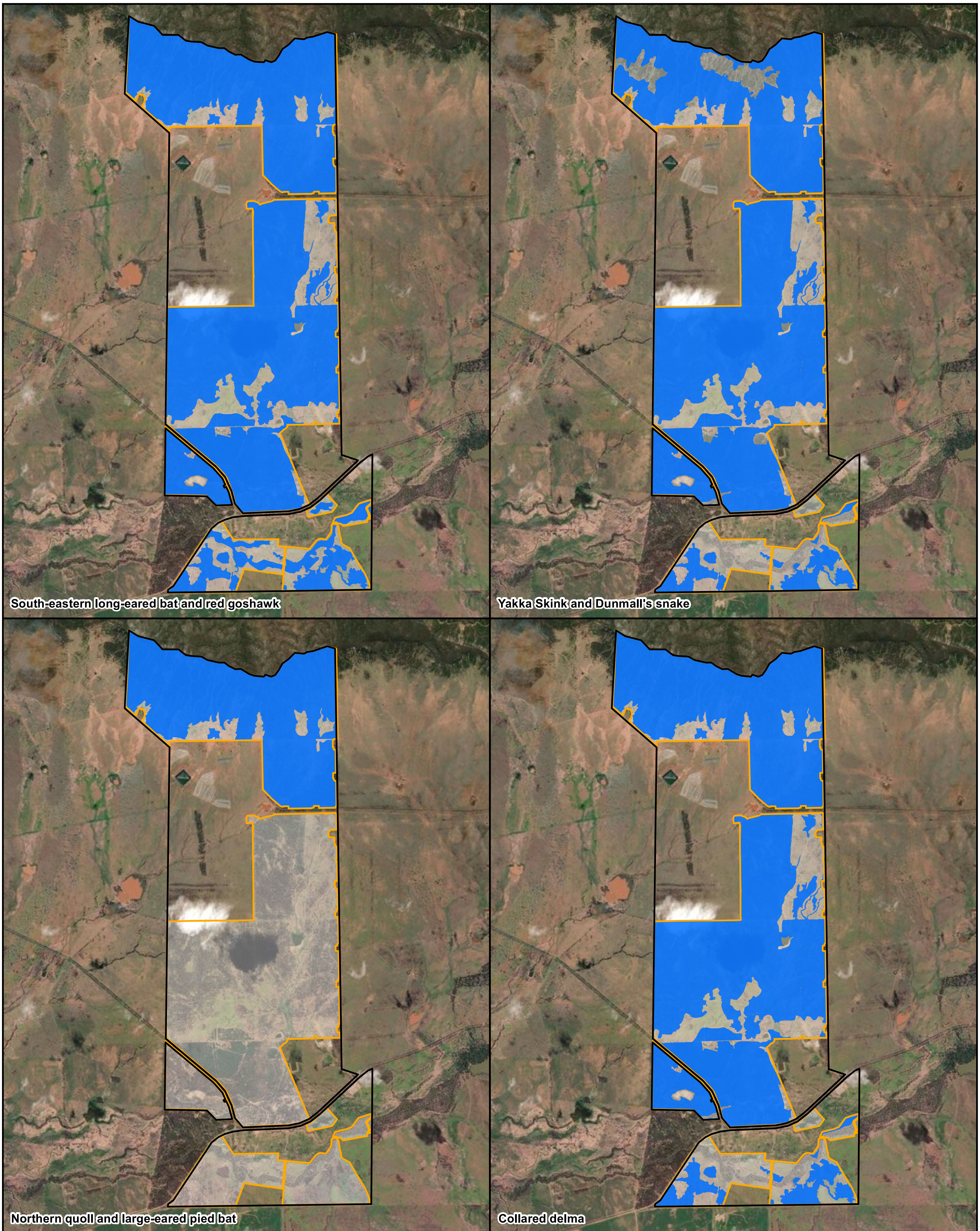
The species is known to occur in a variety of dry forest habitats including River Red Gum, open woodland, mallee, Brigalow and other arid and semi-arid habitats. The preferred habitat is mallee and *Callitris* woodlands (Pennay et al. 2011), and habitats that have a distinct canopy with a dense, cluttered understorey (Turbill and Ellis 2006). It roosts in tree hollows or under bark (NSW NPWS 2003). Surveys suggest the species requires large tracts of forest to occur (Turbill et al. 2008).

The majority of the offset area is considered to provide suitable foraging habitat comprising habitat with a patchy lower storey including *Callitris*. In eastern portion of the offset area comprises large well connect expanses of remnant and mature regrowth vegetation along Brown's creek and at the base of Expedition Range. Older growth communities contain good structure in the form of developed shrub and ground layers and fallen timber and deep leaf litter. Rock crevices and caves along the base and edge of the escarpment also provide roosting habitat for south-eastern long-eared bat. The Bottle Tree offset area is located adjacent to extended tracts of woodlands associated with the Expedition Range (Terrestria 2020).

3.13.2 Threats

The following key threats to south eastern long eared bat will be addressed through the implementation of this OAMP (TSSC 2015b):

- Habitat loss and fragmentation due to clearing of vegetation
- Habitat loss and mortality through inappropriate fire regimes
- Reduction in hollow availability
- overgrazing of habitat by livestock
- invasion of habitat by predatory animals.



SANTOS

Figure 5
Bottle Tree MNES offset areas habitat - 1

Bottle Tree - 7TR39
Bottle Tree offset area
MNES offset habitat

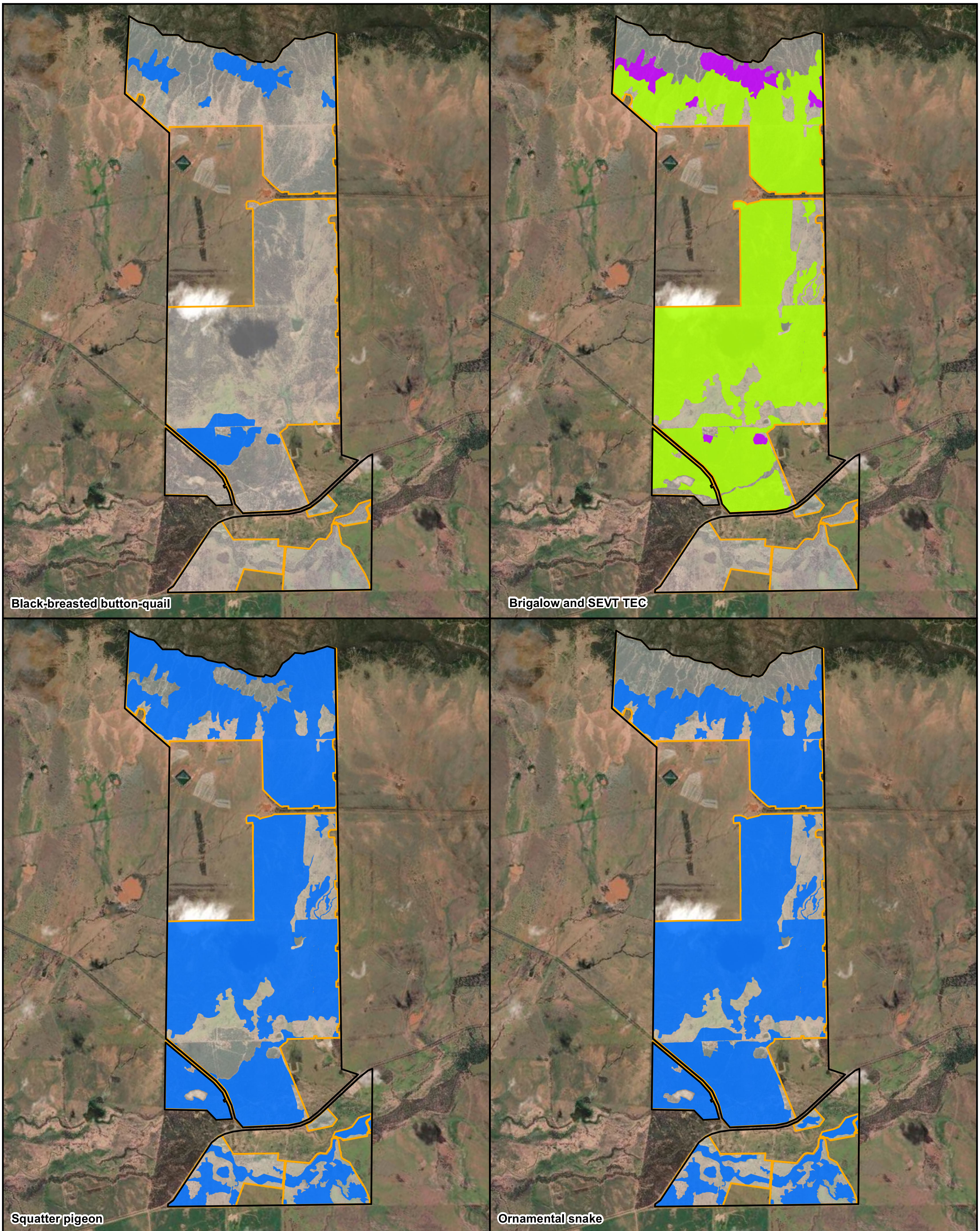
DATA SOURCE:
The following datasets are © State of Qld:
- Cadastral data
Bottle Tree offset area provided by SANTOS

Date: 6/11/2021 Coordinate System: GDA 1994 MGA Zone 55 Projection: Transverse Mercator Datum: GDA 1994 Scale: 1:67,500@A3

0 0.5 1 1.5 2
Kilometres

CO2 Australia

Location diagram



SANTOS

Figure 6
Bottle Tree MNES offset areas habitat - 2

- Bottle Tree - 7TR39
- Bottle Tree offset area
- MNES offset habitat
- SEVT TEC
- Brigalow TEC

DATA SOURCE:
The following datasets are © State of Qld:
- Cadastral data
Bottle Tree offset area provided by SANTOS

Date: 6/11/2021 Coordinate System: GDA 1994 MGA Zone 55 Projection: Transverse Mercator Datum: GDA 1994 Scale: 1:67,500@A3

0 0.5 1 1.5 2
Kilometres

CO2 Australia

Location diagram

Path: P:\GISData\Projects\Santos\ENV_20_0041\9.GTP_Offset_Maps\Bottle Tree\Figure 6 - MNES offset areas 2.mxd

4.0 Environmental outcomes to be achieved

The outcome of this OAMP is to acquit the offset obligations under EPBC 2008/4096 (conditions 15-22) and the GTP SSMP. Progress towards achieving these outcomes will be measured against the interim performance targets and criteria defined in Table 8.

Table 8: Interim performance targets and completion criteria for the EPBC 2008/4096 Bottle Tree offset area

MNES	Baseline	Interim performance targets			Completion criteria
		Year 5	Year 10	Year 15	Year 20
South-eastern long-eared bat	4	Increase in the habitat quality score from baseline score of 4	Increase in the habitat quality score from year 5	Increase in the habitat quality score from year 10	Improve the quality of habitat to achieve a score of at least 6
Collared delma	3	Increase in the habitat quality score from baseline score of 3	Increase in the habitat quality score from year 5	Increase in the habitat quality score from year 10	Improve the quality of habitat to achieve a score of at least 5
Yakka skink	3	Increase in the habitat quality score from baseline score of 3	Increase in the habitat quality score from year 5	Increase in the habitat quality score from year 10	Improve the quality of habitat to achieve a score of at least 5
Northern quoll	4	Increase in the habitat quality score from baseline score of 4	Increase in the habitat quality score from year 5	Increase in the habitat quality score from year 10	Improve the quality of habitat to achieve a score of at least 6
Large-eared pied bat	4	Increase in the habitat quality score from baseline score of 4	Increase in the habitat quality score from year 5	Increase in the habitat quality score from year 10	Improve the quality of habitat to achieve a score of at least 6
Red goshawk	4	Increase in the habitat quality score from baseline score of 4	Increase in the habitat quality score from year 5	Increase in the habitat quality score from year 10	Improve the quality of habitat to achieve a score of at least 6
Black-breasted button-quail	4	Increase in the habitat quality score from baseline score of 4	Increase in the habitat quality score from year 5	Increase in the habitat quality score from year 10	Improve the quality of habitat to achieve a score of at least 6
Dunmall's snake	4	Increase in the habitat quality score from baseline score of 4	Increase in the habitat quality score from year 5	Increase in the habitat quality score from year 10	Improve the quality of habitat to achieve a score of at least 6
Squatter pigeon	4	Increase in the habitat quality score from baseline score of 4	Increase in the habitat quality score from year 5	Increase in the habitat quality score from year 10	Improve the quality of habitat to achieve a score of at least 6
Ornamental snake	4	Increase in the habitat quality score from baseline score of 4	Increase in the habitat quality score from year 5	Increase in the habitat quality score from year 10	Improve the quality of habitat to achieve a score of at least 6
Brigalow TEC	4	Increase in the habitat quality score from baseline score of 4	Increase in the habitat quality score from year 5	Increase in the habitat quality score from year 10	Improve the quality of habitat to achieve a score of at least 6

5.0 Adaptive management

5.1 Adaptive management

This OAMP is based on an adaptive management approach which involves 'flexible decision making that can be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood' (National Research Council 2004).

Adaptive management includes two key phases:

- establishment of the key components of a management framework including engaging stakeholders, developing clear and measurable objectives and performance criteria, identification and selection of potential management actions and the development of monitoring protocols which enable the evaluation of progress towards achieving objectives, and which will effectively contribute to the adaptive management decision making process.
- an iterative learning phase which involves utilisation of the management framework to learn about the natural resource system and iteratively adapt management strategies and approaches based on what is learned (Williams 2011).

The management of natural systems involves uncertainty which can affect the success of the management measures in achieving the objectives and performance criteria. Williams (2011) and Williams and Brown (2016) identify four kinds of uncertainty, outlined as follows, with how they have been addressed through the development of this OAMP:

- environmental variation:
  - caused by external factors that act upon natural systems, but which are not influenced by the resource conditions and dynamics, for example variation in rainfall or temperature
  - largely outside of the control of the manager (Williams 2011)
  - influence is considered in the analysis of the effectiveness of the adaptive management approach, the analysis of the ability to achieve and maintain performance criteria and when considering the need for corrective actions.
- partial observability:
  - includes potential uncertainty arising from variation in the collection of data during monitoring events, and from being unable to completely observe the natural system in its entirety (Williams and Brown 2016)
  - addressed in this OAMP through the development of a monitoring program based on scientifically tested and repeatable methods.
- partial controllability:
  - relates to the difference between the intended effect of the management measures to be implemented through this OAMP and the actual effect of their implementation on the ground (Williams and Brown 2016)
  - address through adherence to an adaptive management approach including regular monitoring of conformance with performance criteria, assessment of adaptive management triggers, the implementation of corrective actions, review and amendments to the OAMP, and reporting to ensure that management measures are being effectively implemented on the ground.

- structural and process uncertainty:
  - concerns a lack of knowledge or understanding regarding biological and ecological processes and relationships, and differing views regarding how natural systems respond to management (Williams and Brown 2016)
  - addressed through the adaptive management approach. Following the results of ongoing management, monitoring and reporting, the OAMP will be reviewed and updated as required to incorporate learnings, updated conservation advice and best practice management techniques.

5.2 OAMP adaptive management framework

5.2.1 Risk assessment

The adaptive management process for this OAMP is supported by a risk assessment through which the known and potential risks for each offset value have been evaluated. The relevant risks were identified based on a review of current literature (i.e. conservation advices, recovery plans etc) and identification of potential site-specific risks. As presented in Appendix D, the risk assessment included an assessment of the likelihood and consequence for each identified risk, both with and without the implementation of control strategies. The results of the risk assessment have informed the adaptive management process including the identification of threats to offset values, management objectives, performance criteria, management actions, monitoring programs, adaptive management triggers and corrective actions.

Implementation of the adaptive management process aims to reduce the risk of the identified threats occurring to ensure that the overall outcome sought by this OAMP are achieved.

5.2.2 Adaptive management process

The adaptive management process for this OAMP includes the following key components:

- **identified threats to offset values** – known and potential threats to the offset values have been identified as part of the risk assessment process
- **relevant offset values** – MNES or other offset matter for which the identified threat is relevant have been indicated
- **management objectives** – management objectives have been developed to address each identified threat to the offset values, and to ensure that the interim performance targets and completion criteria are attained
- **performance criteria** – assessable criteria have been defined to measure adherence to the management objectives
- **management actio**n – specific management actions have been identified to ensure that the performance criteria and management objectives are satisfied, and which will ultimately result in attainment of the interim performance targets and completion criteria
- **monitoring** – a combination of qualitative and quantitative methodologies has been included to assess whether management actions are meeting the performance criteria and management objectives, and ultimately, whether the OAMP is supporting the delivery of the interim performance targets and completion criteria

- **adaptive management trigger** – measurable events or parameters have been identified which, when triggered, indicate that a performance criterion has not been satisfied, instigating the implementation of contingency plans and corrective actions
- **corrective actions** – a two-step process has been established to identify the likely cause of the non-compliance with the performance criteria and allow for identification of suitable corrective actions. Corrective actions include the implementation of a feasible, appropriate and effective action to address the identified issue and ensure the performance criteria is satisfied.

Figure 7 illustrates the ongoing adaptive management cycle of implementation, learning and review, with the aim of achieving the interim performance targets and completion criteria. Through the implementation of this adaptive management process, it is anticipated that the interim performance targets and completion criteria will be attained and maintained for the life of the approval.

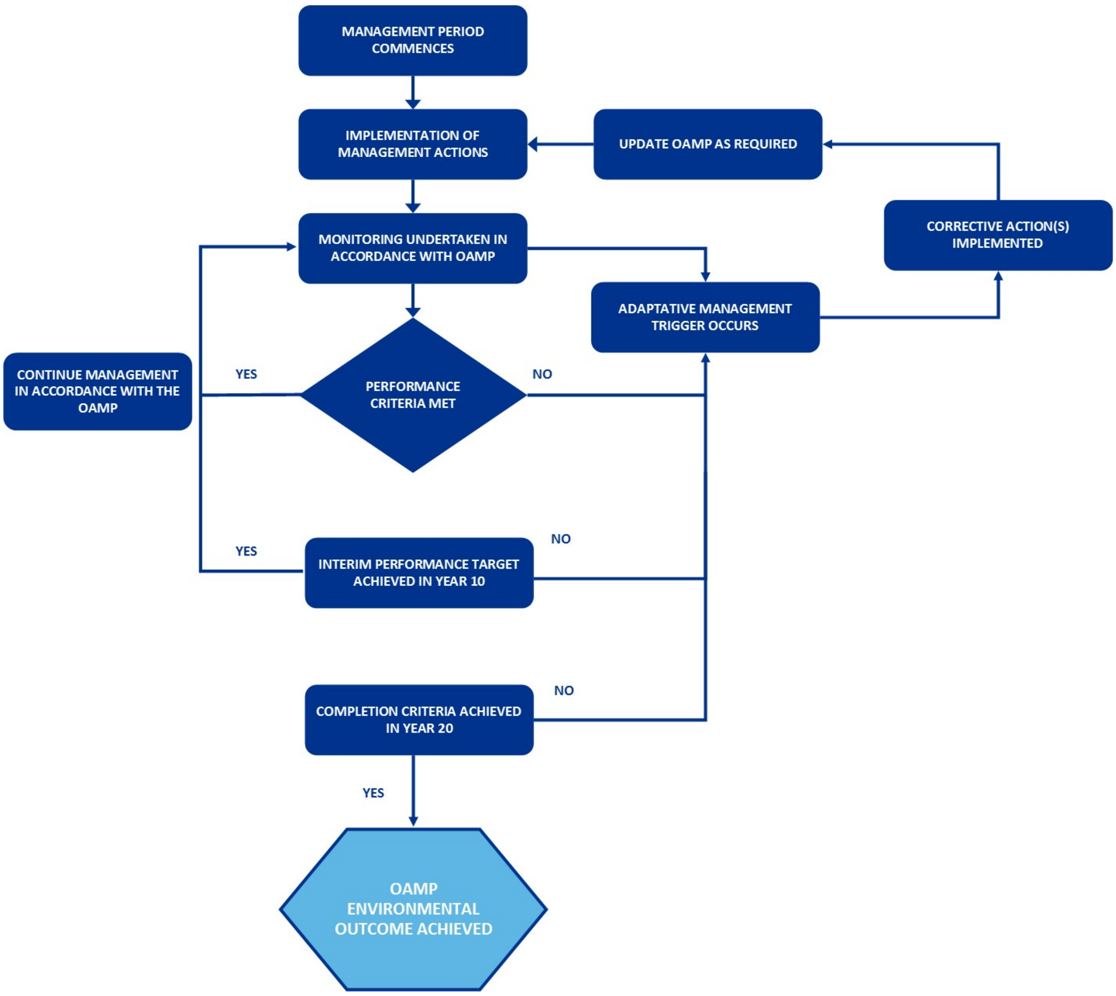


Figure 7: Process for implementation of the OAMP

5.2.3 Timing for implementation of the OAMP

The offset area will be managed and monitored until the interim performance targets and completion criteria are achieved. It is anticipated that through the adaptive management approach, interim performance targets and completion criteria will be achieved within the proposed 20-year management period. However, if the interim performance targets and/or completion criteria for offset values have not been achieved within the anticipated timeframes, management and monitoring will continue beyond the 20-year management period in accordance with this OAMP until the completion criteria have been achieved. Once attained, completion criteria will be maintained for at least the life of the EPBC Act approval relevant to this OAMP.

5.2.4 Risk of offset failure

Based on the adaptive approach to management and the proposed management and monitoring program, it is considered that the management objectives, interim performance targets and completion criteria will be successfully achieved.

In the unlikely event that the interim performance targets are not achieved for one or more offset values by year 5, 10 or 15 for those offset values, Santos will obtain advice from suitably qualified people/groups with the aim of identifying appropriate additional management interventions.

It should be noted that unavoidable temporary perturbations such as severe drought, or insect/fungal pest invasion that may cause a temporary decrease in metrics such as canopy or shrub cover from which the community still may recover within the next 5 year period should not preclude assessment of a satisfactory increase in ecological condition by the completion date.

If it is considered that the completion criteria cannot be achieved, Santos will update this OAMP proposing alternative offset areas in order to acquit the required offset requirements. The revised OAMP will be submitted to the Commonwealth Government.

6.0 Management program

6.1 Management objectives

A summary of the management objectives and performance criteria for the offset area is presented in Table 9, and the complete adaptive management process for this OAMP is encapsulated in Table 10. Management actions, monitoring events, adaptive management triggers and corrective actions have been assigned to each management objective and performance criteria.

Table 9: Summary of the management objectives and performance criteria

Management objectives	Performance criteria
Achieve the completion criteria including habitat quality improvements for offset values and remnant status for those regrowth vegetation communities.	Increase the habitat quality scores for each offset value at each habitat quality assessment site based on the results of baseline and subsequent monitoring events so as to achieve the scores in the completion criteria. Achieve structural and floristic components for a vegetation community to be reclassified as remnant.
Maintain the extent of offset value habitat within the offset area	No unapproved and/or intentional clearing of habitat within the offset area, with the exception of clearing that is required for fencing, access, firebreaks and public safety as outlined in Table 11.
Ensure that the livestock grazing restrictions outlined in Section 6.2.5.1 for fire management and weed control assist in the enhancement of ground cover attributes for offset values and does not result in the degradation of habitat.	Increase the richness and average % cover of native perennial grasses at each habitat quality assessment site based on the results of baseline and subsequent monitoring events.
	Biomass levels of 2,500 kg/ha are retained at each of the monitoring sites at the end of the dry season.
	Livestock are only observed to be grazing in the offset area during strategic grazing event/s
Minimise predation risk by wild dogs to threatened fauna species.	Reduction in Catling* Index for wild dogs from year 1 and subsequent monitoring events.
Minimise predation risk by feral cats to threatened fauna species.	Reduction in Catling* Index for feral cats from year 1 and subsequent monitoring events.
Minimise predation risk by foxes to threatened fauna species.	Reduction in Catling* Index for foxes from year 1 and subsequent monitoring events.
Minimise degradation of offset value habitat by feral horses.	Reduction in the observed presence of feral horse on the property
Minimise degradation of offset value habitat by feral pigs.	Reduction in mean feral pig abundance score from year 1 and subsequent monitoring events.

Management objectives	Performance criteria
Manage invasive weed species to reduce degradation of offset value habitat.	A decrease in species richness and relative abundance of weed species at 80% of monitoring sites from year 1 and subsequent monitoring events. No new weed species are identified at any monitoring site (based on year 1 and subsequent monitoring data).
Reduce the risk of adverse impacts to offset value habitat by inappropriate fire regimes or unplanned fire.	No unplanned fire within the offset area Increase in habitat quality scores as a result of implementation of any fire management measures.
Regrowth Brigalow vegetation managed to meet the criteria for remnant status within the OAMP timeframe.	Regrowth Brigalow vegetation meets the criteria for remnant vegetation
Achieve the interim performance targets and completion criteria for each offset value within 5, 10 and 20 years, respectively.	The interim performance targets are achieved for all offset values by year 5, 10 or 15 The completion criteria are achieved for all offset values by year 20.

* Catling index provides a measure of relative abundance of wild dogs, foxes and feral cats within the offset area. The Catling index will be measured as the percentage of camera nights in which the pest species was observed as part of fauna camera monitoring for the species, as outlined in Section 6.2.7.

Table 10: Management objectives, performance criteria, adaptive management triggers and corrective actions.

Identified threats to offset values	Management objective	Performance criteria	Management action	Monitoring	Trigger for adaptive management and corrective actions	Corrective actions
Degradation of habitat	Achieve the completion criteria including habitat quality improvements for offset values and remnant status for those regrowth vegetation communities.	Increase the habitat quality scores for each offset value at each habitat quality assessment site based on the results of baseline and subsequent monitoring events so as to achieve the scores in the completion criteria. Achieve structural and floristic components for a vegetation community to be reclassified as remnant.	Implementation of the management actions and adaptive management framework as outlined in this OAMP.	Monitoring of offset value habitat quality scores and condition of habitat will be undertaken in accordance with Section 7.0 including: Offset area inspections (Section 7.1). Rapid monitoring events (Section 7.4.1). Habitat quality assessments to determine habitat quality scores (Section 7.4.2). Targeted fauna surveys (Section 7.4.4). The results of monitoring events will be compared against the interim performance targets and completion criteria to determine the progress of the offset area and recorded as part of reporting (Section 8.0).	Interim performance targets are not achieved for one or more offset values by year 5, 10 or 15. Completion criteria are not achieved for one or more offset values by year 20.	Step 1: Investigate cause of trigger • Investigate reasons why the interim performance targets or the completion criteria were not achieved within the specified timeframes. • Re-evaluate the suitability of the relevant management measures in the OAMP. • Identify appropriate corrective actions. Step 2: Implementation of corrective action/s • The appropriate corrective actions will be implemented and may include: ○ Third party review of the OAMP to provide input on the effectiveness of the management actions. ○ Increasing the frequency and intensity of pest animal and weed control measures, or revising the type of measures to be implemented. ○ Modifying the strategic grazing regime to better support enhancement of offset values. ○ For offset values that have not achieved interim performance targets by year 5, 10 or 15 for those offset values, Santos will obtain advice from suitably qualified people/groups with the aim of identifying appropriate additional management interventions. ○ If it is considered that the completion criteria cannot be achieved, Santos will update this OAMP proposing alternative offset areas in order to acquit the required offset requirements in accordance with the offsets assessment guide. The revised OAMP will be submitted to the Commonwealth Government.
Habitat loss through vegetation clearing	Maintain the extent of offset value habitat within the offset area.	No unapproved and/or intentional clearing of habitat within the offset area, with the exception of clearing that is required for fencing, access, firebreaks and public safety as outlined in Table 11.	Protection of the offset area via a Voluntary Declaration under section 19E and 19F of the VMA, as described in Section 2.9.	Reporting to the Commonwealth Government consistent with EPBC approval.	Any activities in contravention of the Voluntary Declaration and this OAMP.	Step 1: Investigate cause of trigger • Investigate reasons why unapproved clearing occurred e.g. unauthorised access • Identify appropriate corrective actions. Step 2: Implementation of corrective action/s • The appropriate corrective actions will be implemented and may include: ○ Addition fencing, signage and/or security for the offset area ○ Restoration of the impacted area
			Comply with the restrictions outlined in Table 11.	Compliance with restrictions for vegetation clearing associated with maintenance and	Clearing for access, fencing, firebreaks or public safety is not undertaken in accordance	Step 1: Investigate cause of trigger

Identified threats to offset values	Management objective	Performance criteria	Management action	Monitoring	Trigger for adaptive management and corrective actions	Corrective actions
			Construction and maintenance of access tracks, fencing and firebreaks will be undertaken in accordance with Sections 6.2.2, 6.2.4 and 6.2.5. In the event that vegetation clearing is required for fencing, access, firebreaks or public safety, all activities will be planned, recorded and monitored.	establishment of access tracks, fencing and firebreaks will also be assessed as part of offset area inspections (Section 7.1).	with the restrictions outlined in Section 6.2.	• If restrictions for clearing associated with fencing, access, firebreaks or public safety are not adhered to, Santos will ensure that all clearing activities cease immediately. • Investigate the reason for unapproved or unintentional clearing. • Following clearing, the area is to be assessed by a suitably qualified ecologist/expert to determine the total clearing extent of offset value habitat. • Identify appropriate corrective actions. Step 2: Implementation of corrective action/s • The appropriate corrective actions will be implemented and may include: ○ Reviewing and modifying protocols for the establishment of fences, access tracks, and firebreaks. ○ Prior to the establishment of fences, access tracks, and firebreaks, the area to be cleared will be clearly marked out with flagging tape and checked prior to clearing. ○ Rehabilitation of the impacted area.
Degradation of habitat by livestock overgrazing.	Ensure that the livestock grazing restrictions outlined in Section 6.2.5.1 for fire management and weed control assist in the enhancement of ground cover attributes for offset values and does not result in the degradation of habitat.	Increase the richness and average % cover of native perennial grasses at each habitat quality assessment site based on the results of baseline and subsequent monitoring events.	Implementation of strategic grazing to reduce fuel loads and control exotic pasture grasses and promote the establishment of native perennial grass species in accordance with Section 6.2.5.1.	Rapid monitoring events and habitat quality assessments will be undertaken in accordance with Section 7.4.1 and 7.4.2. These will include assessment of % cover of native perennial grasses.	Decrease in the richness and average % cover of native perennial grasses at one or more habitat quality assessment sites based on the results of baseline and subsequent monitoring events.	Step 1: Investigate cause of trigger • Investigate the reason for the decrease in richness and average % cover of native perennial grasses • Identify appropriate corrective actions. Step 2: Implementation of Corrective Action/s • The appropriate corrective actions will be implemented and may include: ○ Modifying the strategic grazing regime including modifying the frequency, intensity and/or duration of grazing events. ○ Constructing additional fencing should the current fencing be considered insufficient to manage livestock in accordance with the grazing regime. ○ Installing additional watering points for livestock to manage livestock in accordance with the grazing regime.
		Biomass levels of 2,500 kg/ha are retained at each of the monitoring sites at the end of the dry season.	Implementation of a strategic grazing regime to protect and maintain environmental values in accordance with Section 6.2.5.1.	Biomass monitoring will be undertaken in accordance with Section 7.2.	Biomass monitoring results indicate less than 2,500 kg/ha of biomass is present at any of the monitoring sites at the end of the dry season.	Step 1: Investigate cause of trigger • Investigate the reason for biomass being less than 2,500 kg/ha. • Re-evaluate the strategic grazing regime to assess the suitability of grazing to ensure no less than an average of 2,500 kg/ha of biomass is retained at the end of the dry season. • Identify appropriate corrective actions. Step 2: Implementation of Corrective Action/s

Identified threats to offset values	Management objective	Performance criteria	Management action	Monitoring	Trigger for adaptive management and corrective actions	Corrective actions
						• The appropriate corrective actions will be implemented and may include: ○ Removal of stock or spelling grazing from the area of the offset in which less than 2,500 kg/ha of biomass was identified. ○ Review adherence to livestock grazing restrictions in Section 6.2.5.1. ○ Where relevant, amending livestock management practices in the OAMP, including amending stocking rates, and/or duration and/or frequency of strategic grazing events.
		Livestock are only observed to be grazing in the offset area during strategic grazing event/s.	Existing fencing is always maintained as outlined in Section 6.2.4.	Offset area inspections to be undertaken at least annually (Section 7.1) and will include monitoring to assess the: • condition of fencing to identify any necessary maintenance requirements. • presence of livestock within the offset area.	Livestock are observed within the offset area when not permitted within that area. Damaged fencing is observed.	Step 1: Investigate cause of trigger • If livestock are identified in the offset area, remove stock immediately. • Inspect and evaluate fencing and identify the cause of livestock within the offset area. • Identify appropriate corrective actions. Step 2: Implementation of Corrective Action/s • The appropriate corrective actions will be implemented and may include: ○ Repairing fencing where required to ensure its condition is satisfactory to exclude livestock. ○ Constructing additional fencing should the current fencing be considered insufficient to exclude livestock.
Predation by wild dogs	Minimise predation risk by wild dogs to threatened fauna species.	Reduction in Catling* Index for wild dogs from year 1 and subsequent monitoring events.	Implement control actions for wild dogs in accordance with Section 6.2.7.	Undertake monitoring for wild dogs in accordance with Section 7.3.	An increase in Catling* Index for wild dogs from year 1 and subsequent monitoring events.	Step 1: Investigate cause of trigger • Investigate potential sources or reasons that may have attributed to an increase in the: ○ Catling* index for wild dogs, feral cats and/or foxes ○ relative abundance of feral pigs and horses. ○ Review adherence to pest management control measures as outlined in Section 6.2.7 ○ Identify appropriate corrective actions. Step 2: Implementation of corrective action/s ○ The appropriate corrective actions will be implemented and may include: ○ Increasing the frequency and intensity of pest animal control. ○ Revising methods of pest animal control in accordance with Queensland Department of Agriculture and Fisheries (DAF) guidelines, and coordinate with neighbouring land owners to ensure a consistent approach. ○ Updating pest animal control methods in the OAMP and targeted pest animal control programs.
Predation by feral cats.	Minimise predation risk by feral cats to threatened fauna species.	Reduction in Catling* Index for feral cats from year 1 and subsequent monitoring events.	Implement control actions for feral cats in accordance with Section 6.2.7.	Undertake monitoring for feral cats in accordance with Section 7.3.	An increase in Catling* Index for feral cats from year 1 and subsequent monitoring events.	
Predation by foxes.	Minimise predation risk by foxes to threatened fauna species.	Reduction in Catling* Index for foxes from year 1 and subsequent monitoring events.	Implement control actions for foxes in accordance with Section 6.2.7.	Undertake monitoring for foxes in accordance with Section 7.3.	An increase in Catling* Index for foxes from year 1 and subsequent monitoring events.	
Degradation of habitat by feral horses	Minimise degradation of offset value habitat by feral horses.	Reduction in the observed presence of feral horse on the property.	Implement control actions for feral horses in accordance with Section 6.2.7.	Undertake monitoring for feral horses in accordance with Section 7.3.	An increase in the observed presence of feral horses across monitoring events.	
Degradation of habitat by feral pigs.	Minimise degradation of offset value habitat by feral pigs.	Reduction in mean feral pig abundance score from year 1 and subsequent monitoring events.	Implement control actions for feral pigs in accordance with Section 6.2.7.	Undertake monitoring for feral pigs in accordance with Section 7.3.	An increase in mean feral pig abundance score from year 1 and subsequent monitoring events.	

Identified threats to offset values	Management objective	Performance criteria	Management action	Monitoring	Trigger for adaptive management and corrective actions	Corrective actions
Invasion of habitat by weed species, including exotic grasses.	Manage invasive weed species to reduce degradation of offset value habitat.	A decrease in species richness and relative abundance of weed species at 80% of monitoring sites from year 1 and subsequent monitoring events. No new weed species are identified at any monitoring site (based on year 1 and subsequent monitoring data).	Implement weed control actions in accordance with Section 6.2.6. Adhere to weed hygiene restrictions in accordance with Section 6.2.1.	Undertake weed monitoring in accordance with Section 7.2.	An increase in species richness and relative abundance of weed species at more than 20% of monitoring sites from year 1 and subsequent monitoring events. A new weed species is identified at one or more monitoring sites.	Step 1: Investigate cause of trigger • Investigate potential sources or reasons that may have attributed to an increase in species richness and/or relative abundance of weeds. • Investigate potential sources or reasons for the occurrence of the new weed species. • Review adherence to weed management control measures as outlined in Section 6.2.6 • Review adherence to weed hygiene restrictions as outlined in Section 6.2.1 • Identify appropriate corrective actions. Step 2: Implementation of corrective action/s • The appropriate corrective actions will be implemented and may include: ○ Amending weed hygiene restrictions. ○ Providing additional educational awareness training for all staff and contractors to ensure weed hygiene restrictions are adhered to. ○ Revising weed control methods in accordance with the *Biosecurity Act 2014* (Qld). ○ Increasing the frequency and intensity of weed control. ○ Updating weed control methods in the OAMP and targeted weed control programs.
Inappropriate fire regimes	Reduce the risk of adverse impacts to offset value habitat by inappropriate fire regimes or unplanned fire.	No unplanned fire within the offset area Increase in habitat quality scores as a result of implementation of any fire management measures.	All fire management measures to be implemented in accordance with the program outlined in Section 6.2.5.	Habitat quality assessments to determine habitat quality scores will be undertaken in accordance with Section 7.4.2. Rapid monitoring events will be undertaken to assess the general condition of vegetation in accordance with Section 7.4.1.	As a result of fire management measures, or an unplanned fire, there is a decrease in the habitat quality score for any offset value from baseline and subsequent monitoring events.	Step 1: Investigate cause of trigger • Investigate reasons why the fire management measures have resulted in a decrease in habitat quality scores. • Review adherence to the fire management measures as outlined in Section 6.2.5 • Identify appropriate corrective actions. Step 2: Implementation of corrective action/s • The appropriate corrective actions will be implemented and may include: ○ Increasing the frequency of biomass monitoring. ○ Increasing the frequency of weed control measures. ○ Amending the strategic grazing regime. ○ Reviewing effectiveness of firebreaks, and establishment of additional fire breaks. ○ Review timing and intensity of fuel hazard reduction burns in accordance with the Regional Ecosystem Description Database (REDD) fire management guidelines and conservation advice for the particular offset value.

Identified threats to offset values	Management objective	Performance criteria	Management action	Monitoring	Trigger for adaptive management and corrective actions	Corrective actions
Regrowth Brigalow unlikely to achieve remnant status	Regrowth Brigalow vegetation managed to meet the criteria for remnant status within the OAMP timeframe.	Regrowth Brigalow vegetation meets the criteria for remnant vegetation.	Selective regrowth thinning of Brigalow TEC where regrowth of Brigalow vegetation (RE 11.9.5) occurs at >10,000 stems per hectare in accordance with Section 6.2.3.	Habitat quality assessments (Section 7.4.2). Brigalow regrowth assessment (Section 7.4.5).	Brigalow regrowth exceeds 10,000 stems per hectare based on previous monitoring events.	Step 1: Investigate cause of trigger • Investigate the reasons why stem density is >10,000 stems/ha and whether management intervention is required. mechanical thinning is effective and appropriate Step 2: Implementation of corrective action(s) • The appropriate corrective actions will be implemented and may include: ○ Increasing the frequency thinning activities ○ Revise the type of thinning method used
Offset fails to achieve the interim performance targets and completion criteria within the anticipated 5, 10, 15 and 20 year timeframes, respectively.	Achieve the interim performance targets and completion criteria for each offset value within 5, 10, 15 and 20 years, respectively.	The interim performance targets are achieved for all offset values by year 5, 10 or 15. The completion criteria are achieved for all offset values by year 20.	All management actions outlined in Section 6.0 will be implemented to ensure that the interim performance targets and completion criteria are achieved.	Monitoring of the offset area will be undertaken in accordance with Section 7.0 including: • Offset area inspections (Section 7.1). • Offset value assessments (Section 7.4) The results of monitoring events will be compared against the interim performance targets and completion criteria to determine the progress of offset area and recorded as part of reporting (Section 8.0).	Interim performance targets are not achieved for one or more offset values by year 5, 10 or 15. Completion criteria are not achieved for one or more offset values by year 20.	Step 1: Investigate cause of trigger • Investigate reasons why the interim performance targets or the completion criteria were not achieved within the specified timeframes. • Re-evaluate the suitability of the relevant management measures in the OAMP. • Identify appropriate corrective actions. Step 2: Implementation of corrective action (s) • The appropriate corrective actions will be implemented and may include: ○ Third party review of the OAMP to provide input on the effectiveness of the management actions. ○ Increasing the frequency and intensity of pest animal and weed control measures, or revising the type of measures to be implemented. ○ Modifying the strategic grazing regime, or fire management measures, to better support enhancement of offset values.

6.2 Management actions

6.2.1 General restrictions

Table 11 details the restrictions to be implemented for the offset area to ensure the completion criteria and management objectives are met.

Table 11: Offset area restrictions

Restrictions	Details
Weed hygiene	• Weed hygiene measures will be implemented to prevent the movement of weed material into the offset area. • All persons entering the offset area will be required to ensure vehicles and equipment are weed free. • All contractors entering the offset area must hold a current weed hygiene certificate or equivalent for all vehicles and equipment. • Evidence is to be provided on request to the landowner and Santos environmental advisors that vehicles, slashers or any machinery implementing management actions are clean prior to entry to minimise potential weed spread.
Vehicles	• Vehicle movement will be limited to designated access tracks in the offset area and access will be restricted to authorised personnel only. • Vehicles will travel to track conditions to minimise the risk of vehicle strike to fauna.
Vegetation clearing	• Clearing will be excluded from the offset area through demarcation and protection by means of Voluntary Declaration under the VM Act. Clearing for timber gathering and development will also be excluded. • Clearing of native vegetation will not be permitted within the offset area as part of any management and monitoring activities associated with this OAMP, except for clearing that is required for: o maintenance of access tracks and/or fire breaks o fence construction and maintenance and o ensuring public safety or as directed by emergency management response personnel in the event of unplanned fire or other emergency or associated procedure. • If vegetation clearing is required for fencing, access, firebreaks or public safety, all activities will be appropriately planned, recorded and monitored. • Machinery will not be allowed on site after heavy or prolonged rainfall events until after the site has dried to allow for safe movement of traffic.
Unauthorised access or use	• Access into the offset area will be restricted to authorised personnel only. • The offset area will be demarcated as an exclusion zone in the Santos GIS. • Signs will be installed in prominent locations (i.e. at access points into the offset area) which recognise that the areas are protected for conservation purposes. The signs will advise that access into the offset area is restricted to authorised personnel only. • The property will be suitably fenced to restrict access by unauthorised persons.

Restrictions	Details
	• At no time can persons access the site without first approaching the Land Advisor of the Bottle Tree property and informing them of their intent. • When entering and leaving the property, the Land Advisor must be advised. • Contractors will only be permitted to access the property following the direct engagement by Santos.

6.2.2 Access tracks

Existing access tracks will be utilised to facilitate necessary management, maintenance and monitoring activities as part of this OAMP. If existing access tracks become impassable (through erosion or vegetation regrowth), maintenance activities of these tracks (e.g. grading) will be prioritised over alternative track alignments. Gully crossings are likely to be subject to periodic, ongoing maintenance because of erosion following rain events.

Existing and new access tracks will be no wider than 5 m and vegetation disturbance will be minimised.

6.2.3 Brigalow regrowth restoration

The dominant vegetation community on Bottle Tree consists of regrowth Brigalow with exotic pasture (predominately Buffel grass) understory.

Through the implementation of this OAMP these areas will be restored to establish self-sustaining functional remnant vegetation communities analogous to Brigalow TEC. Regrowth Brigalow within the offset area has been mapped as mature regrowth and immature regrowth, as previously described in Section 3.1. To achieve remnant status the areas of regrowth Brigalow need to demonstrate that the dominant canopy has greater than 70% of the height and greater than 50% of the cover relative to the undisturbed height and cover of that stratum and is dominated by species characteristic of the vegetation's undisturbed canopy.

Thinning randomly selected stems of the dominant species in a Brigalow regrowth community has been found to accelerate:

- growth of retained stems
- recovery of forest structure, and
- recruitment of some native shrub species (Dwyer and Mason 2017).

Selective regrowth thinning will occur where regrowth of Brigalow vegetation (RE 11.9.5) occurs at >10,000 stems per hectare and the density of stems is considered to be affecting the sites capacity to return to remnant status.

It is recommended that Brigalow be selectively thinned when stem densities are very high (e.g. >10,000 stems per hectare). To be effective, thinning has to utilise methods that cause slow stem death (e.g. ringbarking, selective herbicide application) and reduce secondary suckering (these are time and labour-intensive (Peeters and Butler 2014; Dwyer and Mason 2017) .

Where thinning does occur, the vegetation must not be thinned less than the density of a benchmark site for equivalent community. Benchmark sites will be obtained from the Queensland Government database or from nearby remnant vegetation of the same community.

The requirement for management by mechanical thinning will be informed by monitoring events (see Section 7.4.5).

6.2.4 Fencing

To assist with management of livestock control for weed and fuel load management and exclusion of livestock from specific areas of the offset, fencing will be installed as presented in Figure 8. Fencing will be installed to manage livestock access to the wetland and riparian area on the western side of the Bottle Tree offset area. Existing fencing is located around the boundary of the Ooline and *Xerothamnella herbacea* offset areas to exclude stock at all times.

Fencing will comprise of a 4 wire fence consisting of 3 strand 1.57HT barb with a plain high tensile wire at the top, wood and/or steel posts at 7 m spacing, a strainer post every 100 m and 1 gate located every 1 km. This type of fencing is also considered appropriate to facilitate the fauna movement across the property. Importantly, the movement of the species being offset will not be impeded by the proposed fencing design.

Any vegetation disturbance associated with new fence construction will be minimised in accordance with Table 11.

Regular inspections of all fencing will be undertaken in accordance with Section 7.1, and repairs to the fences will be made as required.

6.2.5 Fire management

A planned and co-ordinated fire management strategy will be implemented:

- to minimise the risk and impacts of unplanned fire especially to fire sensitive Brigalow and SEVT TEC
- improve habitat quality through:
  - controlling weeds, biomass levels and fuel loads
  - supporting development of structural components of habitat for offset values (e.g. recruitment of native plants, establishment of fire sensitive native herbs and groundcover, important microhabitat including fallen logs and leaf litter, and increased understorey)
  - promoting germination and recruitment of Eucalypt species and other species characteristic of the specific RE.

Unplanned fire risk will be managed through:

- establishment and regular maintenance of firebreaks (Figure 8)
- monitoring and managing fuel loads primarily through the implementation of a controlled grazing regime (Section 6.2.5.1)
- fuel hazard reduction burns (if required; Section 6.2.5.2).

Firebreaks will be established and maintained around the boundary of the offset area, with green firebreaks established where the offset area joins native vegetation, see Figure 8. Firebreaks will be maintained at least annually in mid / late autumn and, or early spring to remove overhanging trees or fallen debris and dense vegetation. Firebreak maintenance will be undertaken to a width of up to 10 m.

6.2.5.1 Strategic grazing

The Bottle Tree property has in the past been managed as an open grazing enterprise where the focus has been on production and sustaining a viable income from domestic stock.

Strategic grazing within the offset area will be used to manage fuel loads and control exotic weeds and pasture grasses such as *Cenchrus ciliaris*. As increasing grazing intensity is correlated with an increase in weedy cover (Franks 2002), and a decrease in native grass species richness, grazing will be permitted in the offset area on a managed and limited basis to control weeds and reduce fuel loads.

Best practice management for strategic livestock grazing within the Bottle Tree offset area will be undertaken as follows:

- livestock will only be permitted in the offset area to reduce fuel loads, avoid weed seed set and reduce weed cover
- within the offset area a minimum of 2,500 kg/ha of biomass will be retained at the end of the dry season.
- additional fencing will be installed to manage livestock access to the riparian and wetland areas (RE 11.3.27) on the western side of the offset area (Figure 8)
- livestock will be excluded at all times from the Ooline and *Xerothamnella herbacea* offset areas (Figure 2 and Figure 8).

To minimise erosion and subsequent impacts on water quality, strategic grazing will be excluded where rainfall causes inundated or waterlogged soils. The location and extent of grazing exclusion areas will be reviewed annually based on the results of management and monitoring events.

The suitability of conditions for undertaking a grazing event will be informed by biomass monitoring events as described in Section 7.2.

6.2.5.2 Fuel hazard reduction burns

The aim of fuel hazard reduction burns is to manage excess fuel loads, to initiate regeneration of Eucalypt communities and to create habitat with a mosaic of different fire frequencies and times since fire.

Fire management, through fuel hazard reductions burns will be guided by conservation advice documentation (e.g. for MNES) and the Regional Ecosystem Description Database (REDD; Queensland Herbarium 2021), which provides recommendations for fire management for each of the component RE (Table 12), guidelines published in Fire and Biodiversity Monitoring Manual published by South East Queensland Fire and Biodiversity Consortium (2002), local regional fire plans, regional fire authorities and local knowledge of fire behaviour.

Based on this advice, fire is to be excluded from areas of Brigalow TEC and SEVT TEC in the offset area. To reduce the risk of fire occurring within Brigalow TEC and SEVT TEC in the offset area, very cool fuel hazard reduction burns (trickle burns) in a rotational mosaic pattern may be conducted in adjacent areas.

Hazard reduction burns will be considered if fuel hazard ratings within the offset area are unable to be maintained below extreme in accordance with the Overall Fuel Hazard Assessment Guide (Hines et al. 2010; Appendix E) through the implementation of strategic grazing and weed control. However, the location and timing for fuel hazard reduction burns will be informed by the results of biomass monitoring (Section 7.2) and fuel load monitoring (Section 7.1) in conjunction with the results of habitat quality assessments and considering the REDD fire management guidelines for the vegetation community and MNES conservation advices.

In general, fire management will be undertaken in a mosaic pattern at the appropriate time of year when there is:

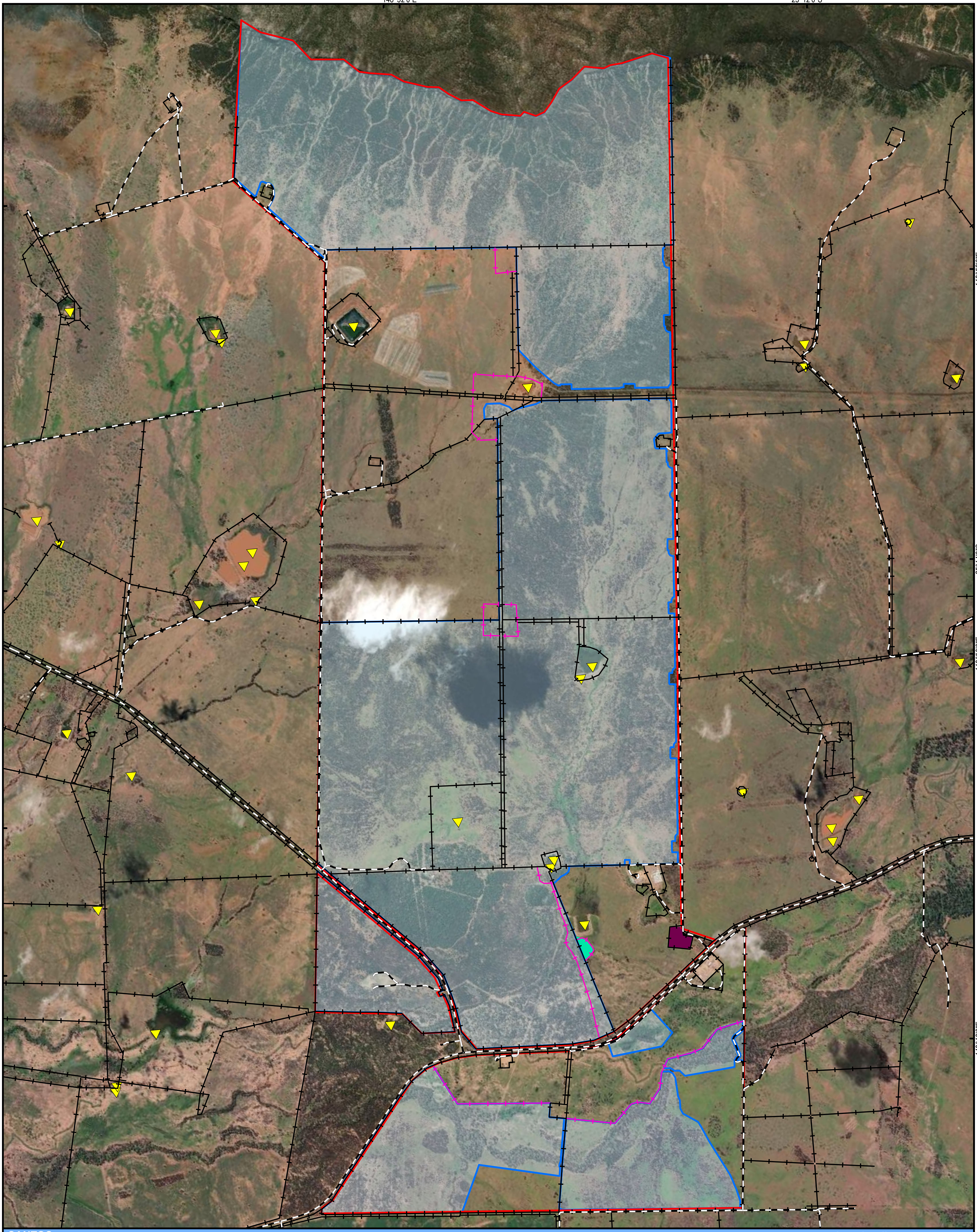
- high soil and fuel moisture levels, ideally following minimum of 40 mm of rainfall
- low ambient temperature and wind speed
- high atmospheric humidity
- the risk of long-term impacts/high intensity fire is low, and/or
- when plants approach a more active growing phase.

Table 12: Fire management guidelines for each component RE

RE	Associated TEC	Fire Exclusion?	Fire Management
11.10.3	-	Yes	• Protection from fire is necessary. • Maintain fire management of surrounding country with numerous small fires throughout the year so that fires will be very limited in extent. • There is typically not enough ground vegetation within this RE to carry a fire.
11.10.4	-	No	• Maintain fire management of surrounding country. • Burn surrounding country only under conditions of good soil moisture and when plants are actively growing. • This RE is likely to be difficult to burn owing to a lack of ground fuel that normally occurs in this RE.
11.10.7	-	No	• Conduct a moderate to high burn every 6-10 years. • Timing for burning should be during late wet to early dry season when there is good soil moisture, early storm season or after good spring rains. • Burn less than 10-30% of the area in any year. • Burn surrounding vegetation under conditions of good soil moisture and when plants are actively growing throughout the year so that fires will be very limited in extent. • Best protection from fire is through the creation of a multi-aged mosaic in surrounding vegetation and perimeter burning.
11.3.2	Poplar Box TEC	No	• Conduct a low to moderate burn every 6-10 years. • Timing for burning should be late wet to early dry season when there is good soil moisture, early storm season or after good spring rains. • Burn less than 30% of the area in any year. • Burn under conditions of good soil moisture and when plants are actively growing. Sometimes a small amount of wind may move the fire front quickly so that burn intensity is not too severe to destroy habitat trees.

RE	Associated TEC	Fire Exclusion?	Fire Management
			• Management of this vegetation type will be based on maintaining vegetation composition, structural diversity, fauna habitats (in particular hollow-bearing trees and logs) and preventing extensive wildfire by: ○ maintaining a fire mosaic ○ control invasive shrubs ○ low to moderate intensity burns with good soil moisture to minimise loss of hollow trees ○ avoiding riparian communities where appropriate.
11.3.17	-	No	• Conduct a burn every 6-10 years, avoiding hottest and driest time of the year. • Burn less than 10% of the area in any year. • Burn in association with fire management of surrounding vegetation. • Protection of this RE also relies on broad-scale management of surrounding country with numerous small fires throughout the year so that fires will be very limited in extent. • Low intensity fires with good soil moisture will be useful in reducing fuel loads and fire spread in later fires. Moderate fires may assist in regeneration of hard-seeded spp. • Best protection from wildfires is probably the creation of a multi-aged mosaic and perimeter burning.
11.3.25	-	No	• Conduct a low intensity burn every 3-5 years primarily during the early dry season. • Protection of this RE also relies on fire management of adjacent vegetation communities with numerous small fires throughout the year so that wildfires will be limited in extent. • In some situations it may be best not to burn as this RE is often critical habitat for fauna and flora species. • If burning is to occur then implement when water level is deep enough to protect the bases of aquatic plants. • If riparian areas need to be burnt to reduce fuel loads then burning should occur when there is good soil moisture and active growth.

RE	Associated TEC	Fire Exclusion?	Fire Management
11.3.27	-	No	• Depending on position in the landscape, protection of this RE relies on broad-scale fire management of surrounding country, with numerous small fires throughout the year so that wildfires will be very limited in extent. • In some situations it may be best not to burn as this RE is often critical habitat for fauna and flora species. • If burning is to occur then implement when water level is deep enough to protect the bases of aquatic plants. • If riparian areas need to be burnt to reduce fuel loads then burning should occur when there is good soil moisture and active growth.
11.9.4	SEVT TEC	Yes	• Protection from fire is necessary. • Maintain fire management of surrounding country with numerous small fires throughout the year so that fires will be very limited in extent. • Maintenance of fire breaks may be appropriate on flat country, but natural features will be useful as breaks in 'wild' country. • Fuel reduction in the surrounding vegetation under low fire danger conditions and/or revegetation of cleared areas reduce the risk of damaging wildfires. • Maintain or re-establish native vegetation communities adjacent to this ecosystem. Grazing may be useful in managing fuel loads created by introduced grasses such as buffel.
11.9.5 and 11.9.5a	Brigalow TEC	Yes	• Protection from fire is necessary. • High intensity fires will cause damage to overstorey. • Maintain fire management of surrounding country so that any fires will be very limited in extent. Frequent fire at the edge of this community keeps fuel loads low. • The invasion of exotic grasses such as buffel grass increases the risk from fire. Grazing may be an option for reducing fuel loads in Brigalow TEC.



SANTOS

Location diagram

Figure 8
Bottle Tree infrastructure

Bottle Tree - 7TR39
Bottle Tree offset area

Infrastructure
Roads/tracks
Dams
Existing fencing
New fencing

DATA SOURCE:
The following datasets are © State of Qld:
- Existing offset area (PMAV 2016/006243, PMAV 2018/004187)
Bottle Tree offset area and infrastructure provided by SANTOS

Date: 7/30/2021 Coordinate System: GDA 1994 MGA Zone 55 Projection: Transverse Mercator Datum: GDA 1994 Scale: 1:32,500@A3

0 0.5 1 1.5 2
Kilometres

CO2 Australia

Path: P:\GISData\Projects\Santos\ENV_20_00419.GTP_Offset_Maps\Bottle Tree\Figure 8 - Infrastructure.mxd

6.2.6 Weed management

Weed management in the offset area will aim to minimise the introduction, establishment and spread of restricted and prohibited pest plants under the *Biosecurity Act 2014* (Qld) and other invasive species, that present a threat to vegetation communities and species habitat in the offset area. Weed management will focus on reducing the extent of the existing weeds as well as minimising the risk of introduction of additional weed species to the offset areas:

Detailed ecological assessments of the Bottle Tree property (Section 2.5) identified a small number of *Opuntia spp*. (*Opuntia stricta* [Prickly pear], *Opuntia tomentosa* [Tree Pear], *Opuntia aurantiaca* [Tiger Pear]); however, the species/populations were deemed to cause no measurable threat to the site or management objectives. In addition, it was noted that the existing biological control measures for the Opuntia spp. were quite effective and that little, if any, further management of these species would be required (Boobook 2015).

Parthenium (*Parthenium hysterophorus*) presents a high potential for introduction to the property, due to its presence in the surrounding region (known to occur in the southern arcadia valley) and ability to disperse.

Reductions in the extent of buffel grass and parthenium are most effectively achieved by maximising the competitive advantage of native ground cover species. This requires native species richness and abundance to be maximised. In historically grazed environments the most effective way to ensure high species richness is through conservatively managed cattle grazing (Fensham 1998). Conservative cattle grazing requires maintenance of enough biomass to maximise grass growth and appropriate spelling to allow for native species to set seed.

Accordingly, a strategic grazing regime will be implemented to reduce the presence and biomass of exotic pasture grasses in the offset areas (refer to Section 6.2.5.1). To supplement this, weeds will be managed using biological, chemical and/or mechanical control in accordance with the control measures outlined in the Biosecurity Queensland Fact Sheets, for the relevant weed species.

Biological control measures will continue to be used to manage Opuntia spp.; however, the species will not be completely eradicated from the Bottle Tree property. For the biological control measures currently in place to remain effective, a small number of plants are required to remain on site.

6.2.7 Pest animal management

Pest animals present or have the potential to occur on or within the immediate vicinity of the Bottle tree property and pose the following threats:

- Predation of fauna by foxes, cats and wild dogs
- Erosion and degradation of habitat and competition by pigs and feral horses.

Pest animal control activities will be undertaken to minimise the introduction of pest animals and control existing pest animal populations in accordance with the *Biosecurity Act*. Table 13 provides examples of approved species-specific pest animal control measures recommended by the Queensland and Commonwealth governments. Results of pest animal assessments will be reviewed following each reporting event to inform the need for, location and timing of species-specific control measures in subsequent years.

Table 13: Examples of species-specific control methods for pest animal species

Species	Status under Biosecurity Act 2014	Example control method	Reference
Wild dog (*Canis familiaris*)	Category 3,4,6	• Ground baiting • Foot hold traps • Shooting	(DAF 2019a)
Fox (*Vulpes vulpes*)	Category 3,4,5,6	• Ground baiting • Trapping • Shooting	(DAF 2019b)
Feral cat (*Felis catus*)	Category 3,4,6	• Night shooting • Poisoning • Trapping	(DAF 2019c)
Pig (*Sus scrofa*)	Category 3,4,6	• Trapping • Shooting • Poisoning	(DAF 2019d)
Feral horse (*Equus caballus*)	-	• Relocation through mustering or trapping	(DAF 2016)

7.0 Monitoring

The results of the monitoring program outlined in the following sections will be used to inform operational management decisions, including adaptive implementation of this OAMP to ensure the performance criteria and management objectives, and ultimately interim performance targets and completion criteria are met.

The monitoring results will also be used to assess adherence to performance criteria, and to determine when corrective actions are required to be implemented. The results will also be compared to those from previous monitoring events to assess change over time and to inform the ongoing implementation of the OAMP.

7.1 Offset area inspections

The aim of offset area inspections is to enable a general assessment of the offset area to identify any potential issues that may require remedial action to be undertaken. Inspections will be undertaken twice per year for the duration of the management period to assess the following:

- condition of fencing, gates and signs and existing gas field infrastructure
- condition of access tracks
- condition of firebreaks
- compliance with restrictions for vegetation clearing associated with maintenance and establishment of access tracks, fencing and firebreaks
- incidence of erosion within offset area, particularly around permanent and semi-permanent water bodies or areas subject to inundation or waterlogging
- damage/degradation resulting from pest animal activity within the offset area
- signs of land degradation and over-grazing
- presence of weed/invasive species
- exclusion of livestock
- incidental fauna observations and any additional risks to offset values (i.e. evidence of vehicle strike)
- within Brigalow regrowth, observations for excessive regrowth Brigalow that may require thinning.

7.2 Biomass monitoring

Biomass monitoring for fire management will be undertaken twice a year, at the end of the wet season and end of the dry season, to:

- determine the risk of fire to the offset site and
- inform fire management strategies to control fuel loads.

Biomass is at its greatest at the end of the wet season (April) with fire risk greatest towards the end of the dry season (October). Biomass will be monitored within the offset areas using appropriate photo standards which will be used to determine dry matter yields and subsequently fuel loads. Biomass monitoring will be undertaken at the same permanent weed monitoring sites established as part of the year 1 monitoring.

Fuel loads will be managed through strategic grazing events (see Section 6.2.5.1) if the biomass assessment at the end of the wet season shows that biomass is greater than 2,500 kg/ha within the offset area.

The stocking rate of these strategic grazing events will be determined through a feed budgeting assessment (see Section 7.2.1) undertaken prior to a grazing event in the offset area. A feed budgeting assessment is a recognised method of determining the stocking rate based on the amount of feed available and the amount of feed desired at the end of the grazing event (i.e. >2,500 kg/ha).

7.2.1 Feed budgeting assessment

The process for undertaking a feed budget assessment will include the following sequence of activities:

- determine the current amount of feed present (kg/ha) using appropriate photo standards available on the Future Beef website[3].
- determine the amount of feed desired (kg/ha) at the end of the grazing event.
- calculate the total useable feed (kg/ha) by subtracting the feed desired from the feed present.
- determine utilisation (i.e. the proportion of useable feed that livestock can use).
- determine the feed available for the grazing animal (kg/ha) by multiplying the total useable feed by the utilisation rate.
- calculate the safe stocking rate by:
  - determining the feed consumption per day (kg/day)
  - determining the number of days feed is required (days)
  - calculating the feed requirement per head (kg/hd) by multiplying the feed consumption per day by the number of days
  - calculating the stocking rate (ha/hd) by dividing the feed requirement per head by feed available
  - calculate the number of stock (head) by dividing the area of the paddock by the stocking rate.

The amount of feed available prior to the grazing event will be estimated using the appropriate photo standards available on the Future Beef website. The “Dry Season Feed Budget” worksheet will then be used to calculate the required stocking rate for the grazing event.

At the completion of the grazing event, photo standards will be used to assess ground cover and ecosystem biomass. Should the grazing event be required to be extended (e.g. as a result of additional rainfall and resultant grass growth and potential weed flowering), the feed budget assessment will be recalculated using the “Dry Season Feed Budget” worksheet.

[3] See https://futurebeef.com.au/knowledge-centre/pastures-forage-crops/pasture-photo-standards/.

7.1 Fuel load monitoring

Fuel load monitoring will be undertaken in accordance with the Overall Fuel Hazard Assessment Guide (Hines et al. 2010; Appendix E). Fuel load assessment monitoring will include a baseline survey in year 1 (post wet season; April), with ongoing fuel load assessment monitoring conducted every year at the same time and location as biomass monitoring post wet season. Monitoring will focus on assessing the key structural layers of the fine fuels that burn in bushfires, specifically bark, elevated fuels, near-surface fuels and surface fuels. This will allow for a rapid assessment of each fuel layer, which in in turn is given a hazard rating and are then combined to provide an overall fuel hazard rating of low, moderate, high, very high or extreme.

The fuel hazard rating will be monitored to compare any changes from previous assessments. In conjunction with results of habitat quality assessments, the results of the fuel load assessments will be used to determine if fuel hazard reduction burns are required within the offset area. Weed management and strategic grazing within the offset area will also be undertaken to maintain fuel hazard rating below extreme.

7.2 Weed monitoring

Weed monitoring sites will be randomly stratified, fixed monitoring sites representative of offset values and incorporating natural variability such as aspect (e.g. a mix of north-, east-, south- and west-facing monitoring sites), community type – (e.g. woodland, riparian). There will also be fixed monitoring sites at strategic trafficable areas (e.g. entry gates, creek crossings, stock watering points) to monitor potential introduction and/or irruptions of prohibited and restricted weed species.

The offset area will be monitored for weeds every two years (post wet season) to determine the species richness and abundance, for the duration of the management period. The results of this monitoring will inform the methods for weed treatment and control (see Section 6.2.6).

Non-native plant cover is also assessed as part of the habitat quality assessments detailed in Section 7.4.2, and the presence of weed species will also be recorded as part of the general offset area inspections (see Section 7.1), where noted.

7.3 Pest animal monitoring

The offset area will be monitored for evidence of pest animals every two years (post wet season), including a baseline survey in year 1 of the distribution and abundance of pest animals.

Based on the results of year 1 surveys, pest animal monitoring sites will be established in year 1. Monitoring of pest animals will target areas of known impacts/movements (e.g. along topographic features, including creeks, pads, paths, ridge-tops and roads) to not only maximise the success of encountering pest animals, but target monitoring in environments that are more regularly impacted (e.g. drainage lines, moist gullies and around swamps and lagoons favoured by feral pigs; Hone 1995). The location of pest animal monitoring sites will be assessed prior to each monitoring event.

Pest animal monitoring will also be undertaken in association with and immediately prior to the pest animal control activities (Section 6.2.7). Initial monitoring results will determine the degree of effort required to control the pest population and post control monitoring will determine the degree of success of control operations.

Monitoring of pest animals will involve the deployment of motion sensing infra-red cameras as well as other techniques such as sand plots as appropriate to determine pest animal species present in the offset area and indicative population numbers.

Methods for determining the presence and relative abundance for foxes, feral cats, rabbits and feral pigs are presented in Table 14. Evidence of pest animals, including feral horses, will be documented during the offset area inspections (see Section 7.1)

Table 14: Pest animal monitoring methodology

<table>
<tr><th>Pest animal</th><th>Methodology to be implemented</th></tr>
<tr><td>Fox</td><td rowspan="3">To assess the relative abundance of foxes and feral cats within the offset area, camera monitoring will be undertaken as follows to provide a measure of the Catling index for each species. The Catling index will be measured as the percentage of camera nights in which the pest species was observed. An increase or decrease in the Catling index value between subsequent monitoring events will represent an increase or a decrease in the relative abundance of pest species and a measure of the success of pest animal control.
• fauna monitoring cameras will be placed in the offset area
• cameras will be placed along tracks and left in place for a minimum of three consecutive nights
• an analysis of the camera footage will be undertaken to determine the percentage of camera nights with animal captures for each species observed. This percentage represents the Catling index (Mitchell and Balogh 2007b, c).</td></tr>
<tr><td>Wild dog</td></tr>
<tr><td>Feral cat</td></tr>
<tr><td>Feral pig</td><td>An assessment of the presence or absence of feral pig signs as a measure of the relative abundance of feral pigs within the offset area in accordance with Mitchell and Balogh (2007a) and Hone (1988), will be undertaken as follows:
• nominate randomly stratified sites across the offset area in environments that are more regularly impacted (e.g. drainage lines, moist gullies, around swamps etc)
• calculate an abundance score for each transect as the percentage of ‘present’ feral pig signs
• calculate the mean abundance score (and variance) across all transects in the offset area.
The average frequency of occurrence across the offset area will be used as an index of abundance and compared between subsequent monitoring events to assess the effectiveness of feral pig control. Furthermore, changes to scores for individual sites/transects can point to areas to target control activities.
[a] Feral pig signs can include rooting, wallows, dung, footprints, travel pads, plant damage and tree rubs, as well as the physical presence of feral pigs</td></tr>
</table>

7.4 Offset value assessments

7.4.1 Rapid monitoring event

Rapid monitoring events will be carried out each year monitoring events are not completed for habitat quality assessments (Section 7.4.2) and targeted fauna survey (Section 7.4.4)

These will be aligned with the offset area inspections (see Section 7.1) and carried out by suitably qualified ecologists during spring and early summer (October to January) to coincide with the optimal time of year for fauna in the Brigalow Belt Bioregion (Eyre et al. 2018).

During each rapid monitoring field assessment, the following will be conducted:

- Incidental fauna surveys including early morning and late evening bird surveys and other MNES species will be conducted throughout the day by the ecologists.
- Photos will be taken at designated and fixed photo monitoring points as outlined in Section 7.4.3. The locations of the fixed photo monitoring points are shown in Figure 9.

7.4.2 Habitat quality assessment

A detailed baseline assessment of habitat quality was completed in April 2020, including establishment of BioCondition sites in all major vegetation communities.

Vegetation condition and habitat quality for each MNES will be assessed in accordance with the Guide to Determining Terrestrial Habitat Quality version 1.2, developed by the Queensland Government to measure the habitat quality of a land-based offset. The species habitat index component of the habitat quality score will be calculated based on the results of the targeted fauna surveys detailed in Section 7.4.4.

Fixed transects were established and assessed as part of the baseline in 2020 (see Figure 9). BioCondition assessments will be undertaken at each of the transects in year 1 and then every two years for the first six years, and then every three years thereafter. As part of year 1 monitoring activities, monitoring points will be marked with a capped stake and a GPS location will be recorded.

The results of habitat quality assessments for subsequent years will include summary data from previous reporting years, presented to allow trend analysis of each of the measured attributes and assess progress towards achieving the interim performance targets and completion criteria.

7.4.3 Photo monitoring

Photo monitoring is a qualitative analysis technique that provides the opportunity for visual time series analysis of changes in vegetation composition, structure and integrity. In areas where active management is being undertaken, photo monitoring offers a simple and effective visual means by which to capture the response of the vegetation to management actions. Photo monitoring will be conducted at all habitat quality assessment sites presented in Figure 9, based on best practice photo monitoring techniques, see Appendix 4 of BioCondition: A Condition Assessment Framework for Terrestrial Biodiversity in Queensland. Assessment Manual. Version 2.2. (Eyre et al. 2015).

Photo monitoring will be undertaken as part of habitat quality assessments (Section 7.4.2) and rapid monitoring events (Section 7.4.1).

7.4.4 Targeted fauna surveys

Targeted fauna surveys will be conducted to assess the distribution and richness of the fauna offset values within the offset area. The targeted fauna survey methods focus on the MNES species that are unlikely to be detected effectively during the rapid assessment surveys due to cryptic behaviour or localised habitat requirements. Targeted surveys will be undertaken generally in accordance with recommended surveys guidelines from the Queensland and Commonwealth governments and/or other reputable published guidelines. Table 15 provides a summary of the proposed methodology, search effort and timing for targeted surveys. It is important to note that the proposed survey methodology will be reviewed prior to each survey event and if considered necessary will be modified to ensure they are based on the ecology, habitat requirements and behavioural aspects of the species of interest.

Targeted fauna surveys will be carried out in conjunction with habitat quality assessments in year 1 and then every two years for the first six years, and then every three years thereafter.

Table 15: Fauna species survey methods

Technique	Regime	Target and method
Elliot B (Box Trap) or Cage Trap	Four per site over four consecutive nights, checked early morning, reopened late afternoon.	Baited with a mixture of oats, peanut butter, vegetable oil and sardines. Placed within suitable micro-habitat for northern quoll.
Funnel Trap	Six at each of five trap sites over four consecutive nights, checked early morning and afternoon.	Placed in pairs either side along a 30m drift-fence. Targeting Dunmall's snake and collared delma.
Anabat	Three units overnight for four consecutive nights	Left overnight on site near entrances to possible roost sites for large-eared pied bat, if considered present, and/or along flyways and near waterbodies.
Harp Trap	Two per night for four consecutive nights, locations chosen based on presence of suitable flyways	Targeting south-eastern long-eared bat, which is not identifiable by ultrasonic calls. Also large-eared pied bat.
Camera Trap	10 over at least 14 consecutive nights	Focused on stations baited with a mixture of oats, peanut butter, vegetable oil and sardines. Targeting northern quoll and possibly yakka skink. (Fleming et al. 2014).
Spotlighting	Meander along watercourses.	Targeting koala. This will also target Dunmall's snake.
Spotlighting	Rocky areas.	Targeting northern quoll and collared delma.
Spotlighting	By vehicle along tracks.	Targeting Dunmall's snake.
Scat Search	Conducted in habitat considered suitable for target species.	Targeting koala and northern quoll. The Spot Assessment Technique (SAT), or a variation, were used to survey for koalas within suitable habitat within the site.
Bird Survey	At waterbodies.	Targeting Australian painted snipe, Australasian bittern and squatter pigeon.
Bird Survey	Meander along watercourses during the day.	Targeting nest sites for red goshawk. Includes diurnal koala search.
Track Traverse	By vehicle and on foot.	Targeting squatter pigeon.
Diurnal Herpetofauna Search	Late morning/early afternoon.	Conducted by two searchers, duration is determined by site-specific habitat quality and presence of suitable micro-habitat. Targeting collared delma, Dunmall's snake and yakka skink.
Platelet Search	In suitable habitat.	Targeting black-breasted button-quail.

7.4.5 Brigalow stem counts

Brigalow regrowth within the offset area will be monitored to assess the stem density of dominant species to inform any requirement for selective thinning within the vegetation community.

As described in Section 6.2.3 selective thinning of Brigalow regrowth will be considered where the density of a dominant tree species within the vegetation community is >10,000 stems/ha and the density of stems is considered to be effecting the sites capacity to return to remnant status.

The number of stems per dominant tree species will be counted in 25 m x 25 m plots within Brigalow regrowth offset areas. The location of each 25 m x 25 m plot will be nested in the habitat quality monitoring locations presented in Figure 9 and will be established as part of the first monitoring event following approval of this OAMP. Stem density assessments will be undertaken in year 1, and then every two years for the first six years, and then every three years thereafter.

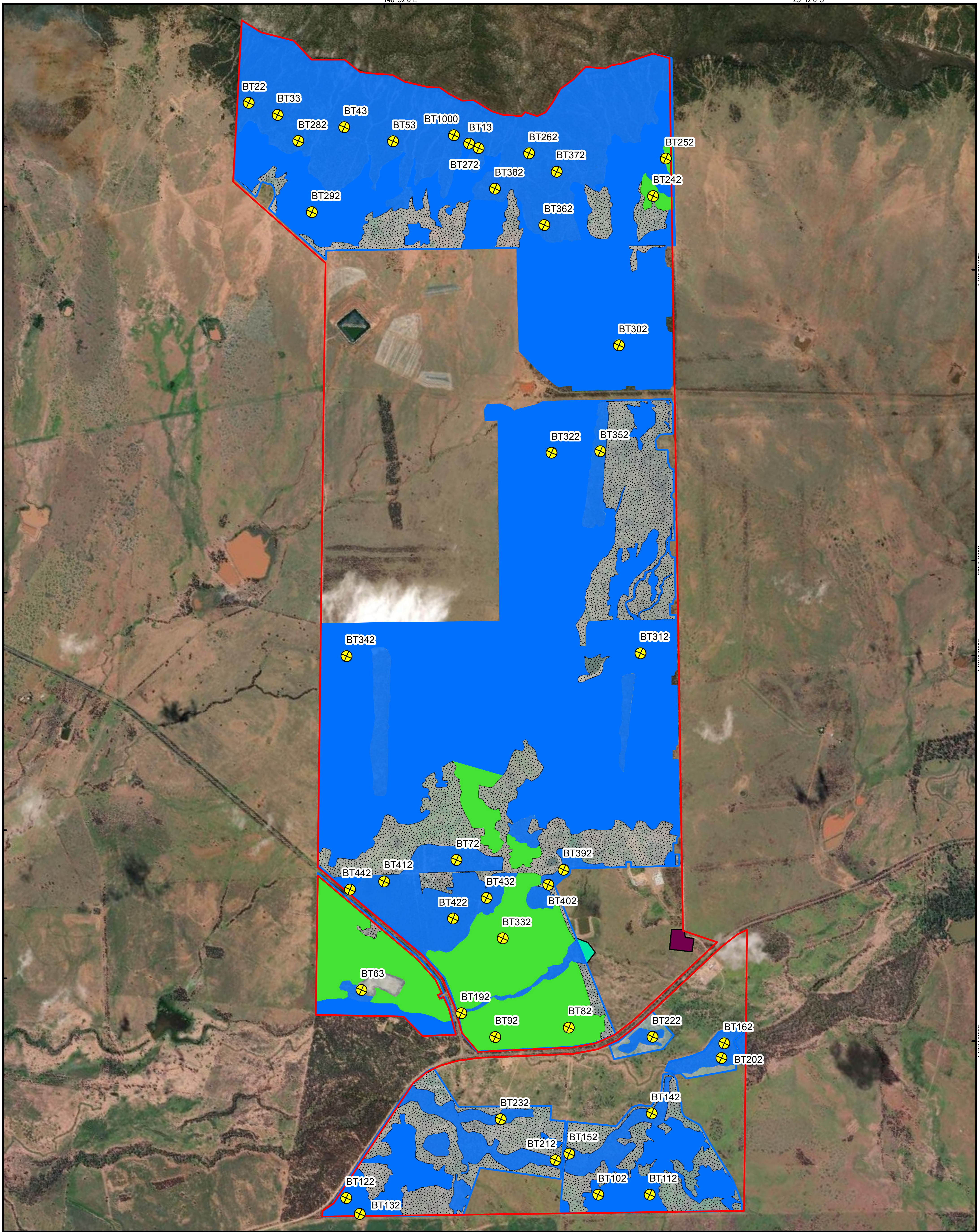


Figure 9
Bottle Tree monitoring sites

Bottle Tree - 7TR39
Bottle Tree offset area
Future habitat areas

Existing offset area (EPBC 2008/4096)
Ooline (Cadelia pentasylis) offset area
Xerothamnella herbacea offset area

Habitat quality assessment sites

MNES habitat within Bottle Tree offset area
Extent of current MNES offset habitat
Rehabilitation offset (EPBC 2008/4059 condition 34)

0 0.5 1 1.5 2
Kilometres

CO2 Australia

Location diagram

DATA SOURCE:
The following datasets are © State of Qld:
- Cadastral data
- Existing offset area (PMAV 2016/006243, PMAV 2018/004187)
Bottle Tree offset area and habitat quality assessment sites provided by SANTOS

Date: 7/30/2021 Coordinate System: GDA 1994 MGA Zone 55 Projection: Transverse Mercator Datum: GDA 1994 Scale: 1:32,500@A3

Path: P:\GISData\Projects\Santos\ENV_20_00419.GTP_Offset_Maps\Bottle Tree\Figure 9 - Monitoring points.mxd

8.0 Reporting

8.1 Reporting

A report detailing the progress of the offset area in achieving the interim performance targets and completion criteria will be prepared for each management year by the suitably qualified ecologist responsible for conducting the monitoring. The report will contain, at a minimum:

- a description of the monitoring conducted, when it was conducted, and by whom
- a discussion of the weather in the lead up to and during the monitoring
- results of monitoring events conducted
- an overview of the management actions implemented since the last report
- a description of the performance criteria not met, any triggers that have been exceeded and the corrective actions that were implemented
- an indication of any risks or potential threats that have become apparent to the management area since the development of this management plan, and activities to be undertaken to manage these threats and/or risks
- progress towards achieving the interim performance targets and completion criteria.

8.2 Update of OAMP

The OAMP will be reviewed, audited and updated every 5 years. In addition, the OAMP will be updated in accordance with the principles of adaptive management, if required, to incorporate any changes identified through management activities, site visits and monitoring activities. This may include the revision of current management actions, identification of additional activities (including monitoring activities) and responses to adaptive management triggers, other environmental threats to the offset area, information obtained through research programs.

9.0 Implementation schedule

Table 16 and Table 17 summarise the implementation schedule for the management, monitoring and reporting activities presented in this OAMP. Santos will be wholly responsible for the implementation of this OAMP and reporting on the performance of the offset area in meeting the offset obligations under EPBC Approval 2008/4096 and Section 4.0 of this OAMP.

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Table 16: Implementation of management actions

Activity		Management years ✓ Activity required ■ Activity to be carried out as required																				Timing	Related monitoring
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20		
General restrictions (Section 6.2.1)	Access, vehicles, vegetation clearing, weed hygiene	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	At all times	General offset inspections (Section 7.1)
Access tracks (Section 6.2.2)	Maintenance/new tracks	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	As required	
Fencing (Section 6.2.4)	Construction of additional fencing to support livestock exclusion and strategic grazing	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	As required	
	Maintenance	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		
Fire management (Section 6.2.5)	Fuel hazard reduction burns	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	As required	Biomass monitoring (Section 7.2)
Grazing (Section 6.2.5.1)	Strategic grazing	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	As required based on the results of biomass monitoring, and informed by weed monitoring	Biomass monitoring (Section 7.2) Weed monitoring (Section 7.2)
Weed management (Section 6.2.6)	Buffel grass and other weeds	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	Control activities in addition to strategic grazing to be undertaken as required	Weed monitoring (Section 7.2)
Pest animal management (Section 6.2.7)	Wild dog, feral cat; fox, pig and feral horse	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	Control activities to be undertaken as required	Pest animal monitoring (Section 7.3)
Brigalow regrowth restoration (Section 6.2.3)	Brigalow regrowth thinning	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	Thinning to be undertaken as required should stem density become >10,000 stems/ha and the density of stems is considered to be affecting the sites capacity to return to remnant status	Brigalow stem counts (Section 7.4.5)
Reporting (Section 8.0)	Annual reporting	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	Annual reports to be prepared each year.	Reporting (Section 8.0)
	Update OAMP					■					■					■					■	The OAMP will be reviewed, audited and updated every 5 years.	

Table 17: Implementation of monitoring events

Survey or monitoring objective	Monitoring activity	Management years ✓ Activity required ■ Activity to be carried out as required																				Timing	Survey/monitoring guidelines	Reliability
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20			
Offset area inspections (Section 7.1)	Twice yearly inspections of to enable a general assessment of the offset area and identify any potential issues that may require remedial action. See Section 7.1 for the criteria to be assessed as part of each inspection.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	Inspections will be undertaken at least twice a year. Usually at the end of the wet season and the end of the dry season, with one of the inspections occurring prior to the submission of the annual report	See Section 7.1 for a list of potential issues to be inspected	General assessment of the offset management areas to identify any potential issues that may require remedial action to be undertaken
Biomass monitoring (Section 7.2)	Biomass monitoring for fire management and to inform strategic grazing regime.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	Twice every year at the end of the wet season (April) and towards the end of the dry season (October)	Assessment against Future Beef photo standards (Section 7.2)	Methodology developed by the Queensland Government
Fuel load monitoring (Section 7.1)	Assessment of the fuel hazard rating within the offset area to inform fire management strategies.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	Annually at the end of the wet season (April)	Overall Fuel Hazard Assessment Guide (Hines et al. 2010; Appendix E)	Method developed by the Victorian Government
Weed monitoring (Section 7.2)	Ongoing weed surveys to assess the effectiveness of weed control	✓		✓		✓		✓		✓		✓		✓		✓		✓		✓		Every two years post wet season	NSW Guidelines for Monitoring weed Control and recovery of native vegetation (Auld 2009) Photo monitoring of selected sites to assess visual changes in weed species and infestations over time. The use of precision unmanned aerial vehicles (drone) technology, aerial imagery and/or remote sensing.	Assessment will be undertaken generally in accordance with published, reputable guidelines
Pest animal monitoring (Section 7.3)	Ongoing pest animal surveys to assess the effectiveness of pest animal control	✓		✓		✓		✓		✓		✓		✓		✓		✓		✓		Every two years post wet season	Monitoring method outlined in Section 7.3	Assessment undertaken generally in accordance with published monitoring techniques developed by the NSW Government

Survey or monitoring objective	Monitoring activity	Management years ✓ Activity required ■ Activity to be carried out as required																				Timing	Survey/monitoring guidelines	Reliability
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20			
Offset value assessments	Rapid monitoring events		✓		✓		✓	✓		✓	✓		✓	✓		✓	✓		✓	✓		Each year monitoring events are not completed for habitat quality assessments (Section 7.5.2), targeted fauna survey (Section 7.5.4)	See Section 7.4.1	
	Assessment of vegetation condition and habitat quality	✓		✓		✓			✓			✓			✓			✓			✓	Year one, and then every two years for the first six years, and then every three years thereafter.	Guide to Determining Terrestrial Habitat Quality version 1.2	Assessment undertaken in accordance with method developed by the Queensland Government and aligns with the EPBC Act Environmental Offsets Policy measure of 'habitat quality' and is intended to provide a consistent framework for environmental offsets in Queensland
	Photo monitoring	✓		✓		✓			✓			✓			✓			✓			✓		Photos at each photo monitoring point will be taken in a north, east, south and westerly direction. A record of the photographs will be maintained, including GPS co-ordinates, date and time of each photograph and the direction in which the photograph was taken	Based on best practice photo monitoring techniques, see Appendix 4 of BioCondition: A Condition Assessment Framework for Terrestrial Biodiversity in Queensland. Assessment Manual. Version 2.2. (Eyre et al. 2015)
	Targeted fauna surveys	✓		✓		✓			✓			✓			✓			✓			✓		See methods outlined in Section 7.4.4	Techniques for fauna surveys are based on recommended survey guidelines published by the Queensland and Commonwealth governments

Survey or monitoring objective	Monitoring activity	Management years ✓ Activity required ■ Activity to be carried out as required																				Timing	Survey/monitoring guidelines	Reliability
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20			
	Brigalow stem counts	✓		✓		✓			✓			✓			✓			✓			✓		See methods outlined in Section 7.4.5	Guidance for thinning of Brigalow regrowth and monitoring based on published research Peeters and Butler 2014; Dwyer and Mason 2017.

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APPENDIX A

Baseline habitat quality score for Bottle Tree offset area

Table A1: Baseline habitat quality score for Bottle Tree offset area (sites BT13 – BT242)

Site	BT13	BT22	BT33	BT43	BT53	BT63	BT72	BT82	BT92	BT102	BT112	BT122	BT132	BT142	BT152	BT162	BT192	BT202	BT212	BT222	BT232	BT242
RE	11.9.5	11.10.4	11.10.4	11.10.4	11.10.4	11.10.7	11.9.5a	11.3.17	11.3.17	11.3.17	11.3.17	11.3.17	11.3.17	11.3.2	11.3.2	11.3.2	11.3.25	11.3.25	11.3.25	11.3.27	11.3.27	11.9.4
Site type*	Adv	Rem	Rem	Rem	Rem	Rem	Rem	Adv	Yng	Yng	Yng	Yng	Yng	Rem	Adv	Rem	Adv	Rem	Rem	Rem	Rem	Yng
Site condition (/10)	4.875	6.25	5.5	6.1875	6.5625	4.375	5.75	4.3125	5.4375	2.75	2.875	2.125	3.0625	3.875	5	4.875	7.125	5.75	6.125	6.875	6.25	1.625
Site context (/10)	7	8	9	9	9	5.5	7	5	6	3.5	3.5	3.5	3.5	6.5	5.5	5.5	6	5.5	5.5	2	4.5	6
Habitat quality score /10 (site condition 60%, site context 40%)																						
SEVT TEC																						3.375
Brigalow TEC	5.725						6.25															
Species habitat index /10																						
Australian painted snipe																				7.6	7.6	
Australasian bittern																				7.6	7.6	
Northern quoll	8.2	8.2	8.2	8.2	8.2	5.4	5	3.4	3.4	3.4	3.4	3.4	3.4	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4
Black-breasted button-quail							4.4															2.8
Collared delma	5.6	6.6	6.6	6.6	6.6	5.4	5	5	2.2	2.2	2.2	2.2	2.2	4.2	4.2	4.2						2.8
Dunmall's snake	7.2	8.2	8.2	8.2	6.6	6	6	5	3.4	3.4	3.4	3.4	3.4	6	6	6						
Large-eared pied bat	7.8	8.8	8.8	8.8	8.8	6	6.2	4.6	4	4	4	4	4	6.4	6.4	6.4	6.4	7.2	7.2	4.6	4.6	4
Ornamental snake								5	5	5	5	5	5	5	5	5	5	5	5	5	5	
Red goshawk	7.2	7.2	7.2	7.2	7.2	5.6	5.6	4.8	4	4	4	4	4	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	4
Squatter pigeon		4.8	4.8	4.8	4.8	4.8		4.8	4	4	4	4	4	7.6	7.6	7.6	7.6	7.6	7.6			
Yakka skink	5.6	7.6	7.6	7.6	7.6	7	5	3.4	2.2	2.2	2.2	2.2	2.2	7.6	7.6	7.6						
South-eastern long-eared bat	4.8	7.2	7.2	7.2	7.2	5.6	5.6	4.8	4	4	4	4	4	9.2	9.2	9.2	8.2	9.2	9.2	5.6	5.6	4
Habitat quality score fauna species /10 (site condition 30%, site context 30%, species habitat index 40%)																						
Australian painted snipe																				5.70	6.27	
Australasian bittern																				5.70	6.27	
Northern quoll	6.84	7.56	7.63	7.84	7.95	5.12	5.83	4.15	4.79	3.24	3.27	3.05	3.33	4.79	4.83	4.79	5.62	5.06	5.17	4.34	4.91	3.89
Black-breasted button-quail							6.31															3.41
Collared delma	5.80	6.92	6.99	7.20	7.31	5.12	5.83	4.79	4.31	2.76	2.79	2.57	2.85	4.79	4.83	4.79						3.41
Dunmall's snake	6.44	7.56	7.63	7.84	7.31	5.36	6.23	4.79	4.79	3.24	3.27	3.05	3.33	5.51	5.55	5.51						
Large-eared pied bat	6.68	7.80	7.87	8.08	8.19	5.36	6.31	4.63	5.03	3.48	3.51	3.29	3.57	5.67	5.71	5.67	6.50	6.26	6.37	4.50	5.07	3.89
Ornamental snake								4.79	5.43	3.88	3.91	3.69	3.97	5.11	5.15	5.11	5.94	5.38	5.49	4.66	5.23	
Red goshawk	6.44	7.16	7.23	7.44	7.55	5.20	6.07	4.71	5.03	3.48	3.51	3.29	3.57	6.79	6.83	6.79	7.62	7.06	7.17	6.34	6.91	3.89
Squatter pigeon		6.20	6.27	6.48	6.59	4.88		4.71	5.03	3.48	3.51	3.29	3.57	6.15	6.19	6.15	6.98	6.42	6.53			
Yakka skink	5.80	7.32	7.39	7.60	7.71	5.76	5.83	4.15	4.31	2.76	2.79	2.57	2.85	6.15	6.19	6.15						
South-eastern long-eared bat	5.48	7.16	7.23	7.44	7.55	5.20	6.07	4.71	5.03	3.48	3.51	3.29	3.57	6.79	6.83	6.79	7.22	7.06	7.17	4.90	5.47	3.89

* Site type: Rem – remnant; Adv – regrowth (advanced); Yng – regrowth (young).

Table A2: Baseline habitat quality score for Bottle Tree offset area (sites BT252 – BT1000)

Site	BT252	BT262	BT272	BT282	BT292	BT302	BT312	BT322	BT332	BT342	BT352	BT362	BT372	BT382	BT392	BT402	BT412	BT422	BT432	BT442	BT1000
RE	11.9.4	11.9.4	11.9.4	11.9.4	11.9.5	11.9.5	11.9.5	11.9.5	11.9.5	11.9.5	11.9.5	11.9.5	11.9.5	11.9.5	11.9.5	11.9.5	11.9.5a	11.9.5a	11.9.5a	11.9.5a	11.9.4
Site type*	Yng	Rem	Rem	Adv	Yng	Yng	Yng	Yng	Yng	Yng	Adv	Adv	Adv	Adv	Rem	Adv	Rem	Rem	Adv	Rem	Rem
Site condition (/10)	2.25	6.0625	5.8125	6.125	3.125	2.625	2.625	1.0625	3.5625	2.375	3.375	3.125	4.1875	2.9375	6.25	5.625	7.1875	7.25	6.125	6.9375	5.3125
Site context (/10)	6	9	9	9	6	6	5	5	7	5	5	7	8	8	6	6	6	7	8	7	9
Habitat quality score /10 (site condition 60%, site context 40%)																					
SEVT TEC	3.75	7.2375	7.0875	7.275																	6.7875
Brigalow TEC					3.975	3.575	2.6375	4.9375	3.425	4.025	4.675	5.7125	4.9625	6.15	5.775	6.7125	7.15	6.875	6.9625	3.975	
Species habitat index /10																					
Australian painted snipe																					
Australasian bittern																					
Northern quoll	4	7.2	7.2	7.2	4	3.4	3.4	3.4	3.4	3.4	4.2	6.4	6.4	6.4	4.2	4.2	4.2	4.2	4.2	4.2	7.2
Black-breasted button-quail	2.8	8.2	8.2	5.6													4.4	4.4	4.4	4.4	6.2
Collared delma	2.8	6.6	6.6	6.6	2.8	2.2	2.2	2.2	3	2.2	5	5.6	5.6	5.6	5	5	5	5	5	5	6.6
Dunmall's snake					5.6	3.4	3.4	3.4	4.2	3.4	5	6.4	7.2	7.2	5.6	5	5.6	5.6	5	5.6	
Large-eared pied bat	4	7.8	7.8	7.8	4	4	4	4	4	4	5.4	7	7	7	5.4	5.4	5.4	5.4	5.4	5.4	7.8
Ornamental snake																					
Red goshawk	4	5.6	5.6	5.6	4	4	4	4	4	4	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6
Squatter pigeon																					
Yakka skink					2.8	2.2	2.2	2.2	2.2	2.2	3.8	4.8	5.6	5.6	5	5	4.2	4.2	3.4	3.4	
South-eastern long-eared bat	4	5.6	5.6	5.6	4	4	4	4	4	4	4.8	4.8	4.8	4.8	5.6	4.8	5.6	5.6	5.6	5.6	5.6
Habitat quality score fauna species /10 (site condition 30%, site context 30%, species habitat index 40%)																					
Australian painted snipe																					
Australasian bittern																					
Northern quoll	4.08	7.40	7.32	7.42	4.34	3.95	3.65	3.18	4.53	3.57	4.19	5.60	6.22	5.84	5.36	5.17	5.64	5.96	5.92	5.86	7.17
Black-breasted button-quail	3.60	7.80	7.72	6.78													5.72	6.04	6.00	5.94	6.77
Collared delma	3.60	7.16	7.08	7.18	3.86	3.47	3.17	2.70	4.37	3.09	4.51	5.28	5.90	5.52	5.68	5.49	5.96	6.28	6.24	6.18	6.93
Dunmall's snake					4.98	3.95	3.65	3.18	4.85	3.57	4.51	5.60	6.54	6.16	5.92	5.49	6.20	6.52	6.24	6.42	
Large-eared pied bat	4.08	7.64	7.56	7.66	4.34	4.19	3.89	3.42	4.77	3.81	4.67	5.84	6.46	6.08	5.84	5.65	6.12	6.44	6.40	6.34	7.41
Ornamental snake																					
Red goshawk	4.08	6.76	6.68	6.78	4.34	4.19	3.89	3.42	4.77	3.81	4.75	5.28	5.90	5.52	5.92	5.73	6.20	6.52	6.48	6.42	6.53
Squatter pigeon																					
Yakka skink					3.86	3.47	3.17	2.70	4.05	3.09	4.03	4.96	5.90	5.52	5.68	5.49	5.64	5.96	5.60	5.54	
South-eastern long-eared bat	4.08	6.76	6.68	6.78	4.34	4.19	3.89	3.42	4.77	3.81	4.43	4.96	5.58	5.20	5.92	5.41	6.20	6.52	6.48	6.42	6.53

* Site type: Rem – remnant; Adv – regrowth (advanced); Yng – regrowth (young).

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APPENDIX B

Bottle Tree offset area boundary co-ordinates (GDA94)

Point	Easting	Northing
1	687362	7216478
2	687333	7216265
3	687386	7215944
4	687291	7215714
5	687418	7215425
6	687372	7215243
7	687471	7214949
8	687461	7214812
9	687506	7214583
10	687547	7214483
11	687518	7214246
12	687567	7214132
13	687552	7213825
14	687612	7213657
15	687663	7213638
16	687674	7213519
17	687739	7213459
18	688005	7213422
19	688297	7213285
20	688355	7213111
21	688410	7213064
22	688472	7212969
23	688677	7212745
24	688710	7212568
25	687079	7211808
26	687037	7211880
27	686892	7211834
28	686852	7211752
29	686449	7211565
30	686422	7211616
31	686332	7211574

Point	Easting	Northing
32	686296	7211530
33	686292	7211493
34	685861	7211293
35	685807	7211297
36	685676	7211577
37	685706	7211608
38	685665	7211696
39	685603	7211733
40	685414	7212137
41	685456	7212162
42	685395	7212267
43	685551	7212756
44	686443	7213178
45	685674	7214842
46	685594	7214808
47	685819	7215510
48	685924	7215501
49	685990	7215523
50	686038	7215578
51	686028	7215656
52	685963	7215670
53	685871	7215671
54	685953	7215927
55	684952	7212826
56	685007	7212714
57	685013	7212615
58	684995	7212568
59	685059	7212501
60	685146	7212389
61	685196	7212352
62	685716	7211243

Point	Easting	Northing
63	685683	7211211
64	685424	7211091
65	685370	7211194
66	685303	7211218
67	685226	7211174
68	685262	7211075
69	685145	7211014
70	685115	7210947
71	684916	7210855
72	684874	7210864
73	684845	7210822
74	684494	7210660
75	684473	7210705
76	684378	7210667
77	684362	7210648
78	684347	7210591
79	683990	7210426
80	683962	7210436
81	683933	7210426
82	683916	7210452
83	683826	7210409
84	683846	7210360
85	683373	7210140
86	683342	7210151
87	683316	7210142
88	683300	7210169
89	683207	7210121
90	683229	7210074
91	682725	7209840
92	682696	7209850
93	682668	7209841

Point	Easting	Northing
94	682650	7209868
95	682562	7209827
96	682581	7209774
97	681923	7209469
98	681895	7209478
99	681850	7209460
100	681832	7209488
101	681742	7209445
102	681762	7209395
103	681663	7209350
104	681464	7209767
105	681507	7209788
106	681487	7209830
107	681444	7209810
108	681213	7210294
109	681172	7210280
110	681136	7210291
111	681097	7210320
112	681050	7210341
113	681004	7210364
114	679938	7209252
115	679780	7209397
116	679661	7209576
117	679247	7210398
118	679338	7210588
119	679525	7210731
120	679766	7210966
121	679888	7211233
122	680259	7212518
123	682382	7213429
124	683105	7211869
125	684867	7212674
126	684809	7212783
127	684899	7212831
128	680189	7212488
129	679832	7211251
130	679714	7210999
131	679631	7210917
132	679595	7210948
133	679568	7210916

Point	Easting	Northing
134	679601	7210883
135	679519	7210798
136	679313	7210648
137	679169	7210933
138	679269	7211188
39	678948	7211955
140	680281	7209018
141	680157	7208737
142	679996	7208776
143	679715	7209167
144	679817	7209263
145	679885	7209195
146	679907	7208673
147	680046	7208498
148	680139	7208409
149	680369	7208347
150	680532	7208163
151	680486	7208141
152	680459	7208144
153	680386	7208180
154	680358	7208188
155	680334	7208187
156	680263	7208113
157	680238	7208093
158	680222	7208073
159	680189	7208077
160	680151	7208080
161	680097	7208056
162	679826	7208458
163	679849	7208525
164	679831	7208563
165	679837	7208619
166	679814	7208674
167	680472	7208121
168	680173	7207992
169	680183	7208021
170	680173	7208041
171	680160	7208061
172	680216	7208050
173	680235	7208058

Point	Easting	Northing
174	680252	7208078
175	680276	7208098
176	680331	7208157
177	680345	7208169
178	680363	7208168
179	680423	7208137
180	679774	7208674
181	679804	7208612
182	679801	7208576
183	679773	7208537
184	679619	7208437
185	679592	7208406
186	679520	7208368
187	679487	7208328
188	679473	7208161
189	679347	7207992
190	679135	7207676
191	678944	7207483
192	678881	7207457
193	678169	7209010
194	678173	7209044
195	678987	7209333
196	679135	7208888
197	679368	7208820
198	679409	7208771
199	679445	7208659
200	679621	7208629
201	679760	7208674
202	678932	7210709
203	678690	7210344
204	679062	7209532
205	678934	7209487
206	678980	7209352
207	678591	7209216
208	678546	7209208
209	678530	7209195
210	678456	7209168
211	678239	7209916
212	677760	7209880
213	677196	7211108

Point	Easting	Northing
214	677239	7211123
215	677346	7211069
216	678712	7210834
217	678881	7210755

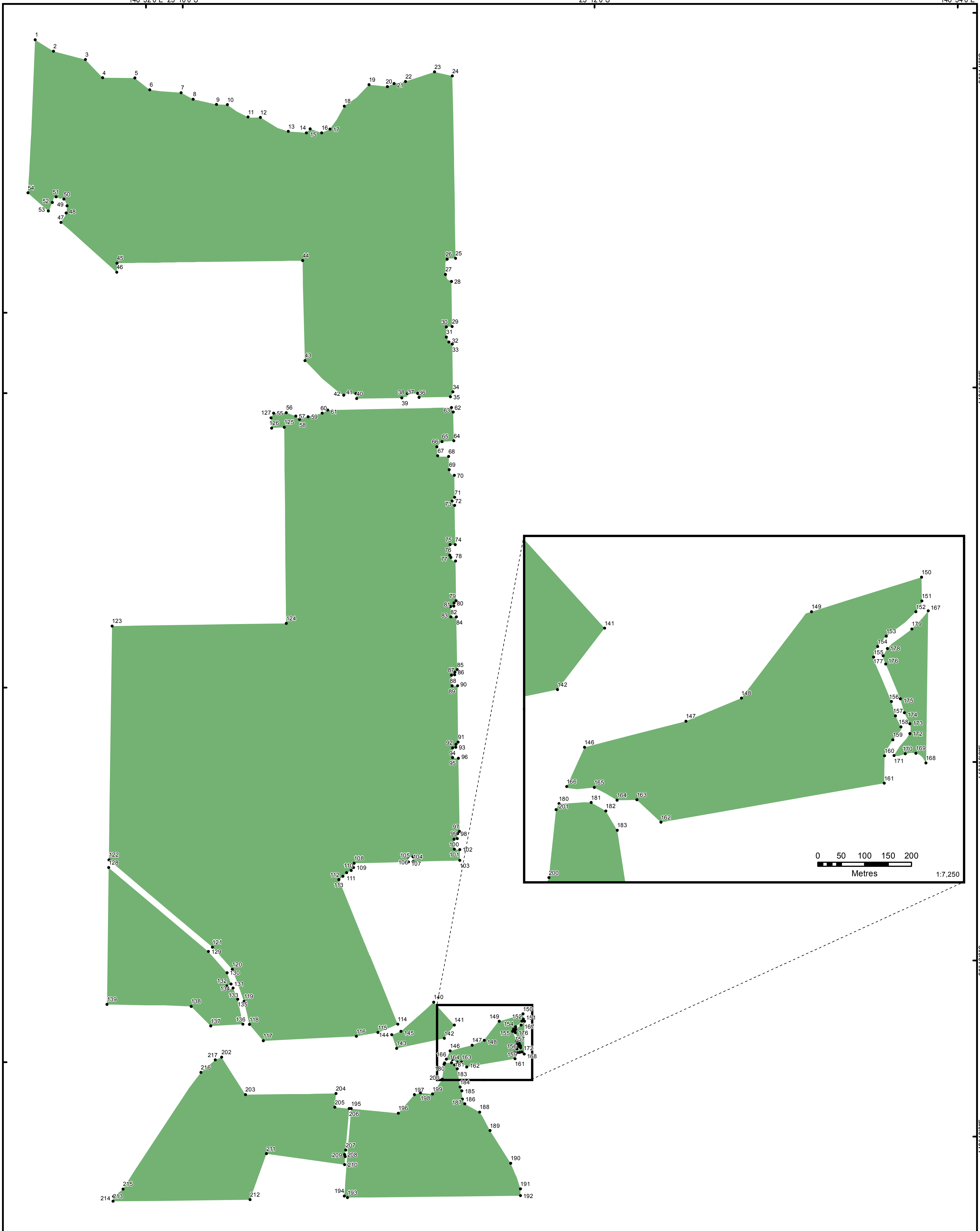

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Figure B-1
Bottle Tree offset area boundary coordinates

Bottle Tree offset area

Reference coordinates

Location diagram

0 0.25 0.5 0.75 1
Kilometres

N

CO2 Australia

Date: 6/11/2021 Coordinate System: GDA 1994 MGA Zone 55 Projection: Transverse Mercator Datum: GDA 1994 Scale: 1:33,500@A3

Path: P:\GISData\Projects\Santos\ENV_20_004\3 GTP_Offset_Maps\Bottle Tree\Figure B-1 - Offset area boundary co-ordinates.mxd

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APPENDIX C

Risk Assessment

Risk Assessment Summary

The following risk assessment assess the potential risk of failing to achieve the management objectives, interim performance targets and completion criteria for the offset area as outlined in this OAMP.

For each risk identified, the potential consequence of the risk (rated from 1 (no impact) to 6 (irreversible impact; Table D1) was assessed against the likelihood of that risk occurring (Table D2) to determine a risk rating. The risk rating was evaluated by using the matrix in Table D2.

The consequence and likelihood of each risk was first considered without the management measures in place to provide an initial risk rating. The consequence and likelihood of each risk occurring was then reassessed following the implementation of the management measures to provide a residual risk rating.

Table D3 provides the risk register which was used to document the findings of the risk assessment process.

Table C1: Consequence rating relative to offset value

	Consequence
I	No impact to MNES Value
II	Small-scale impact to MNES
III	Moderate-scale impact to MNES
IV	Large-scale impact to MNES
V	Extensive population or community scale impact to MNES
VI	Irreversible impact to MNES.

Table C2: Likelihood classification and risk matrix

Santos Risk Matrix

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Consequence	Negligible Harm (I)	Minor Harm (II)	Moderate Harm (III)	Severe Harm (IV)	Single Fatality OR Critical Life Threatening Injuries (V)	Multiple Fatalities (VI)
Safety	**Negligible Harm** + No bodily damage or minimal harm or impairment (hours to days)	**Minor Harm** + Short term impairment (days to weeks)	**Moderate Harm** + Temporary disablement or medium term impairment (weeks to months)	**Severe Harm** + Long term/life altering disablement or impairment	**Single Fatality OR Critical Life Threatening Injuries**	**Multiple Fatalities**
Environment	+ No impact to Environmental Value (EV).	+ Small-scale impact to EV(s) of conservation significance + Potential surface or groundwater impact.	+ Moderate-scale impact to EV(s) of conservation significance + Localised surface or groundwater impact.	+ Large-scale impact to EV(s) of conservation significance + Moderate-scale surface water impact; + Localised impact to groundwater with potential or known beneficial use.	+ Extensive population or community scale impact to EV(s) of conservation significance + Extensive impact to other EV(s).	+ Irreversible impact to EV(s).
Community & Reputation	+ No actual or potential community criticism + Details remain within Santos sites and/or offices	+ Minor level local community criticism (< week) + No reputation impact	+ Local community criticism (> week) or one-day community protest + Local company reputation impacted	+ State-level community criticism or protest over multiple days/locations + State-based company reputation impacted + Very short-term share price impact (< week)	+ National community criticism or large scale protest + Company reputation and approvals impacted + Shareholder intervention or short-term share price impact (< month)	+ Sustained national community criticism or widespread protest + Industry reputation and approvals impacted + Changes at executive/board level or long-term share price impact (> month)
Financial (A$)	< $30k	$30k to $300k	$300k to $3m	$3m to $30m	$30m to $300m	> $300m
Workforce	+ Will require some staff attention over several days. + No actual or potential impact to culture	+ Will require several days local management time. + Minor impact to employee engagement and limited staff turnover	+ Will require head office staff and take several weeks of site management time. + Moderate impact to employee engagement and staff turnover above industry average with some key roles	+ Will require several weeks of senior management time + Impact to employee engagement (< 6 months), moderate turnover of key roles and no succession	+ Will require several months of senior management time + Impact to employee engagement (< 18 months), high staff turnover and attraction issues	+ Will require more than a year of senior management involvement and operations severely disrupted + Impact to employee engagement (> 18 months), significant key role turnover and attraction issues
Compliance	+ Non-conformance with legislation, instruments (e.g. tenure licence) or contract + No regulatory or punitive action	+ Minor breach of legislation, instruments or contract + Notification/report to; request for information by; and/or administrative/ warning notice from the regulator + LOCI Tier 3 or non-hydrocarbon releases notifiable to the regulator	+ Limited number of minor breaches of legislation, instruments or contract + Statutory notice from the regulator + LOCI Tier 2 or non-hydrocarbon releases immediately reportable to the regulator	+ Systemic minor breaches (or one moderate breach) of legislation, instruments or contract + Company charged with an offence with minor penalty/fine + LOCI Tier 1 or cumulative regulator notification of non-hydrocarbon releases	+ Systemic moderate breaches (OR single material breach) of legislation, instruments or contract + Company charged with an offence with moderate penalty/fine	+ Material breaches of legislation, instruments or contract + Company or officers charged with an offence with material penalty/fine, or loss of tenure/operatorship
	I	II	III	IV	V	VI

Likelihood		I	II	III	IV	V	VI
ALMOST CERTAIN (< 4 monthly) Occurs in almost all circumstances OR could occur *within days to weeks*	f	Low	Medium	High	Very High	Very High	Very High
LIKELY (4 monthly - 1 yearly) Occurs in most circumstances OR could occur *within weeks to months*	e	Low	Medium	High	High	Very High	Very High
OCCASIONAL (1 - 3 yearly) Has occurred before in Santos OR could occur *within months to years*	d	Low	Low	Medium	High	High	Very High
POSSIBLE (3 - 10 yearly) Has occurred before in the industry OR could occur *within the next few years*	c	Very Low	Low	Low	Medium	High	Very High
UNLIKELY (10 - 30 yearly) Has occurred elsewhere OR could occur *within decades*	b	Very Low	Very Low	Low	Low	Medium	High
REMOTE (30 - 100 yearly) Requires exceptional circumstances and is unlikely even in the long term OR only occurs as a *"one in 100 year event"*	a	Very Low	Very Low	Very Low	Low	Medium	Medium

Table C3: Risk assessment

Management objective	Risk description	Initial risk rating			Control strategies	Residual risk rating		
		Likelihood	Consequence	Overall risk rating		Likelihood	Consequence	Overall risk rating
Achieve the completion criteria and habitat quality improvements for offset values and remnant status for those regrowth vegetation communities.	Completion criteria and habitat quality improvements are not achieved	D	IV	H	• Implementation of this OAMP, including the management actions and monitoring program outlined in Section 6.0 and Section 7.0. • Implementation of the adaptive management process outlined in Section 5.0 • Obtain advice with the aim of identifying appropriate additional management interventions if interim performance targets are not achieved for one or more offset values by year 5,10 or 15. • If it is considered that the completion criteria cannot be achieved, Santos will update this OAMP proposing alternative offset areas in order to acquit the required offset requirements in accordance with the offsets assessment guide. The revised OAMP will be submitted to the Commonwealth Government.	B	IV	L
Maintain the extent of offset value habitat within the offset area.	Habitat or vegetation loss through land clearing.	D	V	H	• Protection of the offset area via a Voluntary Declaration under section 19E and 19F of the VMA, as described in Section 2.9. • Comply with the restrictions outlined in Table 11. • Construction and maintenance of access tracks, fencing and firebreaks will be undertaken in accordance with Sections 6.2.2, 6.2.4 and 6.2.5 • Restoration of impacted areas subject to any unauthorised clearing.	B	V	M
Ensure that the livestock grazing restrictions for fire management and weed control assist in the enhancement of ground cover attributes for offset values and does not result in the degradation of habitat.	Degradation of offset value habitat quality as a result of livestock grazing	E	III	H	• Implementation of strategic grazing to reduce fuel loads and control exotic pasture grasses and promote the establishment of native perennial grass species in accordance with Section 6.2.5.1 • Annual biomass monitoring to inform strategic grazing regimes. • Rapid monitoring events and habitat quality assessments will be undertaken in accordance with Section 7.5.1 and 7.5.2 including an assessment of % cover of native perennial grasses	B	III	L
Minimise predation risk by wild dogs to threatened fauna species.	Predation of threatened fauna by wild dogs.	D	III	M	• Regular monitoring for pest animals will be undertaken in accordance with the methods detailed in Section 7.3 and pest animal control will be implemented following the results of monitoring in accordance with Section 6.2.7	C	III	L
Minimise predation risk by foxes to threatened fauna species.	Predation of threatened fauna by foxes.	D	III	M		C	III	L
Minimise predation risk by feral cats to threatened fauna species.	Predation of threatened fauna by cats.	D	III	M		C	III	L
Minimise degradation of offset value habitat by feral pigs.	Degradation of habitat by feral pigs.	D	III	M		C	III	L
Minimise degradation of offset value habitat by feral horses.	Degradation of habitat by feral horses.	D	III	M		C	III	L

Management objective	Risk description	Initial risk rating			Control strategies	Residual risk rating		
		Likelihood	Consequence	Overall risk rating		Likelihood	Consequence	Overall risk rating
Manage invasive weed species to reduce degradation of offset value habitat.	Invasion of habitat by weed species, including exotic grasses.	D	III	M	• Regular weed monitoring will be undertaken in accordance with Section 7.2 • Based on the results of monitoring events, weeds will be managed using biological, chemical and/or mechanical control in accordance with the control measures outlined in the Biosecurity Queensland Fact Sheets, for the relevant weed species (see Section 6.2.6)	C	III	L
Reduce the risk of adverse impacts to offset value habitat by inappropriate fire regimes or unplanned fire.	Decrease in the habitat quality score for any offset value from baseline and subsequent monitoring events as a result of fire management measures, or an unplanned fire.	D	IV	H	• Fuel loads within the offset area will be managed through strategic livestock grazing and fuel hazard reduction burns as outlined in Section 6.2.5 • Firebreaks will be established and maintained around the boundary of the offset area, with green firebreaks established where the offset area joins native vegetation. Firebreaks will be maintained at least annually in mid / late autumn and, or early spring to remove overhanging trees or fallen debris and dense vegetation	B	IV	L
Regrowth Brigalow vegetation managed to meet the criteria for remnant status.	Regrowth Brigalow does not achieve remnant status within the OAMP timeframes	D	III	M	• Selective regrowth thinning of Brigalow TEC where regrowth of Brigalow vegetation (RE 11.9.5) occurs at >10,000 stems per hectare in accordance with Section 6.2.3.	C	III	L

Achieve the interim performance targets and completion criteria for each offset value within 5, 10, 15 and 20 years, respectively.	Interim performance targets are not achieved for offset values by year 5, 10 or 15.
	Completion criteria are not achieved for offset values by year 20.
		E	III	H	• Monitoring of the offset area will be undertaken in accordance with Section 7.0 including:
					  ○ Offset area inspections (Section 7.1).
					  ○ Offset value assessments (Section 7.4)
					• The results of monitoring events will be compared against the interim performance targets and completion criteria to determine the progress of offset area and recorded as part of reporting (Section 7.4.5).
						B	III	L

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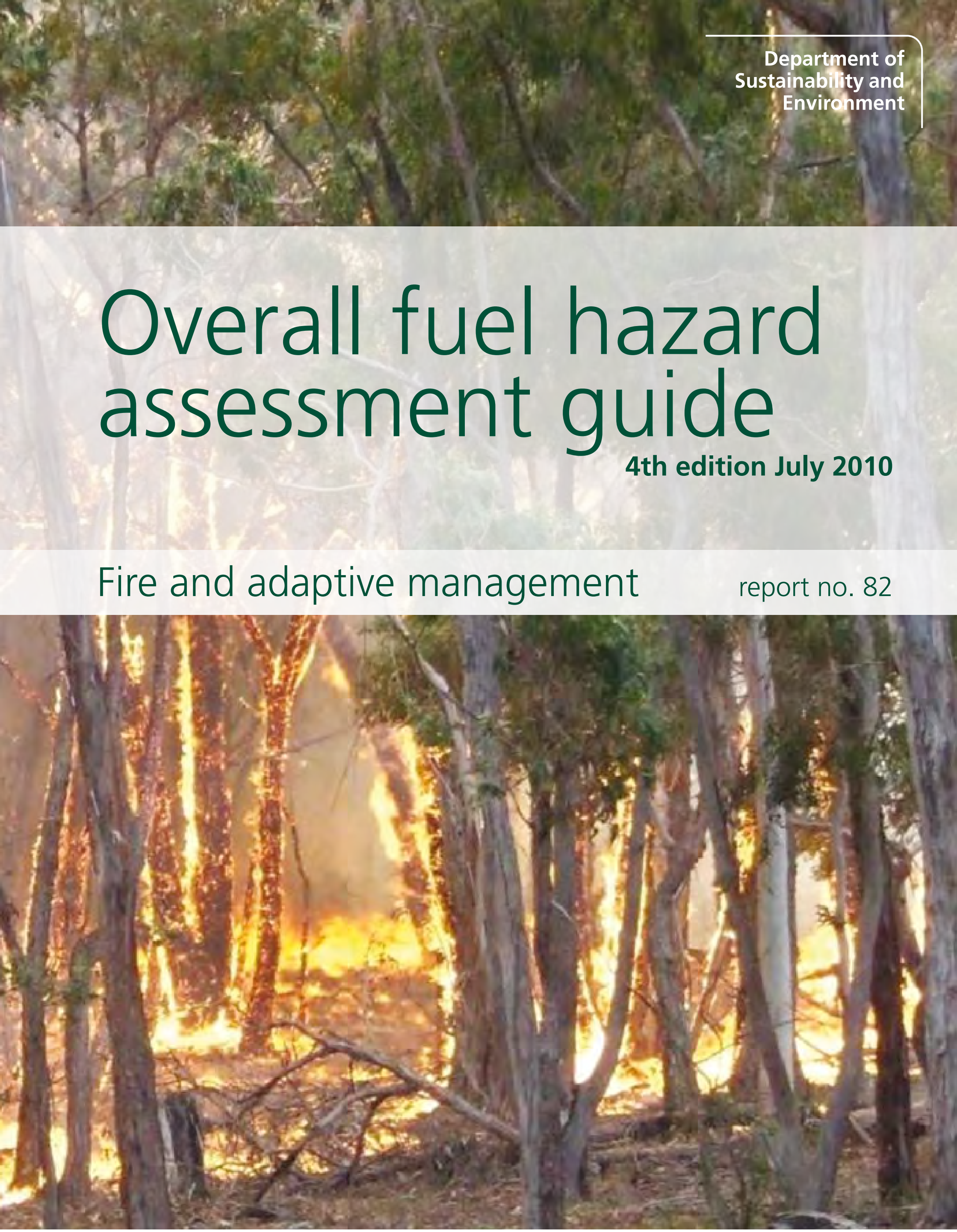
APPENDIX D

Overall Fuel Hazard Assessment Guide



Department of
Sustainability and
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Overall fuel hazard assessment guide

4th edition July 2010

Fire and adaptive management

report no. 82

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Victoria
The Place To Be

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4th edition July 2010

Fire and adaptive management, report no. 82

By Francis Hines, Kevin G Tolhurst, Andrew AG Wilson and Gregory J McCarthy

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Cover image: Elaine – Atchison Rd Fire, Victoria, January 2008. Bark Hazard – Extreme, Elevated Fuel Hazard – Moderate, Near-surface Fuel Hazard – Low, Surface Fuel Hazard – Very High. Overall Fuel Hazard – Extreme. Fire burning under FFDI 17 – High.

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Contents

1. About this guide

1.1 Purpose

The main purpose of this guide is to allow people to:

- make a rapid, visual assessment of fuel arrangement, and
- gain an understanding of how this will affect the chances of controlling a bushfire.

1.2 Audience

This guide has been principally designed to provide information on fuel arrangement to be used by:

- firefighters to assess the difficulty of controlling a bushfire.

Information on fuel arrangement may also be used by:

- asset owners and managers to assess potential bushfire risks to assets
- land and fire managers to provide a measurable objective and trigger for fuel management in fire management plans
- personnel to identify which key attributes and fuel layers are contributing the most to the hazard
- personnel to plan and conduct planned burns
- personnel to assess the effectiveness of planned burning or mechanical hazard reduction
- fire behaviour analysts to produce fire-spread predictions and community warnings.

Those who use the guide for these other purposes need to be mindful of its limitations and how the results are applied and interpreted.

1.3 What fuel is assessed

This guide is for assessing fine fuels that burn in bushfires. Fine fuels are the fuels that burn in the continuous flaming zone at the fire's edge. They contribute the most to the fire's rate of spread and flame height. Typically, they are dead plant material, such as leaves, grass, bark and twigs thinner than 6mm thick, and live plant material thinner than 3mm thick. Once ignited, these fine fuels generally burn out within two minutes.

This guide focuses on assessing the key structural layers of the fine fuel complex, in particular those of bark, elevated, near-surface and surface fuels.

1.4 How the fuel is assessed

Each fuel layer is assessed simply and visually. Assessing the fuel takes only a few minutes and is based on the premise that the eye is better able to integrate local variations in fuel than systematic measurement. Each fuel layer is assessed in turn and given a hazard rating. Particular emphasis is placed on how the fuel is arranged within each of these layers. The hazard ratings are then combined to produce an Overall Fuel Hazard Rating that ranges from Low to Extreme.

1.5 Why fuel arrangement is more important than fuel load

The image below highlights the effect that changing the arrangement of the fuel can have on fire behaviour. Both fires were ignited at the same time in the same way. Both fires are burning in the same fuel load, approximately two broadsheets of newspaper over a 20cm diameter area. The fuel on the right was laid flat and has little vertical orientation. The fuel on the left was crumpled up, which gave it more vertical orientation and exposed more of the surface to the air. As a result, the fire on the left shows significantly greater flame height and the fuel is consumed much faster.

The simple difference in the arrangement of the fuel significantly affects the resulting fire behaviour. The effect would not be discerned if the fuel assessment was based purely on fuel load. An assessment of fuel hazard takes into account the fuel arrangement. It gives a better indication of potential fire behaviour and suppression difficulty.

1.6 Suppression difficulty is not just about fire behaviour

This guide has been mainly developed to allow people to assess the impact of fuel arrangement on suppression difficulty. An assessment of suppression difficulty (how hard it is to control a bushfire) is not based solely on the anticipated fire behaviour. Many other factors affect the chances of a firefighting operation succeeding, including resources, fire size and terrain.

In order to consider the impact of fuels, the other factors need to be treated as if they are constant. The factors that have been held constant are referred to as the Reference Extended First Attack Conditions. Further detail on these conditions is contained in Appendix 1.

1.7 Basis of the Overall Fuel Hazard classification

A comprehensive explanation of this guide is contained in DSE's *Overall fuel hazard assessment guide: a rationale report – fire and adaptive management report no. 83* (in prep.).

This assessment guide updates and builds on work previously published by Wilson (1992a, 1992b, 1993), McCarthy *et al*. (1998a, 1998b, 1998c, 1999, 2001), the Department of Environment and Heritage (2006) and Gould *et al*. (2007a, 2007b).

Classifying Overall Fuel Hazard is complex, with few available measurements. Therefore, we have relied on the perceptions of experienced fire personnel (e.g. fire behaviour specialists, fire managers and firefighters). The collective experience of these personnel is vast, with a broad geographic base across Australia.

1.8 Need for continual learning and development

Although our knowledge about fuels has many gaps, this guide is based on the best available information and experience. The authors acknowledge that this guide will need to change and improve as more information is obtained.

Observers of firefighting operations can improve future editions of this guide by carefully recording what they see. Observations, comments and feedback can be emailed to fire.monitoring@dse.vic.gov.au.

2. How to use the guide

This guide has been kept concise and should not be considered as a standalone document. To produce reliable and consistent results requires extra knowledge which may be gained through local hands-on training in fuel assessment.

2.1 Application

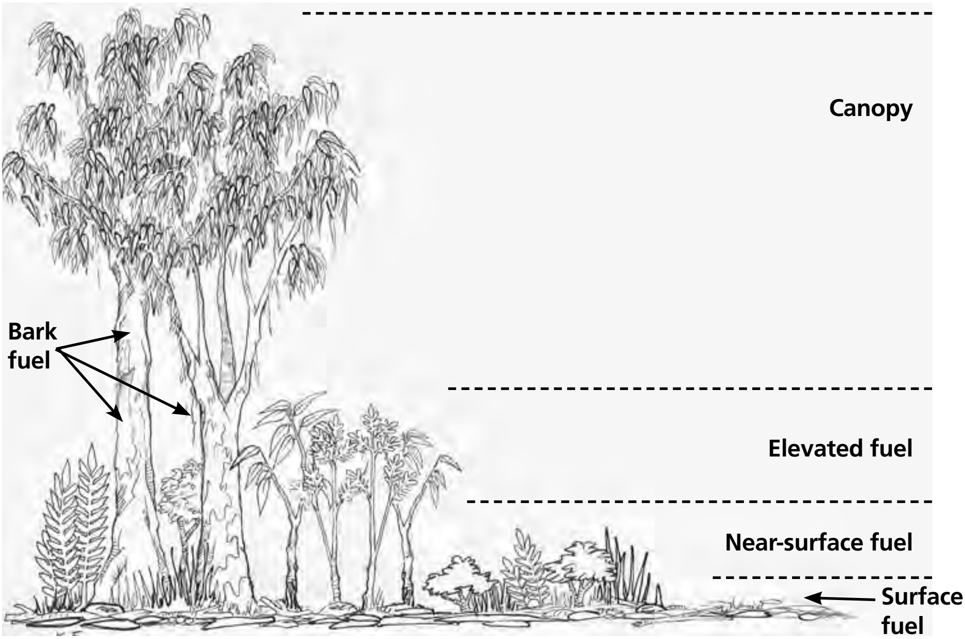
This guide is a tool for rapidly assessing fuel arrangement and its effect on the chances of controlling a bushfire. It may also be used for a range of other fire management purposes, as shown in the table below. Users of this guide should understand the underlying assumptions and limitations before applying it, particularly if applying it for purposes other than the assessment of suppression difficulty.

Application	Methodology
Assess suppression difficulty	Assess the fuels in which the fire may occur or is actually occurring.
Assess fuels for predicting potential risk to assets	Assess the fuels immediately adjacent to the asset as part of an assessment of possible radiant heat loads and defendable space. Assess the fuels further away from the asset; paying particular attention to areas that may generate spotting, such as ridges. Assessments should be focused, particularly in the direction of likely fire attack.
Assess the need for, or success of, fuel management activities	Assess the average fuels across the nominated area by sampling within major vegetation types, slopes and aspects.
Plan and conduct planned burns	Assess the variability in fuels across the nominated area by sampling within major vegetation types, slopes and aspects. Pay particular attention to areas where the burn may escape, such as the tops of gullies, ridge tops and areas adjacent to planned burn boundaries.
Assess fuels for predicting fire behaviour	Assess the fuel values needed as inputs for the appropriate fire behaviour model.

2.2 Fuel layers

Fuel in forests, woodlands and shrublands can be divided into four layers, each based on its position in the vegetation profile (Fig 2.1). This guide focuses on assessing the key structural layers of the fine fuel complex, those of bark, elevated, near-surface and surface fuels.

Figure 2.1 Fuel layers and bark



Use the following descriptions to determine how to separate vegetation into fuel layers.

Layer	Description	Contribution to suppression difficulty
Canopy	• Crowns of the tallest layer of trees. • Under some conditions canopy fuels can play a significant role in fire behaviour and suppression difficulty. Currently, however, these fuels are not assessed as part of Overall Fuel Hazard.	
Bark fuel	• Bark on tree trunks and branches, from ground level to canopy.	Spotting
Elevated fuel	• Fuels are mainly upright in orientation. • Generally most of the plant material is closer to the top of this fuel layer. • Sometimes contains suspended leaves, bark or twigs. • Fuels that have a clear gap between them and the surface fuels. • Can be highly variable in ground coverage. • Low-intensity fire (flame height of less than 0.5m) may pass beneath this layer without consuming much, if any, of it.	Influences the flame height and rate of spread of a fire.
Near-surface fuel	• Live and dead fuels, effectively in touch with the ground, but not lying on it. • Fuel has a mixture of vertical and horizontal orientation. • Bulk of the fuels are closer to the ground than to the top of this layer, or are distributed fairly evenly from the ground up. • Sometimes contains suspended leaves, bark or twigs. • Coverage may range from continuous to having gaps many times the size of the fuel patch. • Low-intensity fire (flame height of less than 0.5m) will consume most or all of this fuel. • Fuel in this layer will always burn when the surface fuel layer burns.	Influences the rate of spread and flame height of a fire.
Surface fuel (litter)	• Leaves, twigs, bark and other fine fuel lying on the ground. • Predominantly horizontal in orientation.	Influences the rate of spread of a fire.

This guide is for assessing fine fuels only. Coarse fuels including logs are not considered. See Section 1.3 for further details.

The descriptions of the fuel layers exclude references to species' names or common vegetation forms, such as shrubs. During a plant's life it may transition back and forth between different layers. For example, juvenile bracken fern can be classified as near-surface fuel before becoming elevated fuel as it matures. Once it dies and collapses it may become near-surface fuel again.

2.3 Assessment based on key attributes of fuel hazard

A fuel hazard rating of Low, Moderate, High, Very High or Extreme is assigned to each fuel layer by assessing it against the key attributes listed below.

Key attribute	
Horizontal continuity of the layer	Determines how readily a piece of burning fuel may ignite the fuel beside it. Identifies which of surface, near-surface or elevated fuels will determine the average flame height.
Vertical continuity of the layer	Determines how readily a piece of burning fuel may ignite the fuel above it.
Amount of dead material in the layer	Determines how much dead material is present to burn and thus help with igniting the live (green) fuels.
Thickness of the fuel pieces	Determines whether the fuel pieces will burn in the flaming front of the fire.
Total weight of fine fuel	Determines the weight of fine fuel contributing to the flaming front of the fire.

The descriptions in the hazard assessment tables do not cover all possible combinations of the key attributes. Users will need to exercise judgement and make an assessment using all key attributes when actual conditions fit between the descriptions.

2.4 Using the descriptions and photographs

This is **not** a photographic guide for assessing fuels. The **descriptions** for each of the key attributes should be used as the basis for determining the fuel hazard rating. Photographs cannot adequately show all of the key attributes that are important in determining fuel hazard. The photographs are provided to illustrate **some** of the key attributes for each fuel hazard rating. They do not represent all possible variations of that particular hazard rating.

2.5 Area of assessment

Within an area of interest fuels are assessed in small patches or plots. The size and number of plots depends on the reason for assessing the fuels. Some applications (such as for input into fire behaviour models) may require a more rigorous and systematic approach to sampling. Other applications (such as assessing fuel hazard during firefighting operations) will necessitate a more rapid informal approach. For whatever purpose the guide is being used it is recommended that the following principles be applied:

- Any assessment of fuels should try to assess the variability in fuels across an area by assessing the fuels at multiple plots.
- The size and number of plots should reflect the level of reliability required of the results.
- For surface, near-surface and elevated fuel layers the result of assessing the plot should reflect the average state of that fuel layer.
- For bark hazard the result of assessing the plot should be based on the trees with the highest rating.
- Always record with the result the name and the version of the guide used.

2.6 Tips for assessing fuel hazard

The process of assessing fuel hazard using this guide is largely subjective. Implementing the following techniques will help to improve accuracy and reliability:

- Identify and agree on examples of the highest rating of fuel hazard for each layer that occur locally. These examples should be used as benchmarks.
- Conduct assessments in pairs of observers and regularly change assessment pairs.
- Assessors should be no more than one hazard rating apart when assessing each layer (e.g. Low or Medium, not Low or High).
- Use different assessors to re-assess completed work and provide feedback.

2.7 Vesta fire behaviour predictions

In dry eucalypt forest with a litter and shrub understorey the *Field guide – fuel assessment and fire behaviour prediction in dry eucalypt forest* (Gould *et al.* 2007b) provides a systematic method for assessing fuel and predicting fire behaviour (rate of spread, flame height, and spotting). The Project Vesta fuel hazard scoring system is similar to the Victorian system developed by Wilson (1992a, 1992b, 1993) and revised by McCarthy *et al*. (1999). The scale that underlies the Vesta fuel hazard scores is directly related to fire behaviour. These scores, along with height measurements of various fuel layers, are needed as inputs into the fire behaviour prediction tables in Gould *et al*. (2007b). Section 9.3 contains a table for translating the fuel hazard rating for each fuel layer into Vesta fuel hazard scores.

2.8 Effect on fire behaviour

Each table for assessing fuel hazard contains information on the effect that the fuel arrangement is likely to have on fire behaviour. This effect is for weather conditions equivalent to a Forest Fire Danger Index (FFDI) of 25 (McArthur 1973). An FFDI of 25 can be achieved in many ways. For the purposes of this guide the specific conditions required to achieve this are:

Temperature: 33°C	Relative Humidity: 25%	Wind Speed: 20km/h
Drought Factor: 10	Slope: 0°	

If weather conditions vary from those listed above the effect on fire behaviour will also vary.

2.9 Fuel assessment data sheet

Appendix 2 contains a sample field data sheet that can be used when assessing fuels.

3. Bark fine fuel

3.1 Identification

Bark fuel is the bark on tree trunks and branches. Bark lying on or near the ground or draped over understorey plants is considered to be surface, near-surface or elevated fuel.

3.2 Identifying bark types

The key attributes for assessing the effect of bark on suppression difficulty are shown below:

Key attribute	Determines	How it is assessed
Ease of ignition	• How readily the bark will ignite. • Whether the fire will burn up the trunk and into the branches of the tree.	Thickness, size and shape of bark pieces.
How bark is attached	• How likely the bark is to break off the tree.	How easily the bark breaks off the tree.
Quantity of combustible bark	• Volume of potential embers that a fire may generate.	Relative quantity of combustible bark.
Size-to-weight ratio of the bark pieces	• How far the wind is likely to carry bark pieces once they break off the tree.	Thickness, size and shape of bark pieces.
Burn out time	• Length of time a piece of bark will stay ignited once it breaks off the tree.	Thickness, size and shape of bark pieces.

Descriptions of trees have been separated into three broad bark types using three of these key attributes – ease of ignition, burn out time and size-to-weight ratio:

1. Fine fibrous barks, including stringybarks
2. Ribbon or candle barks
3. Other bark types, including smooth, platy, papery and coarsely fibrous. The reason for describing these types in some detail is to help observers distinguish them from the above two types.

3.3 Identifying Stringybark and other fine fibrous bark types

Contribution to suppression difficulty	• Bark types that can produce massive quantities of embers and short distance spotting.
Physical description	• Bark is fine fibrous material with easily visible fibres less than 1mm thick covering the whole trunk. • Bark fibres resemble the fine fibres that are twisted together to form natural string. • Old bark is retained on the trunk of the tree for decades, forming a relatively spongy fibrous mass with deep vertical fissures. • Outer bark may weather to a greyish colour, while underlying bark retains its original colour. • Bark may form large strands when peeled off. • Fine, hairlike pieces also break off from the tree when it is rubbed.
Ease of ignition	• Bark is very flammable (can be easily lit with a match when dry). • Fires will readily climb the tree and branches.
How bark is attached	• Young or new bark is held tightly to the trunk. • As bark ages it becomes less tightly held. • Old, long-unburnt bark is held very loosely.
Quantity of combustible bark	• Bark on old, long-unburnt stringybarks can be more than 10cm in depth. During fires it can produce massive quantities of embers.
Size-to-weight ratio	Burning pieces of bark tend to be either: • Very fine lightweight fibres that will be carried for less than 100m. • Small lightweight wads (about the size of a thumb) that will be carried for less than 300m. • Very large wads (bigger than a fist) that fall close to the tree.
Burn out time	• Very fine fibres of bark that will burn out within one minute. • Small wads of bark that will burn out within 2–3 minutes. • Very large wads of bark that will burn for up to 10 minutes.
Hazard accumulation	• Bark hazard can reach Extreme. • Bark hazard increases over time as the thickness and looseness of the old bark increases. • Repeated low intensity fires (<0.5m flame height) may produce a 'black sock' effect on the base of the trunk, but this may have limited effect in reducing the overall quantity of bark and the hazard.

Examples

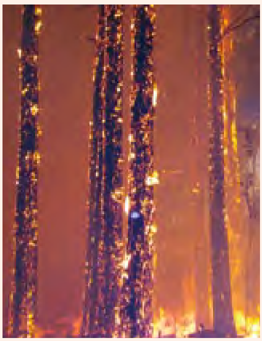


Table 3.1 Assessing the hazard of fine fibrous bark types including stringybarks

Only use this table if at least 10% of the trees in a forest have fine fibrous bark. To achieve a given hazard rating a best fit of both key attributes should be sought. Choices for the hazard rating of fuels that fit across several descriptions may be informed by the effect that different levels of key attributes have on fire behaviour.

Key attributes		Hazard rating	Effect on fire behaviour (at FFDI 25)[1]
How bark is attached	Quantity of combustible bark		
This hazard rating cannot occur when only this bark type is present.		Low	
Bark tightly held. Requires substantial effort to break off bark by hand.	Very little combustible bark. Entire trunk almost completely black or charred.	Moderate	Spotting generally does not hinder fire control. Fires will not climb these trees.
Bark is mostly tightly held with a few pieces loosely attached.	Limited amount of combustible bark. 50–90% of trunk charred. Most of the bark is charred, especially on the lower part of the trunk.	High	Infrequent spotting. Fires will climb some of these trees.
Many pieces of bark loosely held. Deep fissures present in bark.	Large amounts of combustible bark. 10–50% of trunk charred. Upper parts of the tree may not be charred at all.	Very High	Substantial spotting. Fires will climb most of these trees.
Outer bark on trees is weakly attached. Light hand pressure will break off large wads of bark. Deep fissures present in bark.	Huge amounts of combustible bark. <10% of trunk charred. Minimal evidence of charring.	Extreme	Quantity of spotting generated makes fire control very difficult or impossible. Fires will climb virtually all these trees.

Assess bark hazard over a plot 20m in radius. Assessing multiple plots will give better results. Trunk is defined as being the part of the tree between the ground and the branches.

See Section 9.3 for application of bark hazard ratings for the Vesta fire behaviour tables.

1 FFDI 25 is a Forest Fire Danger Index of 25 (McArthur 1973). Refer to Section 2.8 for the specific weather conditions used to achieve this FFDI.

Table 3.2 Examples of Stringybarks and other fine fibrous bark hazard

Low	This hazard rating cannot occur when only this bark type is present.		
Moderate			
High			
Very High			
Extreme			

The photos above show some of the variation possible within each bark hazard rating.

3.4 Identifying ribbon or candle bark types

Effect on suppression difficulty	• Bark types that can produce substantial quantities of spotting at distances greater than 2km. Will also produce short distance spotting.
Physical description	• Trees characterised by the annual shedding of old bark layers, exposing the smooth new bark underneath. • Bark is shed in the form of long strips or ribbons of bark. • Long strips of bark curl tightly inwards to form a candle-like shape (see image lower right). • Bark strips 50cm or more in length fall off and often drape around the trunk and over branches and surrounding shrubs. • Strips of bark are usually less than 2mm thick. • Bark is shed at various times of the year so that the trunk may have a mottled appearance.
Ease of ignition	• Bark is moderately flammable (can be lit with a cigarette lighter when dry). • Fires will climb up ribbons of bark.
How bark is attached	• Bark strips may drape over, or be weakly attached to, the trunk and branches.
Quantity of combustible bark	• Large quantities of bark can be retained in upper trunk and head of the tree.
Size-to-weight ratio	• Bark pieces are relatively light for their large size. • Easily transported by strong updrafts – may travel up to 30km downwind.
Burn out time	• Bark can burn and smoulder within the curled up ribbons for longer than 10 minutes.
Hazard accumulation	• Bark hazard never exceeds Very High. • Bark hazard tends to increase over the long term as ribbons accumulate on the tree. • A low intensity fire (flame height of less than 0.5m) may not reduce the hazard in this bark type.

Example

Note: Loose ribbon or candle-like bark that is retained on the trunk near ground level is not included in the assessment of ribbon or candle bark types. It is usually:

- firmly attached to the trunk of the tree
- consumed in place by a surface fire.

This bark is considered in 'Other bark types' and can also be considered as near-surface fuel.

Smooth-bark trees also shed bark as slabs or flakes. These bark types are considered in 'Other bark types'.

Table 3.3 Assessing the hazard of ribbon or candle bark types

If more than 10% of the trees in a forest are fine fibrous bark trees use Table 3.1 (Assessing the hazard of fine fibrous bark types) to determine the bark hazard for a site.

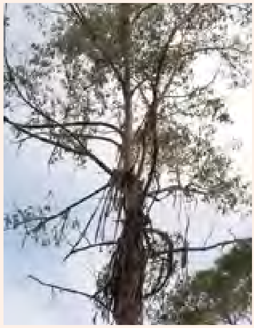
Key attribute Amount of combustible bark	Hazard rating	Effect on fire behaviour (at FFDI 25)[2]
This hazard rating cannot occur when only this bark type is present.	Low	
No long ribbons of bark present. Trunk and branches of trees almost entirely smooth.	Moderate	Spotting generally does not hinder fire control. Fires will not climb these trees.
Long ribbons of bark present on upper trunk (>4m above ground) and in head of trees. Lower trunk mainly smooth.	High	Infrequent spotting. Fires will climb some of these trees.
Long ribbons of bark in the head and upper trunk with: • ribbons hanging down to ground level or, • flammable bark covers trunk.	Very High	Substantial spotting. Fires will climb most of these trees.
This hazard rating cannot occur when only this bark type is present.	Extreme	

Assess bark hazard over a plot 20m in radius. Assessing multiple plots will give better results. Trunk is defined as the part of the tree between the ground and the branches.

See Section 9.3 for application of bark hazard ratings for the Vesta fire behaviour tables.

2 Refer to Section 2.8 for the specific weather conditions used to achieve this FFDI.

Table 3.4 Examples of ribbon or candle bark hazard

Low	This hazard rating cannot occur when only this bark type is present.
Moderate	  
High	  
Very High	  
Extreme	This hazard rating cannot occur when only this bark type is present.

3.5 Identifying other bark types

This bark type includes all other bark types not included in the previous two types. As a result, many different tree species are grouped together. This grouping is based on the ease of ignition, burn out time and size-to-weight ratio of the bark, rather than on botanical values. These other bark types can produce limited quantities of short distance spotting.

This bark type group has been divided into several subgroups. These subgroups are described in some detail to help observers distinguish them from the other two main bark types.

3.5.1 Ironbarks and Platy barks

		Example
Physical description	• Trees characterised by layers of old, coarse bark retained on the trunk and branches. • Bark becomes rough, compacted and furrowed with age • Bark feels very abrasive when rubbed by hand. • Bark pieces tend to be more than 2mm thick when they break off. • There may be little or no evidence of charring on the bark following planned burns.	
Hazard accumulation	• Bark hazard never exceeds Moderate.	

3.5.2 Coarsely fibrous barks

Physical description	• Trees characterised by short strand fibrous bark. • Layers of old dead bark are retained on the trunk and branches. • Unlike stringybark trees, the bark on these trees forms only short strands or chunks when peeled off. • Evidence of charring on the bark may last for up to 10 years.	
Hazard accumulation	• Bark hazard never exceeds High. • Bark hazard increases over the long term as the thickness and looseness of the old bark increases.	

3.5.3 Papery barks

Physical description	• Shrubs and trees growing from 2m to 30m tall, often with flaky shedding bark. • Old bark is retained on the trunk and branches and builds up into a thick spongy mass. • Bark layers tend to split allowing sheets of bark to become loose and eventually peel off. • Evidence of charring on the bark may last for up to 10 years.	**Example** 
Hazard accumulation	• Bark hazard never exceeds High. • Bark hazard increases over the long term as the thickness and looseness of the old bark increases.	

3.5.4 Slab bark, smooth bark and small flakes

Physical description	• Trees characterised by the annual shedding of old bark layers, exposing the smooth living bark underneath. • Bark shed is often seasonal and often annual. • Species where the old bark tends to peel into large slabs (<50cm in length) or small flakes when shed. • Most of the bark falls off the tree soon after it is shed. • Some small amounts of bark may be retained on the stem or branches for several months before falling off, leading to a mottled effect. • The mottled effect leads to discontinuous bark fuel up the tree.	**Example** 
Hazard accumulation	• Bark hazard never exceeds Moderate. • Bark hazard tends to be seasonal.	

Table 3.5 Assessing the hazard of other bark types

If more than 10% of the trees in a forest are fine fibrous bark trees use Table 3.1 (Assessing the hazard of fine fibrous bark types) to determine the bark hazard for a site. To achieve a given hazard rating a best fit of both key attributes should be sought. Choices for the hazard rating of fuels that fit across several descriptions may be informed by the effect that different levels of key attributes have on fire behaviour.

Key attributes			
How bark is attached	**Quantity of combustible bark**	**Hazard rating**	**Effect on fire behaviour (at FFDI 25)[3]**
No trees present. or Trunk and branches of tree entirely smooth or free from loose bark.		Low	No bark present that could contribute to fire behaviour.
Bark rubs off by hand with firm pressure.	Limited amount of combustible bark.	Moderate	Spotting generally does not hinder fire control. Fires will climb some of these trees.
Light hand pressure will break bark off.	Large amounts of combustible bark.	High	Infrequent spotting. Fires will climb most of these trees.
This hazard rating cannot occur when only this bark type is present.		Very High	
This hazard rating cannot occur when only this bark type is present.		Extreme	

Assess bark hazard over a plot 20m in radius. Assessing multiple plots will give better results. Trunk is defined as the part of the tree between the ground and the branches.

See Section 9.3 for application of bark hazard ratings for the Vesta fire behaviour tables.

3 Refer to Section 2.8 for the specific weather conditions used to achieve this FFDI.

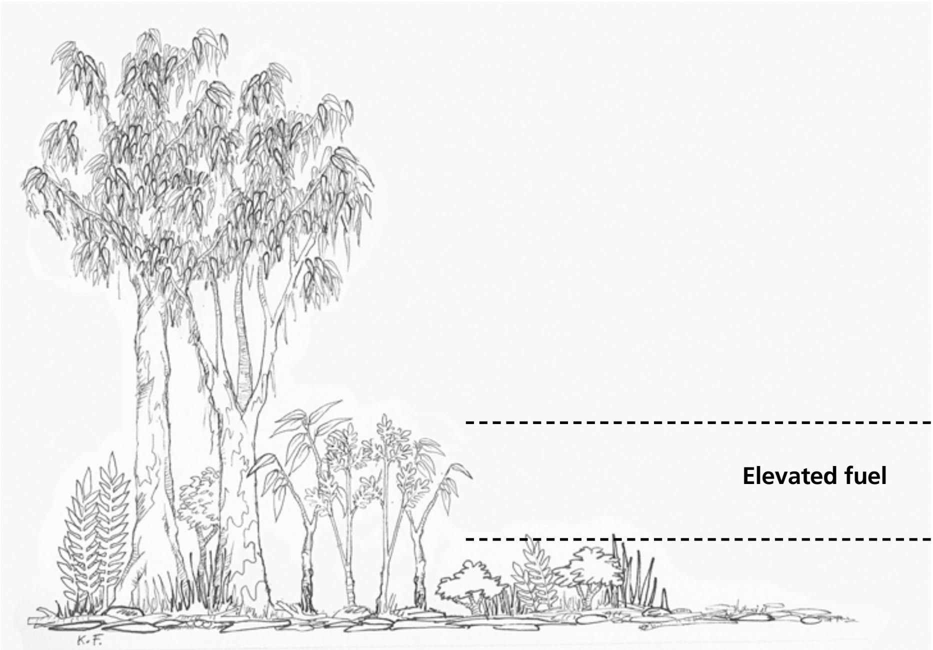
Table 3.6 Examples of other bark types

Low	No trees present. or Trunk and branches of tree entirely smooth or free from loose bark.		
Moderate			
High			
Very High	Does not occur when this is the only bark type present on a site.		
Extreme	Does not occur when this is the only bark type present on a site.		

4. Elevated fine fuel

4.1 Identification

- Fuels are mainly upright in orientation
- Generally most of the plant material is closer to the top of this layer
- Sometimes contains suspended leaves, bark or twigs
- Fuels that have a clear gap between them and the surface fuels
- Elevated fuel can be highly variable in ground coverage
- A low intensity fire (flame height of less than 0.5m) may pass beneath this layer without consuming much, if any, of it.



4.2 Assessment

The elevated fuel hazard is highest when the:

- foliage, twigs and other fuel particles are very fine (maximum thickness 1–2mm)
- proportion of dead material is high
- fuels are arranged with a high level of density and/or horizontal and vertical continuity that promotes the spread of flames
- live foliage has low fuel moisture content.

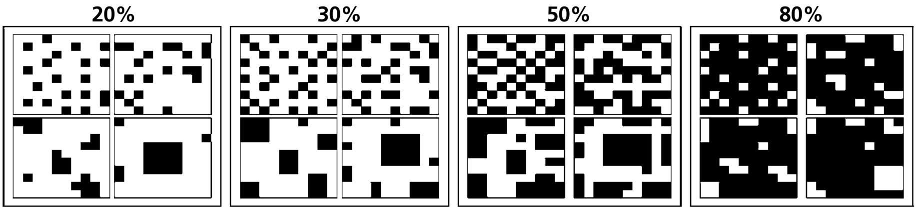
Table 4.1 Assessing elevated fine fuel hazard

To achieve a given hazard rating a best fit of all key attributes should be sought. Choices for the hazard rating of fuels that fit across several descriptions may be informed by the effect that different levels of key attributes have on fire behaviour.

Key attributes					Fuel hazard rating	Effect on fire behaviour (at FFDI 25)[4]
Plant Cover	% dead	Vertical continuity	Vegetation density	Thickness of fuel pieces		
<20% or low flammability species	<20%		Easy to walk in any direction without needing to choose a path between shrubs.		Low	Little or no effect.
20–30%	<20%	Most of the fine fuel is at the top of the layer.	Easy to choose a path through but brush against vegetation occasionally.		Moderate	Does not sustain flames readily.
30–50%	<20%	Most of the fine fuel is at the top of the layer.	Moderately easy to choose a path through, but brush against vegetation most of the time.		High	Causes some patchy increases in the flame height and/or rate of spread of a fire.
50–80%	20–30%	Continuous fine fuel from the bottom to the top of the layer.	Need to carefully select path through.	Mostly less than 1–2mm thick.	Very High	Elevated fuels mostly dictate flame height and rate of spread of a fire.
>70%	>30%	Continuous fine fuel from the bottom to the top of the layer.	Very difficult to select a path through. Need to push through vegetation.	Large amounts of fuel <2mm thick.	Extreme	Elevated fuels almost entirely determine the flame height and rate of spread of a fire.

Assessing plant cover

For the purpose of this guide, plant cover is defined as the amount of ground blocked out by that fuel layer if viewed while looking straight down from above. Each plant is considered opaque – any ground within the perimeter of the plant cannot be seen. The following visual guide can be used to assist in assessing plant cover. Each quarter of any one square has the same percent cover.



4 Refer to Section 2.8 for the specific weather conditions used to achieve this FFDI.

Table 4.2 Examples of elevated fine fuel hazard

Low	Elevated fuel absent or virtually absent	
Moderate		
High		
Very High		
Extreme		

Assess elevated hazard over a plot 10m in radius. Assessing multiple plots will give better results.

See Section 9.3 for application of elevated fuel hazard ratings for the Vesta fire behaviour tables. For the Vesta fire behaviour tables the elevated fuel height (m) should be the average of 10 measurements taken along a 300m walk-through. Measure the typical height from ground level.

5. Near-surface fine fuel

5.1 Identification

- Live and dead fuels effectively in touch with the ground but not lying on it
- Fuel has a mixture of vertical and horizontal orientation
- Either the bulk of the fuels is closer to the ground than the top of this layer, or is distributed fairly evenly from the ground up
- Sometimes contains suspended leaves, bark or twigs
- Coverage may range from continuous to having gaps many times the size of the fuel patch
- A low intensity fire (flame height of less than 0.5m) will consume most or all of this fuel
- Fuel in this layer will always burn when the surface fuel layer burns.

5.2 Assessment

The near-surface fuel hazard is highest when the:

- foliage, twigs and other fine fuel particles are very fine (maximum thickness 1–2mm)
- proportion of dead material is high
- fuels are arranged with a high level of density and /or horizontal and vertical continuity, that promotes the spread of flames
- live foliage has low fuel-moisture content.

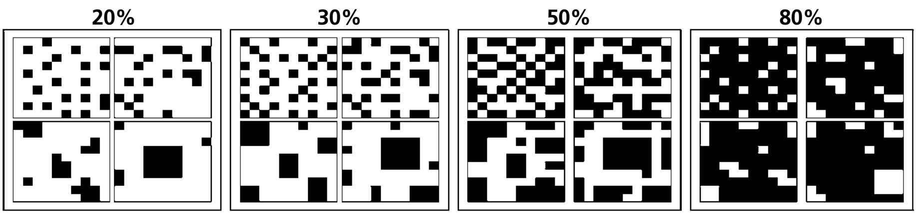
Table 5.1 Assessing near-surface fine fuel hazard

To achieve a given hazard rating a best fit of all key attributes should be sought. Choices for the hazard rating of fuels that fit across several descriptions may be informed by the effect that different levels of key attributes have on fire behaviour.

Key attributes			Fuel hazard rating	Effect on fire behaviour (at FFDI 25)[5]
Plant cover	**% dead**	**Horizontal connectivity**		
<10%	<10%	Near-surface fuel is absent or virtually absent.	Low	Little or no effect.
10–20%	<20%	Gaps many times the size of fuel patches.	Moderate	Occasionally increases flame height.
20–40%	>20%	Gaps between fuel patches are greater than the size of fuel patches. Starting to obscure logs and rocks.	High	Contributes to surface fire spread and causes patchy increase to flame height.
40–60%	>30%	Fuel patches are equal to or larger than the gaps between the fuel patches.	Very High	Contributes significantly to fire spread and flame height. A fire will spread readily in this layer without having to consume the surface layer.
>60%	>50%	Very small gaps between fuel patches. Logs and rocks obscured.	Extreme	Contributes significantly to fire spread and flame height. A fire will spread readily in this layer without having to consume the surface layer.

Assessing plant cover

For the purpose of this guide, plant cover is defined as the amount of ground blocked out by that fuel layer if viewed while looking straight down from above. Each plant is considered opaque – any ground within the perimeter of the plant cannot be seen. The following visual guide can be used to assist in assessing plant cover. Each quarter of any one square has the same percent cover.



5 Refer to Section 2.8 for the specific weather conditions used to achieve this FFDI.

Table 5.2 Examples of near-surface fine fuel hazard

Low	Near-surface fuel is absent or virtually absent	
Moderate		
High		
Very High		
Extreme		

Assess near-surface hazard over a plot 10m in radius. Assessing multiple plots will give better results.

See Section 9.3 for application of near-surface fuel hazard ratings for the Vesta fire behaviour tables. For the Vesta fire behaviour tables the near-surface fuel height (cm) should be the average of 10 measurements taken over a 300m walk through. Measure the typical height from ground level.

6. Surface fine fuel

6.1 Identification

- Leaves, twigs, bark and other fine fuel lying on the ground
- Predominantly horizontal in orientation
- Usually contributes the most to fuel load or quantity
- Includes the partly decomposed fuel (duff) on the soil surface.

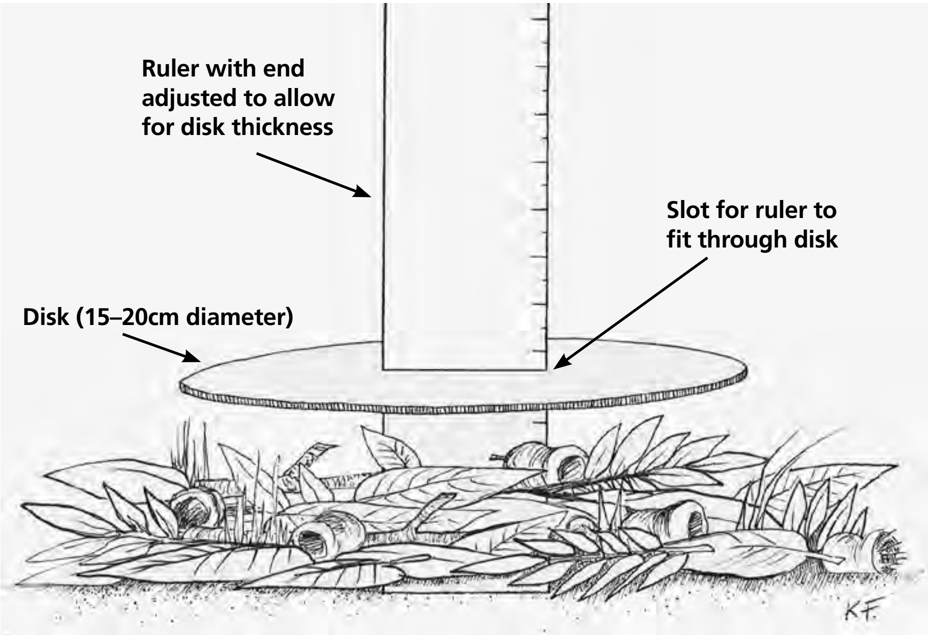
6.2 Assessment

The surface fine fuel hazard is highest when the:

- litter pieces are well connected
- surface litter cover is high, with minimal interruption from rocks, logs or patches of bare soil
- surface litter has substantial depth (greater than 30mm).

6.3 Measurement

Surface litter-bed depth should be measured using a simple depth gauge, as pictured below. This follows the methodology described in McCarthy (2004) and McCarthy *et al*. (1999).



Litter depth should be measured in areas where near-surface fuels do not obscure the litter. Fuel depth is measured using a 15cm circular disk with a ruler through a slot in its centre. To use this gauge, a small gap is made in the litter bed down to mineral soil, then the end of the ruler is placed resting on the mineral soil surface. The disk is pushed down with light pressure until its whole perimeter is in contact with the fuel. Light pressure can be described as 'enough pressure to hold a tennis ball under water'. The ruler is read off level with the top of the disk. Note that the end of the ruler needs to be adjusted to match the thickness of the disk.

Five measurements of litter bed depth should be made at each site. The average of these measurements is one of the attributes that can be used to determine the surface fine fuel hazard.

Table 6.1 Assessing surface fine fuel hazard

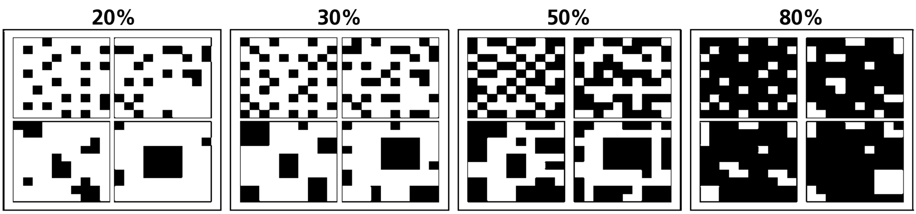
To achieve a given hazard rating a best fit of all key attributes should be sought. Choices for the hazard rating of fuels that fit across several descriptions may be informed by the effect that different levels of key attributes have on fire behaviour.

Key attributes				
Horizontal connectivity	**Surface litter cover**	**Litter-bed depth**	**Fuel hazard rating**	**Effect on fire behaviour (at FFDI 25)[6]**
Litter poorly interconnected. Large areas of bare soil or rock. More soil than litter. Soil surface readily visible through litter bed.	<60%	Very thin litter layer <10mm	Low	Surface fires will not spread.
Litter well connected. Some areas of bare soil or rock. Soil surface occasionally visible through litter bed.	60–80%	Thin litter layer 10–25mm	Moderate	Litter connected well enough to allow fire spread to overcome bare patches.
Litter well connected. Little bare soil.	80–90%	Established litter with layers of leaves ranging from freshly fallen to decomposing. 20–30mm	High	Surface fires spread easily with a continuous fire edge.
Litter completely connected.	>90%	Thick litter layer 25–45mm	Very High	Surface fires spread easily. Increasing flame depth and residence time.
Litter completely connected.	>95%	Very thick layer of litter >35mm	Extreme	Surface fires spread easily. Increasing flame depth and residence time.

Assess surface hazard over a plot 10m in radius. Assessing multiple plots will give better results. For each plot litter bed depth should be an average of five measurements (McCarthy 2004) or more.

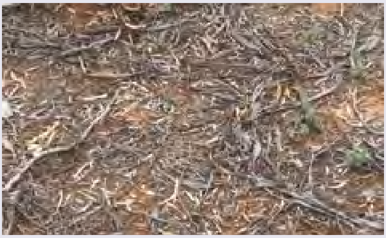
See Section 9.3 for application of surface fuel hazard ratings for the Vesta fire behaviour tables.

The following visual guide can be used to assist in assessing surface litter cover. Each quarter of any one square has the same percent cover.



6 Refer to Section 2.8 for the specific weather conditions used to achieve this FFDI.

Table 6.2 Examples of surface fine fuel hazard

Low		
Moderate		
High		
Very High		
Extreme		

7. Determining the combined surface and near-surface fine fuel hazard rating

Assessments of surface and near-surface fuels must be combined together before an Overall Fuel Hazard rating can be determined. The near-surface fuel rating is used to adjust the surface fine fuel hazard rating, according to Table 7.1.

To determine the effect of near-surface fine fuel hazard:

1. Select the **surface fuel hazard rating** from column ①
2. Select the **near-surface fuel hazard rating** from column ②
3. Select the resulting **combined rating** value ③
4. Use this value to determine the Overall Fuel Hazard rating using the Table 8.1.

Table 7.1 Determining the combined surface and near-surface fine fuel hazard rating

① Surface fine fuel hazard rating	② Near-surface fine fuel hazard rating				
	Low	Moderate	High	Very High	Extreme
	③ Combined surface and near-surface fine fuel hazard rating				
Low	L	L	M	H	VH
Moderate	M	M	H	VH	E
High	H	VH	VH	VH	E
Very High	VH	VH	E	E	E
Extreme	E	E	E	E	E

8. Determining Overall Fuel Hazard

Overall Fuel Hazard = (sum of the influences of) Bark Hazard + Elevated Fine Fuel Hazard + Combined Surface and Near-surface Fine Fuel Hazard.

The following table is used to combine the assessed levels of Bark, Elevated and Combined Surface and Near-surface Fuel Hazard to give an Overall Fuel Hazard rating.

To determine the Overall Fuel Hazard rating:

1. Select the row that corresponds to the **Bark Hazard** ①
2. Select the row that corresponds to the **Elevated Fine Fuel Hazard** ②
3. Select the column that corresponds to the assessed level of **Combined Surface and Near-surface Fine Fuel Hazard** ③
4. Identify where these two intersect and this will provide you with the corresponding Overall Fuel Hazard rating.

Table 8.1 Determining the Overall Fuel Hazard rating

① Bark Hazard	② Elevated Fine Fuel Hazard	③ Combined Surface and Near-surface Fine Fuel Hazard *				
		L	M	H	VH	E
Low or Moderate	L	L	M	M	H	H
	M	L	M	M	H	H
	H	L	M	H	VH	VH
	VH	VH	VH	VH	VH	VH
	E	E	E	E	E	E
High	L	L	M	H	H	H
	M	L	M	H	H	H
	H	L	H	H	VH	VH
	VH	VH	VH	VH	VH	E
	E	E	E	E	E	E
Very High or Extreme	L	L	VH	VH	VH	E
	M	M	VH	VH	E	E
	H	M	VH	E	E	E
	VH	E	E	E	E	E
	E	E	E	E	E	E

* Combined Surface and Near-surface Fine Fuel Hazard is a measure of the Surface Fine Fuel Hazard adjusted to account for the level of near-surface fine fuel (see Table 7.1).

9. Interpreting and applying Overall Fuel Hazard

9.1 Chances of extended first attack success

The chances of extended first attack being successful[1] for a fire ignited in these fuels under the reference extended first attack conditions (Appendix 1) is approximately as follows:

Table 9.1 Chances of extended first attack success

GFDI[2]	FFDI[3]	Overall Fuel Hazard rating[4]				
		Low	Moderate	High	Very High	Extreme
0–2	0–5					
3–7	6–11					
8–20	12–24					
20–49	25–49					
50–74	50–74					
75–99	75–99					
100+	100+					

- Chance of extended first attack success is greater than 95% (almost always succeeds)
- Chance of extended first attack success is between 95% and 50% (succeeds most of the time)
- Chance of extended first attack success is between 49% and 10% (fails most of the time)
- Chance of extended first attack success is less than 10% (almost always fails)

Notes:
1. Extended first attack is deemed successful when a fire is controlled by 0800hrs the day after ignition and at less than 400 hectares.
2. GFDI is the Grass Fire Danger Index at the time of ignition and is assumed to be the highest GFDI expected before 0800hrs the next day.
3. FFDI is the Forest Fire Danger Index at the time of ignition and is assumed to be the highest FFDI expected before 0800hrs the next day.
4. Chance of success is for a fire ignited in fuels with this Overall Fuel Hazard rating.
5. Predicted outcomes will differ if the conditions vary from those listed in the reference extended first attack conditions.
6. Predicted outcomes based on expert opinion and informed by work carried out by Wilson (1992b, 1993), McCarthy *et al*. (1998a, 2001) and Plucinski *et al*. (2007).

9.2 Indicative fuel loads (t/ha)

In the absence of local data obtained by sampling fuel loads destructively the following table of indicative fuel load data from Project Vesta and Victorian studies may be useful. These tonnes per hectare figures may be applied to the Forest Fire Danger Meter Mark V (McArthur 1973) for predicting forward rate of spread and flame height for forest fires.

Table 9.2 Indicative fuel loads (t/ha)

Fuel	Fuel hazard rating				
	Low	Moderate	High	Very High	Extreme
Bark	0	1	2	5	7
Elevated	0–1	1–2	2–3	3–5	5–8
Near-surface	1–2	2–3	3–4	4–6	6–8
Surface	2–4	4–10	8–14	12–20	16–20+

9.3 Determining Vesta fuel hazard scores

The following table translates fuel hazard ratings for each fuel layer into Project Vesta fuel hazard scores. These scores can be used with the fire behaviour prediction tables in publications such as Gould *et al*. (2007b).

To determine the Vesta fuel hazard score:

1. Select the row that corresponds to the fuel hazard rating for required fuel layer 1
2. Select the Vesta fuel hazard score column that corresponds to the same layer 2
3. Identify where these two intersect and this will provide you with the corresponding Vesta fuel hazard score.

Table 9.3 Determining Vesta fuel hazard scores

	Vesta fuel hazard score 2			
Fuel hazard rating 1	**Surface**	**Near-surface**	**Elevated**	**Bark**
Low	1	1	1	0
Moderate	2	2	2	1
High	3	3	3	2
Very High	3.5	3.5	3.5	3
Extreme	4	4	4	4

Notes:

- Surface and near-surface hazard score and near-surface height (cm) is required for fire spread prediction.
- Rate of spread and elevated fuel height (m) is required for flame height prediction.
- Rate of spread, surface and bark fuel hazard scores are required for prediction of spotting distance.

Acknowledgements

This Fuel Hazard Assessment Guide updates and continues to develop work previously conducted by a number of authors. Andrew Wilson laid the foundations for this guide, with the conceptual framework presented in Research Report No. 31; and the visual guides for assessing the influence of bark and elevated fuels on suppression difficulty in the *Eucalypt Bark Hazard Guide and Elevated Fuel Guide* (Reports 32 and 35, respectively). Greg McCarthy (2004) detailed a method for rapidly assessing surface fine fuels in Research Report No. 44.

These three techniques were brought together in the first three editions of the *Overall Fuel Hazard Guide* (McCarthy, Tolhurst and Chatto, 1998b, 1998c, 1999). A subsequent unpublished edition of the guide, produced by Kevin Tolhurst (2005), provided greater detail on the assessment of near-surface fuels. In 2006, Mike Wouters adapted the guide for South Australian conditions, and incorporated the preliminary results from Project Vesta (CSIRO and Department of Conservation and Environment, Western Australia). Further information and results from the final Project Vesta report (Gould *et al.* 2007a) have also been incorporated.

Thanks to Lachie McCaw (Department of Environment and Conservation, Western Australia), Mike Wouters (Department of Environment and Heritage, South Australia), Jim Gould and Miguel Cruz (CSIRO) for their advice and comments during the production of this guide. Thanks must also go to the many other people across Australia who have provided comments and feedback during the production of the guide.

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Wilson, AAG 1993, *Elevated fuel guide*, research report no. 35, Fire Management Branch, Department of Conservation and Environment, Victoria.

Appendix 1. Reference extended first attack conditions

This guide assesses the impact of fuels in suppressing a fire during extended first attack, using local resources. Several factors affect the success of an extended first attack. Therefore, to consider the impact of fuels alone, the other factors must be treated as if they were constant. Table A1 below adapted from Wilson (1993) summarises reference extended first attack conditions for four fuel types.

Table A1. Revised reference extended first attack conditions

Fuel type	Forest fuels	Grass fuels	Mallee and scrub fuels	Heath fuels
Examples of typical resources (on scene within the designated arrival time)	Small dozer (D4) 1 to 2 small 4WD tankers (400l) 6 firefighters	5 x 4WD heavy tankers (4000l) each with 5 firefighters	Small dozer (D4) or tractor with scrub roller 1 to 2 small 4WD tankers (400l) 6 firefighters	Small dozer (D4) 1 to 2 small 4WD tankers (400l) 6 firefighters
Extended attack resources	Potential additional resources deployed to the fire during extended first attack may include heavy tankers, large plant (dozers, graders or tractors) and fire bombing aircraft.			
Arrival time	Within 60 minutes of detection			
Suppression workload	A single fire			
Topography and terrain	Burning on level ground with good access			
Fuel availability[1]	MDF is 10 or AFF is 1.0	100% grass curing	MDF is 10 or AFF is 1.0	
Wind speed[2]	20km/h	30km/h		20km/h
Fire danger rating system[3]	McArthur FFDI	McArthur GFDI	McArthur FFDI	

Notes:

1. MDF (McArthur Drought Factor) is calculated using the Forest Fire Danger Meter (McArthur 1973) and is a measure of the short-term availability of forest fuels. AFF (Available Fuel Factor) is used in Western Australia to define the proportion of litter fuel available for burning (Sneeuwjagt & Peet 1998).
2. Wind speed is measured at 10m height in the open above ground level.
3. FFDI is the McArthur Forest Fire Danger Index, GFDI is the McArthur Grass Fire Danger Index.

The rationale for the reference first attack conditions is documented in DSE's *Overall fuel hazard assessment guide: a rationale report – fire and adaptive management report no. 83* (in prep).

Appendix 2. Sample fuel assessment field work form

Date Assessed:	Assessors:
Sampling Location:	Veg Type:

Plot Information			
Plot No.			
Zone:			
Easting (GDA94 MGA UTM):			
Northing (GDA94 MGA UTM):			

Canopy (20m radius)			
Canopy Ave Height to Top:	m	m	m
Canopy Ave Height to Base:	m	m	m

Bark fuel (20m radius)															
Stringybark Fuel Hazard:	NP	M	H	VH	E	NP	M	H	VH	E	NP	M	H	VH	E
Ribbon Bark Fuel Hazard:	NP	M	H	VH		NP	M	H	VH		NP	M	H	VH	
Other Bark Fuel Hazard:	L	M	H			L	M	H			L	M	H		

Note: NP is bark type not present. Use the highest bark hazard rating to determine Overall Fuel Hazard.

Elevated fuel layer (10m radius)															
Elevated % Cover:					%					%					%
Elevated % Dead					%					%					%
Elevated Fuel Ave Height (m)					m					m					m
Elevated Fuel Hazard:	L	M	H	VH	E	L	M	H	VH	E	L	M	H	VH	E

Near-surface fuel layer (10m radius)															
Near-surface % Cover:					%					%					%
Near-surface % Dead					%					%					%
NS Ave Height (cm):					cm					cm					cm
NS Fuel Hazard:	L	M	H	VH	E	L	M	H	VH	E	L	M	H	VH	E

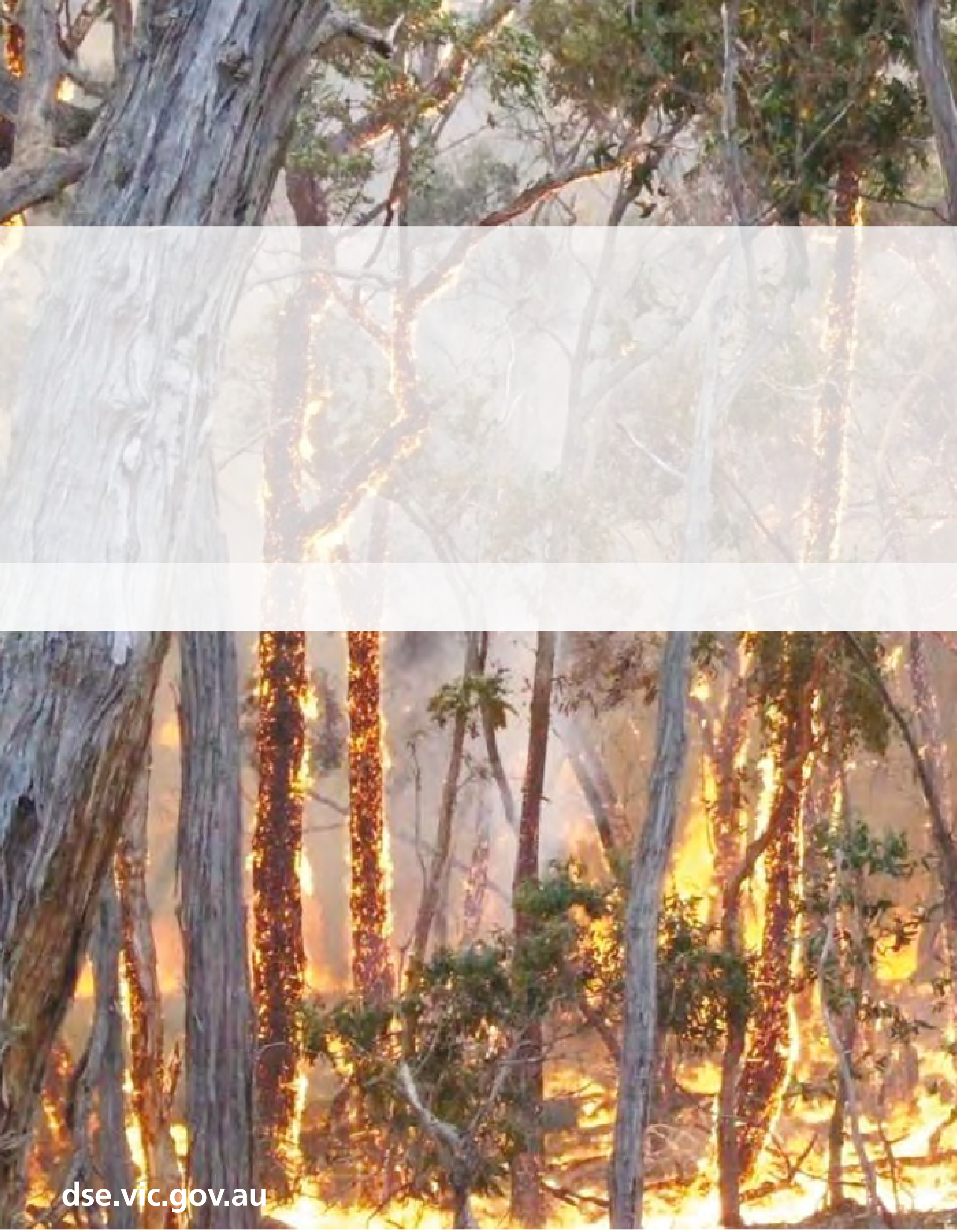
Surface fuel layer (10m radius)															
Surface Litter % Cover:					%					%					%
Ave Litter Depth (mm):					mm					mm					mm
Surface Fuel Hazard	L	M	H	VH	E	L	M	H	VH	E	L	M	H	VH	E

Combined Surface and Near-surface Fine Fuel Hazard calculation (refer Section 7)															
Combined Hazard	L	M	H	VH	E	L	M	H	VH	E	L	M	H	VH	E

Overall Fuel Hazard calculation (refer Section 8)															
Overall Fuel Hazard	L	M	H	VH	E	L	M	H	VH	E	L	M	H	VH	E

Are the plots representative of the average fuels across the sampling location?	Yes	No

If no, explain any significant difference between plots. For example, wet gully runs through the sampling area, no plots were located in this gully.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APPENDIX B

Kentucky Offset Area Management Plan

Santos

Santos GLNG

Kentucky Offset Area Management Plan – EPBC 2008/4096

Document Number: 0007-650-EMP-0017

Date	Rev	Reason For Issue	Reviewed	Endorsed	Approved
30 July 2021	0	For DAWE submission	MB	MB	JC/ED
23 September 2021	1	Updated based on DAWE review	MB	MB	ED

GLNG is a Santos PETRONAS Total KOGAS project.

Santos

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Abbreviations

Acronym	Description
BPA	Biodiversity Planning Assessment
CSG	Coal Seam Gas
°C	Degrees Celsius
DAF	Department of Agriculture and Forestry (Qld)
DAWE	Department of Agriculture, Water and the Environment; formerly Department of the Environment and Energy (DEE)
DES	Department of Environment and Science; formerly Department of Environment and Heritage Protection (DEHP)
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Cth)
GIS	Geographical Information System
GLNG	Gladstone Liquefied Natural Gas
ha	Hectare
km	Kilometre
MNES	Matters of National Environmental Significance
m	Metre
mm	Millimetre
NP	National Park
OAMP	Offset Area Management Plan
PMAV	Property Map of Assessable Vegetation
RE	Regional Ecosystem
REDD	Reginal Ecosystem Description Database
SEVT	Semi-evergreen vine thickets of the Brigalow Belt (North and South) and Nandewar Bioregions
SSMP	Significant Species Management Plan
spp	species
TEC	Threatened Ecological Community

Acronym	Description
TSSC	Threatened Species Scientific Committee
VM Act	*Vegetation Management Act 1999* (Qld)

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Executive summary

This offset area management plan (OAMP) has been prepared to address the requirements of the Santos Gladstone Liquefied Natural Gas (GLNG) Project approval EPBC 2008/4096 to provide suitable offsets for matters of national environmental significance (MNES) to compensate for direct and indirect adverse impacts on MNES.

Santos will secure a 4,302 hectare (ha) offset area on the Kentucky property (Lot 1 WT37). The Kentucky offset area was approved by the Department of Agriculture, Water and the Environment (DAWE) on 23 March 2021 to acquit MNES offset requirements under EPBC 2008/4059, including surplus areas of suitable MNES habitat for Santos to drawdown on for future project offset acquittal. The Kentucky offset area includes (Table ES1):

- 19.79 ha to acquit offset requirements under EPBC 2008/4096 (conditions 15-22) and the Gas Transmission Pipeline Significant Species Management Plan (GTP SSMP; 3380-GLNG-4-1.3-0104 Rev W).
- 2,533.29 ha to acquit offset obligations under EPBC 2008/4059 plus 305.4 ha of future habitat area that will support threatened species in the future following appropriate management as part of this OAMP (approved by DAWE 23 March 2021; however, was provided in addition to acquitting MNES offset obligations under EPBC 2008/4059 to support the overall conservation gain of the offset area).
- 1,443.85 ha of remaining surplus offset value comprising habitat for MNES and will be used by Santos to acquit future project offset requirements.

For MNES where a surplus is noted, Santos proposes to draw down on these to acquit future offset requirements under related approvals. The remaining obligations under EPBC 2008/4096 and the GTP SSMP will be satisfied elsewhere.

The Kentucky property is located within the Santos GLNG Project tenements approximately 50 km north-east of Injune and contiguous with Expedition (Limited Depth) National Park (NP) to the east and Lonesome Holding (proposed NP) to the north. The property is mapped within a state conservation corridor. Key desktop and field surveys of the Kentucky property have been completed to confirm the presence of offset values and suitability to satisfy the Project's offset obligations as follows:

- 2010
  - Preliminary desktop assessment of biodiversity offset values (Ecofund 2010)
  - Detailed field assessment undertaken by Boobook, in May 2010, to ground truth vegetation and confirm presence of environmental values (Boobook 2011).
- 2015
  - Further refine ground-truthed and potential regional ecosystem (RE) types and their extent as well as confirming location of potential areas to support biodiversity offsets based on examination of high-resolution aerial photography provided for the property by Santos (Boobook 2015).
- 2020 (January to May)
  - Update fine-scale RE mapping and BioCondition assessments (Boobook 2020)
  - Targeted flora and fauna surveys and habitat assessments (Boobook 2020).

The outcome of this OAMP is to acquit the offset obligations under EPBC 2008/4096 (conditions 15-22) and the GTP SSMP. The Kentucky offset area will be managed and monitored, based on an adaptive management framework, to achieve the interim performance targets and completion criteria presented in Table ES 2.

The key management actions to be implemented include:

- restricting access to the offset area
- management and restoration of regrowth TEC
- maintenance and upgrades of existing access tracks, fencing and firebreaks
- fire management through strategic grazing and fuel hazard reduction burns
- weed management, and
- pest animal management.

Ongoing monitoring events will be undertaken to assess the effectiveness of the management actions and progress of the offset area in achieving the interim performance targets and completion criteria, including:

- biannual offset area inspections
- biomass monitoring
- fuel load monitoring
- weed monitoring
- pest animal monitoring
- rapid monitoring events
- habitat quality assessments
- brigalow stem counts
- photo monitoring.

Annual reports will be prepared to detail progress of the offset area in achieving the interim performance targets and completion criteria for each management year including the results of management and monitoring activities completed.

Santos will apply to have the offset area protected via a Voluntary Declaration under section 19E and 19F of the Queensland *Vegetation Management Act 1999* (including surplus areas identified in Table ES 1). In accordance with previous OAMPs over the Kentucky property, Santos will lodge the Voluntary Declaration application by 23 March 2022 and the Voluntary Declaration will remain in place for the life of EPBC 2008/4096 and 2008/4059. In addition, once areas of regrowth Brigalow TEC have reached the requirements to achieve remnant status Santos will apply to these areas reclassified as remnant vegetation in accordance with the relevant Queensland legislation.

Table ES 1: Summary of the Kentucky offset area and acquittal

MNES	Disturbance area (ha)	Offset ratio	Offset area (ha)/number of species	Kentucky offset area approved under EPBC 2008/4059**		Kentucky offset area to be secured under EPBC 2008/4096		Surplus area remaining on Kentucky following acquittal of EPBC 2008/4059 and 2008/4096 (ha)
				Offset area to be secured (ha)	Available surplus area (ha)	Offset area to be secured (ha)	Offset requirement satisfied Kentucky?	
Endangered ecological communities								
Brigalow (*Acacia harpophylla* dominant and co-dominant)	11.23	8	89.84	-	-	-	No	
Semi-evergreen vine thickets of the Brigalow Belt (North and South) and Nandewar Bioregions	2.4	8	19.2	-	19.79	19.79	Yes	-
Endangered fauna species								
Australasian bittern (*Botaurus poiciloptilus*)	0.8	8	6.4	-	-	-	No	-
Northern quoll (*Dasyurus hallucatus*)	1.53	8	12.24	145.00	1,463.65	-	No	1,443.85
Australian painted snipe (*Rostratula australis*)	4.79	8	38.32	-	-	-	No	-
Vulnerable fauna species								
Black-breasted button-quail (Turnix melanogaster)	2.61	8	20.88	-	19.79	19.79	Partially	-
Collared delma (*Delma torquata*)	86.22	8	689.76	2,330.00	1,392.18	-	No	1,392.18
Dunmall's snake (*Furina dunmalli*)	79.78	8	638.24	2,370.00	1,463.65	-	No	1,443.85
Fitzroy river turtle (*Rheodytes leukops*)	1.05	8	8.4	Offset obligation satisfied through approved nest protection program				
Large-eared pied bat (*Chalinolobus dwyeri*)	44.11	8	352.88	860.00	1,463.65	-	No	1,443.85
Ornamental snake (*Denisonia maculata*)	25.46	8	203.68	-	-	-	No	
Red goshawk (*Erythrotriorchis radiatus*)	68.91	8	551.28	1,600.00	1,463.65	-	No	1,443.85
South-Eastern long-eared bat (*Nyctophilus corbeni*)	142.91	8	1143.28	2,310.00	1,463.65	-	No	1,443.85
Squatter pigeon (Geophaps *scripta scripta*)	225.15	8	1801.2	1,955.00	1,392.18	-	No	1,392.18
Water mouse (*Xeromys myoides*)	0.01	8	0.08	-	-	-	No	
Yakka skink (*Egernia rugosa*)	63.11	8	504.88	2,420.00	1,443.85	-	No	1,443.85
Migratory birds								
Cattle egret (*Ardea ibis*)	1.67	8	13.36	-	-	-	No	-
Eastern osprey (*Pandion haliaetus*)	1.4	8	11.2	-	-	-		-
Great egret (*Ardea modesta*)	3.83	8	30.64	-	-	-		-
Rainbow bee-eater (*Merops ornatus*)	225.39	8	1803.12	-	-	-		-

MNES	Disturbance area (ha)	Offset ratio	Offset area (ha)/number of species	Kentucky offset area approved under EPBC 2008/4059**		Kentucky offset area to be secured under EPBC 2008/4096		Surplus area remaining on Kentucky following acquittal of EPBC 2008/4059 and 2008/4096 (ha)
				Offset area to be secured (ha)	Available surplus area (ha)	Offset area to be secured (ha)	Offset requirement satisfied Kentucky?	
White-bellied sea-eagle (*Haliaeetus leucogaster*)	25.09	8	200.72	-	-	-		-
Migratory woodland bird species								
Black-faced monarch (*Monarcha melanopsis*)	14.68	8	117.44	-	-	-	No	-
Spectacled monarch (*Monarcha trivirgatus*)								
Satin flycatcher (*Myiagra cyanoleuca*)								
Rufous fantail (*Rhipidura rufifrons*)								
Oriental cuckoo (*Cuculus saturatus*)								
Migratory marine bird species								
Bar-tailed godwit (*Limosa lapponica*)	0.8	8	6.4	-	-	-	No	-
Black-tailed godwit (*Limosa limosa*)	0.8	8	6.4	-	-	-		-
Broad-billed sandpiper (*Limicola falcinellus*)	0.8	8	6.4	-	-	-		-
Common greenshank (*Tringa nebularia*)	0.8	8	6.4	-	-	-		-
Common sandpiper (*Actitis hypoleucos*)	0.8	8	6.4	-	-	-		-
Curlew sandpiper (*Calidris ferruginea*)	0.8	8	6.4	-	-	-		-
Double-banded plover (*Charadrius bicinctus*)	0.8	8	6.4	-	-	-		-
Eastern reef egret (*Egretta sacra*)	0.8	8	6.4	-	-	-		-
Far eastern curlew (*Numenius madagascariensis*)	0.8	8	6.4	-	-	-		-
Great knot (*Calidris tenuirostris*)	0.8	8	6.4	-	-	-		-
Greater sand plover (*Charadrius leschenaultii*)	0.8	8	6.4	-	-	-		-
Grey plover (*Pluvialis squatarola*)	0.8	8	6.4	-	-	-		-
Grey-tailed tattler (*Tringa brevipes*)	0.8	8	6.4	-	-	-		-
Latham's snipe (*Gallinago hardwickii*)	0.8	8	6.4	-	-	-		-
Lesser sand plover (*Charadrius mongolus*)	0.8	8	6.4	-	-	-		-
Little curlew (*Numenius minutus*)	0.8	8	6.4	-	-	-		-
Marsh sandpiper (*Tringa stagnatilis*)	0.8	8	6.4	-	-	-		-
Pacific golden plover (*Pluvialis fulva*)	0.8	8	6.4	-	-	-		-

MNES	Disturbance area (ha)	Offset ratio	Offset area (ha)/number of species	Kentucky offset area approved under EPBC 2008/4059**		Kentucky offset area to be secured under EPBC 2008/4096		Surplus area remaining on Kentucky following acquittal of EPBC 2008/4059 and 2008/4096 (ha)
				Offset area to be secured (ha)	Available surplus area (ha)	Offset area to be secured (ha)	Offset requirement satisfied Kentucky?	
Red knot (*Calidris canutus*)	0.8	8	6.4	-	-	-		-
Red-necked stint (*Calidris ruficollis*)	0.8	8	6.4	-	-	-		-
Ruddy turnstone (*Arenaria interpres*)	0.8	8	6.4	-	-	-		-
Sanderling (*Calidris alba*)	0.8	8	6.4	-	-	-		-
Sharp-tailed sandpiper (*Calidris acuminata*)	0.8	8	6.4	-	-	-		-
Terek sandpiper (*Xenus cinereus*)	0.8	8	6.4	-	-	-		-
Whimbrel (*Numenius phaeopus*)	0.8	8	6.4	-	-	-		-
Migratory tern bird species								
Caspian tern (*Sterna caspia*)	0.05	8	0.4	-	-	-	No	-
Little tern (*Sternula albifrons*)	0.05	8	0.4	-	-	-		-
Endangered flora species								
Ooline (*Cadellia pentastylis*)	36 individuals	6:1	216	Existing 4.5 ha offset area legally secured on Bottle Tree property				
Xerothamnella herbacea	42 individuals	6:1	252	Existing 2.4 ha offset area legally secured on Bottle Tree property				
Philotheca sporadica	0	6:1	0	-	-	-	-	-
Large-fruited zamia (*Cycas megacarpa*)	1,100 individuals	No ratio	3,990[a]	See approved GLNG Gas Transmission Pipeline *Cycas megacarpa* Translocation and Management Plan (3380-GLNG-4-1.3-0013).				

**Plus an additional 305.4 ha of future habitat area has been committed to in addition to offset obligations under EPBC 2008/4059.

Table ES 2: Interim performance targets and completion criteria for the Kentucky offset area

MNES	Baseline	Interim performance targets			Completion criteria
		Year 5	Year 10	**Year 15**	Year 20
SEVT TEC	8	Increase in the habitat quality score from baseline score of 8	Increase in the habitat quality score from year 5	Increase in the habitat quality score from year 10	Improve the quality of habitat to achieve a score of at least 9
Black-breasted button quail	8	Increase in the habitat quality score from baseline score of 8	Increase in the habitat quality score from year 5	Increase in the habitat quality score from year 10	Improve the quality of habitat to achieve a score of at least 9

1.0 Introduction

The Santos Gladstone Liquefied Natural Gas (GLNG) Project involves the development of Coal Seam Gas (CSG) resources in the Surat and Bowen Basins in Queensland, to supply gas via a 430 kilometre (km) gas transmission pipeline (GTP) to the liquefied natural gas (LNG) Facility located on Curtis Island. Throughout the development of the Santos GLNG Project and in accordance with Santos GLNG Project approvals, potentially impacted environmental values are systematically identified and assessed and in order of preference are avoided, minimised or mitigated.

The Santos GLNG Project is required to provide environmental offsets for significant residual impacts on matters of national environmental significance (MNES) in accordance with approvals granted under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

The Kentucky offset area was approved by DAWE on 23 March 2021 to acquit MNES offset requirements under EPBC 2008/4059, including surplus areas of suitable MNES habitat for Santos to drawdown on for future project offset acquittal.

This offset area management plan (OAMP) has been prepared to address the acquittal of the MNES offset obligations under the GLNG Project approval EPBC 2008/4096, specifically offset obligations required under EPBC 2008/4096 (Conditions 15-22) and the Gas Transmission Pipeline Significant Species Management Plan (GTP SSMP; 3380-GLNG-4-1.3-0104 Rev W,) outlined in Table 1, and will draw down on the approved surplus areas within the Kentucky offset area (Figure 1; Figure 2; Section 2.6).

Table 1: Summary of the disturbance in which offsets will be provided for under EPBC 2008/4096 as presented in the approved GTP SSMP

MNES	Disturbance area (ha)	Offset ratio	Offset area (ha)/number of species
Endangered ecological communities			
Brigalow (*Acacia harpophylla* dominant and co-dominant)	11.23	8	89.84
Semi-evergreen vine thickets of the Brigalow Belt (North and South) and Nandewar Bioregions	2.4	8	19.2
Endangered fauna species			
Australasian bittern (*Botaurus poiciloptilus*)	0.8	8	6.4
Northern quoll (*Dasyurus hallucatus*)	1.53	8	12.24
Australian painted snipe (*Rostratula australis*)	4.79	8	38.32
Vulnerable fauna species			
Black-breasted button-quail (Turnix melanogaster)	2.61	8	20.88
Collared delma (*Delma torquata*)	86.22	8	689.76

MNES	Disturbance area (ha)	Offset ratio	Offset area (ha)/number of species
Dunmall's snake (*Furina dunmalli*)	79.78	8	638.24
Fitzroy river turtle (*Rheodytes leukops*)	1.05	8	8.4
Large-eared pied bat (*Chalinolobus dwyeri*)	44.11	8	352.88
Ornamental snake (*Denisonia maculata*)	25.46	8	203.68
Red goshawk (*Erythrotriorchis radiatus*)	68.91	8	551.28
South-Eastern long-eared bat (*Nyctophilus corbeni*)	142.91	8	1143.28
Squatter pigeon (Geophaps *scripta scripta*)	225.15	8	1801.2
Water mouse (*Xeromys myoides*)	0.01	8	0.08
Yakka skink (*Egernia rugosa*)	63.11	8	504.88
Migratory birds			
Cattle egret (*Ardea ibis*)	1.67	8	13.36
Eastern osprey (*Pandion haliaetus*)	1.4	8	11.2
Great egret (*Ardea modesta*)	3.83	8	30.64
Rainbow bee-eater (*Merops ornatus*)	225.39	8	1803.12
White-bellied sea-eagle (*Haliaeetus leucogaster*)	25.09	8	200.72
Migratory woodland bird species			
Black-faced monarch (*Monarcha melanopsis*)	14.68	8	117.44
Spectacled monarch (*Monarcha trivirgatus*)			
Satin flycatcher (*Myiagra cyanoleuca*)			
Rufous fantail (*Rhipidura rufifrons*)			
Oriental cuckoo (*Cuculus saturatus*)			
Migratory marine bird species			
Bar-tailed godwit (*Limosa lapponica*)	0.8	8	6.4
Black-tailed godwit (*Limosa limosa*)	0.8	8	6.4
Broad-billed sandpiper (*Limicola falcinellus*)	0.8	8	6.4

MNES	Disturbance area (ha)	Offset ratio	Offset area (ha)/number of species
Common greenshank (*Tringa nebularia*)	0.8	8	6.4
Common sandpiper (*Actitis hypoleucos*)	0.8	8	6.4
Curlew sandpiper (*Calidris ferruginea*)	0.8	8	6.4
Double-banded plover (*Charadrius bicinctus*)	0.8	8	6.4
Eastern reef egret (*Egretta sacra*)	0.8	8	6.4
Far eastern curlew (*Numenius madagascariensis*)	0.8	8	6.4
Great knot (*Calidris tenuirostris*)	0.8	8	6.4
Greater sand plover (*Charadrius leschenaultii*)	0.8	8	6.4
Grey plover (*Pluvialis squatarola*)	0.8	8	6.4
Grey-tailed tattler (*Tringa brevipes*)	0.8	8	6.4
Latham's snipe (*Gallinago hardwickii*)	0.8	8	6.4
Lesser sand plover (*Charadrius mongolus*)	0.8	8	6.4
Little curlew (*Numenius minutus*)	0.8	8	6.4
Marsh sandpiper (*Tringa stagnatilis*)	0.8	8	6.4
Pacific golden plover (*Pluvialis fulva*)	0.8	8	6.4
Red knot (*Calidris canutus*)	0.8	8	6.4
Red-necked stint (*Calidris ruficollis*)	0.8	8	6.4
Ruddy turnstone (*Arenaria interpres*)	0.8	8	6.4
Sanderling (*Calidris alba*)	0.8	8	6.4
Sharp-tailed sandpiper (*Calidris acuminata*)	0.8	8	6.4
Terek sandpiper (*Xenus cinereus*)	0.8	8	6.4
Whimbrel (*Numenius phaeopus*)	0.8	8	6.4
Migratory tern bird species			
Caspian tern (*Sterna caspia*)	0.05	8	0.4
Little tern (*Sternula albifrons*)	0.05	8	0.4

MNES	Disturbance area (ha)	Offset ratio	Offset area (ha)/number of species
Endangered flora species			
Ooline (*Cadelia pentasyli*)	36 individuals	6:1	216
Xerothamnella herbacea	42 individuals	6:1	252
Philotheca sporadica	0	6:1	0
Large-fruited zamia (*Cycas megacarpa*)	1,100 individuals	No ratio	3,990[a]

1.1 Purpose

This OAMP provides a detailed management and monitoring framework for the Kentucky offset area in accordance with the requirements of EPBC 2008/4096 as presented in Table 2 below.

Table 2: How EPBC Act approval 2008/4096 are satisfied

Condition Number	Condition	How the conditions are met
EPBC Act approval 2008/4096		
8	If a listed threatened species or migratory species or their habitat, or a listed ecological community is encountered during the surveys undertaken as required by condition 5 and is not specified in the Table 1 or 2 at condition 11 and 12, the proponent must submit a separate management plan for each species or ecological community to manage the unexpected impacts of clearing. In relation to each listed species or ecological community, each plan must address: a) the relevant characteristics describing each ecological community b) a map of the location of species, species' habitat, or ecological community in proximity to the ROW; c) measures that will be employed to avoid impact on the species, species' habitat, or ecological community; d) a quantification of the unavoidable impact (in hectares and/or individual specimens); e) where impacts are unavoidable and a disturbance limit is not specified for the listed species or ecological community under condition 11, propose offsets to compensate for the impact on the population of the species' habitat, or the ecological community; f) current legal status (under the EPBC Act); known distribution.	The Gas Transmission Pipeline Significant Species Management Plan (SSMP) has been developed to address all aspects of this condition including (e) the proposal of offsets to compensate for the impact on the population of the species' habitat, or the ecological community. An Offset Plan has been prepared to demonstrate how Santos will acquit the offset requirements for significant, residual, adverse impacts to MNES subject to EPBC 2008/4096 based on the offset ratios presented in the approved GTP SSMP. The Offset Plan complements previous offset plans and proposals submitted to the Commonwealth Government and has been prepared to address the offset commitments outlined in the GTP SSMP. This OAMP includes a detailed management and monitoring program to improve the quality of MNES offset values within the Kentucky offset area. This OAMP is based on an adaptive management framework which involves flexible decision making based on the outcomes of ongoing management and monitoring to ensure the environmental outcomes of the OAMP are achieved. This OAMP for the Kentucky offset area supersedes previous management plans submitted to the Department to satisfy this condition. This OAMP will be implemented following approval.
Offset for Semi-evergreen vine thickets of the Brigalow Belt (North and South) and Nandewar Bioregions (SEVT)		
15	Within 12 months of the commencement of pipeline development the proponent must prepare an Offset Plan to provide an offset area for the approved disturbance limits relating to Semi-evergreen vine thickets of the Brigalow Belt (North and South) and Nandewar Bioregions within the project area. The offset area to be secured must be an area of private land which includes at least 19.2 ha of Semi-evergreen vine thickets of the Brigalow Belt (North and South) and Nandewar Bioregions. Note: Offsetting requirements for this approval can be accommodated as part of a single offset plan addressing the requirements of this approval and those required by EPBC 2008/4059.	The first offset plan for the GTP Project was submitted on 22 April 2011. This plan included properties that would be suitable to meet the offset requirement for Semi-evergreen vine thickets of the Brigalow Belt (North and South) and Nandewar Bioregions (SEVT). A number of revisions have occurred since then; however, the current offset plan supersedes all previously submitted plans. The offset requirement for SEVT is proposed to be acquit on the Kentucky offset area as detailed in the offset plan and this OAMP. The offset plan addresses offset obligations under EPBC 2008/4096 and has been prepared to complement the offset plan addressing offset requirements under EPBC 2008/4059 approved by the Department of Agriculture, Water and the Environment (DAWE) on 23 March 2021.
16	The Offset Plan must include details of the offset area including: the timing and arrangements for property acquisition, maps and site description, environmental values relevant to MNES, connectivity with other habitats and biodiversity corridors, a rehabilitation program, and mechanisms for long-term protection, conservation and management.	An Offset Plan has been prepared to present a summary the offset areas on Kentucky and demonstrate how Santos will satisfy the SEVT offset requirement for the disturbance areas presented in Table 1. The following information has been included in this OAMP for the Kentucky offset area: • timing and arrangements for securing properties – Section 2.7, 5.2.3 and 5.2.4. • maps and site description – Section 2.5, 2.6, Figure 4, Figure 8, Figure 9. • environmental values relevant to MNES – Section 3.0. • connectivity with other habitats and biodiversity corridors – Section 2.2. • a rehabilitation program – Section 6.0 and 7.0. • mechanisms for long-term protection, conservation and management – Section 2.7, 5.2.3 and 5.2.4.
17	The Offset Plan must be submitted for the approval of the Minister within 12 months of the commencement of gas field development. The approved Offset Plan must be implemented within 30 business days of approval.	The first offset plan for the GTP Project was submitted on 22 April 2011. This plan included properties that would be suitable to meet the offset requirement for SEVT. A number of revisions have occurred since then; however, the current offset plan supersedes all previously submitted plans. Once approved, the offset plan will be implemented.
18	If the approved Offset Plan cannot be implemented because of failure of arrangements to secure the necessary area of private land then the proponent must submit for the Minister's approval an alternative Offset Plan. The alternative Offset Plan must provide at least an equivalent environmental outcome to those specified under condition 15. The approved alternative Offset Plan must be implemented.	An offset plan has been prepared to address offset obligations under EPBC 2008/4096 and includes details of the necessary areas of private land required to meet these obligations. Once approved, the offset plan will be implemented.

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Condition Number	Condition	How the conditions are met
19	If the proponent proposes any action within a proposed offset area, other than actions related to managing that area as an offset property, approval must be obtained, in writing from the Department. In seeking Departmental approval the proponent must provide a detailed assessment of the proposed action including a map identifying where the action is proposed to take place and an assessment of all associated adverse impacts on MNES. If the Department agrees to the action within the proposed offset site, the area identified for the action must be excised from the proposed offset and alternative offsets secured of equal or greater environmental value in relation to the impacted MNES.	Currently there are no actions proposed within the Kentucky offset area or any other offset areas subject to the offset plan.
20	The proponent must secure the offset within 2 years of commencement.	An offset plan has been prepared to address offset obligations under EPBC 2008/4096 and includes details of the necessary areas of private land required to meet these obligations. The offset requirement for SEVT is proposed to be acquit on the Kentucky offset area as detailed in the offset plan and this OAMP. Current title documents demonstrating Santos' ownership of the Kentucky property have been provided to the Commonwealth Government previously and can be provided again upon request.
SEVT Offset Area Management		
21	Within 12 months of securing the offset area required under the approved Offset Plan, the proponent must develop an Offset Area Management Plan which must specify measures to improve the environmental values of the offset area in relation to MNES, including; a) the documentation and mapping of current environmental values relevant to MNES of the area; b) measures to address threats to MNES including but not limited to grazing pressure and damage by livestock and adverse impacts from feral animals and weeds; c) measures to provide fire management regimes appropriate for the MNES; d) measures to manage the offset area to improve the condition of the SEVT ecological community within the offset area and to increase the areal extent of SEVT ecological community within the offset area as objectives of the program. e) monitoring, including the undertaking of ecological surveys to assess the success of the management measures against identified milestones and objectives; f) performance measures and reporting requirements against identified objectives, including trigger levels for corrective actions and the actions to be taken to ensure performance measures and objectives are met.	This OAMP includes a detailed management and monitoring program to improve the quality of MNES offset values within the Kentucky offset area. This OAMP is based on an adaptive management framework which involves flexible decision making based on the outcomes of ongoing management and monitoring to ensure the environmental outcomes of the OAMP are achieved. This OAMP for the Kentucky offset area supersedes previous management plans submitted to the Department to satisfy this condition. This OAMP includes: • On-ground ecological assessments of the Kentucky property have been undertaken from 2010 to 2020 including ground-truthing of vegetation communities, fauna surveys and confirmation of suitable habitat to support the Project's MNES offset requirements (see Section 2.4). Section 2.5 and 2.6 provide a detailed summary of the vegetation communities and habitat for MNES offset values identified within the offset area. Section 3.0 further describes the offset areas and suitable habitat to be secured for each of the MNES offset requirements Figure 5 and Figure 6 illustrates the location of MNES offset values within the offset area. Geographical Information Systems (GIS) shapefiles for the offset area will be provided to the Department. • Known or potential threats to each MNES offset value, presented in Section 3.0, have been addressed through the management and monitoring program outlined in Section 6.0 and 7.0, respectively. A strategic grazing regime will be implemented across the offset area, including exclusion of grazing within certain areas of the offset, as outlined Section 6.2.6.1. Pest animals will be controlled in accordance with Section 6.2.8 and monitored regularly in accordance with Section 7.5. Control measures for weeds within the offset area, including buffel grass, are outlined in Section 6.2.7. • Fire management for the offset area will include the control of fuel loads primarily through the implementation of a strategic grazing regime and fuel hazard reduction burns if required (Section 6.2.6). The fire management measures included in this OAMP take into account the fire management advice specific to the vegetation communities 6.2.6 and MNES offset values based on published conservation advice. • It is anticipated that through the implementation of this OAMP regrowth vegetation communities will be improved (see completion criteria in Table 9). Following approval of this OAMP the offset area will be legally secured through a Voluntary Declaration under the Queensland *Vegetation Management Act 1999* (VM Act). The offset area will be mapped as Category A (offset area) on the regulated vegetation management map. The reclassification of Category X Brigalow and SEVT TEC areas to Category A is considered to increase the extent of protected TEC within Queensland. • A detailed monitoring program is outlined in Section 7.0 to assess the progress of the offset area in achieving the environmental outcomes and completion criteria. • The complete adaptive management process for this OAMP is encapsulated in Table 11. Management actions, monitoring events, adaptive management triggers and corrective actions have been assigned to each management objective and performance criteria.
22	Within 12 months of securing the offset area the Offset Area Management Plan must be submitted for the approval of the Minister. The approved Offset Area Management Plan must be implemented.	The offset area management plan for the SEVT offset (Appendix B of the offset plan) supersedes previous management plans submitted to the Commonwealth Government to satisfy this condition. The OAMP will be implemented following approval.

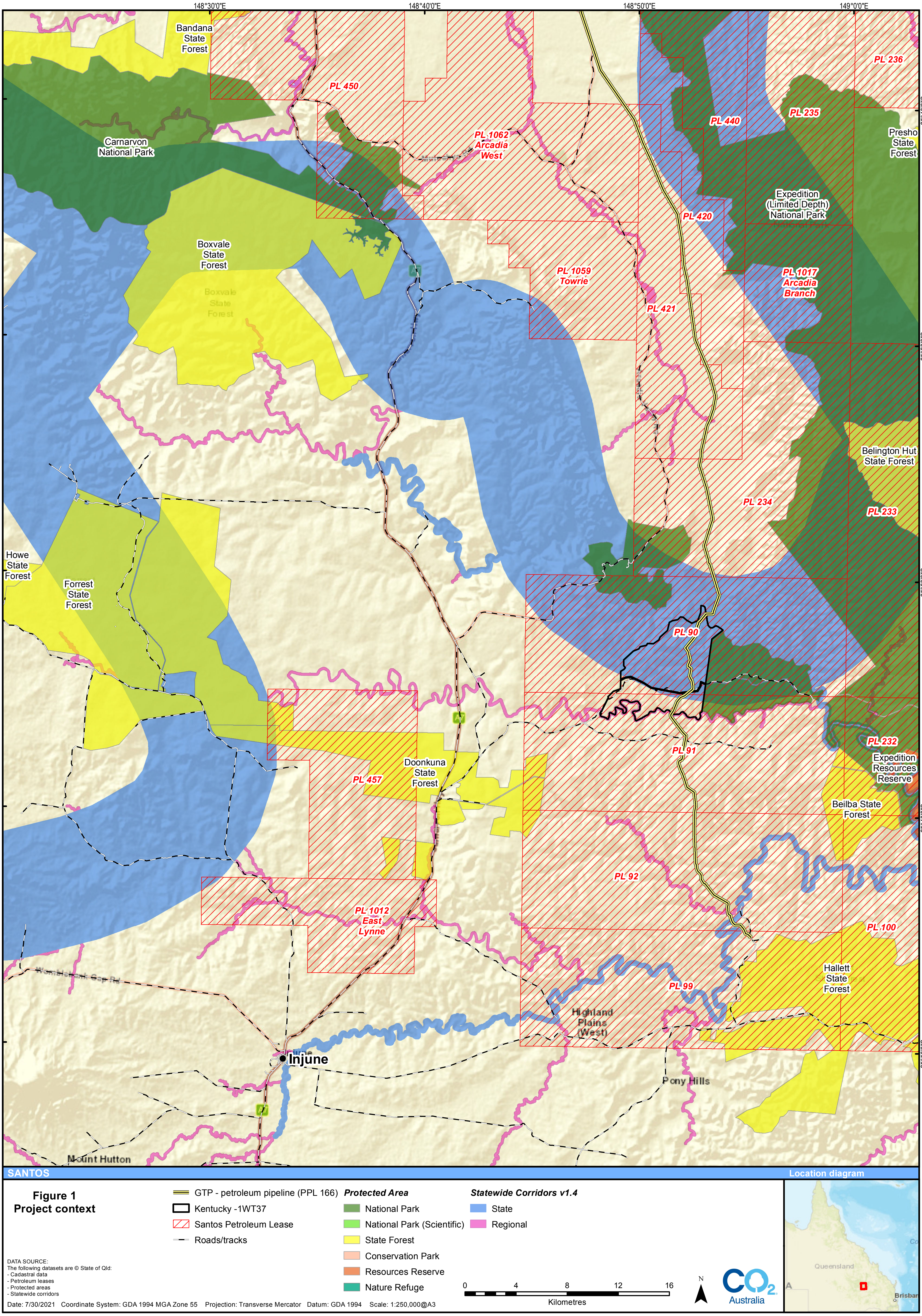

Figure 1
Project context

2.0 Kentucky property

2.1 Property overview

Kentucky (Lot 1 WT37) is a 4,368 ha property located approximately 50 km east north-northeast of Injune in south Central Queensland (Figure 1). The property is owned by Santos and was acquired primarily for its potential environmental offset values for the Santos GLNG Project. Kentucky is situated within Subregion 20 (Arcadia) of the Brigalow Belt South bioregion (Sattler and Williams 1999) within the jurisdiction of the Maranoa Regional Council. Access to the property is via the Beilba Road, east of the Carnarvon Developmental Road between Injune and Rolleston. Current land uses on the property include cattle grazing, activities associated with coal seam gas exploration and production as well as areas dedicated to environmental offsets. The Santos GLNG pipeline also traverses the property in a roughly south-north direction; however, has been excluded from all assessment and offset areas discussed as part of this OAMP (Figure 2).

The property lies within rugged terrain and contains large vegetation remnants that are contiguous with Expedition (Limited Depth) National Park (NP) to the east and Lonesome Holding (proposed NP) to the north. The property is located entirely within the Dawson River catchment, part of the Fitzroy River basin, with the major watercourses being the Dawson River and Baffle Creek. The topography is varied and is comprised mainly of hills, ridges, plateaux and steep scarps, with sandstone of the Precipice and Evergreen Formations forming the underlying geology. Small alluvial flats occur beside the Dawson River. Baffle Creek and its associated tributaries have associated deep gorges which provide a visually spectacular landscape.

Prior to Santos' ownership, vegetation clearing on the property was most extensive in the southern one-third of the property, between Baffle Creek and a steep plateau scarp to the north, for former pastoral development and use. Historical thinning and/or clearing of woody vegetation had also occurred on lowlands associated with the Dawson River in the north of the property. Evidence of historical wildfire, and possibly controlled burning for pastoral purposes, is present throughout the property, with some Brigalow and other communities showing severe fire damage.

Table 3 summarises Kentucky landholder and property details.

Table 3: Kentucky landholder and property details

Landholder and Property Details	
Registered Owner/s on Title:	Total GNG Australia Santos GLNG Pty Ltd PAPL (Downstream) Pty Ltd KGLNG Liquefaction Pty Ltd
ABN/ACN:	ABN 12 131 271 648 (Santos GLNG Pty Ltd)
Phone:	PO Box 329, Roma Queensland 4455
Lot on plan(s):	Lot 1 WT37
Address:	764 Beilba Rd, Beilba Queensland
Tenure:	Freehold

Area:	4,368 ha
Primary Local Government Area:	Maranoa Regional Council
Permits	
Petroleum and gas production permit	PL 90 and PL 91 Santos Toga Pty Ltd
Infrastructure permit	PPL 166 Santos GLNG Pty Ltd

2.2 Connectivity

The Kentucky property is mapped within a state conservation corridor (Figure 1). Conservation corridors have been mapped as part of the Queensland Government's Biodiversity Planning Assessments (BPA) which assess the biodiversity significance of land in a bioregion. The mapping of corridors within the Brigalow Belt Bioregion, in which the Kentucky property is located, has focussed on those corridors that link adjacent bioregions or connect wildlife refugia. Corridors identified as of state significance are considered of the greatest importance at the bioregional scale. As illustrated in Figure 1, the state conservation corridor runs along the eastern portion of the property as part of the contiguous tract of remnant vegetation including Expedition (Limited Depth) NP.

More detail on BPAs can be found at https://www.qld.gov.au/environment/plants-animals/biodiversity/planning.

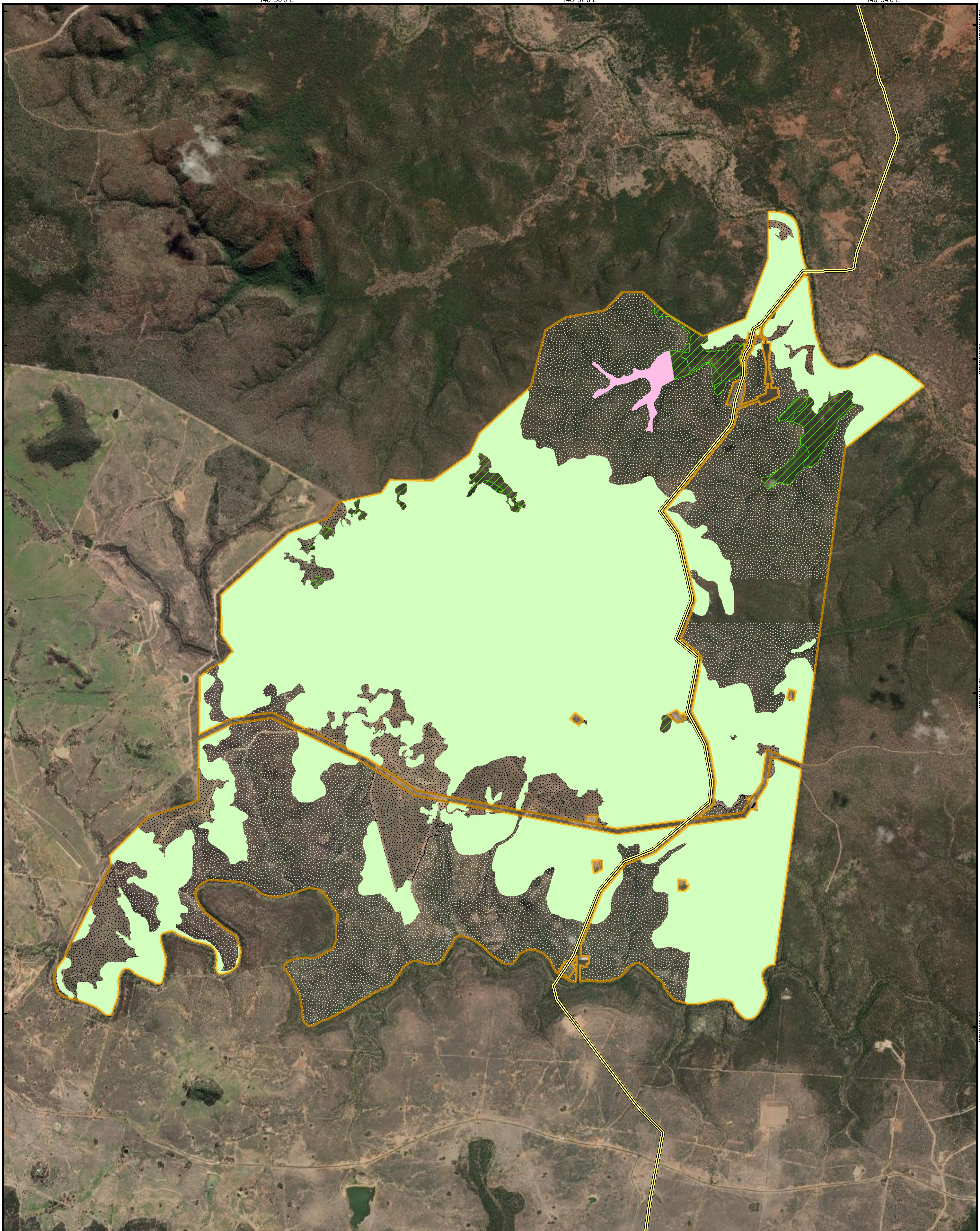

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Figure 2
Property overview

- Kentucky - 1WT37
- Petroleum pipeline (PPL 166)
- Kentucky offset area
- 2008/4096 offset area
- 2008/4059 offset area
- 2008/4059 rehabilitation offset
- Surplus offset area
- Future habitat areas approved under 2008/4059

0 0.5 1 1.5 2
Kilometres

N

CO2 Australia

Location diagram

DATA SOURCE:
The following datasets are © State of Qld:
- Cadastral data
- Petroleum pipeline
Kentucky offset area provided by SANTOS

Date: 7/30/2021 Coordinate System: GDA 1994 MGA Zone 55 Projection: Transverse Mercator Datum: GDA 1994 Scale: 1:37,500@A3

Path: P:\GISData\Projects\Santos\ENV_20_00419.GTP_Offset_Maps\Kentucky\Figure 2 - Property overview.mxd

2.3 Climate

The Kentucky property is characterised by a hotter wet season (typically November to March) and a cooler dry season (typically April to October) (see Figure 3). Weather records from the Injune weather station (#43015), approximately 50 km south-west of Kentucky, show the mean monthly rainfall for the period 1961-1990 ranges from 24.9 millimetres (mm) (September) to 94.6 mm (January). Mean monthly maximum temperatures range from 19.6 degrees Celsius (°C) (July) to 33.7°C (January) and mean monthly minimum temperatures range from 3°C (July) to 19.2°C (January).

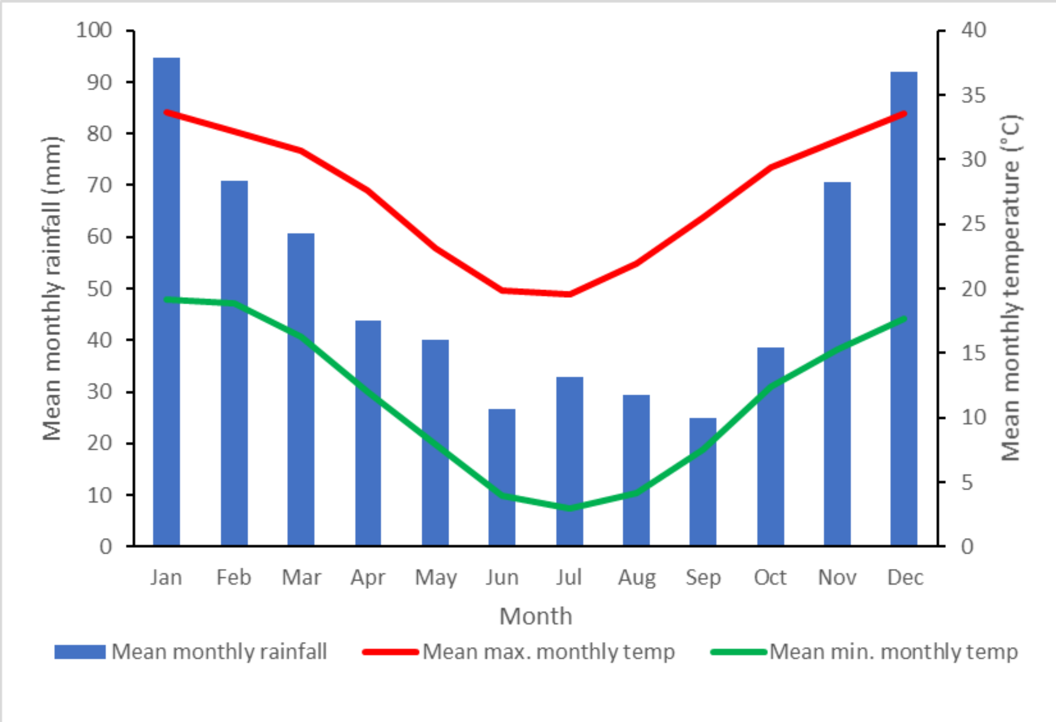


Figure 3: Mean monthly temperature and rainfall records from Injune Post Office weather station (ID: 43015) 1961-1990 (Bureau of Meteorology 2021)

2.4 On-ground property assessments

Santos has dedicated the majority of the Kentucky property for environmental offsets (4,302.3 ha) with the exception of the area excluded for the existing Santos GLNG pipeline and associated infrastructure (65.6 ha).

A combination of desktop and detailed on-ground assessments of the Kentucky offset area have been undertaken to confirm the suitability of the area to satisfy the Project's offset obligations. The key desktop and field surveys of the offset area completed to date are summarised below:

- 2010
    - Preliminary desktop assessment of biodiversity offset values (Ecofund 2010).
    - Detailed field assessment undertaken by Boobook, in May 2010, to ground truth vegetation and confirm presence of environmental values (Boobook 2011).

- 2015
  - Further refine ground-truthed and potential Regional Ecosystem (RE) types and their extent as well as confirming location of potential areas to support biodiversity offsets based on examination of high-resolution aerial photography provided for the property by Santos (Boobook 2015).
- 2020 (January to May)
  - Update large-scale RE mapping across the offset area including verification of presence and extent of remnant and regrowth vegetation communities and threatened ecological communities (TEC) (Boobook 2020). For each area of potential TEC an assessment of vegetation survey data was made against TEC threshold criteria.
  - BioCondition assessments within the Kentucky offset area in accordance with the BioCondition methodology (Eyre et al. 2015). Scores for BioCondition sites were calculated in accordance with Eyre et al. (2015) which compares the values obtained at each survey site with values in the benchmark document for that particular RE (Queensland Herbarium 2019a). Photo monitoring sites were established at all BioCondition assessment sites.
  - Updated RE-based predictive habitat mapping for EPBC Act-listed threatened flora and fauna species confirmed, likely or potentially present within the offset area based on the results of field surveys including microhabitat assessments were conducted at each BioCondition site combined with ecologist knowledge.
  - Targeted fauna surveys to assess fauna species richness for the endangered and vulnerable species as summarised in Table 4 below.
  - Incidental searches for threatened flora species listed under the EPBC Act and/or *Nature Conservation Act 1992* (NC Act) were carried out at vegetation assessment sites and during meanders in targeted habitat types, including remnant and non-remnant vegetation.
  - The timing (season) and duration of the survey period during summer and autumn coincided with good conditions for the identification of spring-summer growing and flowering herbaceous plant species. However, the recent (and continuing) rainfall events that fostered good conditions for plant growth and detectability followed a protracted period of extraordinarily low rainfall which had prevailed over most of the previous two years. These conditions were almost certain to have impacted on the detectability of fauna: for many groups (e.g. reptiles, birds), animals would have left the property or died and it is likely that this impact continued at least partially into the survey period as animal population responses lag to some extent, depending on the taxa involved. For example, it was noted during the survey that small ground-dwelling reptiles were scarce (Boobook 2020).

Table 4*:* Survey techniques for threatened species potentially present within the offset area (Boobook 2020)

Species	Survey methods	Survey effort
Australasian bittern	• Diurnal searches of riparian areas and wetlands	• 10 sites for 15 person/hrs
Australian painted snipe	• Diurnal searches of riparian areas and wetlands	• 10 sites for 15 person/hrs

Species	Survey methods	Survey effort
Black-breasted button-quail	• Diurnal searches of SEVT for birds and/or platelets	• 8 person/hrs in 4 SEVT patches
Squatter pigeon (southern)	• Active/flushing searches of woodland habitat • Waterhole searches • Driving traverses	• 14 diurnal searches, 2 x 30min = 14 person/hours • 6 x 15 min searches • Minimum 2hrs/20km per day for 10 days = 20hrs/200km
Red goshawk	• Scans for soaring birds • Nest searches on watercourses • Driving traverses	• 1 site for 2 person/hrs • 6 sites for 10 person/hrs • Minimum 2hrs/20km per day for 10 days = 20hrs/200km
South-eastern long-eared bat	• Harp trapping in potential habitat	• 20 harp trap-nights
Large-eared pied bat	• Harp trapping in potential habitat • Anabat recording in potential habitat	• 20 harp trap-nights • 12 Anabat nights (sunset to sunrise)
Greater glider	• Nocturnal spotlight searches (on foot) • Nocturnal spotlight searches (driven) • Stag watches	• 11 nocturnal searches, 2 x 1.0-2.5 hr = 29 person/hrs • 2hrs/5km per night for 3 nights = 6hrs/15km • 1 stag-watch site, 2 person/hrs
Koala	• Nocturnal spotlight searches (on foot) • Nocturnal spotlight searches (driven) • Diurnal searches (on foot) for animals, scats, scratches	• 11 nocturnal searches, 2 x 1.0-2.5 hr = 29 person/hrs • 2hrs/5km per night for 3 nights = 6hrs/15km • 14 diurnal searches, 2 x 30min = 14 person/hours
Northern quoll	• Diurnal searches (on foot) of denning habitat for scats • Nocturnal spotlight searches (on foot) • Camera traps in rocky habitat (outcrops and cliff lines)	• 10 diurnal searches, 2 x 30min = 10 person/hours • 11 nocturnal searches, 2 x 1.0-2.5 hr = 29 person/hrs • 47 camera trap-nights
Collared delma	• Diurnal active searches	• 14 diurnal searches, 2 x 30min = 14 person/hours
Dunmall's snake	• Diurnal active searches • Nocturnal active searches	• 14 diurnal searches, 2 x 30min = 14 person/hours • 11 nocturnal searches, 2 x 1.0-2.5 hr = 29 person/hrs

Species	Survey methods	Survey effort
Yakka skink	• Diurnal active searches	• 14 diurnal searches, 2 x 30min = 14 person/hours

2.5 Ground truthed vegetation and habitat mapping

Based on the results of detailed ecological field assessments ground-truthed vegetation within the offset area has been classified as remnant vegetation, vegetation consistent with RE (advanced regrowth) or non-remnant vegetation (Santos 2014). Within the 4,302.3 ha offset area approximately 3,996.9 ha of vegetation (3,305.4 ha of remnant and 691.5 ha of regrowth) was mapped, the remaining is considered non-remnant.

The suitability of areas of vegetation as fauna habitat was determined by the presence and abundance of microhabitat features relevant to the needs of individual species or groups of species (e.g. terrestrial reptiles; Boobook 2020). The results of detailed field assessments were combined with ecologist knowledge to develop RE-based predictive habitat mapping for EPBC Act-listed threatened flora and fauna species confirmed, likely or potentially present within the Kentucky offset area. This assessment also considered the GTP Adverse Impact Assessment Methodology (approved by the Commonwealth government on 16 July 2015) and the habitat mapping rules for the Santos GLNG Project area outlined in the *Predictive Habitat Mapping Rules for Selected MNES Fauna Species within the Roma, Fairview and Arcadia Gas Fields* report (Boobook 2020).

2.5.1 Vegetation description

Table 5 provides a summary of the ground truthed RE mapped on the Kentucky offset area.

Soils at the offset area are predominantly sandy loams and duplex soils. These support vegetation communities dominated by Ironbarks (*Eucalyptus* spp.). Sandy lithosols on plateau crests support shrubby open forests and woodlands of *Eucalyptus, Corymbia* and *Acacia* spp. Smaller areas of clay loam soils derived from fine-grained sediments are present on hill slopes and small valleys: these support Poplar Box (*E. populnea*), Mountain Coolibah (*E. orgadophila*), Brigalow (*A. harpophylla*) and semi-evergreen vine thicket (SEVT) communities. The Dawson River, at the extreme north of the Site, features deep sandy to silty loam alluvium on riverbanks and associated floodplain which support riparian open forest of Queensland Blue Gum (*E. tereticornis*), Rough-barked Apple (*Angophora floribunda*) and Weeping Bottlebrush (*Melaleuca viminalis*); and grassy woodlands of Poplar Box and/or Silver-leaved Ironbark (*E. melanophloia*). There is only limited development of these alluvial or riparian communities on Baffle Creek, which for much of its extent at the offset area is narrowly bounded by steep sandstone cliffs. Grey Gums (*E. major, E. longirostrata*) are present on escarpment slopes and within gorges (Boobook 2020).

Table 5: Ground-truthed RE mapped on the Kentucky offset area

RE	Description	Type	Kentucky offset area (ha)			
			EPBC 2008/4059 offset area	EPBC 2008/4096 offset area	Surplus offset	Total Area
11.3.2	*Eucalyptus populnea* woodland on alluvial plains	Remnant	30.32	-	-	30.32
11.3.25	*Eucalyptus tereticornis* or *E. camaldulensis* woodland fringing drainage lines	Remnant	11.67	-	-	11.67
11.3.27	Freshwater wetlands	Remnant	1.03	-	-	1.03
11.3.39	*Eucalyptus melanophloia* +/- *E. chloroclada* open woodland on undulating plains and valleys with sandy soils	Remnant	46.73	-	-	46.73
11.9.10	*Eucalyptus populnea* open forest with a secondary tree layer of *Acacia harpophylla* and sometimes *Casuarina cristata* on fine-grained sedimentary rocks	Remnant	60.34	-	-	60.34
11.9.2	*Eucalyptus melanophloia* +/- *E. orgadophila* woodland on fine-grained sedimentary rocks	Regrowth	41.71	-	-	41.71
		Remnant	107.76	-	-	107.76
11.9.4	Semi-evergreen vine thicket or *Acacia harpophylla* with a semi-evergreen vine thicket understorey on fine-grained sedimentary rocks	Remnant	22.73	19.79	-	42.52
11.9.5	*Acacia harpophylla* and/or *Casuarina cristata* open forest on fine-grained sedimentary rocks.	Remnant	67.78	-	-	67.78
		Regrowth	3.33	-	-	3.33
11.10.3	*Acacia catenulata* or *A. shirleyi* open forest on coarse-grained sedimentary rocks. Crests and scarps	Remnant	29.17	-	51.67	80.84
11.10.7	*Eucalyptus crebra* woodland on coarse-grained sedimentary rocks	Regrowth	421.45	-	-	421.45

RE	Description	Type	Kentucky offset area (ha)			
			EPBC 2008/4059 offset area	EPBC 2008/4096 offset area	Surplus offset	Total Area
		Remnant	1,314.32	-	-	1,314.32
11.10.8	Semi-evergreen vine thicket in sheltered habitats on medium to coarse-grained sedimentary rocks	Remnant	4.96	-	-	4.96
11.10.11	*Eucalyptus populnea, E. melanophloia* +/- *Callitris glaucophylla* woodland on coarse-grained sedimentary rocks	Regrowth	3.58	-	-	3.58
11.10.13	*Eucalyptus* spp. and/or *Corymbia* spp. open forest on scarps and sandstone tablelands	Remnant	350.96	-	1,186.15	1,537.11
		Regrowth	15.45	-	206.03	221.48
	Non-remnant		-	-	-	305.35
	Total		**2,533.29**	**19.79**	**1,443.85**	**4,302.29**

2.5.2 Habitat description

Table 6 summarises the mapping rules and total area of potential habitat for MNES within the offset area based on the results of detailed field assessments (Boobook 2020). Identified habitat RE for MNES were classified as essential or general habitat using the definitions provided in the Santos Fauna Habitat model (Aurecon 2014) as follows:

- Essential Habitat - is an area containing resources that are considered essential for the maintenance of populations of the species (e.g. potential habitat for breeding, roosting, foraging, shelter, for either migratory or non-migratory species). 'Essential Habitat' is defined from known records and/or expert advice (including the findings of preclearance surveys).
- General Habitat - consists of areas or locations that are used by transient individuals or where species have been recorded but there is insufficient information to assess the area as 'essential/core habitat'. 'General Habitat' may be defined from known records or habitat that is considered to potential support a species according to expert knowledge of habitat relationships, despite the absence of specimen backed records. 'General Habitat' may include areas of suboptimal habitat for species.

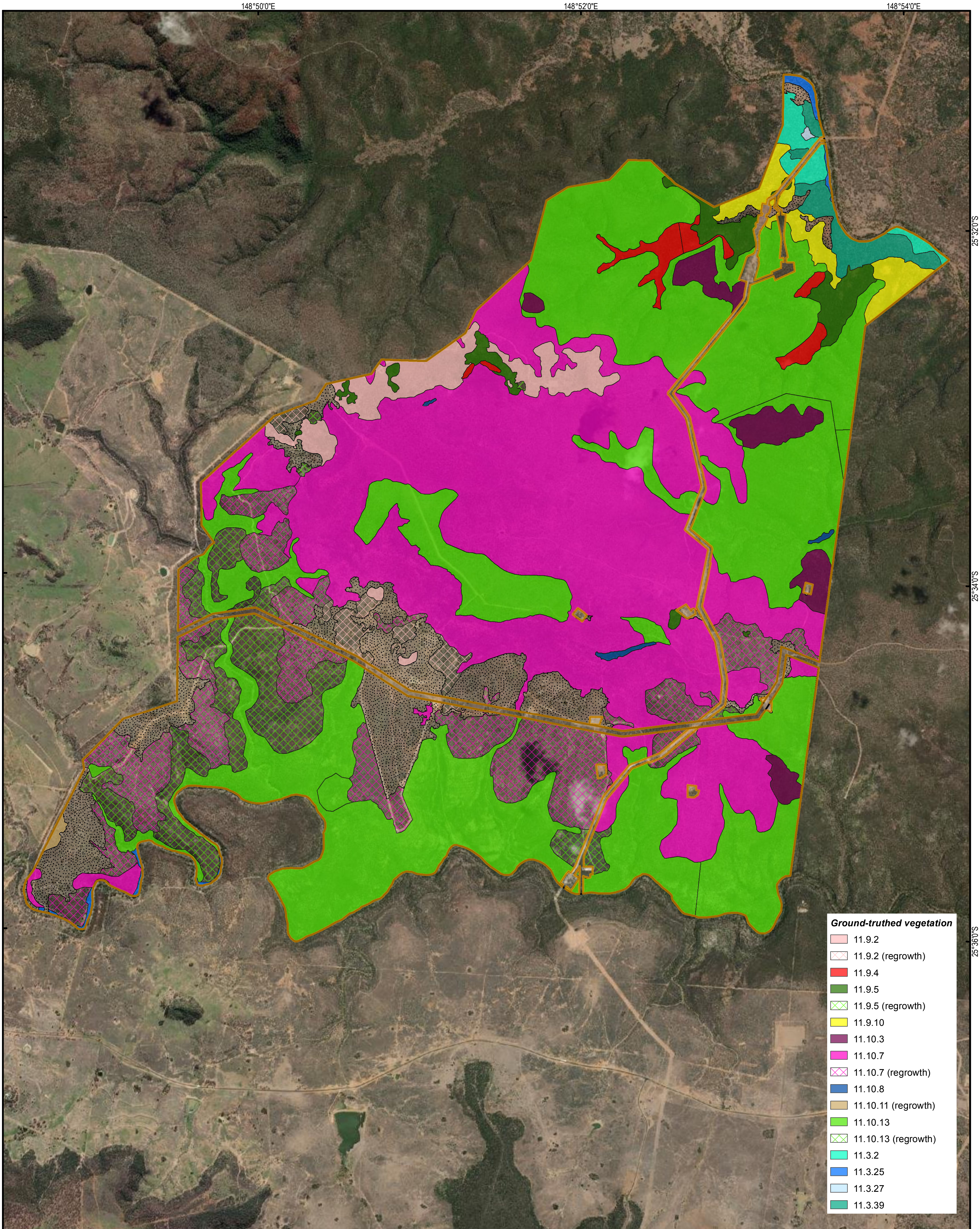
An additional description of the offset area for each MNES is provided in Section 3.0.

Table 6: Extent of suitable habitat for MNES on the Kentucky offset area

Species name	Potentially suitable RE	Habitat mapping rules	Extent of potential habitat available (ha)*
Brigalow TEC	11.9.5	Remnant and regrowth RE 11.9.5 where *Acacia harpophylla* is dominant in the canopy and that the vegetation otherwise met condition criteria (Department of the Environment [DotE] 2013).	-
SEVT TEC	11.9.4	Remnant RE 11.9.4, listed as a component RE for this TEC (Threatened Species Scientific Committee [TSSC] 2001).	19.79
Large-eared pied bat	11.3.2, 11.3.25, 11.3.27, 11.3.39, 11.9.2, 11.9.4, 11.9.5, 11.9.10, 11.10.3, 11.10.7, 11.10.8, 11.10.11, 11.10.13	Mapped Essential Habitat includes all areas of remnant and regrowth vegetation of the nominated RE within 5 km of potentially suitable shelter habitat.	1,463.65
Northern quoll	11.3.2, 11.3.25, 11.3.39, 11.9.2, 11.9.4, 11.9.5, 11.9.10, 11.10.3, 11.10.7, 11.10.8, 11.10.11, 11.10.13	Mapped Essential Habitat includes all nominated RE within 1 km of shelter habitat (extensive areas of dissected sandstone with deep crevices and caves). Mapped General Habitat includes all remnant and regrowth vegetation of the nominated RE in a buffer 1 to 5 km of potentially suitable shelter habitat.	1,463.65
South-eastern long-eared bat	11.3.2, 11.3.25, 11.3.27, 11.3.39, 11.9.2, 11.9.4, 11.9.5, 11.9.10, 11.10.3, 11.10.7, 11.10.8, 11.10.11, 11.10.13	Mapped General Habitat includes all areas of remnant and regrowth vegetation that may be suitable for foraging or shelter.	1,463.65
Red goshawk	11.3.2, 11.3.25, 11.3.27, 11.3.39, 11.9.2, 11.9.4, 11.9.5, 11.9.10, 11.10.3, 11.10.7, 11.10.8, 11.10.11, 11.10.13	This species requires tall trees close to permanent water for nest sites but may forage at a distance from this habitat. Mapped General Habitat includes all areas of remnant and regrowth vegetation of the nominated RE.	1,463.65
Squatter pigeon (southern)	11.3.2, 11.3.25, 11.3.27, 11.3.39, 11.9.2, 11.9.10, 11.10.7, 11.10.11, 11.10.13	Mapped General Habitat includes all areas of remnant and regrowth vegetation of the nominated RE.	1,392.18

Species name	Potentially suitable RE	Habitat mapping rules	Extent of potential habitat available (ha)*
Black-breasted button-quail	11.9.4, 11.9.5, 11.10.8	Mapped General Habitat includes all areas of remnant and regrowth vegetation of the nominated RE. Note that this species is dependent on large patches of habitat, such that small, isolated patches of otherwise suitable habitat may not be occupied. The presence of this species west of Palmgrove NP (Scientific) has not been confirmed.	19.79
Collared delma	11.3.2, 11.3.39, 11.9.2, 11.9.10, 11.10.7, 11.10.11, 11.10.13	Mapped General Habitat includes all areas of remnant and regrowth vegetation of the nominated RE.	1,392.18
Yakka skink	Essential Habitat: 11.3.2, 11.3.39, 11.9.2, 11.10.7, 11.10.11 General Habitat: 11.9.5, 11.9.10, 11.10.3, 11.10.13	Mapped Essential Habitat is based on known records within the nominated RE and includes all remnant and regrowth vegetation of the nominated RE. Mapped General Habitat includes all remnant and regrowth vegetation of the nominated RE. This may include sub-optimal habitat.	1,443.85 (general habitat)
Dunmall's snake	11.3.2, 11.3.25, 11.3.27, 11.3.39, 11.9.2, 11.9.4, 11.9.5, 11.9.10, 11.10.3, 11.10.7, 11.10.8, 11.10.11, 11.10.13	Mapped General Habitat includes all remnant and regrowth vegetation of the nominated RE.	1,463.65
Australian painted snipe	11.3.27	This species uses shallow ephemeral and permanent wetlands with low vegetative cover within and at the margins. Mapped General Habitat includes wetland RE potentially suitable for foraging.	-

* Extent of habitat available to acquit offset requirements under EPBC 2008/4096 following acquittal of offsets requirements for EPBC 2008/4059.



SANTOS

Figure 4
Kentucky ground-truthed vegetation

Kentucky - 1WT37
Kentucky offset area
Future habitat areas

Location diagram

DATA SOURCE:
The following datasets are © State of Qld:
- Cadastral data
- Petroleum pipeline
Kentucky offset area provided by SANTOS

Date: 6/11/2021 Coordinate System: GDA 1994 MGA Zone 55 Projection: Transverse Mercator Datum: GDA 1994 Scale: 1:35,000@A3

0 0.5 1 1.5 2
Kilometres

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CO2 Australia

Path: P:\GISData\Projects\Santos\ENV_20_0041\3 GTP_Offset_Maps\Kentucky\Figure 4 - Vegetation and offset area.mxd

2.6 Offset area

The Kentucky offset area is 4,302.3 ha and comprises the majority of the 4,367.9 ha property, as illustrated in Figure 4. The Santos GLNG pipeline and associated infrastructure is located within the remaining 65.6 ha and has been excluded from the offset area and this OAMP. The offset area includes:

- 19.79 ha to acquit offset requirements under EPBC 2008/4096 (conditions 15-22) and the GTP SSMP.
- 2,533.29 ha to acquit offset obligations under EPBC 2008/4059 plus 305.4 ha of future habitat area that will support threatened species in the future following appropriate management as part of this OAMP (approved by DAWE 23 March 2021; however, was provided in addition to acquitting MNES offset obligations under EPBC 2008/4059 to support the overall conservation gain of the offset area).
- 1,443.85 ha of remaining surplus offset value comprising habitat for MNES and will be used by Santos to acquit future project offset requirements.

Table 7 provides a summary the Kentucky offset area including the offset area allocated to acquit the MNES offset requirements under EPBC 2008/4096, EPBC 2008/4059 and the remaining area of surplus offset values available within the Kentucky offset area. For MNES where a surplus is noted, Santos proposes to draw down on these to acquit future offset requirements under related approvals.

The results of the detailed field assessments including the ground-truthed RE mapping and fauna habitat associations discussed in Section 2.5, were used to inform the suitability to acquit the MNES offset requirements.

A baseline habitat quality score for each MNES offset value was determined generally in accordance with the *Guide to Determining Terrestrial Habitat Quality* (version 1.3; Department of Environment and Science [DES] 2020) based on the results of the detailed field assessments (Section 2.4). The baseline habitat quality score will be used as a measure to assess the success of the OAMP through the interim performance targets and completion criteria outlined in Section 4.0. A detailed summary of the baseline habitat quality scores for each MNES is provided in Appendix B.

Table 7: Summary of the Kentucky offset area and acquittal

MNES	Disturbance area (ha)	Offset ratio	Offset area (ha)/number of species	Kentucky offset area approved under EPBC 2008/4059**		Kentucky offset area to be secured under EPBC 2008/4096		Surplus area remaining on Kentucky following acquittal of EPBC 2008/4059 and 2008/4096 (ha)
				Offset area to be secured (ha)	Available surplus area (ha)	Offset area to be secured (ha)	Offset requirement satisfied Kentucky?	
Endangered ecological communities								
Brigalow (*Acacia harpophylla* dominant and co-dominant)	11.23	8	89.84	-	-	-	No	
Semi-evergreen vine thickets of the Brigalow Belt (North and South) and Nandewar Bioregions	2.4	8	19.2	-	19.79	19.79	Yes	-
Endangered fauna species								
Australasian bittern (*Botaurus poiciloptilus*)	0.8	8	6.4	-	-	-	No	-
Northern quoll (*Dasyurus hallucatus*)	1.53	8	12.24	145.00	1,463.65	-	No	1,443.85
Australian painted snipe (*Rostratula australis*)	4.79	8	38.32	-	-	-	No	-
Vulnerable fauna species								
Black-breasted button-quail (Turnix melanogaster)	2.61	8	20.88	-	19.79	19.79	Partially	-
Collared delma (*Delma torquata*)	86.22	8	689.76	2,330.00	1,392.18	-	No	1,392.18
Dunmall's snake (*Furina dunmalli*)	79.78	8	638.24	2,370.00	1,463.65	-	No	1,443.85
Fitzroy river turtle (*Rheodytes leukops*)	1.05	8	8.4	Offset obligation satisfied through approved nest protection program				
Large-eared pied bat (*Chalinolobus dwyeri*)	44.11	8	352.88	860.00	1,463.65	-	No	1,443.85
Ornamental snake (*Denisonia maculata*)	25.46	8	203.68	-	-	-	No	
Red goshawk (*Erythrotriorchis radiatus*)	68.91	8	551.28	1,600.00	1,463.65	-	No	1,443.85
South-Eastern long-eared bat (*Nyctophilus corb*eni)	142.91	8	1143.28	2,310.00	1,463.65	-	No	1,443.85
Squatter pigeon (Geophaps *scripta scripta*)	225.15	8	1801.2	1,955.00	1,392.18	-	No	1,392.18
Water mouse (*Xeromys myoides*)	0.01	8	0.08	-	-	-	No	
Yakka skink (*Egernia rugosa*)	63.11	8	504.88	2,420.00	1,443.85	-	No	1,443.85
Migratory birds								
Cattle egret (*Ardea ibis*)	1.67	8	13.36	-	-	-		-
Eastern osprey (*Pandion haliaetus*)	1.4	8	11.2	-	-	-	No	-
Great egret (*Ardea modesta*)	3.83	8	30.64	-	-	-		-
Rainbow bee-eater (*Merops ornatus*)	225.39	8	1803.12	-	-	-		-

MNES	Disturbance area (ha)	Offset ratio	Offset area (ha)/number of species	Kentucky offset area approved under EPBC 2008/4059**		Kentucky offset area to be secured under EPBC 2008/4096		Surplus area remaining on Kentucky following acquittal of EPBC 2008/4059 and 2008/4096 (ha)
				Offset area to be secured (ha)	Available surplus area (ha)	Offset area to be secured (ha)	Offset requirement satisfied Kentucky?	
White-bellied sea-eagle (*Haliaeetus leucogaster*)	25.09	8	200.72	-	-	-		-
Migratory woodland bird species								
Black-faced monarch (*Monarcha melanopsis*)	14.68	8	117.44	-	-	-	No	-
Spectacled monarch (*Monarcha trivirgatus*)								
Satin flycatcher (*Myiagra cyanoleuca*)								
Rufous fantail (*Rhipidura rufifrons*)								
Oriental cuckoo (*Cuculus saturatus*)								
Migratory marine bird species								
Bar-tailed godwit (*Limosa lapponica*)	0.8	8	6.4	-	-	-	No	-
Black-tailed godwit (*Limosa limosa*)	0.8	8	6.4	-	-	-		-
Broad-billed sandpiper (*Limicola falcinellus*)	0.8	8	6.4	-	-	-		-
Common greenshank (*Tringa nebularia*)	0.8	8	6.4	-	-	-		-
Common sandpiper (*Actitis hypoleucos*)	0.8	8	6.4	-	-	-		-
Curlew sandpiper (*Calidris ferruginea*)	0.8	8	6.4	-	-	-		-
Double-banded plover (*Charadrius bicinctus*)	0.8	8	6.4	-	-	-		-
Eastern reef egret (*Egretta sacra*)	0.8	8	6.4	-	-	-		-
Far eastern curlew (*Numenius madagascariensis*)	0.8	8	6.4	-	-	-		-
Great knot (*Calidris tenuirostris*)	0.8	8	6.4	-	-	-		-
Greater sand plover (*Charadrius leschenaultii*)	0.8	8	6.4	-	-	-		-
Grey plover (*Pluvialis squatarola*)	0.8	8	6.4	-	-	-		-
Grey-tailed tattler (*Tringa brevipes*)	0.8	8	6.4	-	-	-		-
Latham’s snipe (*Gallinago hardwickii*)	0.8	8	6.4	-	-	-		-
Lesser sand plover (*Charadrius mongolus*)	0.8	8	6.4	-	-	-		-
Little curlew (*Numenius minutus*)	0.8	8	6.4	-	-	-		-
Marsh sandpiper (*Tringa stagnatilis*)	0.8	8	6.4	-	-	-		-
Pacific golden plover (*Pluvialis fulva*)	0.8	8	6.4	-	-	-		-

MNES	Disturbance area (ha)	Offset ratio	Offset area (ha)/number of species	Kentucky offset area approved under EPBC 2008/4059**		Kentucky offset area to be secured under EPBC 2008/4096		Surplus area remaining on Kentucky following acquittal of EPBC 2008/4059 and 2008/4096 (ha)
				Offset area to be secured (ha)	Available surplus area (ha)	Offset area to be secured (ha)	Offset requirement satisfied Kentucky?	
Red knot (*Calidris canutus*)	0.8	8	6.4	-	-	-		-
Red-necked stint (*Calidris ruficollis*)	0.8	8	6.4	-	-	-		-
Ruddy turnstone (*Arenaria interpres*)	0.8	8	6.4	-	-	-		-
Sanderling (*Calidris alba*)	0.8	8	6.4	-	-	-		-
Sharp-tailed sandpiper (*Calidris acuminata*)	0.8	8	6.4	-	-	-		-
Terek sandpiper (*Xenus cinereus*)	0.8	8	6.4	-	-	-		-
Whimbrel (*Numenius phaeopus*)	0.8	8	6.4	-	-	-		-
Migratory tern bird species								
Caspian tern (*Sterna caspia*)	0.05	8	0.4	-	-	-	No	-
Little tern (*Sternula albifrons*)	0.05	8	0.4	-	-	-		-
Endangered flora species								
Ooline (*Cadelia pentasyli*)	36 individuals	6:1	216	Existing 4.5 ha offset area legally secured on Bottle Tree property				
Xerothamnella herbacea	42 individuals	6:1	252	Existing 2.4 ha offset area legally secured on Bottle Tree property				
Philotheca sporadica	0	6:1	0	-	-	-	-	-
Large-fruited zamia (*Cycas megacarpa*)	1,100 individuals	No ratio	3,990[a]	See approved GLNG Gas Transmission Pipeline *Cycas megacarpa* Translocation and Management Plan (3380-GLNG-4-1.3-0013).				

**Plus an additional 305.4 ha of future habitat area has been committed to in addition to offset obligations under EPBC 2008/4059.

2.7 Development and land use

Santos has comitted to excluding any development for the Project from the Kentucky offset area.

The areas on the Kentucky property outside of the offset area may be utilised for petroleum and/or farming infrastructure and facilities; however, no infrastructure will be located within the offset area or impact the offset area's ability to achieve the completion criteria outlined in this OAMP.

Prior to being acquired by Santos GLNG, the Kentucky property was formerly utilised for grazing purposes. The following ancillary infrastructure is still present on the property and will be maintained ongoing without impact to the offset area:

- Cattle Yards; and
- Kentucky house.

2.8 Offset protection

The 4,302.3 ha Kentucky offset area (including surplus areas identified in Table 7) will be protected via a Voluntary Declaration under section 19E and 19F of the VM Act and will be declared as an area of high nature conservation value. Santos will apply for the offset area to be secured under a Voluntary Declaration by 23 March 2022. The Voluntary Declaration will be registered on the property title and will be binding on current and future landowners.

A Voluntary Declaration under the VM Act is an authorised legally binding mechanism and is considered appropriate to legally secure MNES values and protect the area from vegetation clearing. The offset area will be mapped as a Category A area on the Property Map of Assessable Vegetation (PMAV). A Category A area on a PMAV is described as an "Area subject to compliance notices, offsets and voluntary declarations".

The Voluntary Declaration will remain in place for the life of EPBC 2008/4096 and 2008/4059. The Voluntary Declaration may only be removed in accordance with the provisions of the VM Act or if the chief executive the Queensland Department of Natural Resources, Mines and Energy considers it necessary.

Offset area coordinates for the proposed declared area for the Voluntary Declaration are given in Appendix C.

In addition, once areas of regrowth vegetation on the Kentucky property have reached the requirements to achieve remnant status Santos will apply to these areas reclassified as remnant vegetation in accordance with the relevant Queensland legislation. Santos will notify DAWE within 30 business days of the reclassification occurring.

2.9 EPBC Act Environmental Offset Policy

Table 8 outlines how the GLNG Project offset obligations acquit on the Kentucky offset area meet the requirements of the EPBC Act Environmental Offsets Policy.

Table 8: Assessment against Principles of the Offset Policy

Principle	How the principle is met in this offset proposal
1. deliver an overall conservation outcome that improves or maintains the viability of the aspect of the environment that is protected by national environment law and affected by the proposed action	The offset area partially acquits MNES offset requirements under EPBC 2008/4096 as outlined in Table 7. The remaining will be acquit elsewhere. The offset area will be managed and monitored to improve the quality of Brigalow TEC, SEVT TEC and viability of habitat for threatened species. This will include the management of regrowth vegetation to become self-sustaining functional remnant vegetation communities. This OAMP sets out specific management objectives with interim performance targets and completion criteria. Management actions are outlined with accompanying adaptive management triggers and corrective actions in the event that monitoring identifies that interim performance targets are not attained or completion criteria are not attained and/or maintained. The offset area will be managed and monitored from approval of the OAMP for a minimum of 20 years. It is anticipated that the completion criteria will be achieved within a 20-year period.
2. be built around direct offsets but may include other compensatory measures	MNES offset obligations under EPBC 2008/4096 (conditions 15-22) and the GTP SSMP will be acquit through the delivery of direct land-based offsets on the Kentucky offset area and additional land based offset areas to be secured by Santos.
3. be in proportion to the level of statutory protection that applies to the protected matter 4. be of a size and scale proportionate to the residual impacts on the protected matter	At the time of the Project's approval under the EPBC Act the magnitude of an offset package and specific offset ratios to compensate for the impacts of development were determined on a case-by-case basis with consideration of the principles discussed in the EPBC Act draft Environmental Offsets Policy 2007 and the Queensland Government offset policies in place at the time (see Table 1). The Commonwealth government has since introduced the EPBC Act Environmental Offsets Policy (DSEWPaC 2012) which outlines the government's requirements for the provision of environmental offsets under the EPBC Act to compensate for residual adverse impacts on MNES. On the 16 July 2015, the Commonwealth Government accepted Santos' approach to determining significant residual, adverse impacts to MNES which is consistent with the EPBC Act Environmental Offsets Policy. The approved GTP SSMP details the proposed impacts on MNES subject to EPBC 2008/4096 required to be offset including the offset ratios used to determine the quantum of the proposed offset areas.
5. effectively account for and manage the risks of the offset not succeeding	This OAMP has been developed in consideration of known and identified threats to the offset values to manage the risk of failing to the achieve the completion criteria and overall environmental outcomes for the offset area. Threats to the offset site are managed through the implementation of the management measures discussed in Section 6.0, including: • Fire prevention and management • Weed monitoring and control • Clearing protection

Principle	How the principle is met in this offset proposal
	• Management of grazing • Restricted access. The relevant risks were identified based on a review of current literature (i.e. conservation advices, recovery plans etc.) and identification of potential site-specific risks based on the results of field surveys and discussions with the landholder. The results of the risk assessment, presented in Appendix D, have informed the adaptive management process including the identification of threats to offset values, management objectives, performance criteria, management actions, monitoring programs, adaptive management triggers and corrective actions. If the offset cannot attain and maintain the completion criteria then additional offsets will be provided to compensate for the impact and the failed offset (see Section 5.2.4).
6. be additional to what is already required, determined by law or planning regulations or agreed to under other schemes or programs (this does not preclude the recognition of state or territory offsets that may be suitable as offsets under the EPBC Act for the same action)	The environmental outcomes proposed to be achieved through the implementation of this OAMP are based on additional management and monitoring measures conducted as part of business as usual on the Kentucky property. For example, under the *Biosecurity Act 2014* a person has a general biosecurity obligation to: take all reasonable and practical steps to prevent or minimise each biosecurity risk. The steps proposed in this OAMP are above reasonable and practical steps required to control feral animals and weeds in central Queensland. Once the Voluntary Declaration has been secured over the offset area, environmental laws prevent other land uses inconsistent with this OAMP being approved over this part of the property.
7. be efficient, effective, timely, transparent, scientifically robust and reasonable	The Kentucky offset area has been identified to be suitable using an evidence based and scientifically robust approach. The environmental outcomes to be achieved through this OAMP will be delivered progressively over 20 years. The offset area will be legally secured through a Voluntary Declaration under the VM Act therefore any vegetation clearing contravention of this OAMP is not permissible without specific Queensland government approval. The preparation and implementation of this OAMP supports the efficient, effective, timely, transparent and scientifically robust approach to providing offsets.
8. have transparent governance arrangements including being able to be readily measured, monitored, audited and enforced.	This OAMP includes a detailed monitoring program which will assess the effectiveness of the management actions undertaken and the progress of the offset area in achieving the environmental outcomes. The results of all management and monitoring programs will be included in annual reports (Section 8.1). An implementation schedule for monitoring and management is provided in Section 9.0 which will be reviewed at least annually to ensure the timely implementation of this OAMP.

3.0 Offset values

3.1 Brigalow TEC

3.1.1 Offset area

Brigalow TEC within the offset area comprises areas of remnant and regrowth RE 11.9.5.

The extent of brigalow-dominated forest within the Kentucky property is predominantly comprised of remnant RE 11.9.5 communities (67.8 ha), with approximately 3.3 ha of regrowth brigalow vegetation. Brigalow communities are present within the northern portion of the offset area (where they are closely associated with SEVT), and occur as small, scattered patches within the west, northwest and eastern portions of the property. Patches of remnant brigalow are in generally good condition and are all considered to meet TEC status under the EPBC Act (DotE 2013). Canopy cover is relatively closed, weed cover is low to absent and fallen timber is present. Regrowth brigalow only occurs as small, isolated patches within the property. This habitat provides suitable foraging values for a variety of forest bird species that prefer a closed canopy. There is abundant shelter for ground fauna (particularly reptiles) in the form of fallen logs, rocks and low shrubs. Peeling bark is common in this habitat providing refuge for arboreal reptiles. There is evidence of severe damage from historical wildfires within the Brigalow communities (Boobook 2020).

3.1.2 Threats

The following key threats to Brigalow TEC identified on the property will be addressed through the implementation of this OAMP (DAWE 2020b):

- clearing of vegetation
- inappropriate fire regimes and management
- pest plant infestation
- potential knowledge gaps, and
- increased grazing by livestock.

3.2 SEVT TEC

3.2.1 Offset area

SEVT TEC within the offset area comprises areas of remnant and regrowth RE 11.9.4. Note that RE 11.10.8 is a SEVT community that is present on the Kentucky property, however it is not a listed component of SEVT TEC under the EPBC Act (TSSC 2001).

SEVT TEC is generally restricted to hilly slopes and valley sides within the offset area (Boobook 2015; Boobook 2020). These areas include the presence of large rocks with extensive areas of rocky crevice habitat. The canopy height within the majority of SEVT vegetation is considered to meet the benchmark for RE 11.9.4 in the area and is considered to be reasonably dense in patches. The shrub and ground layers are patchy. Where a suitable shrub/low tree layer occurs there is a thick leaf litter layer, however fallen timber is generally lacking throughout. This habitat provides significant value in the form of potential shelter sites for several target threatened species including, but not limited to, the northern quoll, large-eared pied bat, collared delma and yakka skink (Boobook 2020).

3.2.2 Threats

The following key threats to SEVT TEC identified on the property will be addressed through the implementation of this OAMP (DAWE 2020l):

- clearing of vegetation
- inappropriate fire regimes
- invasion by introduced pasture species
- increased grazing by livestock, and
- disturbance by pest animals.

3.3 Northern quoll

3.3.1 Offset area

Habitat for the northern quoll within the offset area comprises REs 11.3.2, 11.3.25, 11.3.39, 11.9.2, 11.9.4, 11.9.5, 11.9.10, 11.10.3, 11.10.7, 11.10.8, 11.10.11, 11.10.13.

General habitat for the northern quoll includes all areas of remnant and regrowth vegetation that may contain or is nearby suitable den sites. This species is dependent on the presence of suitable shelter habitat in the form of caves and deep crevices in extensive rock formations (commonly sandstone) and forages in associated woodland and forest habitat (DAWE 2020c). Within the Kentucky property, suitable habitat for the northern quoll is likely present within most woodland and forest. Patches of Brigalow TEC and SEVT TEC would provide significant value in the form of potential den and shelter habitat suitable den sites (Boobook 2020).

3.3.2 Threats

The following key threats to the northern quoll identified on the property will be addressed through the implementation of this OAMP (Boobook 2015; DAWE 2020c):

- degradation and fragmentation of habitat
- overgrazing by stock
- predation by feral predators
- inappropriate fire regimes and management, and
- lethal toxic ingestion of cane toads.

3.4 Black-breasted button-quail

3.4.1 Offset area

Habitat within the offset area for the black-breasted button-quail comprises REs 11.9.4, 11.9.5, 11.10.8.

The black-breasted button-quail is known to prefer SEVT communities and other closed forest types with dense leaf litter and low shrubs (DAWE 2020m; Mathieson and Smith 2009). Within areas of SEVT vegetation where a suitable shrub/low tree layer occurs there is a thick leaf litter layer. Within areas of remnant Brigalow vegetation areas of scattered shrubs are present, often of SEVT species. Small sections of habitat for this species are present in the northern remnant parts of Kentucky, particularly where remnant SEVT and Brigalow exist. Most patches of Brigalow and SEVT within the offset area have high levels of groundcover suitable to the black-breasted button-quail (Boobook 2020). The managed recovery of regrowth vegetation (particularly SEVT) to remnant status over time is considered one of the best ways to provide habitat for this species.

3.4.2 Threats

The following key threats to the black-breasted button-quail identified on the property will be addressed through the implementation of this OAMP (Boobook 2015; DAWE 2020m):

- predation by feral predators, and
- inappropriate fire regimes and management.

3.5 Collared delma

3.5.1 Offset area

Habitat for collared delma within the offset area comprises REs 11.3.2, 11.3.39, 11.9.2, 11.9.10, 11.10.7, 11.10.11, 11.10.13.

Habitat for collared delma is present over much of the Kentucky property, especially in areas of remnant and regrowth vegetation that have not recently been heavily cleared (the northern two thirds of the property).

The collared delma is known to occur in REs on land zones 3, 9 and 10 (Brigalow Belt Reptiles Workshop 2010), and appears to require rocks, timber, bark or other surface debris for shelter (DAWE, 2020d). It tends to prefer eucalypt woodlands and open forest that provides these suitable microhabitat features (Brigalow Belt Reptiles Workshop 2010). Potential habitat within the offset area is widespread throughout the property with many of the eucalypt woodlands and forests providing adequate fallen timber, rocks and/or groundcover (Boobook 2020).

3.5.2 Threats

The following key threats to the collared delma identified on the property will be addressed through the implementation of this OAMP (Boobook 2015; DAWE 2020d):

- habitat loss through clearing
- habitat degradation from overgrazing by stock, and
- inappropriate fire regimes and management.

3.6 Dunmall's snake

3.6.1 Offset area

Habitat for Dunmall's snake within the offset area comprises REs 11.3.2, 11.3.25, 11.3.27, 11.3.39, 11.9.2, 11.9.4, 11.9.5, 11.9.10, 11.10.3, 11.10.7, 11.10.8, 11.10.11, 11.10.13.

Habitat for Dunmall's snake can be found over much of the Kentucky property, especially in areas of remnant and regrowth vegetation that have not recently been heavily cleared (the northern two thirds of the property).

Dunmall's snake occurs in a variety of open dry sclerophyll woodlands and forests (typically dominated by *Eucalyptus, Acacia* and *Callitris* spp.) and on a broad range of land zones (Brigalow Belt Reptiles Workshop 2010; DAWE 2020g). They are associated with partly buried rocks and boulders, fallen timber and root cavities for shelter (DAWE 2020g). Areas comprising abundant fallen timber, large rocks and extensive rock crevice habitat are particularly prevalent along patches of Brigalow and SEVT understorey. Several eucalypt woodlands throughout the property are also associated with suitable microhabitat features. These areas are considered to provide suitable foraging and shelter habitat for Dunmall's snake. One individual has been recorded within the offset area encountered during nocturnal active searching (spotlighting) in regrowth of RE 11.9.2 (Boobook 2020).

3.6.2 Threats

The following key threats to Dunmall's snake identified on the property will be addressed through the implementation of this OAMP (Boobook 2015; DAWE 2020g):

- habitat loss through clearing
- habitat degradation from overgrazing by stock, and
- inappropriate fire regimes and management.

3.7 Large-eared pied bat

3.7.1 Offset area

Habitat for large-eared pied bat within the offset area comprises areas of remnant and regrowth REs 11.3.2, 11.3.25, 11.3.27, 11.3.39, 11.9.2, 11.9.4, 11.9.5, 11.9.10, 11.10.3, 11.10.7, 11.10.8, 11.10.11, 11.10.13.

The large-eared pied bat is likely to be primarily utilising suitable roosting and shelter sites on the larger rocky outcrops and ridges along the western margin of the offset area. Suitable foraging habitat for the species occurs across much of the offset area within areas of adjacent remnant and mature regrowth vegetation. The species requires a combination of sandstone cliffs/escarpments to provide roosting habitat that is adjacent to fertile woodlands (preferably Box Gum) or river/rainforest corridors for foraging (TSSC 2012). Characteristic calls of the species were recorded (Anabat recorder) at five locations, all within 1 km of apparently suitable roost habitat i.e. dissected sandstone cliffs and scarp slopes, in the west and southeast of the offset property (Boobook 2020). Suitable roosting habitat may be present in the nearby slopes on the exposed Clematis Sandstone.

3.7.2 Threats

The following key threats to the large-eared pied bat identified on the property will be addressed through the implementation of this OAMP (Boobook 2015):

- habitat loss through clearing
- destruction and abandonment of nursery sites and roosting hollows.

3.8 South-eastern long-eared bat

3.8.1 Offset area

Habitat for south-eastern long-eared bat comprises areas of remnant and regrowth REs 11.3.2, 11.3.25, 11.3.27, 11.3.39, 11.9.2, 11.9.4, 11.9.5, 11.9.10, 11.10.3, 11.10.7, 11.10.8, 11.10.11, 11.10.13.

The south-eastern long-eared bat is known to occur in a variety of dry forest habitats including River Red Gum, open woodland, mallee, Brigalow and other arid and semi-arid habitats (TSSC 2015). The preferred habitat is mallee and *Callitris* woodlands (Pennay et al. 2011), and habitats that have a distinct canopy with a dense, cluttered understorey (Turbill and Ellis 2006). Surveys have suggested the species requires large tracts of forest to occur (Turbill et al. 2008). They typically roost in dead trees, dead spouts of living trees or under bark (New South Wales National Parks and Wildlife Service [NSW NPWS] 2003; TSSC 2015). The majority of Kentucky is considered to provide suitable habitat for the south-eastern long-eared bat and contains several REs with an understorey of *Callitris* (Boobook 2020).

3.8.2 Threats

The following key threats to the south-eastern long-eared bat identified on the property will be addressed through the implementation of this OAMP (Boobook 2015):

- habitat loss through clearing
- destruction and abandonment of nursery sites and roosting hollows.

3.9 Red goshawk

3.9.1 Offset area

Habitat for red goshawk within the offset area comprises areas of remnant and regrowth REs 11.3.2, 11.3.25, 11.3.27, 11.3.39, 11.9.2, 11.9.4, 11.9.5, 11.9.10, 11.10.3, 11.10.7, 11.10.8, 11.10.11, 11.10.13.

The red goshawk is a highly mobile species with a large home range. Breeding habitat is in intact tall forest associated with major drainage lines; however, the species may often forage much further away from these areas (DAWE 2020f). Kentucky contains large areas of woodland that act as habitat for the red goshawk. Preferred foraging habitat for the species generally consists of mid-dense woodlands containing a high abundance of small birds (prey) (DAWE 2020f), which are generally prevalent throughout the offset area. Very dense and very open habitats are less favourable as foraging habitat. Suitable breeding habitat for the red goshawk includes tall, open forests along Baffle Creek to the south and the Dawson River in the north (Boobook 2020).

3.9.2 Threats

The following key threats to the red goshawk identified on the property will be addressed through the implementation of this OAMP (Boobook 2015; DAWE 2020f):

- habitat loss through clearing
- inappropriate fire regimes and management, and
- habitat degradation from overgrazing by stock.

3.10 Squatter pigeon

3.10.1 Offset area

Habitat for the squatter pigeon within the offset area comprises areas of remnant and regrowth REs 11.3.2, 11.3.25, 11.3.27, 11.3.39, 11.9.2, 11.9.10, 11.10.7, 11.10.11, 11.10.13.

The squatter pigeon favours open-forests to sparse, open-woodlands and scrub that have patchy, tussock-grassy understories (DAWE 2020h), and includes communities that are remnant, regrowth and partly modified. Squatter pigeons tend to breed in woodlands within 1 km of a water source and forage within 3 km of a water source (DAWE 2020h). The extent of existing general habitat for this species on Kentucky includes most of the property except for the denser remnant SEVT in the north. Woodland surrounding permanent water sources such as farm dams and other watercourses such as the Dawson River in the north are likely to be the most suitable habitat for the squatter pigeon. During more favourable conditions (following a rain event), watercourses such as Baffle Creek in the south and ephemeral drainage features would also provide reliable sources of water (Boobook 2020).

Although not observed within the Kentucky in 2020, the squatter pigeon has been recorded within the Kentucky previously (Boobook 2011; Boobook 2015). In addition, on two occasions (1/2/2020 and 2/2/2020) a single bird was seen on Fairview Road within 2 km of Kentucky.

3.10.2 Threats

The following key threats to the squatter pigeon identified on the property will be addressed through the implementation of this OAMP (Boobook 2015; DAWE 2020h):

- habitat loss and fragmentation through clearing
- introduction of invasive weeds, and
- habitat degradation from overgrazing by stock.

3.11 Yakka skink

3.11.1 Offset area

Essential habitat for yakka skink within the offset area comprises areas of remnant and regrowth REs 11.3.2, 11.3.39, 11.9.2, 11.10.7, 11.10.11 and general habitat for the species comprises RE 11.9.5, 11.9.10, 11.10.3 and 11.10.13.

Habitat for the yakka skink on Kentucky extends across most of the property where woodland and scrub vegetation are present. The species is commonly found under partly buried rocks and logs or in abandoned animal burrows (Brigalow Belt Reptiles Workshop 2010). Remnant vegetation along the Dawson River in the north and other large tracts of remnant and regrowth vegetation throughout the property (particularly Narrow-leaved Ironbark woodland) provide variable cover of woody debris and ground litter. Older growth communities contain good structure in the form of developed shrub and ground layers and fallen timber and deep leaf litter (Boobook 2020).

3.11.2 Threats

The following key threats to the yakka skink identified on the property will be addressed through the implementation of this OAMP (Boobook 2015; DAWE 2020e):

- habitat loss and fragmentation through clearing
- habitat degradation from overgrazing by stock, and
- Inappropriate fire regimes and management.

3.12 Additional MNES Present on Kentucky

The below TEC and threatened species are MNES listed under the EPBC Act found on the Kentucky offset area that are not required to acquit the current MNES offset requirements under EPBC 2008/4059.

3.12.1 Poplar Box TEC

3.12.1.1 Offset area

Areas of remnant RE 11.3.2 are considered to support Poplar Box Grassy Woodland of Alluvial Plains TEC (Poplar Box TEC).

Poplar Box TEC vegetation communities within the Kentucky offset area are characterised by all remnant *Eucalyptus populnea* open woodland on alluvial plains (RE 11.3.2). These communities occur along the quaternary alluvium associated with the Dawson River in the north of the offset area and are generally in good condition (Boobook, 2020). Canopy cover is open and shrubs are absent, and weeds have very low presence. Grasses, fallen timber and ground litter cover are variable, ranging from very abundant to very low (Boobook 2020).

3.12.1.2 Threats

The following key threats to Poplar Box TEC identified on the property will be addressed through the implementation of this OAMP (DEE 2019):

- clearing of vegetation
- inappropriate fire regimes
- invasion by introduced pasture species

- increased grazing by livestock, and
- disturbance by pest animals.

3.12.2 Australian painted snipe & Australasian bittern

3.12.2.1 Offset area

Habitat for the Australian painted snipe and Australasian bittern within the offset area comprise wetland RE 11.3.27 in the northernmost part of the property adjacent to the Dawson River. The small wetland area and associated vegetation is considered to provide potentially suitable foraging habitat for these species.

3.12.2.2 Threats

The following key threats to the Australian painted snipe and Australian bittern identified on the property will be addressed through the implementation of this OAMP (Boobook 2015; DAWE 2020a, k):

- degradation of wetland habitat
- grazing and associated trampling of habitat, and
- weed incursion into habitat.

3.12.3 Greater glider

3.12.3.1 Offset area

Habitat for the greater glider within the offset area comprises remnant and regrowth RE 11.3.2, 11.3.25, 11.3.27, 11.3.39, 11.9.2, 11.9.10, 11.10.7, 11.10.11, 11.10.13.

Greater glider habitat is restricted to eucalypt forests and woodlands, typically with a preference for foraging in forests with a range of eucalypt species (TSSC 2016). Large hollow-bearing trees are required for denning and home ranges of individuals are small (only venturing approximately 1-4 km from dens) (TSSC 2016). Potential habitat within the Kentucky offset area is widespread and is most prevalent in the northern half of the property. The greater glider has been recorded in the far north of the property along the Dawson River in RE 11.3.25.

3.12.3.2 Threats

The following key threats to the greater glider identified on the property will be addressed through the implementation of this OAMP (DAWE 2020i):

- degradation and fragmentation of habitat
- predation by feral predators, and
- inappropriate fire regimes and management.

3.12.4 Koala

3.12.4.1 Offset area

Habitat for the koala within the offset area comprises areas of remnant and regrowth RE 11.3.2, 11.3.25, 11.3.27, 11.3.39, 11.9.2, 11.9.10, 11.10.7, 11.10.11, 11.10.13.

Koala habitat is broadly defined as eucalypt forests and woodlands or shrubland with emergent eucalypt species and can include both remnant and regrowth communities, provided adequate mature Koala food trees are present (DAWE 2020j). Potential habitat for the koala within the Kentucky offset area is widespread. Characteristic scratches were detected on the bark of Grey Gums (*Eucalyptus major*) in RE 11.10.13 and Queensland Blue Gums (*Eucalyptus tereticornis*) in REs 11.3.25 and 11.3.27 as part of targeted field surveys from January to May 2020. Scats of this species have also previously been reported from the property in RE 11.10.11 (*Eucalyptus populnea* regrowth) (Boobook 2020).

3.12.4.2 Threats

The following key threats to the koala identified on the property will be addressed through the implementation of this OAMP (DAWE 2020j):

- degradation and fragmentation of habitat
- predation by feral predators, and
- inappropriate fire regimes and management.

3.12.5 Threatened Flora

Previous surveys have confirmed the presence of one EPBC Act listed flora species. *Bertya opponens* is known to occur on the escarpment edges in the northern half of Kentucky.

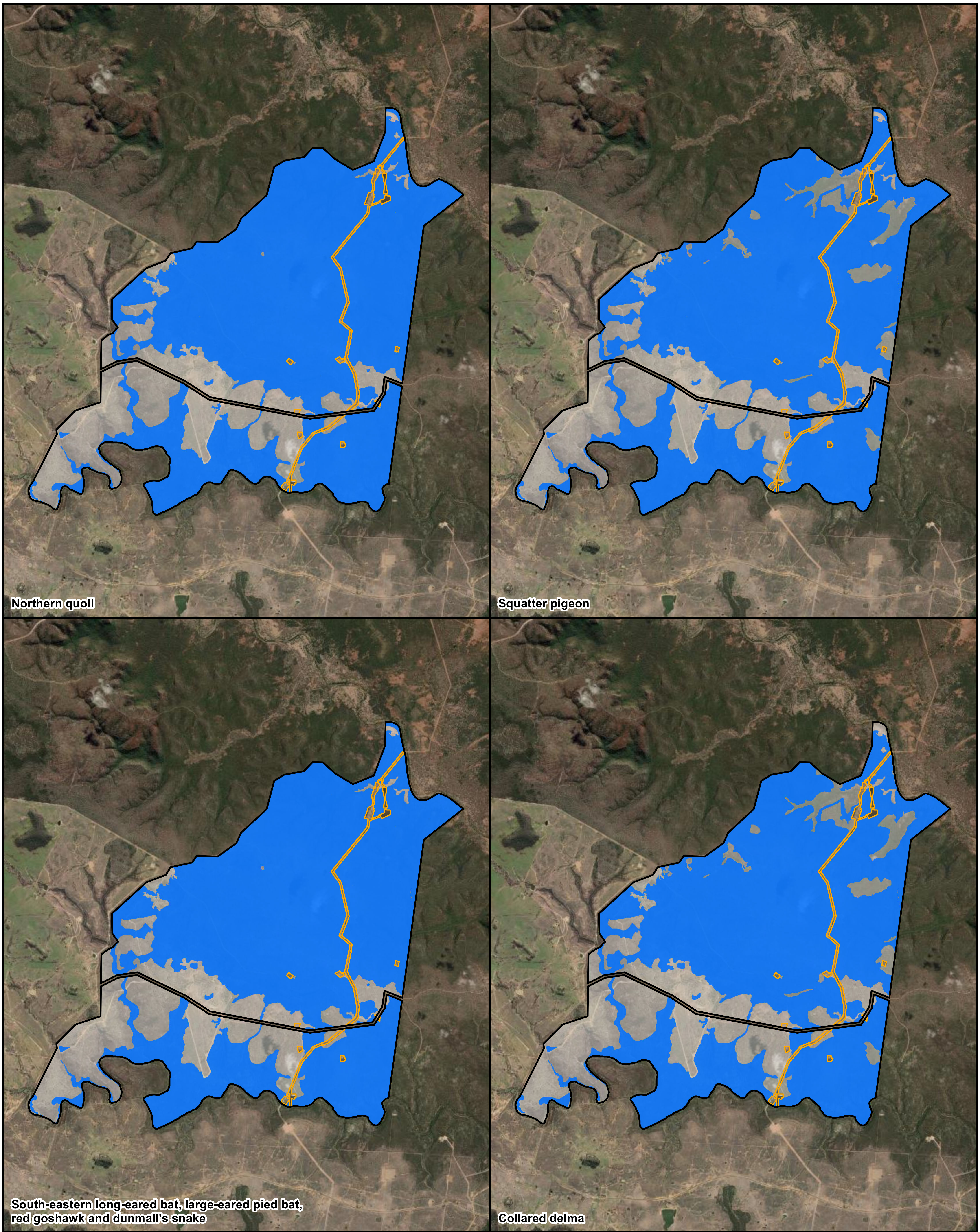

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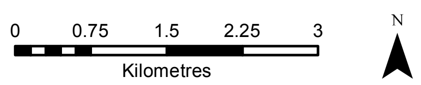
Figure 5
Kentucky MNES offset areas habitat - 1

Kentucky - 1WT37
Kentucky offset area
MNES offset habitat

Location diagram



CO2 Australia

DATA SOURCE:
The following datasets are © State of Qld:
- Cadastral data

Date: 6/11/2021 Coordinate System: GDA 1994 MGA Zone 55 Projection: Transverse Mercator Datum: GDA 1994 Scale: 1:75,000@A3

Path: P:\GISData\Projects\Santos\ENV_20_00419.GTP_Offset_Maps\Kentucky\Figure 5 - MNES offset areas 1.mxd

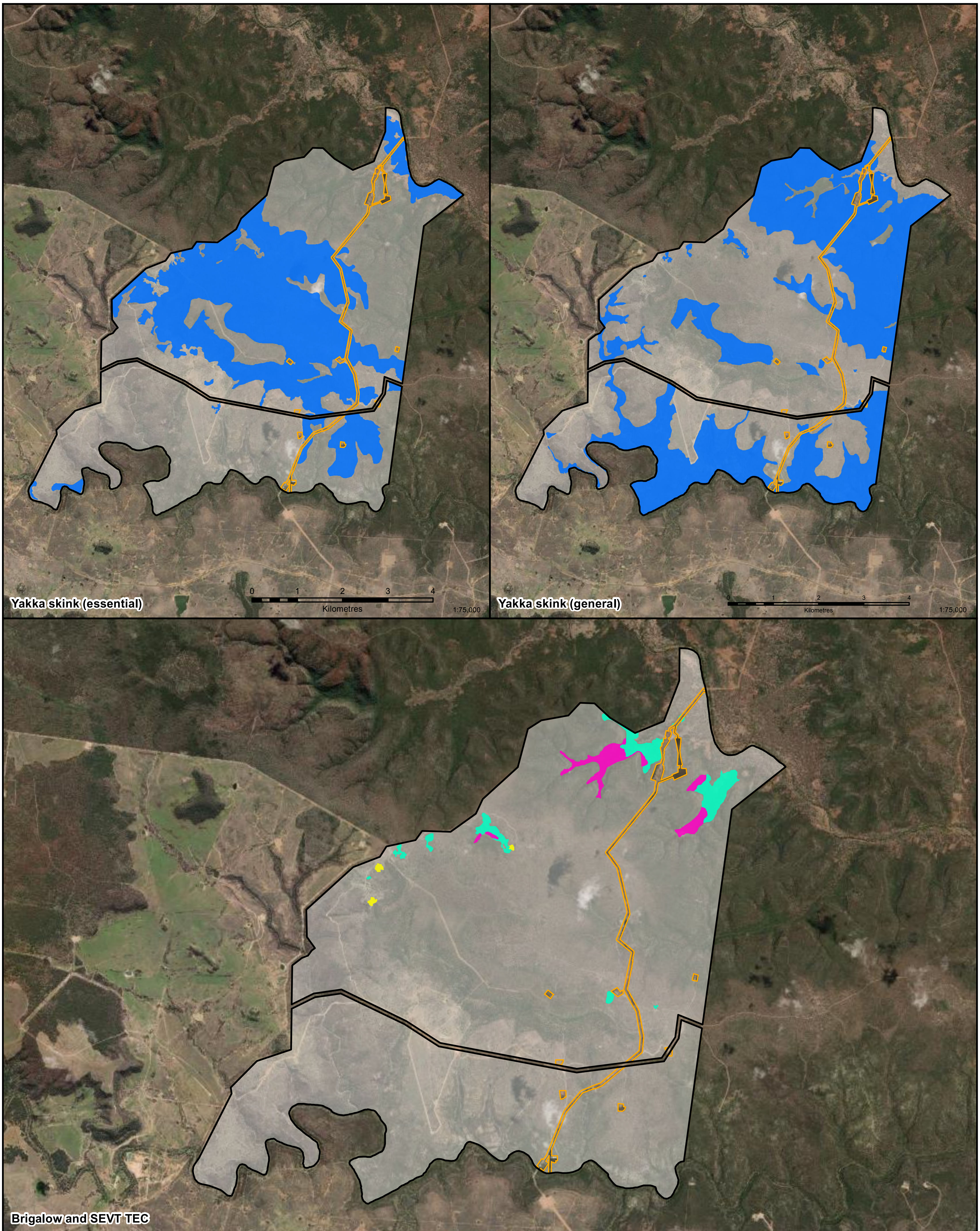


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Figure 6
Kentucky MNES offset areas habitat - 2

Kentucky - 1WT37
Kentucky offset area
MNES offset habitat

Brigalow and SEVT TEC
11.9.4
11.9.5
11.9.5 (regrowth)

DATA SOURCE:
The following datasets are © State of Qld:
- Cadastral data

Date: 6/11/2021 Coordinate System: GDA 1994 MGA Zone 55 Projection: Transverse Mercator Datum: GDA 1994 Scale: 1:55,000@A3

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Location diagram

Path: P:\GIS\Data\Projects\Santos\ENV_20_004\3.GTP_Offset_Maps\Kentucky\Figure 6 - MNES offset areas 2.mxd

4.0 Environmental outcomes to be achieved

The outcome of this OAMP is to acquit the offset obligations under EPBC 2008/4096 (conditions 15-22) and the GTP SSMP. Progress towards achieving these outcomes will be measured against the interim performance targets and criteria defined in Table 9.

Table 9: Interim performance targets and completion criteria for the Kentucky offset area

MNES	Baseline	Interim performance targets			Completion criteria
		Year 5	Year 10	Year 15	Year 20
SEVT TEC	8	Increase in the habitat quality score from baseline score of 8	Increase in the habitat quality score from year 5	Increase in the habitat quality score from year 10	Improve the quality of habitat to achieve a score of at least 9
Black-breasted button quail	8	Increase in the habitat quality score from baseline score of 8	Increase in the habitat quality score from year 5	Increase in the habitat quality score from year 10	Improve the quality of habitat to achieve a score of at least 9

5.0 Adaptive management

5.1 Adaptive management

This OAMP is based on an adaptive management approach which involves 'flexible decision making that can be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood' (National Research Council 2004).

Adaptive management includes two key phases:

- establishment of the key components of a management framework including engaging stakeholders, developing clear and measurable objectives and performance criteria, identification and selection of potential management actions and the development of monitoring protocols which enable the evaluation of progress towards achieving objectives, and which will effectively contribute to the adaptive management decision making process.
- an iterative learning phase which involves utilisation of the management framework to learn about the natural resource system and iteratively adapt management strategies and approaches based on what is learned (Williams 2011).

The management of natural systems involves uncertainty which can affect the success of the management measures in achieving the objectives and performance criteria. Williams (2011) and Williams and Brown (2016) identify four kinds of uncertainty, outlined as follows, with how they have been addressed through the development of this OAMP:

- environmental variation:
    - caused by external factors that act upon natural systems, but which are not influenced by the resource conditions and dynamics, for example variation in rainfall or temperature
    - largely outside of the control of the manager (Williams 2011), and
    - influence is considered in the analysis of the effectiveness of the adaptive management approach, the analysis of the ability to achieve and maintain performance criteria and when considering the need for corrective actions.
- partial observability:
    - includes potential uncertainty arising from variation in the collection of data during monitoring events, and from being unable to completely observe the natural system in its entirety (Williams and Brown 2016), and
    - addressed in this OAMP through the development of a monitoring program based on scientifically tested and repeatable methods.
- partial controllability:
    - relates to the difference between the intended effect of the management measures to be implemented through this OAMP and the actual effect of their implementation on the ground (Williams and Brown 2016), and
    - address through adherence to an adaptive management approach including regular monitoring of conformance with performance criteria, assessment of adaptive management triggers, the implementation of corrective actions, review and amendments to the OAMP, and reporting to ensure that management measures are being effectively implemented on the ground.

- structural and process uncertainty:
  - concerns a lack of knowledge or understanding regarding biological and ecological processes and relationships, and differing views regarding how natural systems respond to management (Williams and Brown 2016), and
  - addressed through the adaptive management approach. Following the results of ongoing management, monitoring and reporting, the OAMP will be reviewed and updated as required to incorporate learnings, updated conservation advice and best practice management techniques.

5.2 OAMP adaptive management framework

5.2.1 Risk assessment

The adaptive management process for this OAMP is supported by a risk assessment through which the known and potential risks for each offset value have been evaluated. The relevant risks were identified based on a review of current literature (i.e. conservation advices, recovery plans etc) and identification of potential site-specific risks. As presented in Appendix D, the risk assessment included an assessment of the likelihood and consequence for each identified risk, both with and without the implementation of control strategies. The results of the risk assessment have informed the adaptive management process including the identification of threats to offset values, management objectives, performance criteria, management actions, monitoring programs, adaptive management triggers and corrective actions.

Implementation of the adaptive management process aims to reduce the risk of the identified threats occurring to ensure that the overall outcome sought by this OAMP are achieved.

5.2.2 Adaptive management process

The adaptive management process for this OAMP includes the following key components:

- **identified threats to offset values** – known and potential threats to the offset values have been identified as part of the risk assessment process
- **relevant offset values** – MNES or other offset matter for which the identified threat is relevant have been indicated
- **management objectives** – management objectives have been developed to address each identified threat to the offset values, and to ensure that the interim performance targets and completion criteria are attained
- **performance criteria** – assessable criteria have been defined to measure adherence to the management objectives
- **management actio**n – specific management actions have been identified to ensure that the performance criteria and management objectives are satisfied, and which will ultimately result in attainment of the interim performance targets and completion criteria
- **monitoring** – a combination of qualitative and quantitative methodologies has been included to assess whether management actions are meeting the performance criteria and management objectives, and ultimately, whether the OAMP is supporting the delivery of the interim performance targets and completion criteria

- **adaptive management trigger** – measurable events or parameters have been identified which, when triggered, indicate that a performance criterion has not been satisfied, instigating the implementation of contingency plans and corrective actions
- **Corrective actions** – a two-step process has been established to identify the likely cause of the non-compliance with the performance criteria and allow for identification of suitable corrective actions. Corrective actions include the implementation of a feasible, appropriate and effective action to address the identified issue and ensure the performance criteria is satisfied.

Figure 7 illustrates the ongoing adaptive management cycle of implementation, learning and review, with the aim of achieving the interim performance targets and completion criteria. Through the implementation of this adaptive management process, it is anticipated that the interim performance targets and completion criteria will be attained and maintained for the life of the approval.

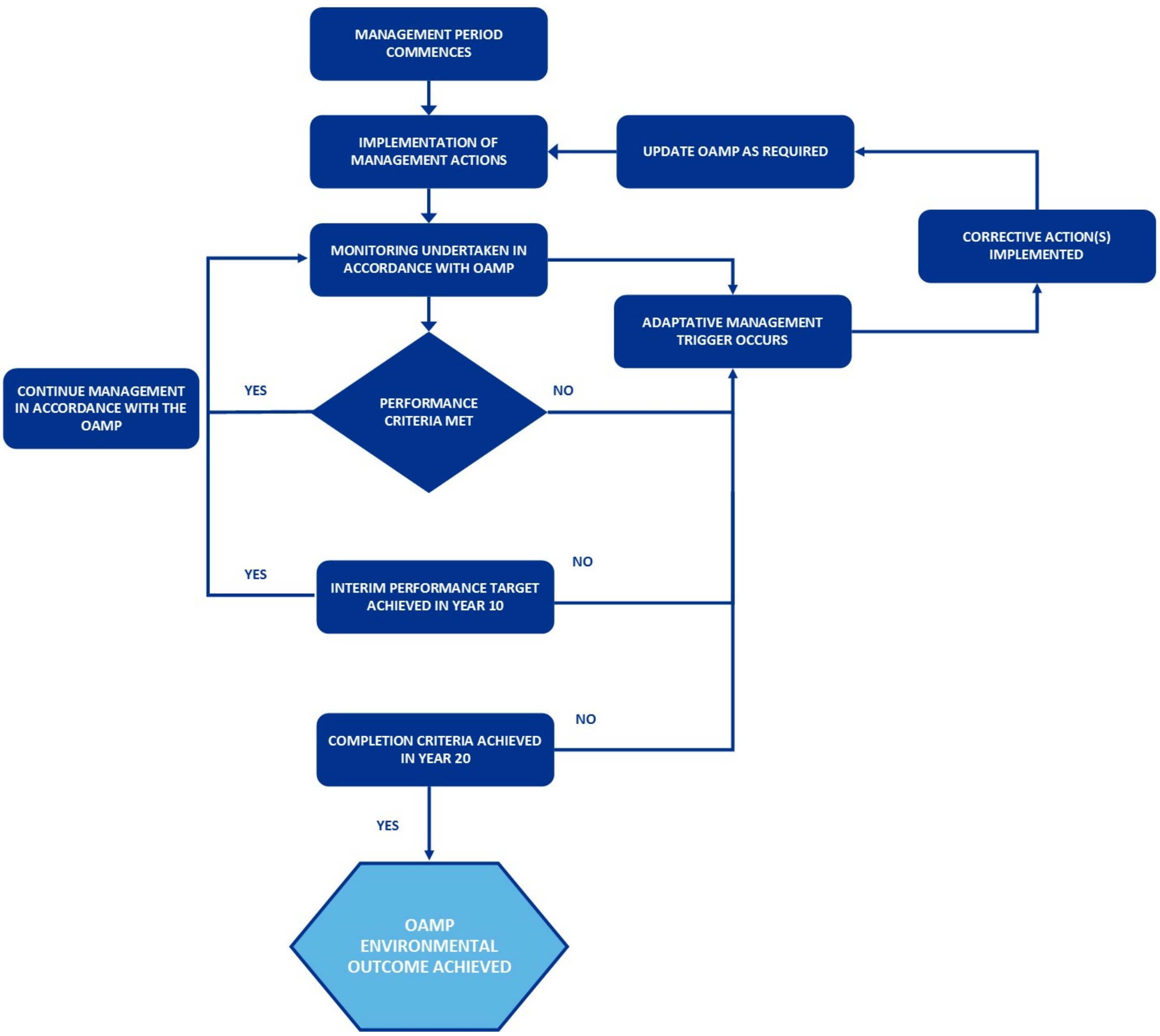

Figure 7: Process for implementation of the OAMP

5.2.3 Timing for implementation of the OAMP

The offset area will be managed and monitored until the interim performance targets and completion criteria are achieved. It is anticipated that through the adaptive management approach, interim performance targets and completion criteria will be achieved within the proposed 20-year management period. However, if the interim performance targets and/or completion criteria for offset values have not been achieved within the anticipated timeframes, management and monitoring will continue beyond the 20-year management period in accordance with this OAMP until the completion criteria have been achieved. Once attained, completion criteria will be maintained for at least the life of the EPBC Act approval relevant to this OAMP.

5.2.4 Risk of offset failure

Based on the adaptive approach to management and the proposed management and monitoring program, it is considered that the management objectives, interim performance targets and completion criteria will be successfully achieved.

In the unlikely event that the interim performance targets are not achieved for one or more offset values by year 5, 10 or 15 for those offset values, Santos will obtain advice from suitably qualified people/groups with the aim of identifying appropriate additional management interventions.

It should be noted that unavoidable temporary perturbations such as severe drought, or insect/fungal pest invasion that may cause a temporary decrease in metrics such as canopy or shrub cover from which the community still may recover within the next 5-year period should not preclude assessment of a satisfactory increase in ecological condition by the completion date.

If it is considered that the completion criteria cannot be achieved, Santos will update this OAMP proposing alternative offset areas in order to acquit the required offset requirements. The revised OAMP will be submitted to the Commonwealth Government.

6.0 Management program

6.1 Management objectives

A summary of the management objectives and performance criteria for the offset area is presented in Table 10, and the complete adaptive management process for this OAMP is encapsulated in Table 11. Management actions, monitoring events, adaptive management triggers and corrective actions have been assigned to each management objective and performance criteria.

Table 10: Summary of the management objectives and performance criteria

Management objectives	Performance criteria
Achieve the completion criteria including habitat quality improvements for offset values and remnant status for those regrowth vegetation communities.	Increase the habitat quality scores for each offset value at each habitat quality assessment site based on the results of baseline and subsequent monitoring events so as to achieve the scores in the completion criteria. Achieve structural and floristic components for a vegetation community to be reclassified as remnant.
Maintain the extent of offset value habitat within the offset area.	No unapproved and/or intentional clearing of habitat within the offset area, with the exception of clearing that is required for fencing, access, firebreaks and public safety as outlined in Table 12.
Ensure that the livestock grazing restrictions outlined in Section 6.2.6.1 for fire management and weed control assist in the enhancement of ground cover attributes for offset values and does not result in the degradation of habitat.	Increase the richness and average % cover of native perennial grasses at each habitat quality assessment site based on the results of baseline and subsequent monitoring events.
	Biomass levels of 2,500 kilograms per hectare (kg/ha) are retained at each of the monitoring sites at the end of the dry season.
	Livestock are only observed to be grazing in the offset area during strategic grazing event/s.
Minimise predation risk by wild dogs to threatened fauna species.	Reduction in Catling* Index for wild dogs from year 1 and subsequent monitoring events.
Minimise predation risk by feral cats to threatened fauna species.	Reduction in Catling* Index for feral cats from year 1 and subsequent monitoring events.
Minimise predation risk by foxes to threatened fauna species.	Reduction in Catling* Index for foxes from year 1 and subsequent monitoring events.
Minimise degradation of offset value habitat by feral horses.	Reduction in the observed presence of feral horse on the property.
Minimise degradation of offset value habitat by feral pigs.	Reduction in mean feral pig abundance score from year 1 and subsequent monitoring events.

Management objectives	Performance criteria
Manage invasive weed species to reduce degradation of offset value habitat.	A decrease in species richness and relative abundance of weed species at 80% of monitoring sites from year 1 and subsequent monitoring events. No new weed species are identified at any monitoring site (based on year 1 and subsequent monitoring data).
Reduce the risk of adverse impacts to offset value habitat by inappropriate fire regimes or unplanned fire.	No unplanned fire within the offset area. Increase in habitat quality scores as a result of implementation of any fire management measures.
Regrowth Brigalow vegetation managed to meet the criteria for remnant status within the OAMP timeframe.	Regrowth Brigalow vegetation meets the criteria for remnant vegetation.
Achieve the interim performance targets and completion criteria for each offset value within 5, 10, and 20 years, respectively.	The interim performance targets are achieved for all offset values by year 5, 10 or 15. The completion criteria are achieved for all offset values by year 20.

* Catling index provides a measure of relative abundance of wild dogs, foxes and feral cats within the offset area. The Catling index will be measured as the percentage of camera nights in which the pest species was observed as part of fauna camera monitoring for the species, as outlined in Section 6.2.8.

Table 11: Management objectives, performance criteria, adaptive management triggers and corrective actions.

Identified threats to offset values	Management objective	Performance criteria	Management action	Monitoring	Trigger for adaptive management and corrective actions	Corrective actions
Degradation of habitat	Achieve the completion criteria including habitat quality improvements for offset values and remnant status for those regrowth vegetation communities.	Increase the habitat quality scores for each offset value at each habitat quality assessment site based on the results of baseline and subsequent monitoring events to achieve the scores in the completion criteria. Achieve structural and floristic components for a vegetation community to be reclassified as remnant.	Implementation of the management actions and adaptive management framework as outlined in this OAMP.	Monitoring of offset value habitat quality scores and condition of habitat will be undertaken in accordance with Section 7.0 including: Offset area inspections (Section 7.1). Rapid monitoring events (Section 7.6.1). Habitat quality assessments to determine habitat quality scores (Section 7.6.2). Targeted fauna surveys (Section 7.6.4). The results of monitoring events will be compared against the interim performance targets and completion criteria to determine the progress of the offset area and recorded as part of reporting (Section 8.0).	Interim performance targets are not achieved for one or more offset values by year 5, 10 or 15. Completion criteria are not achieved for one or more offset values by year 20.	Step 1: Investigate cause of trigger • Investigate reasons why the interim performance targets or the completion criteria were not achieved within the specified timeframes. • Re-evaluate the suitability of the relevant management measures in the OAMP. • Identify appropriate corrective actions. Step 2: Implementation of corrective action/s • The appropriate corrective actions will be implemented and may include: ○ Third party review of the OAMP to provide input on the effectiveness of the management actions. ○ Increasing the frequency and intensity of pest animal and weed control measures, or revising the type of measures to be implemented. ○ Modifying the strategic grazing regime to better support enhancement of offset values. ○ For offset values that have not achieved interim performance targets by year 5, 10 or 15 for those offset values, Santos will obtain advice from suitably qualified people/groups with the aim of identifying appropriate additional management interventions. ○ If it is considered that the completion criteria cannot be achieved, Santos will update this OAMP proposing alternative offset areas in order to acquit the required offset requirements in accordance with the offsets assessment guide. The revised OAMP will be submitted to the Commonwealth Government.
Habitat loss through vegetation clearing	Maintain the extent of offset value habitat within the offset area.	No unapproved and/or intentional clearing of habitat within the offset area, with the exception of clearing that is required for fencing, access, firebreaks and public safety as outlined in Table 12.	Protection of the offset area via a Voluntary Declaration under section 19E and 19F of the VM Act, as described in Section 2.7.	Reporting to the Commonwealth Government consistent with EPBC approval.	Any activities in contravention of the Voluntary Declaration and this OAMP.	Step 1: Investigate cause of trigger • Investigate reasons why unapproved clearing occurred e.g. unauthorised access. • Identify appropriate corrective actions. Step 2: Implementation of corrective action/s • The appropriate corrective actions will be implemented and may include: ○ Addition fencing, signage and/or security for the offset area. ○ Restoration of the impacted area.
			Comply with the restrictions outlined in Table 12. Construction and maintenance of access tracks, fencing and firebreaks will be	Compliance with restrictions for vegetation clearing associated with maintenance and establishment of access tracks, fencing and firebreaks will also be assessed as part of offset	Clearing for access, fencing, firebreaks or public safety is not undertaken in accordance with the restrictions outlined in Section 6.2	Step 1: Investigate cause of trigger • If restrictions for clearing associated with fencing, access, firebreaks or public safety are not adhered to, Santos will ensure that all clearing activities cease immediately. • Investigate the reason for unapproved or unintentional clearing.

Identified threats to offset values	Management objective	Performance criteria	Management action	Monitoring	Trigger for adaptive management and corrective actions	Corrective actions
			undertaken in accordance with Sections 6.2.2, 6.2.5 and 6.2.6. If vegetation clearing is required for fencing, access, firebreaks or public safety, all activities will be planned, recorded and monitored.	area inspections (Section 7.1).		• Following clearing, the area is to be assessed by a suitably qualified ecologist/expert to determine the total clearing extent of offset value habitat. • Identify appropriate corrective actions. Step 2: Implementation of corrective action/s • The appropriate corrective actions will be implemented and may include: ○ Reviewing and modifying protocols for the establishment of fences, access tracks, and firebreaks. ○ Prior to the establishment of fences, access tracks, and firebreaks, the area to be cleared will be clearly marked out with flagging tape and checked prior to clearing. ○ Rehabilitation of the impacted area.
Degradation of habitat by livestock overgrazing.	Ensure that the livestock grazing restrictions outlined in 0 for fire management and weed control assist in the enhancement of ground cover attributes for offset values and does not result in the degradation of habitat.	Increase the richness and average % cover of native perennial grasses at each habitat quality assessment site based on the results of baseline and subsequent monitoring events.	Implementation of strategic grazing to reduce fuel loads and control exotic pasture grasses and promote the establishment of native perennial grass species in accordance with Section 6.2.6.1.	Rapid monitoring events and habitat quality assessments will be undertaken in accordance with Section 7.6.1 and 7.6.2. These will include assessment of % cover of native perennial grasses and incidental flora surveys.	Decrease in the richness and average % cover of native perennial grasses at one or more habitat quality assessment sites based on the results of baseline and subsequent monitoring events.	Step 1: Investigate cause of trigger • Investigate the reason for the decrease in richness and average % cover of native perennial grasses. • Identify appropriate corrective actions. Step 2: Implementation of Corrective Action/s • The appropriate corrective actions will be implemented and may include: ○ Modifying the strategic grazing regime including modifying the frequency, intensity and/or duration of grazing events. ○ Constructing additional fencing should the current fencing be considered insufficient to manage livestock in accordance with the grazing regime. ○ Installing additional watering points for livestock to manage livestock in accordance with the grazing regime.
		Biomass levels of 2,500 kg/ha are retained at each of the monitoring sites at the end of the dry season.	Implementation of a strategic grazing regime to protect and maintain environmental values in accordance with Section 6.2.6.1.	Biomass monitoring will be undertaken in accordance with Section 7.2.	Biomass monitoring results indicate less than 2,500 kg/ha of biomass is present at any of the monitoring sites at the end of the dry season.	Step 1: Investigate cause of trigger • Investigate the reason for biomass being less than 2,500 kg/ha. • Re-evaluate the strategic grazing regime to assess the suitability of grazing to ensure no less than an average of 2,500 kg/ha of biomass is retained at the end of the dry season. • Identify appropriate corrective actions. Step 2: Implementation of Corrective Action/s • The appropriate corrective actions will be implemented and may include: ○ Removal of stock or spelling grazing from the area of the offset in which less than 2,500kg/ha of biomass was identified.

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Identified threats to offset values	Management objective	Performance criteria	Management action	Monitoring	Trigger for adaptive management and corrective actions	Corrective actions
						○ Review adherence to livestock grazing restrictions in Section 6.2.6.1. ○ Where relevant, amending livestock management practices in the OAMP, including amending stocking rates, and/or duration and/or frequency of strategic grazing events.
		Livestock are only observed to be grazing in the offset area during strategic grazing event/s.	Existing fencing is always maintained as outlined in Section 6.2.5.	Offset area inspections to be undertaken at least annually (Section 7.1) and will include monitoring to assess the: • condition of fencing to identify any necessary maintenance requirements. • presence of livestock within the offset area.	Livestock are observed within the offset area when not permitted within that area. Damaged fencing is observed.	Step 1: Investigate cause of trigger • If livestock are identified in the offset area, remove stock immediately. • Inspect and evaluate fencing and identify the cause of livestock within the offset area. • Identify appropriate corrective actions. Step 2: Implementation of Corrective Action/s • The appropriate corrective actions will be implemented and may include: ○ Repairing fencing where required to ensure its condition is satisfactory to exclude livestock. ○ Constructing additional fencing should the current fencing be considered insufficient to exclude livestock.
Predation by wild dogs	Minimise predation risk by wild dogs to threatened fauna species.	Reduction in Catling* Index for wild dogs from year 1 and subsequent monitoring events.	Implement control actions for wild dogs in accordance with Section 6.2.8.	Undertake monitoring for wild dogs in accordance with Section 7.5.	An increase in Catling* Index for wild dogs from year 1 and subsequent monitoring events.	Step 1: Investigate cause of trigger • Investigate potential sources or reasons that may have attributed to an increase in the: ○ Catling* index for wild dogs, feral cats and/or foxes. ○ relative abundance of feral pigs and horses. ○ Review adherence to pest management control measures as outlined in Section 6.2.8. ○ Identify appropriate corrective actions. Step 2: Implementation of corrective action/s ○ The appropriate corrective actions will be implemented and may include: ○ Increasing the frequency and intensity of pest animal control. ○ Revising methods of pest animal control in accordance with Queensland Department of Agriculture and Fisheries (DAF) guidelines, and coordinate with neighbouring landowners to ensure a consistent approach. ○ Updating pest animal control methods in the OAMP and targeted pest animal control programs.
Predation by feral cats.	Minimise predation risk by feral cats to threatened fauna species.	Reduction in Catling* Index for feral cats from year 1 and subsequent monitoring events.	Implement control actions for feral cats in accordance with Section 6.2.8.	Undertake monitoring for feral cats in accordance with Section 7.5.	An increase in Catling* Index for feral cats from year 1 and subsequent monitoring events.	
Predation by foxes.	Minimise predation risk by foxes to threatened fauna species.	Reduction in Catling* Index for foxes from year 1 and subsequent monitoring events.	Implement control actions for foxes in accordance with Section 6.2.8.	Undertake monitoring for foxes in accordance with Section 7.5.	An increase in Catling* Index for foxes from year 1 and subsequent monitoring events.	
Degradation of habitat by feral horses	Minimise degradation of offset value habitat by feral horses.	Reduction in the observed presence of feral horses on the property.	Implement control actions for feral horses in accordance with Section 6.2.8.	Undertake monitoring for feral horses in accordance with Section 7.5.	An increase in the observed presence of feral horses across monitoring events.	
Degradation of habitat by feral pigs.	Minimise degradation of offset value habitat by feral pigs.	Reduction in mean feral pig abundance score from year 1 and subsequent monitoring events.	Implement control actions for feral pigs in accordance with Section 6.2.8.	Undertake monitoring for feral pigs in accordance with Section 7.5.	An increase in mean feral pig abundance score from year 1 and subsequent monitoring events.	
Invasion of habitat by weed species, including exotic grasses.	Manage invasive weed species to reduce degradation of offset value habitat.	A decrease in species richness and relative abundance of weed species at 80% of monitoring sites from year	Implement weed control actions in accordance with Section 6.2.7. Adhere to weed hygiene restrictions in	Undertake weed monitoring in accordance with Section 7.3.	An increase in species richness and relative abundance of weed species at more than 20% of monitoring sites from	Step 1: Investigate cause of trigger • Investigate potential sources or reasons that may have attributed to an increase in species richness and/or relative abundance of weeds.

Identified threats to offset values	Management objective	Performance criteria	Management action	Monitoring	Trigger for adaptive management and corrective actions	Corrective actions
		1 and subsequent monitoring events. No new weed species are identified at any monitoring site (based on year 1 and subsequent monitoring data).	accordance with Section 6.2.1.		year 1 and subsequent monitoring events. A new weed species is identified at one or more monitoring sites.	• Investigate potential sources or reasons for the occurrence of the new weed species. • Review adherence to weed management control measures as outlined in Section 6.2.7. • Review adherence to weed hygiene restrictions as outlined in Section 6.2.1. • Identify appropriate corrective actions. Step 2: Implementation of corrective action/s • The appropriate corrective actions will be implemented and may include: o Amending weed hygiene restrictions. o Providing additional educational awareness training for all staff and contractors to ensure weed hygiene restrictions are adhered to. o Revising weed control methods in accordance with the *Biosecurity Act 2014* (Qld). o Increasing the frequency and intensity of weed control. o Updating weed control methods in the OAMP and targeted weed control programs.
Inappropriate fire regimes	Reduce the risk of adverse impacts to offset value habitat by inappropriate fire regimes or unplanned fire.	No unplanned fire within the offset area. Increase in habitat quality scores as a result of implementation of any fire management measures.	All fire management measures to be implemented in accordance with the program outlined in Section 6.2.6.	Habitat quality assessments to determine habitat quality scores will be undertaken in accordance with Section 7.6.2. Rapid monitoring events will be undertaken to assess the general condition of vegetation in accordance with Section 7.6.1.	As a result of fire management measures, or an unplanned fire, there is a decrease in the habitat quality score for any offset value from baseline and subsequent monitoring events.	Step 1: Investigate cause of trigger • Investigate reasons why the fire management measures have resulted in a decrease in habitat quality scores. • Review adherence to the fire management measures as outlined in Section 6.2.6. • Identify appropriate corrective actions. Step 2: Implementation of corrective action/s • The appropriate corrective actions will be implemented and may include: o Increasing the frequency of biomass monitoring. o Increasing the frequency of weed control measures. o Amending the strategic grazing regime. o Reviewing effectiveness of firebreaks, and establishment of additional fire breaks. o Review timing and intensity of fuel hazard reduction burns in accordance with the Regional Ecosystem Description Database (REDD) fire management guidelines and conservation advice for the particular offset value.
Regrowth Brigalow unlikely to achieve remnant status	Regrowth Brigalow vegetation managed to meet the criteria for remnant status within the OAMP timeframe.	Regrowth Brigalow vegetation meets the criteria for remnant vegetation.	Selective regrowth thinning of Brigalow TEC where regrowth of Brigalow vegetation (RE 11.9.5) occurs at >10,000 stems per	Habitat quality assessments (Section 7.6.2). Brigalow regrowth assessment (Section 7.6.5).	Brigalow regrowth exceeds 10,000 stems per hectare based on previous monitoring events.	Step 1: Investigate cause of trigger • Investigate the reasons why stem density is >10,000 stems/ha and whether management intervention is required. mechanical thinning is effective and appropriate. Step 2: Implementation of corrective action(s)

Identified threats to offset values	Management objective	Performance criteria	Management action	Monitoring	Trigger for adaptive management and corrective actions	Corrective actions
			hectare in accordance with Section 6.2.3.			• The appropriate corrective actions will be implemented and may include: ○ Increasing the frequency thinning activities. ○ Revise the type of thinning method used.
Offset fails to achieve the interim performance targets and completion criteria within the anticipated 5, 10, 15 and 20 year timeframes, respectively.	Achieve the interim performance targets and completion criteria for each offset value within 5, 10, 15 and 20 years, respectively.	The interim performance targets are achieved for all offset values by year 5, 10 or 15. The completion criteria are achieved for all offset values by year 20.	All management actions outlined in Section 6.0 will be implemented to ensure that the interim performance targets and completion criteria are achieved.	Monitoring of the offset area will be undertaken in accordance with Section 7.0 including: • Offset area inspections (Section 7.1). • Offset value assessments (Section 7.6). The results of monitoring events will be compared against the interim performance targets and completion criteria to determine the progress of offset area and recorded as part of reporting (Section 8.0).	Interim performance targets are not achieved for one or more offset values by year 5, 10 or 15. Completion criteria are not achieved for one or more offset values by year 20.	Step 1: Investigate cause of trigger • Investigate reasons why the interim performance targets or the completion criteria were not achieved within the specified timeframes. • Re-evaluate the suitability of the relevant management measures in the OAMP. • Identify appropriate corrective actions. Step 2: Implementation of corrective action (s) • The appropriate corrective actions will be implemented and may include: ○ Third party review of the OAMP to provide input on the effectiveness of the management actions. ○ Increasing the frequency and intensity of pest animal and weed control measures, or revising the type of measures to be implemented. ○ Modifying the strategic grazing regime, or fire management measures, to better support enhancement of offset values.

6.2 Management actions

6.2.1 General restrictions

Table 12 details the restrictions to be implemented for the offset area to ensure the completion criteria and management objectives are met.

Table 12: Offset area restrictions

Restrictions	Details
Weed hygiene	• Weed hygiene measures will be implemented to prevent the movement of weed material into the offset area. • All persons entering the offset area will be required to ensure vehicles and equipment are weed free. • All contractors entering the offset area must hold a current weed hygiene certificate or equivalent for all vehicles and equipment. • Evidence is to be provided on request to the Santos land advisor of the Kentucky property that vehicles, slashers or any machinery implementing management actions are clean prior to entry to minimise potential weed spread.
Vehicles	• Vehicle movement will be limited to designated access tracks in the offset area and access will be restricted to authorised personnel only. • Vehicles will travel to track conditions to minimise the risk of vehicle strike to fauna.
Vegetation clearing	• Clearing will be excluded from the offset area through demarcation and protection by means of Voluntary Declaration under the VM Act. Clearing for timber gathering and development will also be excluded. • Clearing of native vegetation will not be permitted within the offset area as part of any management and monitoring activities associated with this OAMP, except for clearing that is required for: o maintenance of access tracks and/or fire breaks o fence construction and maintenance and o ensuring public safety or as directed by emergency management response personnel in the event of unplanned fire or other emergency or associated procedure. • If vegetation clearing is required for fencing, access, firebreaks or public safety, all activities will be appropriately planned, recorded and monitored. • Machinery will not be allowed on site after heavy or prolonged rainfall events until after the site has dried to allow for safe movement of traffic.
Unauthorised access or use	• Access into the offset area will be restricted to authorised personnel only. • The offset area will be demarcated as an exclusion zone in the Santos GIS. • Signs will be installed in prominent locations (i.e. at access points into the offset area) which recognise that the areas are protected for conservation purposes. The signs will advise that access into the offset area is restricted to authorised personnel only • The property will be suitably fenced to restrict access by unauthorised persons.

Restrictions	Details
	• At no time can persons access the site without first approaching Santos land advisor of the Kentucky property and informing them of their intent. • When entering and leaving the property, the land advisor must be advised. • Contractors will only be permitted to access the property following the direct engagement by Santos.

6.2.2 Access tracks

Existing access tracks will be utilised to facilitate necessary management, maintenance and monitoring activities as part of this OAMP. If existing access tracks become impassable (through erosion or vegetation regrowth), maintenance activities of these tracks (e.g. grading) will be prioritised over alternative track alignments. Gully crossings are likely to be subject to periodic, ongoing maintenance because of erosion following rain events.

Existing and new access tracks will be no wider than 5 m and vegetation disturbance will be minimised.

6.2.3 Brigalow regrowth restoration

Through the implementation of this OAMP areas of regrowth Brigalow will be restored to establish self-sustaining functional remnant vegetation communities analogous to Brigalow TEC. Regrowth Brigalow within the offset area has been mapped as advanced regrowth, as previously described in Section 3.1. To achieve remnant status the areas of regrowth Brigalow need to demonstrate that the dominant canopy has greater than 70% of the height and greater than 50% of the cover relative to the undisturbed height and cover of that stratum and is dominated by species characteristic of the vegetation's undisturbed canopy.

Thinning randomly selected stems of the dominant species in a Brigalow regrowth community has been found to accelerate:

- growth of retained stems
- recovery of forest structure, and
- recruitment of some native shrub species (Dwyer and Mason 2017).

Selective regrowth thinning will occur where regrowth of Brigalow vegetation (RE 11.9.5) occurs at >10,000 stems per hectare and the density of stems is considered to be affecting the sites capacity to return to remnant status.

It is recommended that Brigalow be selectively thinned when stem densities are very high (e.g. >10,000 stems per hectare). To be effective, thinning has to utilise methods that cause slow stem death (e.g. ringbarking, selective herbicide application) and reduce secondary suckering (these are time and labour-intensive (Peeters and Butler 2014; Dwyer and Mason 2017) .

Where thinning does occur, the vegetation must not be thinned less than the density of a benchmark site for equivalent community. Benchmark sites will be obtained from the Queensland Government database or from nearby remnant vegetation of the same community.

The requirement for management by mechanical thinning will be informed by monitoring events (see Section 7.6.5).

6.2.4 SEVT rehabilitation program

The rehabilitation program for SEVT on Kentucky has been designed to deliver on the overall objectives of the *National recovery plan for the "Semi-evergreen vine thickets of the Brigalow Belt (North and South) and Nandewar Bioregions* (McDonald 2010) and focus on the threats identified as affecting SEVT communities (see Section 3.2.2). The overall objective of the recovery plan is "to maintain and conserve the environmental values of the semi-evergreen vine thicket ecological community over the long term, by minimising the loss of both remnant and regrowth SEVT and improving their condition and management".

The management measures identified throughout Section 6.0 have been designed to manage the threats affecting SEVT and to maintain and conserve the environmental values of the SEVT present on Kentucky. The completion criteria require the protection of remnant and regrowth SEVT and improving condition of these communities over the life of the offset.

6.2.5 Fencing

To assist with management of livestock control for weed and fuel load management existing fencing will be maintained, as presented in Figure 8.

Any additional fencing required to be installed will comprise of a 4 wire fence consisting of 3 strand 1.57HT barb with a plain high tensile wire at the top, wood and/or steel posts at 7 m spacing, a strainer post every 100 m and 1 gate located every km. This type of fencing is also considered appropriate to facilitate the fauna movement across the property. Importantly, the movement of the species being offset will not be impeded by the proposed fencing design.

Any vegetation disturbance associated with new fence construction will be minimised in accordance with Table 12.

Regular inspections of all fencing will be undertaken in accordance with Section 7.1, and repairs to the fences will be made as required.

6.2.6 Fire management

A planned and co-ordinated fire management strategy will be implemented to:

- minimise the risk and impacts of unplanned fire (by monitoring and controlling fuel loads, if required) especially to fire sensitive Brigalow and SEVT TEC
- improve habitat quality through:
    - controlling weeds and fuel loads
    - supporting development of structural components of habitat for offset values (e.g. recruitment of native plants, establishment of fire sensitive native herbs and groundcover, important microhabitat including fallen logs and leaf litter, and increased understorey), and
    - promoting germination and recruitment of Eucalypt species and other species characteristic of the specific RE.

Unplanned fire risk will be managed through:

- establishment and regular maintenance of firebreaks (Figure 8)
- monitoring and managing fuel loads primarily through the implementation of a controlled grazing regime (section 6.2.6.1), and

- fuel hazard reduction burns (if required; section 6.2.6.2).

Where possible, firebreaks will be established and maintained around the boundary of the offset area, with green firebreaks established where the offset area joins native vegetation, see Figure 8. Firebreaks will be maintained at least annually in mid / late autumn and, or early spring to remove overhanging trees or fallen debris and dense vegetation. Firebreak maintenance will be undertaken to a width of up to 10 m.

6.2.6.1 Strategic grazing

The Kentucky property has in the past been managed as an open grazing enterprise where the focus has been on production and sustaining a viable income from domestic stock.

Strategic grazing within the offset area will be used to manage fuel loads and control exotic weeds and pasture grasses such as *Cenchrus ciliaris*. As increasing grazing intensity is correlated with an increase in weedy cover (Franks 2002), and a decrease in native grass species richness, grazing will be permitted in the offset area on a managed and limited basis to control weeds and reduce fuel loads.

Best practice management for strategic livestock grazing within the offset area will be undertaken as follows:

- livestock will only be permitted in the offset area to reduce fuel loads, avoid weed seed set and reduce weed cover
- within the offset area a minimum of 2,500 kg/ha of biomass will be retained at the end of the dry season.

To minimise erosion and subsequent impacts on water quality, strategic grazing will be excluded where rainfall causes inundated or waterlogged soils. The location and extent of strategic grazing areas will be reviewed annually based on the results of management and monitoring events.

The suitability of conditions for undertaking a grazing event will be informed by biomass monitoring events as described in Section 7.2.

6.2.6.2 Fuel hazard reduction burns

The aim of fuel hazard reduction burns is to manage excess fuel loads, to initiate regeneration of eucalypt communities and to create habitat with a mosaic of different fire frequencies and times since fire.

Fire management, through fuel hazard reductions burns will be guided by conservation advice documentation (e.g. for MNES) and the Regional Ecosystem Description Database (REDD; Queensland Herbarium 2019b), which provides recommendations for fire management for each of the component RE (Table 13), guidelines published in Fire and Biodiversity Monitoring Manual published by South East Queensland Fire and Biodiversity Consortium (2002), local regional fire plans, regional fire authorities and local knowledge of fire behaviour.

Based on this advice, fire is to be excluded from areas of Brigalow TEC and SEVT TEC in the offset area. To reduce the risk of fire occurring within Brigalow TEC and SEVT TEC in the offset area, very cool fuel hazard reduction burns (trickle burns) in a rotational mosaic pattern may be conducted in adjacent areas.

Hazard reduction burns will be considered if fuel hazard ratings within the offset area are unable to be maintained below extreme in accordance with the Overall Fuel Hazard Assessment Guide (Hines et al. 2010; Appendix E) through the implementation of strategic grazing and weed control. However, the location and timing for fuel hazard reduction burns will be informed by the results of biomass monitoring (Section 7.2) and fuel load monitoring (Section 7.3) in conjunction with the results of habitat quality assessments and considering the REDD fire management guidelines for the vegetation community and MNES conservation advices.

In general, fire management will be undertaken in a mosaic pattern at the appropriate time of year when there is:

- high soil and fuel moisture levels, ideally following minimum of 40 mm of rainfall
- low ambient temperature and wind speed
- high atmospheric humidity
- the risk of long-term impacts/high intensity fire is low, and/or
- when plants approach a more active growing phase.

Table 13: Fire Management Guidelines for dominant vegetation communities on Kentucky

RE	Associated TEC	Fire Exclusion?	Fire Management
11.3.2	Poplar Box TEC	No	• Conduct a low to moderate burn every 6-10 years. • Timing for burning should be late wet to early dry season when there is good soil moisture, early storm season or after good spring rains. • Burn less than 30% of the area in any year. • Burn under conditions of good soil moisture and when plants are actively growing. Sometimes a small amount of wind may move the fire front quickly so that burn intensity is not too severe to destroy habitat trees.
11.3.25	-	No	• Conduct a low intensity burn every 3-5 years primarily during the early dry season. • Protection of this RE also relies on fire management of adjacent vegetation communities with numerous small fires throughout the year so that wildfires will be limited in extent. • In some situations it may be best not to burn as this RE is often critical habitat for fauna and flora species. • If burning is to occur then implement when water level is deep enough to protect the bases of aquatic plants. • If riparian areas need to be burnt to reduce fuel loads then burning should occur when there is good soil moisture and active growth.
11.3.27	-	No	• Depending on position in the landscape, protection of this RE relies on broad-scale fire management of surrounding country, with numerous small fires throughout the year so that wildfires will be very limited in extent. • In some situations it may be best not to burn as this RE is often critical habitat for fauna and flora species. • If burning is to occur then implement when water level is deep enough to protect the bases of aquatic plants. • If riparian areas need to be burnt to reduce fuel loads then burning should occur when there is good soil moisture and active growth.

RE	Associated TEC	Fire Exclusion?	Fire Management
11.3.39	-	No	• Conduct low to moderate intensity burn in late wet to early dry season when there is good soil moisture every 6-10 years. • Restrict to less than 30% in any year. Management of this vegetation type should be based on maintaining vegetation composition, structural diversity, fauna habitats (in particular hollow-bearing trees and logs) and preventing extensive wildfire. Maintaining a fire mosaic will help ensure protection of habitat and mitigate against wildfires.
11.9.2	-	No	• Conduct low to moderate intensity burns in the late wet to early dry season when there is good soil moisture every 6-10 years. • Restrict to less than 30% in any year. • Burn under conditions of good soil moisture and when plants are actively growing. Management of this vegetation type should be based on maintaining vegetation composition, structural diversity, fauna habitats (in particular hollow-bearing trees and logs) and preventing extensive wildfire. Maintaining a fire mosaic will help ensure protection of habitat and mitigate against wildfires.
11.9.4	SEVT TEC	Yes	• Protection from fire is necessary. • Maintain fire management of surrounding country with numerous small fires throughout the year so that fires will be very limited in extent. • Maintenance of fire breaks may be appropriate on flat country, but natural features will be useful as breaks in 'wild' country. • Fuel reduction in the surrounding vegetation under low fire danger conditions and/or revegetation of cleared areas reduce the risk of damaging wildfires. • Maintain or re-establish native vegetation communities adjacent to this ecosystem. Grazing may be useful in managing fuel loads created by introduced grasses such as buffel.
11.9.5	Brigalow TEC	Yes	• Protection from fire is necessary. • High intensity fires will cause damage to overstorey. • Maintain fire management of surrounding country so that any fires will be very limited in extent. Frequent fire at the edge of this community keeps fuel loads low. • The invasion of exotic grasses such as buffel grass increases the risk from fire. Grazing may be an option for reducing fuel loads in Brigalow TEC.

RE	Associated TEC	Fire Exclusion?	Fire Management
11.9.10	-	Yes	• Protection from fire is necessary. • Maintain fire management of surrounding country so that wildfires will be very limited in extent. Frequent fire at the edge of this RE keeps fuel loads low.
11.10.3	-	Yes	• Protection from fire is necessary. • Maintain fire management of surrounding country with numerous small fires throughout the year so that fires will be very limited in extent. • There is typically not enough ground vegetation within this RE to carry a fire.
11.10.7	-	No	• Conduct a moderate to high burn every 6-10 years. • Timing for burning should be during late wet to early dry season when there is good soil moisture, early storm season or after good spring rains. • Burn less than 10-30% of the area in any year. • Burn surrounding vegetation under conditions of good soil moisture and when plants are actively growing throughout the year so that fires will be very limited in extent. • Best protection from fire is through the creation of a multi-aged mosaic in surrounding vegetation and perimeter burning.
11.10.8	-	Yes	• Protection from fire is necessary. • Protection primarily relies on broad-scale management of surrounding country with numerous small fires throughout the year so that wildfires will be very limited in extent.
11.10.11	-	No	• Conduct moderate intensity burns in the late wet to early dry season when there is good soil moisture every 3-5 years. • Burn less than 30% in any year.
11.10.13	-	Yes	• Protection from fire is necessary. • Burn surrounding country only under conditions of good soil moisture and when plants are actively growing. • Will be difficult to burn owing to a lack of ground fuel that normally occurs in this RE.

6.2.7 Weed management

Weed management in the offset area will aim to minimise the introduction, establishment and spread of restricted and prohibited pest plants under the *Biosecurity Act 2014* (Qld) and other invasive species not regulated under the *Biosecurity Act 2014*, that present a threat to vegetation communities and species habitat in the offset area. Weed management will focus on reducing the extent of existing weeds as well as minimising the risk of introduction of additional weed species to the offset areas.

Ecological assessments of the Kentucky property (Section 2.4) identified a small number of *Opuntia* spp. (Prickly pear [*Opuntia stricta*], Tree Pear [*Opuntia tomentosa*], Tiger Pear [*Opuntia aurantiaca*]); however, the species/populations were deemed to cause no measurable threat to the site or management objectives. In addition, it was noted that the existing biological control measures for the *Opuntia* spp. were quite effective and that little, if any, further management of these species would be required (Boobook 2015).

Parthenium (*Parthenium hysterophorus*) presents a high potential for introduction to the property, due to its presence in the surrounding region (known to occur in the southern arcadia valley) and ability to disperse.

Reductions in the extent of buffel grass, green panic and parthenium are most effectively achieved by maximising the competitive advantage of native ground cover species. This requires native species richness and abundance to be maximised. In historically grazed environments the most effective way to ensure high species richness is through conservatively managed cattle grazing (Fensham 1998). Conservative cattle grazing requires maintenance of enough biomass to maximise grass growth and appropriate spelling to allow for native species to set seed.

Accordingly, a strategic grazing regime will be implemented to reduce the presence and biomass of exotic pasture grasses in the offset areas (refer to Section 6.2.6.1). To supplement this, weeds will be managed using biological, chemical and/or mechanical control in accordance with the control measures outlined in the Biosecurity Queensland Fact Sheets, for the relevant weed species.

Biological control measures will continue to be used to manage *Opuntia* spp.; however, the species will not be completely eradicated from the Kentucky property. For the biological control measures currently in place to remain effective, a small number of plants are required to remain on site.

6.2.8 Pest animal management

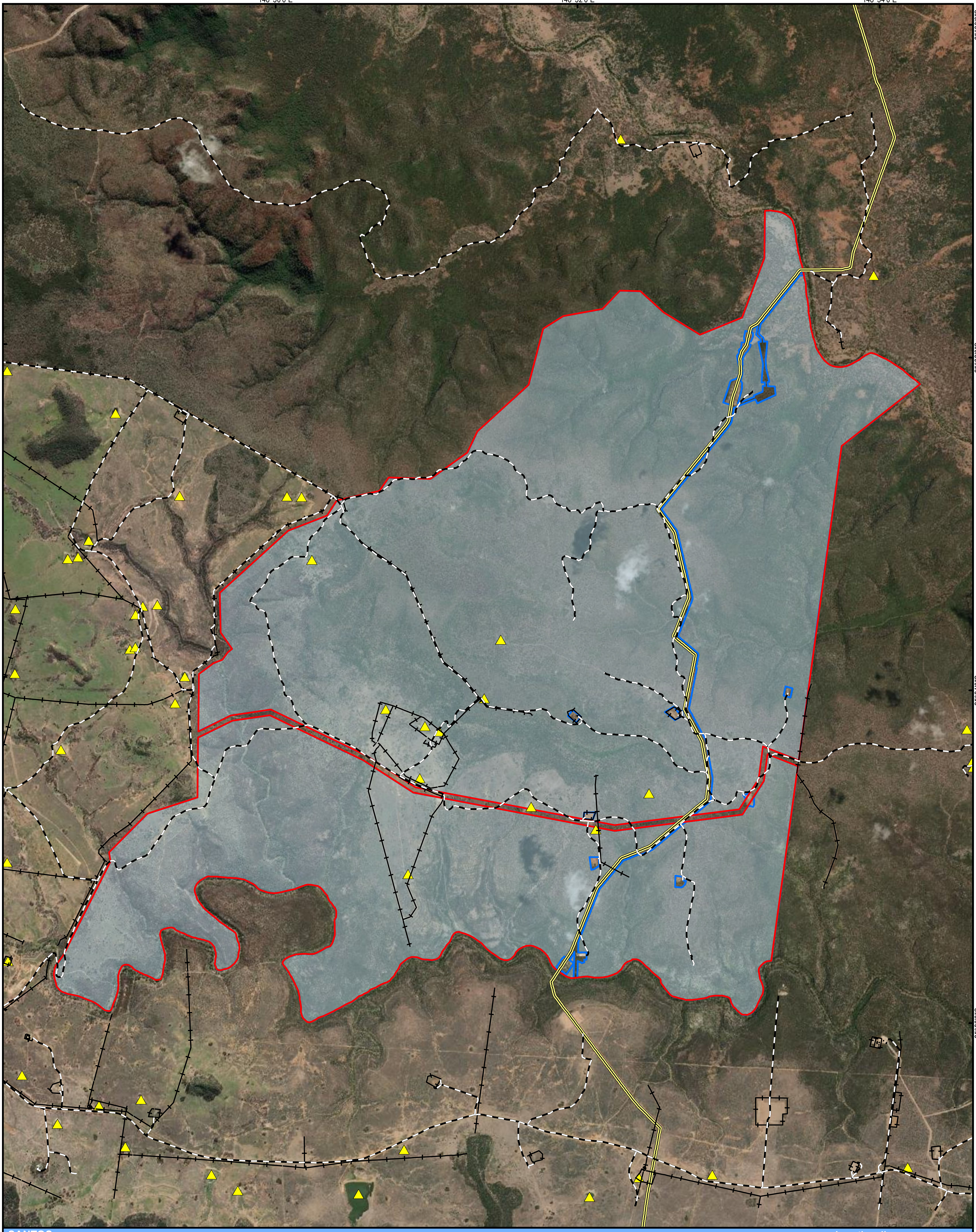
Pest animals present or have the potential to occur on or within the immediate vicinity of the Kentucky property and pose the following threats:

- predation of fauna by foxes, cats and wild dogs, and
- erosion and degradation of habitat and competition by pigs and feral horses.

Pest animal control activities will be undertaken to minimise the introduction of pest animals and control existing pest animal populations. Control methods utilised will be in accordance with the *Biosecurity Act 2014*. Table 14 provides examples of approved species-specific pest animal control measures recommended by the Queensland and Commonwealth governments. Results of pest animal assessments will be reviewed following each reporting event to inform the need for, location and timing of species-specific control measures in subsequent years.

Table 14: Examples of species-specific control methods for pest animal species

Species	Status under Biosecurity Act 2014	Example control method	Reference
Wild dog (*Canis familiaris*)	Category 3,4,6	• Ground baiting • Foot hold traps • Shooting	(DAF 2019a)
Fox (*Vulpes vulpes*)	Category 3,4,5,6	• Ground baiting • Trapping • Shooting	(DAF 2019b)
Feral cat (*Felis catus*)	Category 3,4,6	• Night shooting • Poisoning • Trapping	(DAF 2019c)
Pig (*Sus scrofa*)	Category 3,4,6	• Trapping • Shooting • Poisoning	(DAF 2019d)
Feral horse (*Equus caballus*)	-	• Relocation through mustering or trapping	(DAF 2016)



SANTOS

Figure 8
Kentucky infrastructure

Kentucky - 1WT37
Kentucky offset area
Petroleum pipeline (PPL 166)

Infrastructure
Roads/tracks
Dams
Existing fencing

Location diagram

DATA SOURCE:
The following datasets are © State of Qld:
- Cadastral data
- Petroleum pipeline
Kentucky offset area and infrastructure provided by SANTOS

Date: 7/30/2021 Coordinate System: GDA 1994 MGA Zone 55 Projection: Transverse Mercator Datum: GDA 1994 Scale: 1:37,500@A3

0 0.5 1 1.5 2
Kilometres

N

CO2 Australia

Path: P:\GISData\Projects\Santos\ENV_20_00419.GTP_Offset_Maps\Kentucky\Figure 8 - Infrastructure.mxd

7.0 Monitoring

The results of the monitoring program outlined in the following sections will be used to inform operational management decisions, including adaptive implementation of this OAMP to ensure the performance criteria and management objectives, and ultimately interim performance targets and completion criteria are met.

The monitoring results will also be used to assess adherence to performance criteria, and to determine when corrective actions are required to be implemented. The results will also be compared to those from previous monitoring events to assess change over time and to inform the ongoing implementation of the OAMP.

7.1 Offset area inspections

The aim of offset area inspections is to enable a general assessment of the offset area to identify any potential issues that may require remedial action to be undertaken. Inspections will be undertaken twice per year for the duration of the management period to assess the following:

- condition of fencing, gates and signs and existing gas field infrastructure
- condition of access tracks
- condition of firebreaks
- compliance with restrictions for vegetation clearing associated with maintenance and establishment of access tracks, fencing and firebreaks
- incidence of erosion within offset area, particularly around permanent and semi-permanent water bodies or areas subject to inundation or waterlogging
- damage/degradation resulting from pest animal activity within the offset area
- signs of land degradation and over-grazing
- presence of weed/invasive species
- exclusion of livestock
- incidental fauna observations and any additional risks to offset values (i.e. evidence of vehicle strike), and
- within Brigalow regrowth, observations for excessive regrowth Brigalow that may require thinning.

7.2 Biomass monitoring

Biomass monitoring for fire management will be undertaken twice a year, at the end of the wet season and end of the dry season, to:

- determine the risk of fire to the offset site and
- inform fire management strategies to control fuel loads.

Biomass is at its greatest at the end of the wet season (around April) with fire risk greatest towards the end of the dry season (October). Biomass will be monitored within the offset areas using appropriate photo standards[1] which will be used to determine dry matter yields and subsequently fuel loads. Biomass monitoring will be undertaken at the same permanent weed monitoring sites established as part of the year 1 monitoring.

Fuel loads will be managed through strategic grazing events (see Section 6.2.6.1) if the biomass assessment at the end of the wet season shows that biomass is greater than 2,500 kg/ha within the offset area.

The stocking rate of these strategic grazing events will be determined through a feed budgeting assessment (see Section 7.2.1) undertaken prior to a grazing event in the offset area. A feed budgeting assessment is a recognised method of determining the stocking rate based on the amount of feed available and the amount of feed desired at the end of the grazing event (i.e. >2,500 kg/ha).

7.2.1 Feed budgeting assessment

The process for undertaking a feed budget assessment will include the following sequence of activities:

- determine the current amount of feed present (kg/ha) using appropriate photo standards available on the Future Beef website[1].
- determine the amount of feed desired (kg/ha) at the end of the grazing event.
- calculate the total useable feed (kg/ha) by subtracting the feed desired from the feed present.
- determine utilisation (i.e. the proportion of useable feed that livestock can use).
- determine the feed available for the grazing animal (kg/ha) by multiplying the total useable feed by the utilisation rate.
- calculate the safe stocking rate by:
  - determining the feed consumption per day (kg/day)
  - determining the number of days feed is required (days)
  - calculating the feed requirement per head (kg/hd) by multiplying the feed consumption per day by the number of days
  - calculating the stocking rate (ha/hd) by dividing the feed requirement per head by feed available, and
  - calculate the number of stock (head) by dividing the area of the paddock by the stocking rate.

The amount of feed available prior to the grazing event will be estimated using the appropriate photo standards available on the Future Beef website. The “Dry Season Feed Budget” worksheet will then be used to calculate the required stocking rate for the grazing event.

At the completion of the grazing event, photo standards will be used to assess ground cover and ecosystem biomass. Should the grazing event be required to be extended (e.g. as a result of additional rainfall and resultant grass growth and potential weed flowering), the feed budget assessment will be recalculated using the “Dry Season Feed Budget” worksheet.

[1] See https://futurebeef.com.au/knowledge-centre/pastures-forage-crops/pasture-photo-standards/.

7.3 Fuel load monitoring

Fuel load monitoring will be undertaken in accordance with the Overall Fuel Hazard Assessment Guide (Hines et al. 2010; Appendix E). Fuel load assessment monitoring will include a baseline survey in year 1 (post wet season; April), with ongoing fuel load assessment monitoring conducted every year at the same time and location as biomass monitoring post wet season. Monitoring will focus on assessing the key structural layers of the fine fuels that burn in bushfires, specifically bark, elevated fuels, near-surface fuels and surface fuels. This will allow for a rapid assessment of each fuel layer, which in in turn is given a hazard rating and are then combined to provide an overall fuel hazard rating of low, moderate, high, very high or extreme.

The fuel hazard rating will be monitored to compare any changes from previous assessments. In conjunction with results of habitat quality assessments, the results of the fuel load assessments will be used to determine if fuel hazard reduction burns are required within the offset area. Weed management and strategic grazing within the offset area will also be undertaken to maintain fuel hazard rating below extreme.

7.4 Weed monitoring

Weed monitoring sites will be randomly stratified, fixed monitoring sites representative of offset values and incorporating natural variability such as aspect (e.g. a mix of north-, east-, south- and west-facing monitoring sites), community type – (e.g. woodland, riparian). There will also be fixed monitoring sites at strategic trafficable areas (e.g. entry gates, creek crossings, stock watering points) to monitor potential introduction and/or irruptions of prohibited and restricted weed species.

The offset area will be monitored for weeds every two years (post wet season) to determine the species richness and abundance, for the duration of the management period. The results of this monitoring will inform the methods for weed treatment and control (see Section 6.2.7).

Non-native plant cover is also assessed as part of the habitat quality assessments detailed in Section 7.6.2, and the presence of weed species will also be recorded as part of the general offset area inspections (see Section 7.1), where noted.

7.5 Pest animal monitoring

The offset area will be monitored for evidence of pest animals every two years (post wet season), including a baseline survey in year 1 of the distribution and abundance of pest animals.

Based on the results of year 1 surveys, pest animal monitoring sites will be established in year 1. Monitoring of pest animals will target areas of known impacts/movements (e.g. along topographic features, including creeks, pads, paths, ridge-tops and roads) to not only maximise the success of encountering pest animals, but target monitoring in environments that are more regularly impacted (e.g. drainage lines, moist gullies and around swamps and lagoons favoured by feral pigs; Hone 1995). The location of pest animal monitoring sites will be assessed prior to each monitoring event.

Pest animal monitoring will also be undertaken in association with and immediately prior to the pest animal control activities (Section 6.2.8). Initial monitoring results will determine the degree of effort required to control the pest population and post control monitoring will determine the degree of success of control operations.

Monitoring of pest animals will involve the deployment of motion sensing infra-red cameras as well as other techniques such as sand plots as appropriate to determine pest animal species present in the offset area and indicative population numbers.

Methods for determining the presence and relative abundance for foxes, feral cats, rabbits and feral pigs are presented in Table 15. Evidence of pest animals, including feral horses, will be documented during the offset area inspections (see Section 7.1)

Table 15: Pest animal monitoring methodology

<table>
<tr><th>Pest animal</th><th>Methodology to be implemented</th></tr>
<tr><td>Fox</td><td rowspan="3">To assess the relative abundance of foxes and feral cats within the offset area, camera monitoring will be undertaken as follows to provide a measure of the Catling index for each species. The Catling index will be measured as the percentage of camera nights in which the pest species was observed. An increase or decrease in the Catling index value between subsequent monitoring events will represent an increase or a decrease in the relative abundance of pest species and a measure of the success of pest animal control.
fauna monitoring cameras will be placed in the offset area
cameras will be placed along tracks and left in place for a minimum of three consecutive nights, and
an analysis of the camera footage will be undertaken to determine the percentage of camera nights with animal captures for each species observed. This percentage represents the Catling index (Mitchell and Balogh 2007b, c).</td></tr>
<tr><td>Wild dog</td></tr>
<tr><td>Feral cat</td></tr>
<tr><td>Feral pig</td><td>An assessment of the presence or absence of feral pig signs as a measure of the relative abundance of feral pigs within the offset area in accordance with Mitchell and Balogh (2007a) and Hone (1988), will be undertaken as follows:
nominate randomly stratified sites across the offset area in environments that are more regularly impacted (e.g. drainage lines, moist gullies, around swamps etc)
calculate an abundance score for each transect as the percentage of ‘present’ feral pig signs, and
calculate the mean abundance score (and variance) across all transects in the offset area.
The average frequency of occurrence across the offset area will be used as an index of abundance and compared between subsequent monitoring events to assess the effectiveness of feral pig control. Furthermore, changes to scores for individual sites/transects can point to areas to target control activities.

[a] Feral pig signs can include rooting, wallows, dung, footprints, travel pads, plant damage and tree rubs, as well as the physical presence of feral pigs</td></tr>
</table>

7.6 Offset value assessments

7.6.1 Rapid monitoring event

Rapid monitoring events will be carried out each year monitoring events are not completed for habitat quality assessments (Section 7.6.2) and targeted fauna survey (Section 7.6.4).

These will be aligned with the offset area inspections (see Section 7.1) and carried out by suitably qualified ecologists during spring and early summer (October to January) to coincide with the optimal time of year for fauna in the Brigalow Belt Bioregion (Eyre et al. 2018).

During each rapid monitoring field assessment, the following will be conducted:

- Incidental fauna surveys including early morning and late evening bird surveys and other MNES fauna species will be conducted throughout the day by the ecologists.
- Photos will be taken at designated and fixed photo monitoring points as outlined in 7.6.3. The locations of the fixed photo monitoring points are shown in Figure 9.

7.6.2 Habitat quality assessment

A detailed baseline assessment of habitat quality was completed in April 2020, including establishment of BioCondition sites in all major vegetation communities.

Vegetation condition and habitat quality for each MNES will be assessed in accordance with the *Guide to Determining Terrestrial Habitat Quality* version 1.2, developed by the Queensland Government to measure the habitat quality of a land-based offset. The species habitat index component of the habitat quality score will be calculated based on the results of the targeted fauna surveys detailed in Section 7.6.4.

Fixed transects were established and assessed as part of the baseline in 2020 (see Figure 9). BioCondition assessments will be undertaken at each of the transects in year 1 and then every two years for the first six years, and then every three years thereafter. As part of year 1 monitoring activities, monitoring points will be marked with a capped stake and a GPS location will be recorded.

The results of habitat quality assessments for subsequent years will include summary data from previous reporting years, presented to allow trend analysis of each of the measured attributes and assess progress towards achieving the interim performance targets and completion criteria.

7.6.3 Photo monitoring

Photo monitoring is a qualitative analysis technique that provides the opportunity for visual time series analysis of changes in vegetation composition, structure and integrity. In areas where active management is being undertaken, photo monitoring offers a simple and effective visual means by which to capture the response of the vegetation to management actions. Photo monitoring will be conducted at all BioCondition sites presented in Figure 9, based on best practice photo monitoring techniques, see Appendix 4 of *BioCondition: A Condition Assessment Framework for Terrestrial Biodiversity in Queensland. Assessment Manual* version 2.2. (Eyre et al. 2015).

Photo monitoring will be undertaken as part of habitat quality assessments (Section 7.6.2) and rapid monitoring events (Section 7.6.1).

7.6.4 Targeted fauna surveys

Targeted fauna surveys will be conducted to assess the distribution and richness of the fauna offset values within the offset area. The targeted fauna survey will focus on the MNES species that are unlikely to be detected effectively during the rapid assessment surveys due to cryptic behaviour or localised habitat requirements. Targeted surveys will be undertaken generally in accordance with recommended surveys guidelines from the Queensland and Commonwealth governments and/or other reputable published guidelines. Table 16 provides a summary of the proposed methodology, search effort and timing for targeted surveys. It is important to note that the proposed survey methodology will be reviewed prior to each survey event and if considered necessary will be modified to ensure they are based on the ecology, habitat requirements and behavioural aspects of the species of interest.

Targeted fauna surveys will be carried out in conjunction with habitat quality assessments, every two years for the first six years, and then every three years thereafter.

Table 16: Fauna species survey methods

Technique	Regime	Target and method
Elliot B (Box Trap) or Cage Trap	Four per site over four consecutive nights, checked early morning, reopened late afternoon.	Baited with a mixture of oats, peanut butter, vegetable oil and sardines. Placed within suitable micro-habitat for northern quoll.
Funnel Trap	Six at each of five trap sites over four consecutive nights, checked early morning and afternoon.	Placed in pairs either side along a 30 m drift-fence. Targeting Dunmall's snake and collared delma.
Anabat	Three units overnight for four consecutive nights.	Left overnight on site near entrances to possible roost sites for large-eared pied bat, if considered present, and/or along flyways and near waterbodies.
Harp Trap	Two per night for four consecutive nights, locations chosen based on presence of suitable flyways.	Targeting south-eastern long-eared bat, which is not identifiable by ultrasonic calls. Also, large-eared pied bat.
Camera Trap	10 over at least 14 consecutive nights.	Focused on stations baited with a mixture of oats, peanut butter, vegetable oil and sardines. Targeting northern quoll and possibly yakka skink. (Fleming et al. 2014).
Spotlighting	Meander along watercourses.	Targeting koala. This will also target Dunmall's snake.
Spotlighting	Rocky areas.	Targeting northern quoll and collared delma.
Spotlighting	By vehicle along tracks.	Targeting Dunmall's snake.
Scat Search	Conducted in habitat considered suitable for target species.	Targeting koala and northern quoll. The Spot Assessment Technique (SAT), or a variation, were used to survey for koalas within suitable habitat within the site.
Bird Survey	At waterbodies.	Targeting Australian painted snipe, Australasian bittern and squatter pigeon (southern).
Bird Survey	Meander along watercourses during the day.	Targeting nest sites for red goshawk. Includes diurnal koala search.
Track Traverse	By vehicle and on foot.	Targeting squatter pigeon (southern).
Diurnal Herpetofauna Search	Late morning/early afternoon.	Conducted by two searchers, duration is determined by site-specific habitat quality and presence of suitable micro-habitat. Targeting collared delma, Dunmall's snake and yakka skink.
Platelet Search	In suitable habitat.	Targeting black-breasted button-quail.

7.6.5 Brigalow stem counts

Brigalow regrowth within the offset area will be monitored to assess the stem density of dominant species to inform any requirement for selective thinning within the vegetation community.

As described in Section 6.2.3 selective thinning of Brigalow regrowth will be considered where the density of a dominant tree species within the vegetation community is >10,000 stems/ha and the density of stems is considered to be effecting the sites capacity to return to remnant status.

The number of stems per dominant tree species will be counted in 25 m x 25 m plots within Brigalow regrowth offset areas. The location of each 25 m x 25 m plot will be nested in the habitat quality monitoring locations presented in Figure 9 and will be established as part of the first monitoring event following approval of this OAMP. Stem density assessments will be undertaken in year 1, and then every two years for the first six years, and then every three years thereafter.

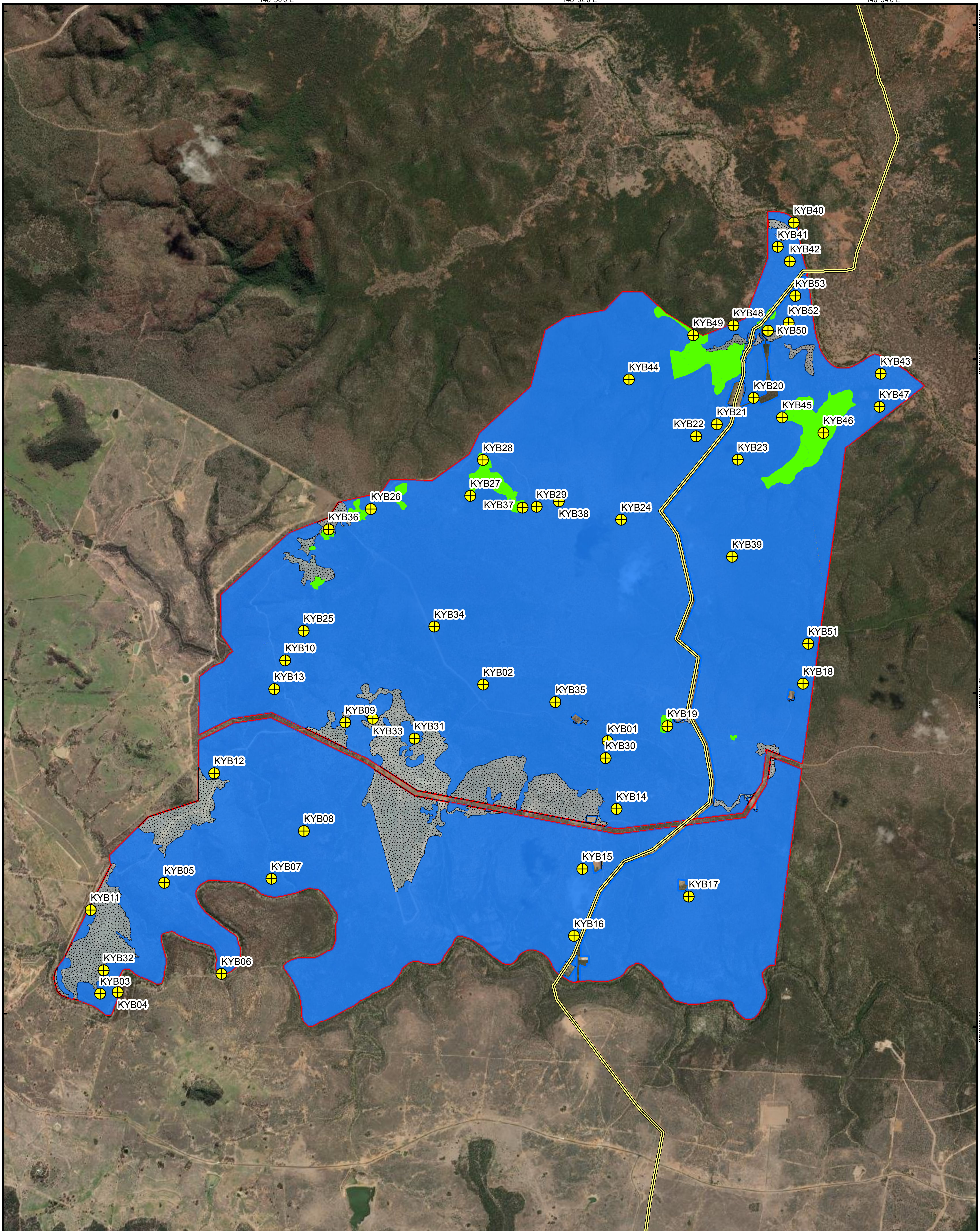


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Figure 9
Kentucky
monitoring sites

Kentucky - 1WT37

Kentucky offset area

Future habitat areas

Petroleum pipeline (PPL 166)

Habitat quality assessment sites

MNES habitat within Kentucky offset area

Extent of current MNES offset habitat

Rehabilitation offset (EPBC 2008/4059 condition 34)

Location diagram

DATA SOURCE:
The following datasets are © State of Qld:
- Cadastral data
- Petroleum pipeline
Kentucky offset area and habitat quality assessment sites provided by SANTOS

0 0.5 1 1.5 2
Kilometres

N

CO2 Australia

Date: 6/11/2021 Coordinate System: GDA 1994 MGA Zone 55 Projection: Transverse Mercator Datum: GDA 1994 Scale: 1:37,500@A3

Path: P:\GISData\Projects\Santos\ENV_20_00419.GTP_Offset_Maps\Kentucky\Figure 9 - Monitoring points.mxd

8.0 Reporting

8.1 Reporting

A report detailing the progress of the offset area in achieving the interim performance targets and completion criteria will be prepared for each management year by the suitably qualified ecologist responsible for conducting the monitoring. The report will contain, at a minimum:

- a description of the monitoring conducted, when it was conducted, and by whom
- a discussion of the weather in the lead up to and during the monitoring
- results of monitoring events conducted
- an overview of the management actions implemented since the last report
- a description of the performance criteria not met, any triggers that have been exceeded and the corrective actions that were implemented
- an indication of any risks or potential threats that have become apparent to the management area since the development of this management plan, and activities to be undertaken to manage these threats and/or risks
- progress towards achieving the interim performance targets and completion criteria.

8.2 Update of OAMP

The OAMP will be reviewed, audited and updated every 5 years. In addition, the OAMP will be updated in accordance with the principles of adaptive management, if required, to incorporate any changes identified through management activities, site visits and monitoring activities. This may include the revision of current management actions, identification of additional activities (including monitoring activities) and responses to adaptive management triggers, other environmental threats to the offset area, information obtained through research programs.

9.0 Implementation schedule

Table 17 and Table 18 summarise the implementation schedule for the management, monitoring and reporting activities presented in this OAMP. Santos will be wholly responsible for the implementation of this OAMP and reporting on the performance of the offset area in meeting the offset obligations under EPBC Approval 2008/4096 and Section 4.0 of this OAMP.

Table 17: Implementation of management actions

Activity		Management years ✓ Activity required ■ Activity to be carried out as required																				Timing	Related monitoring
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20		
General restrictions (Section 6.2.1)	Access, vehicles, vegetation clearing, weed hygiene	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	At all times	General offset inspections (Section 7.1)
Access tracks (Section 6.2.2)	Maintenance/new tracks	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	As required	
Fencing (Section 6.2.5)	Construction of additional fencing to support livestock exclusion and strategic grazing	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	As required	
	Maintenance	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		
Fire management (Section 6.2.6)	Fuel hazard reduction burns	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	As required	Biomass monitoring (Section 7.2)
Grazing (Section 6.2.6.1)	Strategic grazing	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	As required based on the results of biomass monitoring, and informed by weed monitoring	Biomass monitoring (Section 7.2) Weed monitoring (Section 7.4)
Weed management (Section 6.2.7)	Buffel grass and other weeds	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	Control activities in addition to strategic grazing to be undertaken as required	Weed monitoring (Section 7.4)
Pest animal management (Section 6.2.8)	Wild dog, feral cat; fox, pig and feral horse	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	Control activities to be undertaken as required	Pest animal monitoring (Section 7.5)
Brigalow regrowth restoration (Section 6.2.3)	Brigalow regrowth thinning	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	Thinning to be undertaken as required should stem density become >10,000 stems/ha and the density of stems is considered to be affecting the sites capacity to return to remnant status	Brigalow stem counts (Section 7.6.5)
Reporting (Section 8.0)	Annual reporting	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	Annual reports to be prepared each year.	Reporting (Section 7.6.5)
	Update OAMP					■					■					■					■	The OAMP will be reviewed, audited and updated every 5 years.	

Table 18: Offset Plan monitoring events

Survey or monitoring objective	Monitoring activity	Management years ✓ Activity required ■ Activity to be carried out as required																				Timing	Survey/monitoring guidelines	Reliability
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20			
Offset area inspections (Section 7.1)	Twice yearly inspections of to enable a general assessment of the offset area and identify any potential issues that may require remedial action. See Section 7.1 for the criteria to be assessed as part of each inspection	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	Inspections will be undertaken at least twice a year. Usually at the end of the wet season and the end of the dry season, with one of the inspections occurring prior to the submission of the annual report.	See Section 7.1 for a list of potential issues to be inspected	General assessment of the offset management areas to identify any potential issues that may require remedial action to be undertaken
Biomass monitoring (Section 7.2)	Biomass monitoring for fire management and to inform strategic grazing regime	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	Twice every year at the end of the wet season (April) and towards the end of the dry season (October)	Assessment against Future Beef photo standards (Section 7.2)	Methodology developed by the Queensland Government
Fuel load monitoring (Section 7.3)	Assessment of the fuel hazard rating within the offset area to inform fire management strategies	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	Annually at the end of the wet season (April)	Overall Fuel Hazard Assessment Guide (Hines et al. 2010; Appendix E)	Method developed by the Victorian Government
Weed monitoring (Section 7.4)	Ongoing weed surveys to assess the effectiveness of weed control	✓		✓		✓		✓		✓		✓		✓		✓		✓		✓		Every two years post wet season	NSW Guidelines for Monitoring weed Control and recovery of native vegetation (Auld 2009). Photo monitoring of selected sites to assess visual changes in weed species and infestations over time. The use of precision unmanned aerial vehicles (drone) technology, aerial imagery and/or remote sensing.	Assessment will be undertaken generally in accordance with published, reputable guidelines
Pest animal monitoring (Section 7.5)	Ongoing pest animal surveys to assess the effectiveness of pest animal control	✓		✓		✓		✓		✓		✓		✓		✓		✓		✓		Every two years post wet season	Monitoring method outlined in Section 7.5	Assessment undertaken generally in accordance with published monitoring techniques developed by the NSW Government

Survey or monitoring objective	Monitoring activity	Management years ✓ Activity required ■ Activity to be carried out as required																				Timing	Survey/monitoring guidelines	Reliability
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20			
Offset value assessments (Section 7.6)	Rapid monitoring events		✓		✓		✓	✓		✓	✓		✓	✓		✓	✓		✓	✓		Each year monitoring events are not completed for habitat quality assessments (Section 7.6.2), targeted fauna survey (Section 7.6.4)	See Section 7.6.1	
	Assessment of vegetation condition and habitat quality	✓		✓		✓			✓			✓			✓			✓			✓	Every two years for the first six years following the 2020 baseline, and then every three years thereafter	Guide to Determining Terrestrial Habitat Quality version 1.2	Assessment undertaken in accordance with method developed by the Queensland Government and aligns with the EPBC Act Environmental Offsets Policy measure of 'habitat quality' and is intended to provide a consistent framework for environmental offsets in Queensland
	Photo monitoring	✓		✓		✓			✓			✓			✓			✓			✓		Photos at each photo monitoring point will be taken in a north, east, south and westerly direction. A record of the photographs will be maintained, including GPS co-ordinates, date and time of each photograph and the direction in which the photograph was taken	Based on best practice photo monitoring techniques, see Appendix 4 of BioCondition: A Condition Assessment Framework for Terrestrial Biodiversity in Queensland. Assessment Manual. Version 2.2. (Eyre et al. 2015)
	Targeted fauna surveys	✓		✓		✓			✓			✓			✓			✓			✓		See methods outlined in Section 7.6.4	Techniques for fauna surveys area based on recommended survey guidelines published by the Queensland and Commonwealth governments

Survey or monitoring objective	Monitoring activity	Management years ✓ Activity required ■ Activity to be carried out as required																				Timing	Survey/monitoring guidelines	Reliability
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20			
	Brigalow stem counts	✓		✓		✓			✓			✓			✓			✓			✓		See methods outlined in Section 7.6.5	Guidance for thinning of Brigalow regrowth and monitoring based on published research Peeters and Butler 2014; Dwyer and Mason 2017

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10.0 References

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APPENDIX A

Baseline habitat quality score for Kentucky offset area

Table A1: Baseline habitat quality score for Kentucky offset area (sites KYB01 – KYB21)

Site	KYB01	KYB02	KYB03	KYB04	KYB05	KYB06	KYB07	KYB08	KYB09	KYB10	KYB11	KYB12	KYB13	KYB14	KYB15	KYB16	KYB17	KYB18	KYB19	KYB20	KYB21
RE	11.10.7	11.10.13	11.10.7	11.3.25	11.10.7	11.3.25	11.10.13	11.10.13	11.9.2	11.10.7	11.10.11	11.10.7	11.10.13	11.10.7	11.10.7	11.10.13	11.10.7	11.10.3	11.9.5	11.10.13	11.10.3
Site type*	Rem	Rem	Reg	Rem	Reg	Rem	Rem	Reg	Reg	Reg	Reg	Reg	Reg	Rem	Reg	Reg	Rem	Rem	Rem	Rem	Rem
Site condition (/10)	8.125	7.5625	6.9375	6.4375	4.8125	6.625	8.9375	5.4375	7.1875	7.0625	7.875	6.1875	6.875	9.125	6.5	5.6875	7.5625	7.8125	8.5625	7.875	7.5625
Site context (/10)	10	10	3	2	7	7	9.5	9	3	9	0	6	9	9.5	9.5	9	10	10	10	10	10
Habitat quality score /10 (site condition 60%, site context 40%)																					
SEVT TEC																					
Brigalow TEC																			9.14		
Species habitat index /10																					
Australian painted snipe																					
Australasian bittern																					
Northern quoll	8.2	8.2	4.8	6.6	4.8	6.6	7.2	6.2	4.8	4.8	4.8	4.8	4.8	6.6	4.8	5.6	6.6	6.6	6.6	7.2	6
Black-breasted button-quail																			3.6		
Collared delma	8.2	8.2	6.2		6.2		8.2	6.2	6.2	6.2	6.2	6.2	6.2	8.2	6.2	6.2	8.2			8.2	
Dunmall's snake	8.2	8.2	6.2	8.2	6.2	8.2	8.2	6.2	6.2	6.2	6.2	6.2	6.2	8.2	6.2	6.2	8.2	8.2	8.2	8.2	8.2
Large-eared pied bat	7.2	7.2	6.2	7.2	6.2	7.2	7.2	6.2	6.2	6.2	6.2	6.2	6.2	7.2	6.2	6.2	7.2	7.2	7.2	7.2	7.2
Red goshawk	6.2	6.2	4	8.8	4	8.8	4	4	4	4	4	4	4	6.2	4	4	6.2	6.2	6.2	6.2	6.2
Squatter pigeon	8.2	8.2	8.2	8.2	8.2	8.2	6.2	6.2	8.2	8.2	8.2	8.2	6.2	8.2	8.2	6.2	8.2			6.2	
Yakka skink	6.6	6.6	4.8		4.8		3.6	3.6	4.8	5.6	5.6	5.6	3.6	5.6	5.6	3.6	5.6	3.6	4.2	3.6	3.6
South-eastern long-eared bat	7.2	7.2	3.6	9.8	3.6	9.8	7.2	3.6	3.6	3.6	3.6	3.6	3.6	7.2	3.6	3.6	7.2	7.2	7.2	7.2	7.2
Habitat quality score fauna species /10 (site condition 30%, site context 30%, species habitat index 40%)																					
Australian painted snipe																					
Australasian bittern																					
Northern quoll	8.72	8.55	4.90	5.17	5.46	6.73	8.41	6.81	4.98	6.74	4.28	5.58	6.68	8.23	6.72	6.65	7.91	7.98	8.21	8.24	7.67
Black-breasted button-quail																			7.01		
Collared delma	8.72	8.55	5.46		6.02		8.81	6.81	5.54	7.30	4.84	6.14	7.24	8.87	7.28	6.89	8.55			8.64	
Dunmall's snake	8.72	8.55	5.46	5.81	6.02	7.37	8.81	6.81	5.54	7.30	4.84	6.14	7.24	8.87	7.28	6.89	8.55	8.62	8.85	8.64	8.55
Large-eared pied bat	8.32	8.15	5.46	5.41	6.02	6.97	8.41	6.81	5.54	7.30	4.84	6.14	7.24	8.47	7.28	6.89	8.15	8.22	8.45	8.24	8.15
Red goshawk	7.92	7.75	4.58	6.05	5.14	7.61	7.13	5.93	4.66	6.42	3.96	5.26	6.36	8.07	6.40	6.01	7.75	7.82	8.05	7.84	7.75
Squatter pigeon	8.72	8.55	6.26	5.81	6.82	7.37	8.01	6.81	6.34	8.10	5.64	6.94	7.24	8.87	8.08	6.89	8.55			7.84	
Yakka skink	8.08	7.91	4.90		5.46		6.97	5.77	4.98	7.06	4.60	5.90	6.20	7.83	7.04	5.85	7.51	6.78	7.25	6.80	6.71
South-eastern long-eared bat	8.32	8.15	4.42	6.45	4.98	8.01	8.41	5.77	4.50	6.26	3.80	5.10	6.20	8.47	6.24	5.85	8.15	8.22	8.45	8.24	8.15

* Site type: Rem – remnant; Reg – regrowth

Table A2: Baseline habitat quality score for Kentucky offset area (sites KYB22 – KYB42)

Site	KYB22	KYB23	KYB24	KYB25	KYB26	KYB27	KYB28	KYB29	KYB30	KYB31	KYB32	KYB33	KYB34	KYB35	KYB36	KYB37	KYB38	KYB39	KYB40	KYB41	KYB42
RE	11.10.13	11.10.13	11.10.7	11.10.7	11.9.2	11.9.4	11.9.5	11.9.2	11.10.8	11.9.2	11.10.7	11.9.2	11.10.13	11.10.13	11.9.5	11.9.5	11.9.2	11.10.3	11.3.25	11.3.2	11.3.27
Site type*	Rem	Rem	Rem	Rem	Rem	Rem	Rem	Rem	Rem	Reg	Rem	Reg	Rem	Rem	Reg	Reg	Rem	Rem	Rem	Rem	Rem
Site condition (/10)	7.5625	7.6875	8.125	8.4375	9.5625	8.0625	7.4375	8.375	7.9375	6.25	6.375	5.6875	7.25	9	7.4375	5.5	7.6875	7.0625	7.5625	6.6875	7.5625
Site context (/10)	10	10	10	9.5	9.5	10	10	10	9.5	2	4	3	10	10	9	10	10	10	9	10	10
Habitat quality score /10 (site condition 60%, site context 40%)																					
SEVT TEC						8.84															
Brigalow TEC							8.46								8.06	7.30					
Species habitat index /10																					
Australian painted snipe																					7.2
Australasian bittern																					5.6
Northern quoll	7.2	7.2	6.6	6.6	6.6	6.6	6.6	6.6	8.2	4.8	6.6	4.8	6.6	6.6	5.6	4.8	5.6	6.6	6.6	6.6	
Black-breasted button-quail						8.2	3.6		8.2						1	1					
Collared delma	8.2	8.2	8.2	8.2	8.2			8.2		6.2	8.2	6.2	8.2	8.2			8.2			8.2	
Dunmall's snake	8.2	8.2	8.2	8.2	8.2	8.2	8.2	8.2	8.2	6.2	8.2	6.2	8.2	8.2	6.2	6.2	8.2	8.2	8.2	8.2	8.2
Large-eared pied bat	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	6.2	7.2	6.2	7.2	7.2	6.2	6.2	7.2	7.2	7.2	7.2	7.2
Red goshawk	4	4	6.2	6.2	6.2	5.4	6.2	6.2	6.2	4	6.2	4	6.2	6.2	4	4	6.2	6.2	8.8	6.2	8.8
Squatter pigeon	6.2	6.2	8.2	8.2	8.2			8.2		8.2	8.2	8.2	8.2	8.2			8.2		8.2	8.2	8.2
Yakka skink	3.6	3.6	6.6	6.6	6.6		4.2	6.6		4.8	6.6	4.8	6.6	6.6	2.4	2.4	6.6	3.6		6.6	
South-eastern long-eared bat	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	6.4	3.6	7.2	3.6	7.2	7.2	3.6	3.6	7.2	7.2	7.2	7.2	7.2
Habitat quality score fauna species /10 (site condition 30%, site context 30%, species habitat index 40%)																					
Australian painted snipe																					8.15
Australasian bittern																					7.51
Northern quoll	8.15	8.19	8.08	8.02	8.36	8.06	7.87	8.15	8.51	4.40	5.75	4.53	7.82	8.34	7.17	6.57	7.55	7.76	7.61	7.65	
Black-breasted button-quail						8.70	6.67		8.51						5.33	5.05					
Collared delma	8.55	8.59	8.72	8.66	9.00			8.79		4.96	6.39	5.09	8.46	8.98			8.59			8.29	
Dunmall's snake	8.55	8.59	8.72	8.66	9.00	8.70	8.51	8.79	8.51	4.96	6.39	5.09	8.46	8.98	7.41	7.13	8.59	8.40	8.25	8.29	8.55
Large-eared pied bat	8.15	8.19	8.32	8.26	8.60	8.30	8.11	8.39	8.11	4.96	5.99	5.09	8.06	8.58	7.41	7.13	8.19	8.00	7.85	7.89	8.15
Red goshawk	6.87	6.91	7.92	7.86	8.20	7.58	7.71	7.99	7.71	4.08	5.59	4.21	7.66	8.18	6.53	6.25	7.79	7.60	8.49	7.49	8.79
Squatter pigeon	7.75	7.79	8.72	8.66	9.00			8.79		5.76	6.39	5.89	8.46	8.98			8.59		8.25	8.29	8.55
Yakka skink	6.71	6.75	8.08	8.02	8.36		6.91	8.15		4.40	5.75	4.53	7.82	8.34	5.89	5.61	7.95	6.56		7.65	
South-eastern long-eared bat	8.15	8.19	8.32	8.26	8.60	8.30	8.11	8.39	7.79	3.92	5.99	4.05	8.06	8.58	6.37	6.09	8.19	8.00	7.85	7.89	8.15

* Site type: Rem – remnant; Reg – regrowth

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Table A3: Baseline habitat quality score for Kentucky offset area (sites KYB43 – KYB53)

Site	KYB43	KYB44	KYB45	KYB46	KYB47	KYB48	KYB49	KYB50	KYB51	KYB52	KYB53
RE	11.3.39	11.9.4	11.9.4	11.9.5	11.9.10	11.9.10	11.9.5	11.9.10	11.10.8	11.3.39	11.3.2
Site type*	Rem	Rem	Rem	Rem	Rem	Rem	Rem	Rem	Rem	Rem	Rem
Site condition (/10)	5.6875	6.375	7.5625	9.0625	6.875	7.625	8.25	9.5625	8.0625	9.0625	7.75
Site context (/10)	9.5	10	10	10	10	9.5	10	9.5	10	10	10
Habitat quality score /10 (site condition 60%, site context 40%)											
SEVT TEC		7.83	8.54								
Brigalow TEC				9.44							
Species habitat index /10											
Australian painted snipe											
Australasian bittern											
Northern quoll	6.6	8.2	8.2	7.2	5.6	5.6	7.2	5.6	8.2	6.6	6.6
Black-breasted button-quail		8.2	8.2	3.6			3.6		8.2		
Collared delma	8.2				8.2	8.2		8.2		8.2	8.2
Dunmall's snake	8.2	8.2	8.2	8.2	8.2	8.2	8.2	8.2	8.2	8.2	8.2
Large-eared pied bat	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2
Red goshawk	6.2	5.4	5.4	6.2	6.2	6.2	6.2	6.2	5.4	6.2	6.2
Squatter pigeon	8.2	3.4	3.4	3.4	8.2	8.2	3.4	8.2	3.4	8.2	8.2
Yakka skink	6.6			4.2	6.6	6.6	4.2	6.6		6.6	6.6
South-eastern long-eared bat	7.2	6.4	6.4	7.2	7.2	7.2	7.2	7.2	6.4	7.2	7.2
Habitat quality score fauna species /10 (site condition 30%, site context 30%, species habitat index 40%)											
Australian painted snipe											
Australasian bittern											
Northern quoll	7.20	8.19	8.55	8.60	7.30	7.38	8.36	7.96	8.70	8.36	7.97
Black-breasted button-quail		8.19	8.55	7.16			6.92		8.70		
Collared delma	7.84				8.34	8.42		9.00		9.00	8.61
Dunmall's snake	7.84	8.19	8.55	9.00	8.34	8.42	8.76	9.00	8.70	9.00	8.61
Large-eared pied bat	7.44	7.79	8.15	8.60	7.94	8.02	8.36	8.60	8.30	8.60	8.21
Red goshawk	7.04	7.07	7.43	8.20	7.54	7.62	7.96	8.20	7.58	8.20	7.81
Squatter pigeon	7.84	6.27	6.63	7.08	8.34	8.42	6.84	9.00	6.78	9.00	8.61
Yakka skink	7.20			7.40	7.70	7.78	7.16	8.36		8.36	7.97
South-eastern long-eared bat	7.44	7.47	7.83	8.60	7.94	8.02	8.36	8.60	7.98	8.60	8.21

* Site type: Rem – remnant; Reg – regrowth

APPENDIX B

Kentucky offset Area boundary co-ordinates (GDA94)

Point	Easting	Northing	Point	Easting	Northing	Point	Easting	Northing
1	689696	7176244	32	689232	7174116	63	683646	7172004
2	689873	7176227	33	689311	7174091	64	684405	7172694
3	689999	7176134	34	689284	7173922	65	684836	7172862
4	690042	7175915	35	689274	7173901	66	684945	7173031
5	690079	7175737	36	689255	7173874	67	685417	7173133
6	690094	7175679	37	688498	7172945	68	685520	7173282
7	690115	7175600	38	688495	7172926	69	685983	7173268
8	690076	7175590	39	688675	7172680	70	686393	7173559
9	689620	7175021	40	688685	7172652	71	686503	7173796
10	689594	7174994	41	688843	7171973	72	687071	7174313
11	689527	7174955	42	688839	7171948	73	687235	7174936
12	689514	7174900	43	688671	7171526	74	687456	7175075
13	689477	7174908	44	688673	7171511	75	687892	7175154
14	689464	7174830	45	688911	7171311	76	688086	7175358
15	689462	7174808	46	688793	7170711	77	688315	7175351
16	689478	7174803	47	688986	7170350	78	688571	7175115
17	689469	7174783	48	689060	7169942	79	688975	7174869
18	689436	7174784	49	689039	7169717	80	689440	7175060
19	689427	7174711	50	688805	7169523	81	689690	7175719
20	689414	7174709	51	688029	7169424	82	690095	7175565
21	689403	7174694	52	685816	7169844	83	690122	7175565
22	689411	7174681	53	685265	7170199	84	690124	7175555
23	689407	7174660	54	684212	7170707	85	690086	7175554
24	689387	7174640	55	683767	7170642	86	688684	7170740
25	689390	7174601	56	683407	7170465	87	688738	7170670
26	689408	7174509	57	683415	7171101	88	688750	7170693
27	689413	7174448	58	683575	7171223	89	688767	7170696
28	689395	7174397	59	683673	7171260	90	688777	7170687
29	689369	7174376	60	683735	7171345	91	688781	7170673
30	689318	7174356	61	683783	7171381	92	688780	7170639
31	689308	7174340	62	683655	7171562	93	688697	7170591

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Point	Easting	Northing
94	688584	7170680
95	687561	7170702
96	687654	7170629
97	687604	7170562
98	687687	7169566
99	687815	7169567
100	687782	7169486
101	687682	7169494
102	690080	7175524
103	690129	7175525
104	690135	7175494
105	690149	7175437
106	690151	7175380
107	690156	7175309
108	690168	7175253
109	690177	7175170
110	690179	7175120
111	690193	7175044
112	690205	7174951
113	690230	7174840
114	690243	7174811
115	690264	7174725
116	690354	7174584
117	690420	7174533
118	690510	7174510
119	690638	7174535
120	690773	7174615
121	690842	7174654
122	690883	7174664
123	691038	7174597
124	691223	7174482
125	691417	7174319
126	690545	7173632
127	690069	7170142
128	689675	7170299
129	689625	7169937
130	689522	7169777
131	689456	7169758
132	689479	7169710
133	689408	7169599
134	688914	7169541
135	689090	7169693
136	689114	7169944
137	689037	7170368
138	688850	7170718
139	688930	7171171
140	688958	7171306
141	688950	7171335
142	688729	7171523
143	688889	7171927
144	688890	7171955
145	688730	7172659
146	688721	7172686
147	688686	7172741
148	688552	7172927
149	688555	7172942
150	689294	7173851
151	689328	7173913
152	689353	7174057
153	689590	7174151
154	689609	7174105
155	689812	7174200
156	689803	7174293
157	689727	7174297
158	689723	7174344
159	689743	7174346
160	689709	7174498
161	689702	7174569
162	689708	7174662
163	689721	7174793
164	689681	7174791
165	689678	7174828
166	689630	7174881
167	689644	7174977
168	689924	7170965
169	690000	7170944
170	689978	7170842
171	689901	7170862
172	689553	7174936
173	689612	7174965
174	689598	7174873
175	689649	7174816
176	689651	7174790
177	689622	7174789
178	689674	7174545
179	689657	7174338
180	689693	7174341
181	689697	7174299
182	689670	7174301
183	689671	7174235
184	689571	7174195
185	689578	7174178
186	689394	7174107
187	689442	7174280
188	689439	7174299
189	689442	7174329
190	689423	7174358
191	689444	7174431
192	689441	7174517
193	689448	7174537
194	689443	7174573
195	689451	7174592
196	689451	7174610
197	689480	7174661
198	689507	7174695
199	689527	7174727
200	689536	7174758
201	689515	7174771
202	689519	7174790
203	689535	7174794
204	689561	7174851
205	689564	7174888
206	689544	7174892
207	687508	7170636
208	689724	7170214
209	690061	7170078
210	689766	7167921
211	689684	7167896
212	689630	7167833
213	689634	7167755

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Point	Easting	Northing
214	689665	7167667
215	689675	7167590
216	689652	7167517
217	689599	7167407
218	689539	7167337
219	689442	7167323
220	689388	7167366
221	689332	7167431
222	689304	7167504
223	689222	7167532
224	689114	7167530
225	689010	7167500
226	688881	7167485
227	688800	7167491
228	688642	7167544
229	688594	7167603
230	688546	7167665
231	688539	7167703
232	688298	7167925
233	688247	7167937
234	688211	7167923
235	688169	7167906
236	688123	7167861
237	688054	7167784
238	687955	7167747
239	687801	7167733
240	687722	7167744
241	687612	7167733
242	687618	7167916
243	687661	7167896
244	687691	7167903
245	687689	7167932
246	687715	7167932
247	687715	7168012
248	687621	7168012
249	687623	7168111
250	687853	7168699
251	688122	7169030
252	688298	7169101
253	688405	7169133

Point	Easting	Northing
254	688471	7169172
255	688817	7169461
256	689444	7169543
257	689506	7169640
258	689531	7169638
259	689565	7169629
260	689574	7169655
261	689574	7169725
262	689565	7169730
263	689684	7169917
264	688701	7168862
265	688790	7168850
266	688789	7168808
267	688819	7168805
268	688808	7168763
269	688770	7168733
270	688698	7168739
271	683406	7170397
272	683785	7170584
273	684203	7170645
274	685235	7170146
275	685794	7169787
276	688027	7169363
277	688719	7169450
278	688419	7169201
279	688120	7169079
280	688084	7169055
281	687815	7168726
282	687534	7168022
283	687486	7167949
284	687466	7167967
285	687437	7167934
286	687380	7167848
287	687404	7167824
288	687397	7167806
289	687340	7167860
290	687299	7167939
291	687205	7168046
292	687093	7168089
293	687012	7168074

Point	Easting	Northing
294	686931	7168016
295	686900	7167965
296	686874	7167939
297	686801	7167926
298	686759	7167942
299	686636	7168029
300	686501	7168150
301	686301	7168239
302	686250	7168223
303	686210	7168159
304	686168	7168098
305	686118	7168026
306	686076	7167951
307	685999	7167926
308	685893	7167937
309	685837	7167958
310	685740	7167950
311	685676	7167901
312	685632	7167834
313	685534	7167700
314	685436	7167656
315	685274	7167564
316	685114	7167466
317	684975	7167396
318	684825	7167318
319	684770	7167298
320	684630	7167237
321	684573	7167279
322	684553	7167319
323	684538	7167465
324	684526	7167545
325	684480	7167661
326	684412	7167791
327	684343	7167893
328	684359	7167931
329	684458	7167981
330	684605	7167997
331	684690	7167995
332	684825	7168065
333	684870	7168082

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Point	Easting	Northing
334	684921	7168206
335	684919	7168371
336	684940	7168428
337	684914	7168518
338	684848	7168610
339	684810	7168672
340	684735	7168749
341	684640	7168764
342	684489	7168720
343	684369	7168690
344	684248	7168671
345	684096	7168705
346	683979	7168791
347	683760	7168841
348	683642	7168851
349	683520	7168855
350	683394	7168777
351	683379	7168655
352	683433	7168550
353	683522	7168458
354	683800	7168245
355	683840	7168151
356	683865	7168054
357	683822	7167910
358	683736	7167837
359	683619	7167822
360	683590	7167890
361	683603	7167974
362	683577	7168081
363	683498	7168141
364	683380	7168174
365	683161	7168260
366	683114	7168289
367	683007	7168263
368	682983	7168211
369	683038	7167991
370	683036	7167910
371	683004	7167744
372	682973	7167709
373	682930	7167711

Point	Easting	Northing
374	682706	7167817
375	682644	7167869
376	682571	7167866
377	682528	7167792
378	682518	7167621
379	682493	7167511
380	682459	7167421
381	682437	7167371
382	682370	7167369
383	682291	7167434
384	682136	7167505
385	681972	7167549
386	681864	7167600
387	681825	7167675
388	681805	7167770
389	681824	7167856
390	681873	7167931
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393	682418	7169122
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397	687852	7169069
398	687857	7168967
399	687798	7168935
400	687768	7168931
401	687581	7168018
402	687572	7167729
403	687541	7167728
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408	687574	7167894
409	687525	7167926

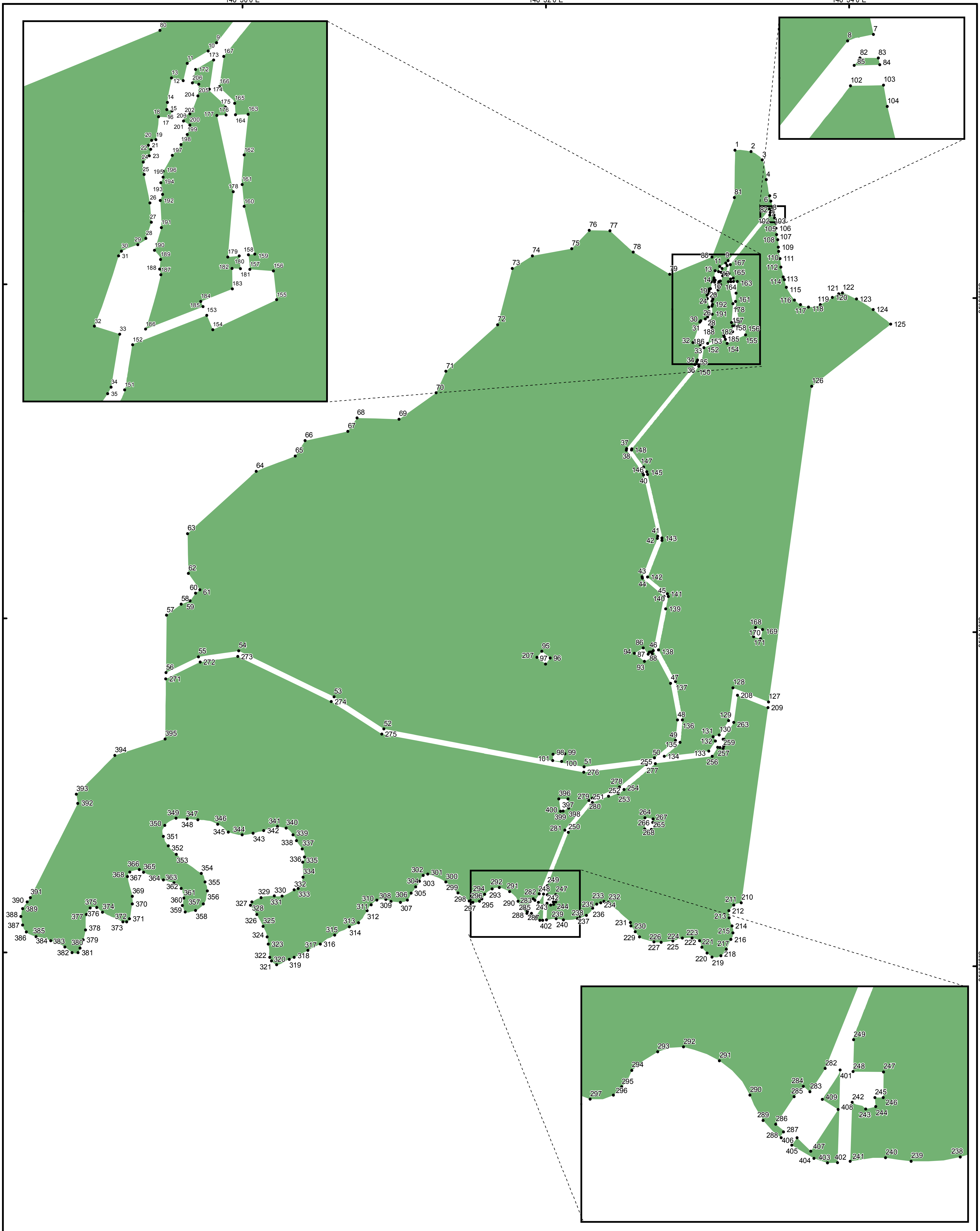

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Figure B1
Kentucky offset area boundary coordinates

• Reference coordinates
Kentucky offset area

Location diagram

0 0.25 0.5 0.75 1
Kilometres

N

CO2 Australia

Date: 6/11/2021 Coordinate System: GDA 1994 MGA Zone 55 Projection: Transverse Mercator Datum: GDA 1994 Scale: 1:37,500@A3

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APPENDIX C

Risk Assessment

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Risk Assessment Summary

The following risk assessment assess the potential risk of failing to achieve the management objectives, interim performance targets and completion criteria for the offset area as outlined in this OAMP.

For each risk identified, the potential consequence of the risk (rated from 1 (no impact) to 6 (irreversible impact; Table D1) was assessed against the likelihood of that risk occurring (Table D2) to determine a risk rating. The risk rating was evaluated by using the matrix in Table D2.

The consequence and likelihood of each risk was first considered without the management measures in place to provide an initial risk rating. The consequence and likelihood of each risk occurring was then reassessed following the implementation of the management measures to provide a residual risk rating.

Table D3 provides the risk register which was used to document the findings of the risk assessment process.

Table C1: Consequence rating relative to offset value

	Consequence
I	No impact to MNES Value
II	Small-scale impact to MNES
III	Moderate-scale impact to MNES
IV	Large-scale impact to MNES
V	Extensive population or community scale impact to MNES
VI	Irreversible impact to MNES.

Table C2: Likelihood classification and risk matrix

Santos Risk Matrix

Consequence

	Negligible Harm	Minor Harm	Moderate Harm	Severe Harm	Single Fatality OR Critical Life Threatening Injuries	Multiple Fatalities
Safety	+ No bodily damage or minimal harm or impairment (hours to days)	+ Short term impairment (days to weeks)	+ Temporary disablement or medium term impairment (weeks to months)	+ Long term/life altering disablement or impairment		
Environment	+ No impact to Environmental Value (EV).	+ Small-scale impact to EV(s) of conservation significance + Potential surface or groundwater impact.	+ Moderate-scale impact to EV(s) of conservation significance + Localised surface or groundwater impact.	+ Large-scale impact to EV(s) of conservation significance + Moderate-scale surface water impact; + Localised impact to groundwater with potential or known beneficial use.	+ Extensive population or community scale impact to EV(s) of conservation significance + Extensive impact to other EV(s).	+ Irreversible impact to EV(s).
Community & Reputation	+ No actual or potential community criticism + Details remain within Santos sites and/or offices	+ Minor level local community criticism (< week) + No reputation impact	+ Local community criticism (> week) or one-day community protest + Local company reputation impacted	+ State-level community criticism or protest over multiple days/locations + State-based company reputation impacted + Very short-term share price impact (< week)	+ National community criticism or large scale protest + Company reputation and approvals impacted + Shareholder intervention or short-term share price impact (< month)	+ Sustained national community criticism or widespread protest + Industry reputation and approvals impacted + Changes at executive/board level or long-term share price impact (> month)
Financial (A$)	< $30k	$30k to $300k	$300k to $3m	$3m to $30m	$30m to $300m	> $300m
Workforce	+ Will require some staff attention over several days. + No actual or potential impact to culture	+ Will require several days local management time. + Minor impact to employee engagement and limited staff turnover	+ Will require head office staff and take several weeks of site management time. + Moderate impact to employee engagement and staff turnover above industry average with some key roles	+ Will require several weeks of senior management time + Impact to employee engagement (< 6 months), moderate turnover of key roles and no succession	+ Will require several months of senior management time + Impact to employee engagement (< 18 months), high staff turnover and attraction issues	+ Will require more than a year of senior management involvement and operations severely disrupted + Impact to employee engagement (> 18 months), significant key role turnover and attraction issues
Compliance	+ Non-conformance with legislation, instruments (e.g. tenure licence) or contract + No regulatory or punitive action	+ Minor breach of legislation, instruments or contract + Notification/report to; request for information by; and/or administrative/ warning notice from the regulator + LOCI Tier 3 or non-hydrocarbon releases notifiable to the regulator	+ Limited number of minor breaches of legislation, instruments or contract + Statutory notice from the regulator + LOCI Tier 2 or non-hydrocarbon releases immediately reportable to the regulator	+ Systemic minor breaches (or one moderate breach) of legislation, instruments or contract + Company charged with an offence with minor penalty/fine + LOCI Tier 1 or cumulative regulator notification of non-hydrocarbon releases	+ Systemic moderate breaches (OR single material breach) of legislation, instruments or contract + Company charged with an offence with moderate penalty/fine	+ Material breaches of legislation, instruments or contract + Company or officers charged with an offence with material penalty/fine, or loss of tenure/operatorship

Likelihood

		I	II	III	IV	V	VI
ALMOST CERTAIN (< 4 monthly) Occurs in almost all circumstances OR could occur *within days to weeks*	f	Low	Medium	High	Very High	Very High	Very High
LIKELY (4 monthly - 1 yearly) Occurs in most circumstances OR could occur *within weeks to months*	e	Low	Medium	High	High	Very High	Very High
OCCASIONAL (1 - 3 yearly) Has occurred before in Santos OR could occur *within months to years*	d	Low	Low	Medium	High	High	Very High
POSSIBLE (3 - 10 yearly) Has occurred before in the industry OR could occur *within the next few years*	c	Very Low	Low	Low	Medium	High	Very High
UNLIKELY (10 - 30 yearly) Has occurred elsewhere OR could occur *within decades*	b	Very Low	Very Low	Low	Low	Medium	High
REMOTE (30 - 100 yearly) Requires exceptional circumstances and is unlikely even in the long term OR only occurs as a *"one in 100 year event"*	a	Very Low	Very Low	Very Low	Low	Medium	Medium

Table C3: Risk assessment

Management objective	Risk description	Initial risk rating			Control strategies	Residual risk rating		
		Likelihood	Consequence	Overall risk rating		Likelihood	Consequence	Overall risk rating
Achieve the completion criteria and habitat quality improvements for offset values and remnant status for those regrowth vegetation communities.	Completion criteria and habitat quality improvements are not achieved	D	IV	H	• Implementation of this OAMP, including the management actions and monitoring program outlined in Section 6.0 and Section 7.0. • Implementation of the adaptive management process outlined in Section 5.0 • Obtain advice with the aim of identifying appropriate additional management interventions if interim performance targets are not achieved for one or more offset values by year 5, 10 or 15. • If it is considered that the completion criteria cannot be achieved, Santos will update this OAMP proposing alternative offset areas in order to acquit the required offset requirements in accordance with the offsets assessment guide. The revised OAMP will be submitted to the Commonwealth Government.	B	IV	L
Maintain the extent of offset value habitat within the offset area.	Habitat or vegetation loss through land clearing.	D	V	H	• Protection of the offset area via a Voluntary Declaration under section 19E and 19F of the VM Act, as described in Section 2.7. • Comply with the restrictions outlined in Table 12. • Construction and maintenance of access tracks, fencing and firebreaks will be undertaken in accordance with Sections 6.2.2, 6.2.5 and 6.2.6 • Restoration of impacted areas subject to any unauthorised clearing.	B	V	M
Ensure that the livestock grazing restrictions for fire management and weed control assist in the enhancement of ground cover attributes for offset values and does not result in the degradation of habitat.	Degradation of offset value habitat quality as a result of livestock grazing	E	III	H	• Implementation of strategic grazing to reduce fuel loads and control exotic pasture grasses and promote the establishment of native perennial grass species in accordance with Section 6.2.6.1. • Annual biomass monitoring to inform strategic grazing regimes. • Rapid monitoring events and habitat quality assessments will be undertaken in accordance with Section 7.6.1 and 7.6.2 including an assessment of % cover of native perennial grasses	B	III	L
Minimise predation risk by wild dogs to threatened fauna species.	Predation of threatened fauna by wild dogs.	D	III	M	• Regular monitoring for pest animals will be undertaken in accordance with the methods detailed in Section 7.5 and pest animal control will be implemented following the results of monitoring in accordance with Section 6.2.8	C	III	L
Minimise predation risk by foxes to threatened fauna species.	Predation of threatened fauna by foxes.	D	III	M		C	III	L
Minimise predation risk by feral cats to threatened fauna species.	Predation of threatened fauna by cats.	D	III	M		C	III	L
Minimise degradation of offset value habitat by feral pigs.	Degradation of habitat by feral pigs.	D	III	M		C	III	L

Management objective	Risk description	Initial risk rating			Control strategies	Residual risk rating		
		Likelihood	Consequence	Overall risk rating		Likelihood	Consequence	Overall risk rating
Minimise degradation of offset value habitat by feral horses.	Degradation of habitat by feral horses.	D	III	M		C	III	L
Manage invasive weed species to reduce degradation of offset value habitat.	Invasion of habitat by weed species, including exotic grasses.	D	III	M	• Regular weed monitoring will be undertaken in accordance with Section 7.3 • Based on the results of monitoring events, weeds will be managed using biological, chemical and/or mechanical control in accordance with the control measures outlined in the Biosecurity Queensland Fact Sheets, for the relevant weed species (see Section 6.2.7)	C	III	L
Reduce the risk of adverse impacts to offset value habitat by inappropriate fire regimes or unplanned fire.	Decrease in the habitat quality score for any offset value from baseline and subsequent monitoring events as a result of fire management measures, or an unplanned fire.	D	IV	H	• Fuel loads within the offset area will be managed through strategic livestock grazing and fuel hazard reduction burns as outlined in Section 6.2.6 • Firebreaks will be established and maintained around the boundary of the offset area, with green firebreaks established where the offset area joins native vegetation. Firebreaks will be maintained at least annually in mid / late autumn and, or early spring to remove overhanging trees or fallen debris and dense vegetation	B	IV	L
Achieve the interim performance targets and completion criteria for each offset value within 5, 10, 15 and 20 years, respectively.	Interim performance targets are not achieved for offset values by year 5, 10 or 15. Completion criteria are not achieved for offset values by year 20.	E	III	H	• Monitoring of the offset area will be undertaken in accordance with Section 7.0 including: ○ Offset area inspections (Section 7.1). ○ Offset value assessments (Section 7.6) • The results of monitoring events will be compared against the interim performance targets and completion criteria to determine the progress of offset area and recorded as part of reporting (Section 7.6.5).	B	III	L

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APPENDIX D

Overall Fuel Hazard Assessment Guide

Department of
Sustainability and
Environment

Overall fuel hazard assessment guide

4th edition July 2010

Fire and adaptive management

report no. 82

A Victorian
Government
initiative

Victoria
The Place To Be

Overall fuel hazard assessment guide

4th edition July 2010

Fire and adaptive management, report no. 82

By Francis Hines, Kevin G Tolhurst, Andrew AG Wilson and Gregory J McCarthy

This publication was produced with the support of the Attorney-General's Department of the Australian Government, who part funded this project through the Natural Disaster Resilience Grants Program.

Australian Government
Attorney-General's Department
Emergency Management Australia

Images have been provided by Department of Sustainability and Environment – Victoria, Department of Environment and Heritage – South Australia, Country Fire Service – South Australia, Department of Conservation and Environment – Western Australia and Christian Pearson – Misheye. Katy Friend drew the illustrations.

Cover image: Elaine – Atchison Rd Fire, Victoria, January 2008. Bark Hazard – Extreme, Elevated Fuel Hazard – Moderate, Near-surface Fuel Hazard – Low, Surface Fuel Hazard – Very High. Overall Fuel Hazard – Extreme. Fire burning under FFDI 17 – High.

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Contents

1. About this guide

1.1 Purpose

The main purpose of this guide is to allow people to:

- make a rapid, visual assessment of fuel arrangement, and
- gain an understanding of how this will affect the chances of controlling a bushfire.

1.2 Audience

This guide has been principally designed to provide information on fuel arrangement to be used by:

- firefighters to assess the difficulty of controlling a bushfire.

Information on fuel arrangement may also be used by:

- asset owners and managers to assess potential bushfire risks to assets
- land and fire managers to provide a measurable objective and trigger for fuel management in fire management plans
- personnel to identify which key attributes and fuel layers are contributing the most to the hazard
- personnel to plan and conduct planned burns
- personnel to assess the effectiveness of planned burning or mechanical hazard reduction
- fire behaviour analysts to produce fire-spread predictions and community warnings.

Those who use the guide for these other purposes need to be mindful of its limitations and how the results are applied and interpreted.

1.3 What fuel is assessed

This guide is for assessing fine fuels that burn in bushfires. Fine fuels are the fuels that burn in the continuous flaming zone at the fire's edge. They contribute the most to the fire's rate of spread and flame height. Typically, they are dead plant material, such as leaves, grass, bark and twigs thinner than 6mm thick, and live plant material thinner than 3mm thick. Once ignited, these fine fuels generally burn out within two minutes.

This guide focuses on assessing the key structural layers of the fine fuel complex, in particular those of bark, elevated, near-surface and surface fuels.

1.4 How the fuel is assessed

Each fuel layer is assessed simply and visually. Assessing the fuel takes only a few minutes and is based on the premise that the eye is better able to integrate local variations in fuel than systematic measurement. Each fuel layer is assessed in turn and given a hazard rating. Particular emphasis is placed on how the fuel is arranged within each of these layers. The hazard ratings are then combined to produce an Overall Fuel Hazard Rating that ranges from Low to Extreme.

1.5 Why fuel arrangement is more important than fuel load

The image below highlights the effect that changing the arrangement of the fuel can have on fire behaviour. Both fires were ignited at the same time in the same way. Both fires are burning in the same fuel load, approximately two broadsheets of newspaper over a 20cm diameter area. The fuel on the right was laid flat and has little vertical orientation. The fuel on the left was crumpled up, which gave it more vertical orientation and exposed more of the surface to the air. As a result, the fire on the left shows significantly greater flame height and the fuel is consumed much faster.

The simple difference in the arrangement of the fuel significantly affects the resulting fire behaviour. The effect would not be discerned if the fuel assessment was based purely on fuel load. An assessment of fuel hazard takes into account the fuel arrangement. It gives a better indication of potential fire behaviour and suppression difficulty.

1.6 Suppression difficulty is not just about fire behaviour

This guide has been mainly developed to allow people to assess the impact of fuel arrangement on suppression difficulty. An assessment of suppression difficulty (how hard it is to control a bushfire) is not based solely on the anticipated fire behaviour. Many other factors affect the chances of a firefighting operation succeeding, including resources, fire size and terrain.

In order to consider the impact of fuels, the other factors need to be treated as if they are constant. The factors that have been held constant are referred to as the Reference Extended First Attack Conditions. Further detail on these conditions is contained in Appendix 1.

1.7 Basis of the Overall Fuel Hazard classification

A comprehensive explanation of this guide is contained in DSE's *Overall fuel hazard assessment guide: a rationale report – fire and adaptive management report no. 83* (in prep.).

This assessment guide updates and builds on work previously published by Wilson (1992a, 1992b, 1993), McCarthy *et al*. (1998a, 1998b, 1998c, 1999, 2001), the Department of Environment and Heritage (2006) and Gould *et al*. (2007a, 2007b).

Classifying Overall Fuel Hazard is complex, with few available measurements. Therefore, we have relied on the perceptions of experienced fire personnel (e.g. fire behaviour specialists, fire managers and firefighters). The collective experience of these personnel is vast, with a broad geographic base across Australia.

1.8 Need for continual learning and development

Although our knowledge about fuels has many gaps, this guide is based on the best available information and experience. The authors acknowledge that this guide will need to change and improve as more information is obtained.

Observers of firefighting operations can improve future editions of this guide by carefully recording what they see. Observations, comments and feedback can be emailed to fire.monitoring@dse.vic.gov.au.

2. How to use the guide

This guide has been kept concise and should not be considered as a standalone document. To produce reliable and consistent results requires extra knowledge which may be gained through local hands-on training in fuel assessment.

2.1 Application

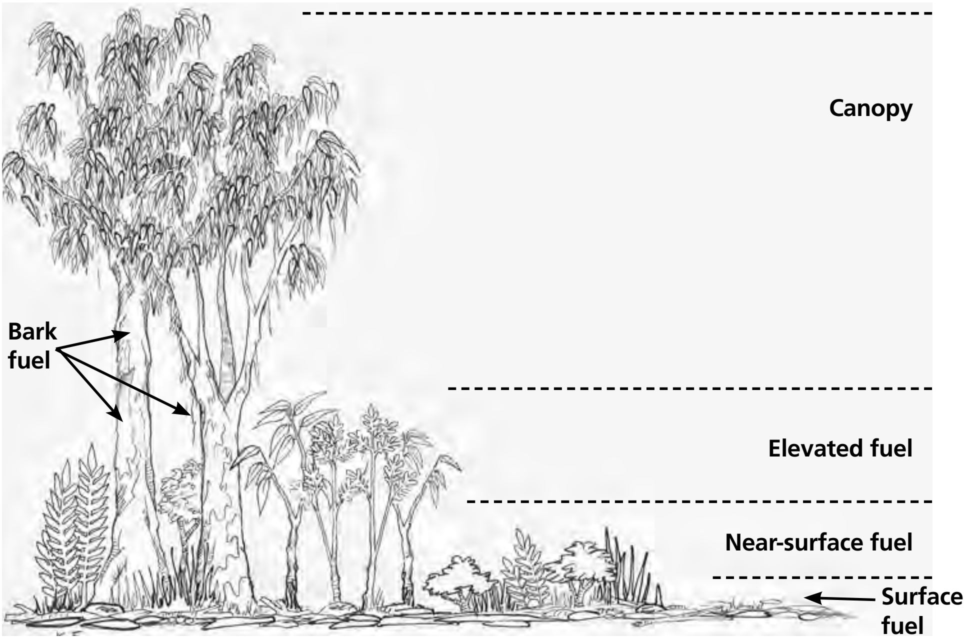
This guide is a tool for rapidly assessing fuel arrangement and its effect on the chances of controlling a bushfire. It may also be used for a range of other fire management purposes, as shown in the table below. Users of this guide should understand the underlying assumptions and limitations before applying it, particularly if applying it for purposes other than the assessment of suppression difficulty.

Application	Methodology
Assess suppression difficulty	Assess the fuels in which the fire may occur or is actually occurring.
Assess fuels for predicting potential risk to assets	Assess the fuels immediately adjacent to the asset as part of an assessment of possible radiant heat loads and defendable space. Assess the fuels further away from the asset; paying particular attention to areas that may generate spotting, such as ridges. Assessments should be focused, particularly in the direction of likely fire attack.
Assess the need for, or success of, fuel management activities	Assess the average fuels across the nominated area by sampling within major vegetation types, slopes and aspects.
Plan and conduct planned burns	Assess the variability in fuels across the nominated area by sampling within major vegetation types, slopes and aspects. Pay particular attention to areas where the burn may escape, such as the tops of gullies, ridge tops and areas adjacent to planned burn boundaries.
Assess fuels for predicting fire behaviour	Assess the fuel values needed as inputs for the appropriate fire behaviour model.

2.2 Fuel layers

Fuel in forests, woodlands and shrublands can be divided into four layers, each based on its position in the vegetation profile (Fig 2.1). This guide focuses on assessing the key structural layers of the fine fuel complex, those of bark, elevated, near-surface and surface fuels.

Figure 2.1 Fuel layers and bark



Use the following descriptions to determine how to separate vegetation into fuel layers.

Layer	Description	Contribution to suppression difficulty
Canopy	• Crowns of the tallest layer of trees. • Under some conditions canopy fuels can play a significant role in fire behaviour and suppression difficulty. Currently, however, these fuels are not assessed as part of Overall Fuel Hazard.	
Bark fuel	• Bark on tree trunks and branches, from ground level to canopy.	Spotting
Elevated fuel	• Fuels are mainly upright in orientation. • Generally most of the plant material is closer to the top of this fuel layer. • Sometimes contains suspended leaves, bark or twigs. • Fuels that have a clear gap between them and the surface fuels. • Can be highly variable in ground coverage. • Low-intensity fire (flame height of less than 0.5m) may pass beneath this layer without consuming much, if any, of it.	Influences the flame height and rate of spread of a fire.
Near-surface fuel	• Live and dead fuels, effectively in touch with the ground, but not lying on it. • Fuel has a mixture of vertical and horizontal orientation. • Bulk of the fuels are closer to the ground than to the top of this layer, or are distributed fairly evenly from the ground up. • Sometimes contains suspended leaves, bark or twigs. • Coverage may range from continuous to having gaps many times the size of the fuel patch. • Low-intensity fire (flame height of less than 0.5m) will consume most or all of this fuel. • Fuel in this layer will always burn when the surface fuel layer burns.	Influences the rate of spread and flame height of a fire.
Surface fuel (litter)	• Leaves, twigs, bark and other fine fuel lying on the ground. • Predominantly horizontal in orientation.	Influences the rate of spread of a fire.

This guide is for assessing fine fuels only. Coarse fuels including logs are not considered. See Section 1.3 for further details.

The descriptions of the fuel layers exclude references to species' names or common vegetation forms, such as shrubs. During a plant's life it may transition back and forth between different layers. For example, juvenile bracken fern can be classified as near-surface fuel before becoming elevated fuel as it matures. Once it dies and collapses it may become near-surface fuel again.

2.3 Assessment based on key attributes of fuel hazard

A fuel hazard rating of Low, Moderate, High, Very High or Extreme is assigned to each fuel layer by assessing it against the key attributes listed below.

Key attribute	
Horizontal continuity of the layer	Determines how readily a piece of burning fuel may ignite the fuel beside it. Identifies which of surface, near-surface or elevated fuels will determine the average flame height.
Vertical continuity of the layer	Determines how readily a piece of burning fuel may ignite the fuel above it.
Amount of dead material in the layer	Determines how much dead material is present to burn and thus help with igniting the live (green) fuels.
Thickness of the fuel pieces	Determines whether the fuel pieces will burn in the flaming front of the fire.
Total weight of fine fuel	Determines the weight of fine fuel contributing to the flaming front of the fire.

The descriptions in the hazard assessment tables do not cover all possible combinations of the key attributes. Users will need to exercise judgement and make an assessment using all key attributes when actual conditions fit between the descriptions.

2.4 Using the descriptions and photographs

This is **not** a photographic guide for assessing fuels. The **descriptions** for each of the key attributes should be used as the basis for determining the fuel hazard rating. Photographs cannot adequately show all of the key attributes that are important in determining fuel hazard. The photographs are provided to illustrate **some** of the key attributes for each fuel hazard rating. They do not represent all possible variations of that particular hazard rating.

2.5 Area of assessment

Within an area of interest fuels are assessed in small patches or plots. The size and number of plots depends on the reason for assessing the fuels. Some applications (such as for input into fire behaviour models) may require a more rigorous and systematic approach to sampling. Other applications (such as assessing fuel hazard during firefighting operations) will necessitate a more rapid informal approach. For whatever purpose the guide is being used it is recommended that the following principles be applied:

- Any assessment of fuels should try to assess the variability in fuels across an area by assessing the fuels at multiple plots.
- The size and number of plots should reflect the level of reliability required of the results.
- For surface, near-surface and elevated fuel layers the result of assessing the plot should reflect the average state of that fuel layer.
- For bark hazard the result of assessing the plot should be based on the trees with the highest rating.
- Always record with the result the name and the version of the guide used.

2.6 Tips for assessing fuel hazard

The process of assessing fuel hazard using this guide is largely subjective. Implementing the following techniques will help to improve accuracy and reliability:

- Identify and agree on examples of the highest rating of fuel hazard for each layer that occur locally. These examples should be used as benchmarks.
- Conduct assessments in pairs of observers and regularly change assessment pairs.
- Assessors should be no more than one hazard rating apart when assessing each layer (e.g. Low or Medium, not Low or High).
- Use different assessors to re-assess completed work and provide feedback.

2.7 Vesta fire behaviour predictions

In dry eucalypt forest with a litter and shrub understorey the *Field guide – fuel assessment and fire behaviour prediction in dry eucalypt forest* (Gould *et al.* 2007b) provides a systematic method for assessing fuel and predicting fire behaviour (rate of spread, flame height, and spotting). The Project Vesta fuel hazard scoring system is similar to the Victorian system developed by Wilson (1992a, 1992b, 1993) and revised by McCarthy *et al*. (1999). The scale that underlies the Vesta fuel hazard scores is directly related to fire behaviour. These scores, along with height measurements of various fuel layers, are needed as inputs into the fire behaviour prediction tables in Gould *et al*. (2007b). Section 9.3 contains a table for translating the fuel hazard rating for each fuel layer into Vesta fuel hazard scores.

2.8 Effect on fire behaviour

Each table for assessing fuel hazard contains information on the effect that the fuel arrangement is likely to have on fire behaviour. This effect is for weather conditions equivalent to a Forest Fire Danger Index (FFDI) of 25 (McArthur 1973). An FFDI of 25 can be achieved in many ways. For the purposes of this guide the specific conditions required to achieve this are:

Temperature: 33°C	Relative Humidity: 25%	Wind Speed: 20km/h
Drought Factor: 10	Slope: 0°	

If weather conditions vary from those listed above the effect on fire behaviour will also vary.

2.9 Fuel assessment data sheet

Appendix 2 contains a sample field data sheet that can be used when assessing fuels.

3. Bark fine fuel

3.1 Identification

Bark fuel is the bark on tree trunks and branches. Bark lying on or near the ground or draped over understorey plants is considered to be surface, near-surface or elevated fuel.

3.2 Identifying bark types

The key attributes for assessing the effect of bark on suppression difficulty are shown below:

Key attribute	Determines	How it is assessed
Ease of ignition	• How readily the bark will ignite. • Whether the fire will burn up the trunk and into the branches of the tree.	Thickness, size and shape of bark pieces.
How bark is attached	• How likely the bark is to break off the tree.	How easily the bark breaks off the tree.
Quantity of combustible bark	• Volume of potential embers that a fire may generate.	Relative quantity of combustible bark.
Size-to-weight ratio of the bark pieces	• How far the wind is likely to carry bark pieces once they break off the tree.	Thickness, size and shape of bark pieces.
Burn out time	• Length of time a piece of bark will stay ignited once it breaks off the tree.	Thickness, size and shape of bark pieces.

Descriptions of trees have been separated into three broad bark types using three of these key attributes – ease of ignition, burn out time and size-to-weight ratio:

1. Fine fibrous barks, including stringybarks
2. Ribbon or candle barks
3. Other bark types, including smooth, platy, papery and coarsely fibrous. The reason for describing these types in some detail is to help observers distinguish them from the above two types.

3.3 Identifying Stringybark and other fine fibrous bark types

Contribution to suppression difficulty	• Bark types that can produce massive quantities of embers and short distance spotting.
Physical description	• Bark is fine fibrous material with easily visible fibres less than 1mm thick covering the whole trunk. • Bark fibres resemble the fine fibres that are twisted together to form natural string. • Old bark is retained on the trunk of the tree for decades, forming a relatively spongy fibrous mass with deep vertical fissures. • Outer bark may weather to a greyish colour, while underlying bark retains its original colour. • Bark may form large strands when peeled off. • Fine, hairlike pieces also break off from the tree when it is rubbed.
Ease of ignition	• Bark is very flammable (can be easily lit with a match when dry). • Fires will readily climb the tree and branches.
How bark is attached	• Young or new bark is held tightly to the trunk. • As bark ages it becomes less tightly held. • Old, long-unburnt bark is held very loosely.
Quantity of combustible bark	• Bark on old, long-unburnt stringybarks can be more than 10cm in depth. During fires it can produce massive quantities of embers.
Size-to-weight ratio	Burning pieces of bark tend to be either: • Very fine lightweight fibres that will be carried for less than 100m. • Small lightweight wads (about the size of a thumb) that will be carried for less than 300m. • Very large wads (bigger than a fist) that fall close to the tree.
Burn out time	• Very fine fibres of bark that will burn out within one minute. • Small wads of bark that will burn out within 2–3 minutes. • Very large wads of bark that will burn for up to 10 minutes.
Hazard accumulation	• Bark hazard can reach Extreme. • Bark hazard increases over time as the thickness and looseness of the old bark increases. • Repeated low intensity fires (<0.5m flame height) may produce a 'black sock' effect on the base of the trunk, but this may have limited effect in reducing the overall quantity of bark and the hazard.

Examples

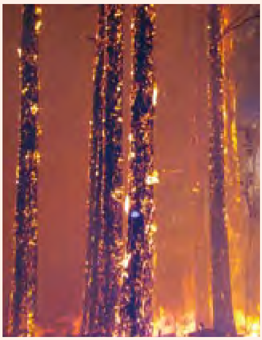


Table 3.1 Assessing the hazard of fine fibrous bark types including stringybarks

Only use this table if at least 10% of the trees in a forest have fine fibrous bark. To achieve a given hazard rating a best fit of both key attributes should be sought. Choices for the hazard rating of fuels that fit across several descriptions may be informed by the effect that different levels of key attributes have on fire behaviour.

Key attributes		Hazard rating	Effect on fire behaviour (at FFDI 25)[1]
How bark is attached	Quantity of combustible bark		
This hazard rating cannot occur when only this bark type is present.		Low	
Bark tightly held. Requires substantial effort to break off bark by hand.	Very little combustible bark. Entire trunk almost completely black or charred.	Moderate	Spotting generally does not hinder fire control. Fires will not climb these trees.
Bark is mostly tightly held with a few pieces loosely attached.	Limited amount of combustible bark. 50–90% of trunk charred. Most of the bark is charred, especially on the lower part of the trunk.	High	Infrequent spotting. Fires will climb some of these trees.
Many pieces of bark loosely held. Deep fissures present in bark.	Large amounts of combustible bark. 10–50% of trunk charred. Upper parts of the tree may not be charred at all.	Very High	Substantial spotting. Fires will climb most of these trees.
Outer bark on trees is weakly attached. Light hand pressure will break off large wads of bark. Deep fissures present in bark.	Huge amounts of combustible bark. <10% of trunk charred. Minimal evidence of charring.	Extreme	Quantity of spotting generated makes fire control very difficult or impossible. Fires will climb virtually all these trees.

Assess bark hazard over a plot 20m in radius. Assessing multiple plots will give better results. Trunk is defined as being the part of the tree between the ground and the branches.

See Section 9.3 for application of bark hazard ratings for the Vesta fire behaviour tables.

1 FFDI 25 is a Forest Fire Danger Index of 25 (McArthur 1973). Refer to Section 2.8 for the specific weather conditions used to achieve this FFDI.

Table 3.2 Examples of Stringybarks and other fine fibrous bark hazard

Low	This hazard rating cannot occur when only this bark type is present.
Moderate	
High	
Very High	
Extreme	

The photos above show some of the variation possible within each bark hazard rating.

3.4 Identifying ribbon or candle bark types

		Example
Effect on suppression difficulty	• Bark types that can produce substantial quantities of spotting at distances greater than 2km. Will also produce short distance spotting.	 
Physical description	• Trees characterised by the annual shedding of old bark layers, exposing the smooth new bark underneath. • Bark is shed in the form of long strips or ribbons of bark. • Long strips of bark curl tightly inwards to form a candle-like shape (see image lower right). • Bark strips 50cm or more in length fall off and often drape around the trunk and over branches and surrounding shrubs. • Strips of bark are usually less than 2mm thick. • Bark is shed at various times of the year so that the trunk may have a mottled appearance.	
Ease of ignition	• Bark is moderately flammable (can be lit with a cigarette lighter when dry). • Fires will climb up ribbons of bark.	
How bark is attached	• Bark strips may drape over, or be weakly attached to, the trunk and branches.	
Quantity of combustible bark	• Large quantities of bark can be retained in upper trunk and head of the tree.	
Size-to-weight ratio	• Bark pieces are relatively light for their large size. • Easily transported by strong updrafts – may travel up to 30km downwind.	
Burn out time	• Bark can burn and smoulder within the curled up ribbons for longer than 10 minutes.	
Hazard accumulation	• Bark hazard never exceeds Very High. • Bark hazard tends to increase over the long term as ribbons accumulate on the tree. • A low intensity fire (flame height of less than 0.5m) may not reduce the hazard in this bark type.	

Note: Loose ribbon or candle-like bark that is retained on the trunk near ground level is not included in the assessment of ribbon or candle bark types. It is usually:

- firmly attached to the trunk of the tree
- consumed in place by a surface fire.

This bark is considered in 'Other bark types' and can also be considered as near-surface fuel.

Smooth-bark trees also shed bark as slabs or flakes. These bark types are considered in 'Other bark types'.

Table 3.3 Assessing the hazard of ribbon or candle bark types

If more than 10% of the trees in a forest are fine fibrous bark trees use Table 3.1 (Assessing the hazard of fine fibrous bark types) to determine the bark hazard for a site.

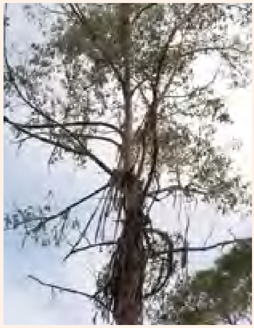
Key attribute Amount of combustible bark	Hazard rating	Effect on fire behaviour (at FFDI 25)[2]
This hazard rating cannot occur when only this bark type is present.	Low	
No long ribbons of bark present. Trunk and branches of trees almost entirely smooth.	Moderate	Spotting generally does not hinder fire control. Fires will not climb these trees.
Long ribbons of bark present on upper trunk (>4m above ground) and in head of trees. Lower trunk mainly smooth.	High	Infrequent spotting. Fires will climb some of these trees.
Long ribbons of bark in the head and upper trunk with: • ribbons hanging down to ground level or, • flammable bark covers trunk.	Very High	Substantial spotting. Fires will climb most of these trees.
This hazard rating cannot occur when only this bark type is present.	Extreme	

Assess bark hazard over a plot 20m in radius. Assessing multiple plots will give better results. Trunk is defined as the part of the tree between the ground and the branches.

See Section 9.3 for application of bark hazard ratings for the Vesta fire behaviour tables.

2 Refer to Section 2.8 for the specific weather conditions used to achieve this FFDI.

Table 3.4 Examples of ribbon or candle bark hazard

Low	This hazard rating cannot occur when only this bark type is present.		
Moderate			
High			
Very High			
Extreme	This hazard rating cannot occur when only this bark type is present.		

3.5 Identifying other bark types

This bark type includes all other bark types not included in the previous two types. As a result, many different tree species are grouped together. This grouping is based on the ease of ignition, burn out time and size-to-weight ratio of the bark, rather than on botanical values. These other bark types can produce limited quantities of short distance spotting.

This bark type group has been divided into several subgroups. These subgroups are described in some detail to help observers distinguish them from the other two main bark types.

3.5.1 Ironbarks and Platy barks

		Example
Physical description	• Trees characterised by layers of old, coarse bark retained on the trunk and branches. • Bark becomes rough, compacted and furrowed with age • Bark feels very abrasive when rubbed by hand. • Bark pieces tend to be more than 2mm thick when they break off. • There may be little or no evidence of charring on the bark following planned burns.	
Hazard accumulation	• Bark hazard never exceeds Moderate.	

3.5.2 Coarsely fibrous barks

Physical description	• Trees characterised by short strand fibrous bark. • Layers of old dead bark are retained on the trunk and branches. • Unlike stringybark trees, the bark on these trees forms only short strands or chunks when peeled off. • Evidence of charring on the bark may last for up to 10 years.	
Hazard accumulation	• Bark hazard never exceeds High. • Bark hazard increases over the long term as the thickness and looseness of the old bark increases.	

3.5.3 Papery barks

Physical description

- Shrubs and trees growing from 2m to 30m tall, often with flaky shedding bark.
- Old bark is retained on the trunk and branches and builds up into a thick spongy mass.
- Bark layers tend to split allowing sheets of bark to become loose and eventually peel off.
- Evidence of charring on the bark may last for up to 10 years.

Hazard accumulation

- Bark hazard never exceeds High.
- Bark hazard increases over the long term as the thickness and looseness of the old bark increases.

Example

3.5.4 Slab bark, smooth bark and small flakes

Physical description

- Trees characterised by the annual shedding of old bark layers, exposing the smooth living bark underneath.
- Bark shed is often seasonal and often annual.
- Species where the old bark tends to peel into large slabs (<50cm in length) or small flakes when shed.
- Most of the bark falls off the tree soon after it is shed.
- Some small amounts of bark may be retained on the stem or branches for several months before falling off, leading to a mottled effect.
- The mottled effect leads to discontinuous bark fuel up the tree.

Hazard accumulation

- Bark hazard never exceeds Moderate.
- Bark hazard tends to be seasonal.

Example

Table 3.5 Assessing the hazard of other bark types

If more than 10% of the trees in a forest are fine fibrous bark trees use Table 3.1 (Assessing the hazard of fine fibrous bark types) to determine the bark hazard for a site. To achieve a given hazard rating a best fit of both key attributes should be sought. Choices for the hazard rating of fuels that fit across several descriptions may be informed by the effect that different levels of key attributes have on fire behaviour.

Key attributes		**Hazard rating**	**Effect on fire behaviour (at FFDI 25)[3]**
How bark is attached	**Quantity of combustible bark**		
No trees present. or Trunk and branches of tree entirely smooth or free from loose bark.		Low	No bark present that could contribute to fire behaviour.
Bark rubs off by hand with firm pressure.	Limited amount of combustible bark.	Moderate	Spotting generally does not hinder fire control. Fires will climb some of these trees.
Light hand pressure will break bark off.	Large amounts of combustible bark.	High	Infrequent spotting. Fires will climb most of these trees.
This hazard rating cannot occur when only this bark type is present.		Very High	
This hazard rating cannot occur when only this bark type is present.		Extreme	

Assess bark hazard over a plot 20m in radius. Assessing multiple plots will give better results. Trunk is defined as the part of the tree between the ground and the branches.

See Section 9.3 for application of bark hazard ratings for the Vesta fire behaviour tables.

3 Refer to Section 2.8 for the specific weather conditions used to achieve this FFDI.

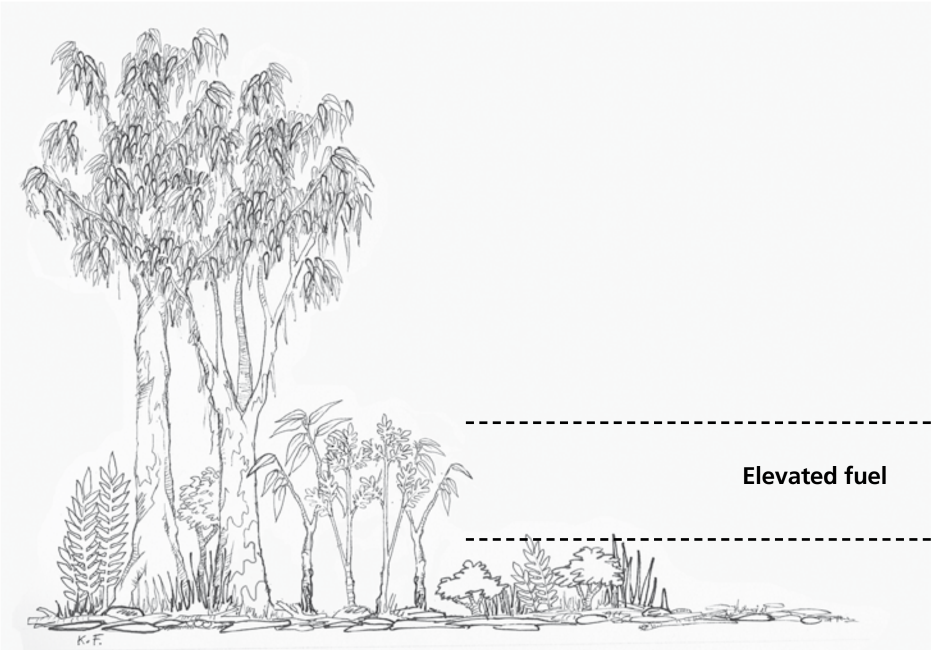
Table 3.6 Examples of other bark types

Low	No trees present. or Trunk and branches of tree entirely smooth or free from loose bark.		
Moderate			
High			
Very High	Does not occur when this is the only bark type present on a site.		
Extreme	Does not occur when this is the only bark type present on a site.		

4. Elevated fine fuel

4.1 Identification

- Fuels are mainly upright in orientation
- Generally most of the plant material is closer to the top of this layer
- Sometimes contains suspended leaves, bark or twigs
- Fuels that have a clear gap between them and the surface fuels
- Elevated fuel can be highly variable in ground coverage
- A low intensity fire (flame height of less than 0.5m) may pass beneath this layer without consuming much, if any, of it.



4.2 Assessment

The elevated fuel hazard is highest when the:

- foliage, twigs and other fuel particles are very fine (maximum thickness 1–2mm)
- proportion of dead material is high
- fuels are arranged with a high level of density and/or horizontal and vertical continuity that promotes the spread of flames
- live foliage has low fuel moisture content.

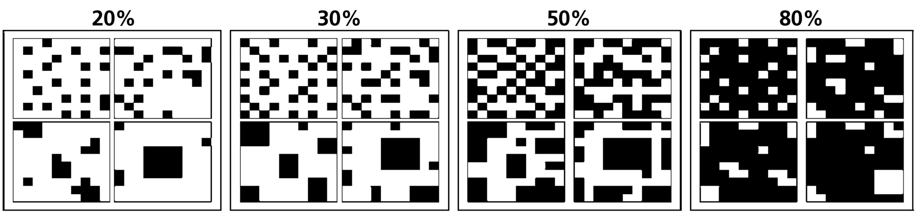
Table 4.1 Assessing elevated fine fuel hazard

To achieve a given hazard rating a best fit of all key attributes should be sought. Choices for the hazard rating of fuels that fit across several descriptions may be informed by the effect that different levels of key attributes have on fire behaviour.

Key attributes					Fuel hazard rating	Effect on fire behaviour (at FFDI 25)[4]
Plant Cover	**% dead**	**Vertical continuity**	**Vegetation density**	**Thickness of fuel pieces**		
<20% or low flammability species	<20%		Easy to walk in any direction without needing to choose a path between shrubs.		Low	Little or no effect.
20–30%	<20%	Most of the fine fuel is at the top of the layer.	Easy to choose a path through but brush against vegetation occasionally.		Moderate	Does not sustain flames readily.
30–50%	<20%	Most of the fine fuel is at the top of the layer.	Moderately easy to choose a path through, but brush against vegetation most of the time.		High	Causes some patchy increases in the flame height and/or rate of spread of a fire.
50–80%	20–30%	Continuous fine fuel from the bottom to the top of the layer.	Need to carefully select path through.	Mostly less than 1–2mm thick.	Very High	Elevated fuels mostly dictate flame height and rate of spread of a fire.
>70%	>30%	Continuous fine fuel from the bottom to the top of the layer.	Very difficult to select a path through. Need to push through vegetation.	Large amounts of fuel <2mm thick.	Extreme	Elevated fuels almost entirely determine the flame height and rate of spread of a fire.

Assessing plant cover

For the purpose of this guide, plant cover is defined as the amount of ground blocked out by that fuel layer if viewed while looking straight down from above. Each plant is considered opaque – any ground within the perimeter of the plant cannot be seen. The following visual guide can be used to assist in assessing plant cover. Each quarter of any one square has the same percent cover.



4 Refer to Section 2.8 for the specific weather conditions used to achieve this FFDI.

Table 4.2 Examples of elevated fine fuel hazard

Low	Elevated fuel absent or virtually absent	
Moderate		
High		
Very High		
Extreme		

Assess elevated hazard over a plot 10m in radius. Assessing multiple plots will give better results.

See Section 9.3 for application of elevated fuel hazard ratings for the Vesta fire behaviour tables. For the Vesta fire behaviour tables the elevated fuel height (m) should be the average of 10 measurements taken along a 300m walk-through. Measure the typical height from ground level.

5. Near-surface fine fuel

5.1 Identification

- Live and dead fuels effectively in touch with the ground but not lying on it
- Fuel has a mixture of vertical and horizontal orientation
- Either the bulk of the fuels is closer to the ground than the top of this layer, or is distributed fairly evenly from the ground up
- Sometimes contains suspended leaves, bark or twigs
- Coverage may range from continuous to having gaps many times the size of the fuel patch
- A low intensity fire (flame height of less than 0.5m) will consume most or all of this fuel
- Fuel in this layer will always burn when the surface fuel layer burns.

5.2 Assessment

The near-surface fuel hazard is highest when the:

- foliage, twigs and other fine fuel particles are very fine (maximum thickness 1–2mm)
- proportion of dead material is high
- fuels are arranged with a high level of density and /or horizontal and vertical continuity, that promotes the spread of flames
- live foliage has low fuel-moisture content.

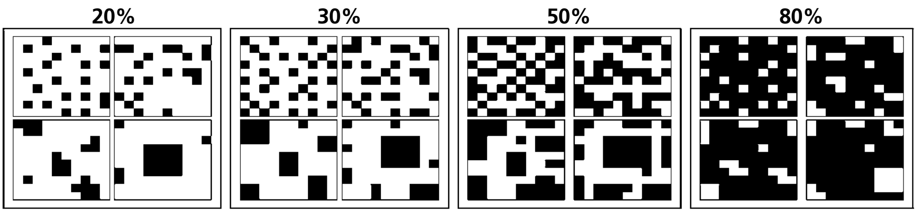
Table 5.1 Assessing near-surface fine fuel hazard

To achieve a given hazard rating a best fit of all key attributes should be sought. Choices for the hazard rating of fuels that fit across several descriptions may be informed by the effect that different levels of key attributes have on fire behaviour.

Key attributes: Plant cover	Key attributes: % dead	Key attributes: Horizontal connectivity	Fuel hazard rating	Effect on fire behaviour (at FFDI 25)[5]
<10%	<10%	Near-surface fuel is absent or virtually absent.	Low	Little or no effect.
10–20%	<20%	Gaps many times the size of fuel patches.	Moderate	Occasionally increases flame height.
20–40%	>20%	Gaps between fuel patches are greater than the size of fuel patches. Starting to obscure logs and rocks.	High	Contributes to surface fire spread and causes patchy increase to flame height.
40–60%	>30%	Fuel patches are equal to or larger than the gaps between the fuel patches.	Very High	Contributes significantly to fire spread and flame height. A fire will spread readily in this layer without having to consume the surface layer.
>60%	>50%	Very small gaps between fuel patches. Logs and rocks obscured.	Extreme	Contributes significantly to fire spread and flame height. A fire will spread readily in this layer without having to consume the surface layer.

Assessing plant cover

For the purpose of this guide, plant cover is defined as the amount of ground blocked out by that fuel layer if viewed while looking straight down from above. Each plant is considered opaque – any ground within the perimeter of the plant cannot be seen. The following visual guide can be used to assist in assessing plant cover. Each quarter of any one square has the same percent cover.



5 Refer to Section 2.8 for the specific weather conditions used to achieve this FFDI.

Table 5.2 Examples of near-surface fine fuel hazard

Low	Near-surface fuel is absent or virtually absent	
Moderate		
High		
Very High		
Extreme		

Assess near-surface hazard over a plot 10m in radius. Assessing multiple plots will give better results.

See Section 9.3 for application of near-surface fuel hazard ratings for the Vesta fire behaviour tables. For the Vesta fire behaviour tables the near-surface fuel height (cm) should be the average of 10 measurements taken over a 300m walk through. Measure the typical height from ground level.

6. Surface fine fuel

6.1 Identification

- Leaves, twigs, bark and other fine fuel lying on the ground
- Predominantly horizontal in orientation
- Usually contributes the most to fuel load or quantity
- Includes the partly decomposed fuel (duff) on the soil surface.

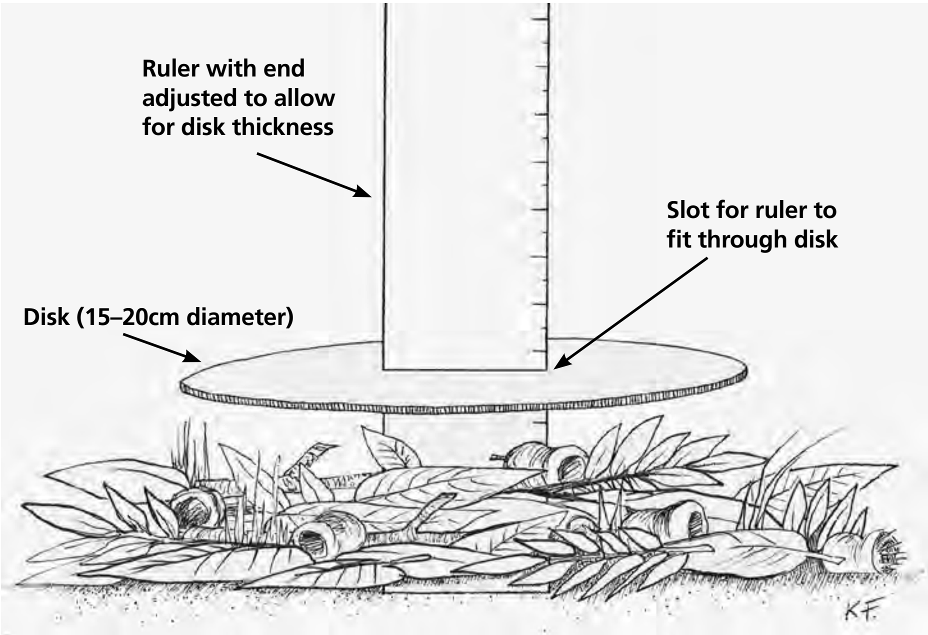
6.2 Assessment

The surface fine fuel hazard is highest when the:

- litter pieces are well connected
- surface litter cover is high, with minimal interruption from rocks, logs or patches of bare soil
- surface litter has substantial depth (greater than 30mm).

6.3 Measurement

Surface litter-bed depth should be measured using a simple depth gauge, as pictured below. This follows the methodology described in McCarthy (2004) and McCarthy *et al*. (1999).



Litter depth should be measured in areas where near-surface fuels do not obscure the litter. Fuel depth is measured using a 15cm circular disk with a ruler through a slot in its centre. To use this gauge, a small gap is made in the litter bed down to mineral soil, then the end of the ruler is placed resting on the mineral soil surface. The disk is pushed down with light pressure until its whole perimeter is in contact with the fuel. Light pressure can be described as 'enough pressure to hold a tennis ball under water'. The ruler is read off level with the top of the disk. Note that the end of the ruler needs to be adjusted to match the thickness of the disk.

Five measurements of litter bed depth should be made at each site. The average of these measurements is one of the attributes that can be used to determine the surface fine fuel hazard.

Table 6.1 Assessing surface fine fuel hazard

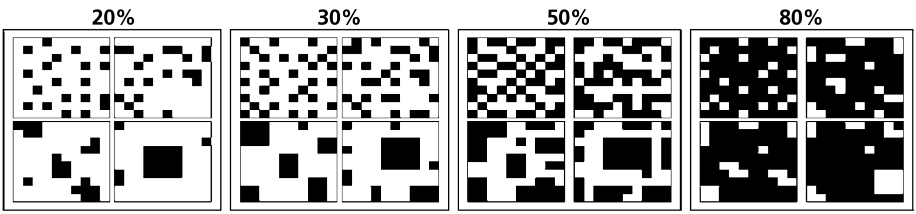
To achieve a given hazard rating a best fit of all key attributes should be sought. Choices for the hazard rating of fuels that fit across several descriptions may be informed by the effect that different levels of key attributes have on fire behaviour.

Key attributes			Fuel hazard rating	Effect on fire behaviour (at FFDI 25)[6]
Horizontal connectivity	**Surface litter cover**	**Litter-bed depth**		
Litter poorly interconnected. Large areas of bare soil or rock. More soil than litter. Soil surface readily visible through litter bed.	<60%	Very thin litter layer <10mm	Low	Surface fires will not spread.
Litter well connected. Some areas of bare soil or rock. Soil surface occasionally visible through litter bed.	60–80%	Thin litter layer 10–25mm	Moderate	Litter connected well enough to allow fire spread to overcome bare patches.
Litter well connected. Little bare soil.	80–90%	Established litter with layers of leaves ranging from freshly fallen to decomposing. 20–30mm	High	Surface fires spread easily with a continuous fire edge.
Litter completely connected.	>90%	Thick litter layer 25–45mm	Very High	Surface fires spread easily. Increasing flame depth and residence time.
Litter completely connected.	>95%	Very thick layer of litter >35mm	Extreme	Surface fires spread easily. Increasing flame depth and residence time.

Assess surface hazard over a plot 10m in radius. Assessing multiple plots will give better results. For each plot litter bed depth should be an average of five measurements (McCarthy 2004) or more.

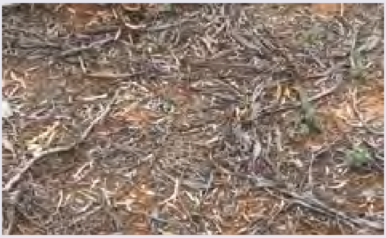
See Section 9.3 for application of surface fuel hazard ratings for the Vesta fire behaviour tables.

The following visual guide can be used to assist in assessing surface litter cover. Each quarter of any one square has the same percent cover.



6 Refer to Section 2.8 for the specific weather conditions used to achieve this FFDI.

Table 6.2 Examples of surface fine fuel hazard

Low		
Moderate		
High		
Very High		
Extreme		

7. Determining the combined surface and near-surface fine fuel hazard rating

Assessments of surface and near-surface fuels must be combined together before an Overall Fuel Hazard rating can be determined. The near-surface fuel rating is used to adjust the surface fine fuel hazard rating, according to Table 7.1.

To determine the effect of near-surface fine fuel hazard:

1. Select the **surface fuel hazard rating** from column ❶
2. Select the **near-surface fuel hazard rating** from column ❷
3. Select the resulting **combined rating** value ❸
4. Use this value to determine the Overall Fuel Hazard rating using the Table 8.1.

Table 7.1 Determining the combined surface and near-surface fine fuel hazard rating

❶ Surface fine fuel hazard rating	❷ Near-surface fine fuel hazard rating				
	Low	Moderate	High	Very High	Extreme
	❸ Combined surface and near-surface fine fuel hazard rating				
Low	L	L	M	H	VH
Moderate	M	M	H	VH	E
High	H	VH	VH	VH	E
Very High	VH	VH	E	E	E
Extreme	E	E	E	E	E

8. Determining Overall Fuel Hazard

Overall Fuel Hazard = (sum of the influences of) Bark Hazard + Elevated Fine Fuel Hazard + Combined Surface and Near-surface Fine Fuel Hazard.

The following table is used to combine the assessed levels of Bark, Elevated and Combined Surface and Near-surface Fuel Hazard to give an Overall Fuel Hazard rating.

To determine the Overall Fuel Hazard rating:

1. Select the row that corresponds to the **Bark Hazard** 1
2. Select the row that corresponds to the **Elevated Fine Fuel Hazard** 2
3. Select the column that corresponds to the assessed level of **Combined Surface and Near-surface Fine Fuel Hazard** 3
4. Identify where these two intersect and this will provide you with the corresponding Overall Fuel Hazard rating.

Table 8.1 Determining the Overall Fuel Hazard rating

1 Bark Hazard	2 Elevated Fine Fuel Hazard	3 Combined Surface and Near-surface Fine Fuel Hazard *				
		L	M	H	VH	E
Low or Moderate	L	L	M	M	H	H
	M	L	M	M	H	H
	H	L	M	H	VH	VH
	VH	VH	VH	VH	VH	VH
	E	E	E	E	E	E
High	L	L	M	H	H	H
	M	L	M	H	H	H
	H	L	H	H	VH	VH
	VH	VH	VH	VH	VH	E
	E	E	E	E	E	E
Very High or Extreme	L	L	VH	VH	VH	E
	M	M	VH	VH	E	E
	H	M	VH	E	E	E
	VH	E	E	E	E	E
	E	E	E	E	E	E

* Combined Surface and Near-surface Fine Fuel Hazard is a measure of the Surface Fine Fuel Hazard adjusted to account for the level of near-surface fine fuel (see Table 7.1).

9. Interpreting and applying Overall Fuel Hazard

9.1 Chances of extended first attack success

The chances of extended first attack being successful[1] for a fire ignited in these fuels under the reference extended first attack conditions (Appendix 1) is approximately as follows:

Table 9.1 Chances of extended first attack success

GFDI[2]	FFDI[3]	Overall Fuel Hazard rating[4]				
		Low	Moderate	High	Very High	Extreme
0–2	0–5					
3–7	6–11					
8–20	12–24					
20–49	25–49					
50–74	50–74					
75–99	75–99					
100+	100+					

- Chance of extended first attack success is greater than 95% (almost always succeeds)
- Chance of extended first attack success is between 95% and 50% (succeeds most of the time)
- Chance of extended first attack success is between 49% and 10% (fails most of the time)
- Chance of extended first attack success is less than 10% (almost always fails)

Notes:

1. Extended first attack is deemed successful when a fire is controlled by 0800hrs the day after ignition and at less than 400 hectares.
2. GFDI is the Grass Fire Danger Index at the time of ignition and is assumed to be the highest GFDI expected before 0800hrs the next day.
3. FFDI is the Forest Fire Danger Index at the time of ignition and is assumed to be the highest FFDI expected before 0800hrs the next day.
4. Chance of success is for a fire ignited in fuels with this Overall Fuel Hazard rating.
5. Predicted outcomes will differ if the conditions vary from those listed in the reference extended first attack conditions.
6. Predicted outcomes based on expert opinion and informed by work carried out by Wilson (1992b, 1993), McCarthy *et al*. (1998a, 2001) and Plucinski *et al*. (2007).

9.2 Indicative fuel loads (t/ha)

In the absence of local data obtained by sampling fuel loads destructively the following table of indicative fuel load data from Project Vesta and Victorian studies may be useful. These tonnes per hectare figures may be applied to the Forest Fire Danger Meter Mark V (McArthur 1973) for predicting forward rate of spread and flame height for forest fires.

Table 9.2 Indicative fuel loads (t/ha)

Fuel	Fuel hazard rating				
	Low	Moderate	High	Very High	Extreme
Bark	0	1	2	5	7
Elevated	0–1	1–2	2–3	3–5	5–8
Near-surface	1–2	2–3	3–4	4–6	6–8
Surface	2–4	4–10	8–14	12–20	16–20+

9.3 Determining Vesta fuel hazard scores

The following table translates fuel hazard ratings for each fuel layer into Project Vesta fuel hazard scores. These scores can be used with the fire behaviour prediction tables in publications such as Gould *et al*. (2007b).

To determine the Vesta fuel hazard score:

1. Select the row that corresponds to the fuel hazard rating for required fuel layer ❶
2. Select the Vesta fuel hazard score column that corresponds to the same layer ❷
3. Identify where these two intersect and this will provide you with the corresponding Vesta fuel hazard score.

Table 9.3 Determining Vesta fuel hazard scores

	Vesta fuel hazard score ❷			
Fuel hazard rating ❶	**Surface**	**Near-surface**	**Elevated**	**Bark**
Low	1	1	1	0
Moderate	2	2	2	1
High	3	3	3	2
Very High	3.5	3.5	3.5	3
Extreme	4	4	4	4

Notes:

- Surface and near-surface hazard score and near-surface height (cm) is required for fire spread prediction.
- Rate of spread and elevated fuel height (m) is required for flame height prediction.
- Rate of spread, surface and bark fuel hazard scores are required for prediction of spotting distance.

Acknowledgements

This Fuel Hazard Assessment Guide updates and continues to develop work previously conducted by a number of authors. Andrew Wilson laid the foundations for this guide, with the conceptual framework presented in Research Report No. 31; and the visual guides for assessing the influence of bark and elevated fuels on suppression difficulty in the *Eucalypt Bark Hazard Guide and Elevated Fuel Guide* (Reports 32 and 35, respectively). Greg McCarthy (2004) detailed a method for rapidly assessing surface fine fuels in Research Report No. 44.

These three techniques were brought together in the first three editions of the *Overall Fuel Hazard Guide* (McCarthy, Tolhurst and Chatto, 1998b, 1998c, 1999). A subsequent unpublished edition of the guide, produced by Kevin Tolhurst (2005), provided greater detail on the assessment of near-surface fuels. In 2006, Mike Wouters adapted the guide for South Australian conditions, and incorporated the preliminary results from Project Vesta (CSIRO and Department of Conservation and Environment, Western Australia). Further information and results from the final Project Vesta report (Gould *et al.* 2007a) have also been incorporated.

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Appendix 1. Reference extended first attack conditions

This guide assesses the impact of fuels in suppressing a fire during extended first attack, using local resources. Several factors affect the success of an extended first attack. Therefore, to consider the impact of fuels alone, the other factors must be treated as if they were constant. Table A1 below adapted from Wilson (1993) summarises reference extended first attack conditions for four fuel types.

Table A1. Revised reference extended first attack conditions

Fuel type	Forest fuels	Grass fuels	Mallee and scrub fuels	Heath fuels
Examples of typical resources (on scene within the designated arrival time)	Small dozer (D4) 1 to 2 small 4WD tankers (400l) 6 firefighters	5 x 4WD heavy tankers (4000l) each with 5 firefighters	Small dozer (D4) or tractor with scrub roller 1 to 2 small 4WD tankers (400l) 6 firefighters	Small dozer (D4) 1 to 2 small 4WD tankers (400l) 6 firefighters
Extended attack resources	Potential additional resources deployed to the fire during extended first attack may include heavy tankers, large plant (dozers, graders or tractors) and fire bombing aircraft.			
Arrival time	Within 60 minutes of detection			
Suppression workload	A single fire			
Topography and terrain	Burning on level ground with good access			
Fuel availability[1]	MDF is 10 or AFF is 1.0	100% grass curing	MDF is 10 or AFF is 1.0	
Wind speed[2]	20km/h	30km/h		20km/h
Fire danger rating system[3]	McArthur FFDI	McArthur GFDI	McArthur FFDI	

Notes:

1. MDF (McArthur Drought Factor) is calculated using the Forest Fire Danger Meter (McArthur 1973) and is a measure of the short-term availability of forest fuels. AFF (Available Fuel Factor) is used in Western Australia to define the proportion of litter fuel available for burning (Sneeuwjagt & Peet 1998).
2. Wind speed is measured at 10m height in the open above ground level.
3. FFDI is the McArthur Forest Fire Danger Index, GFDI is the McArthur Grass Fire Danger Index.

The rationale for the reference first attack conditions is documented in DSE's *Overall fuel hazard assessment guide: a rationale report – fire and adaptive management report no. 83* (in prep).

Appendix 2. Sample fuel assessment field work form

Date Assessed:	Assessors:
Sampling Location:	Veg Type:

Plot Information			
Plot No.			
Zone:			
Easting (GDA94 MGA UTM):			
Northing (GDA94 MGA UTM):			

Canopy (20m radius)			
Canopy Ave Height to Top:	m	m	m
Canopy Ave Height to Base:	m	m	m

Bark fuel (20m radius)															
Stringybark Fuel Hazard:	NP	M	H	VH	E	NP	M	H	VH	E	NP	M	H	VH	E
Ribbon Bark Fuel Hazard:	NP	M	H	VH		NP	M	H	VH		NP	M	H	VH	
Other Bark Fuel Hazard:	L	M	H			L	M	H			L	M	H		

Note: NP is bark type not present. Use the highest bark hazard rating to determine Overall Fuel Hazard.

Elevated fuel layer (10m radius)															
Elevated % Cover:	%					%					%				
Elevated % Dead	%					%					%				
Elevated Fuel Ave Height (m)	m					m					m				
Elevated Fuel Hazard:	L	M	H	VH	E	L	M	H	VH	E	L	M	H	VH	E

Near-surface fuel layer (10m radius)															
Near-surface % Cover:	%					%					%				
Near-surface % Dead	%					%					%				
NS Ave Height (cm):	cm					cm					cm				
NS Fuel Hazard:	L	M	H	VH	E	L	M	H	VH	E	L	M	H	VH	E

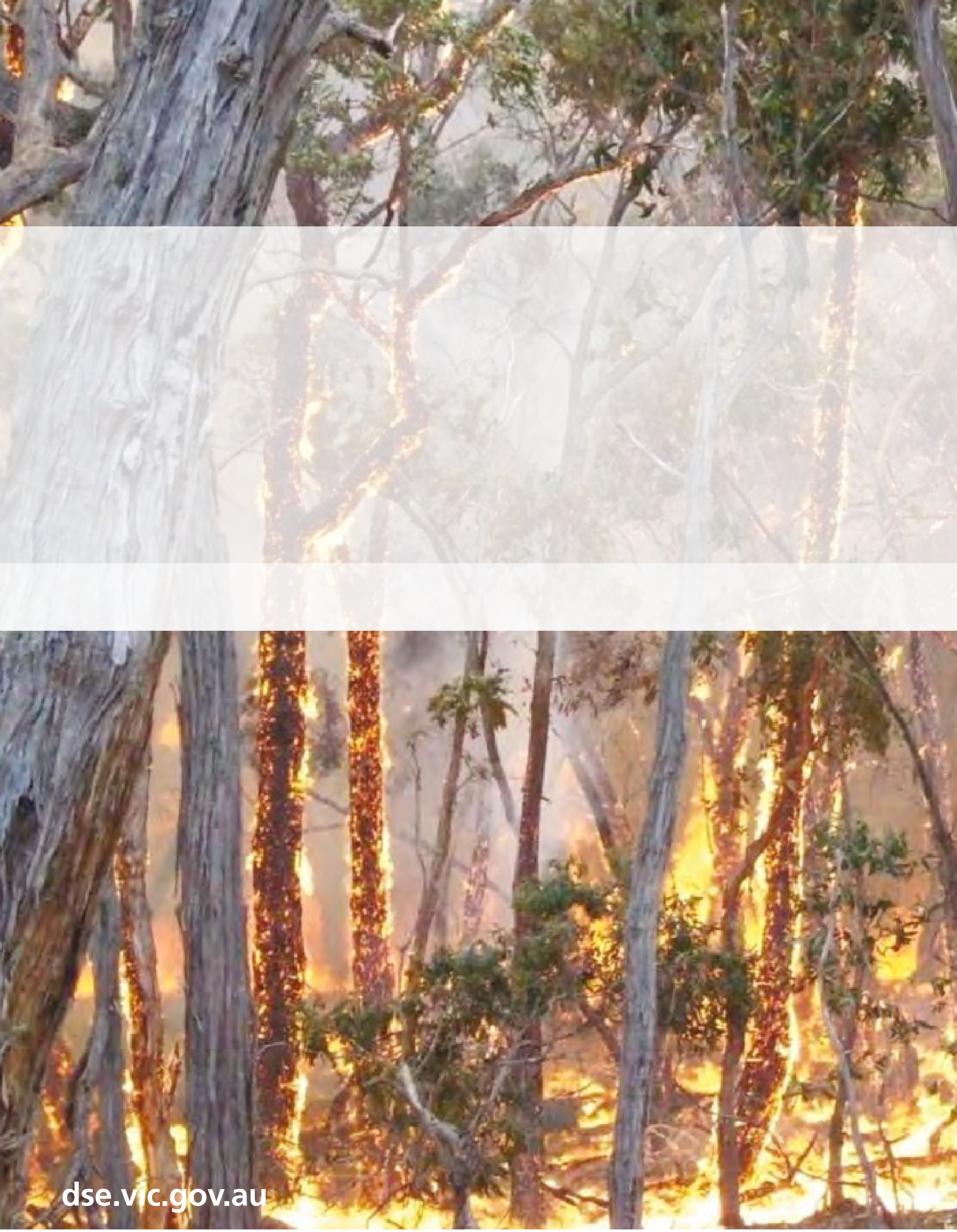
Surface fuel layer (10m radius)															
Surface Litter % Cover:	%					%					%				
Ave Litter Depth (mm):	mm					mm					mm				
Surface Fuel Hazard	L	M	H	VH	E	L	M	H	VH	E	L	M	H	VH	E

Combined Surface and Near-surface Fine Fuel Hazard calculation (refer Section 7)															
Combined Hazard	L	M	H	VH	E	L	M	H	VH	E	L	M	H	VH	E

Overall Fuel Hazard calculation (refer Section 8)															
Overall Fuel Hazard	L	M	H	VH	E	L	M	H	VH	E	L	M	H	VH	E

Are the plots representative of the average fuels across the sampling location?	Yes	No

If no, explain any significant difference between plots. For example, wet gully runs through the sampling area, no plots were located in this gully.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